Debugging with GDB

The GNU Source-Level Debugger

Tenth Edition, for GDB version 7.6-18.0.31

(GDB)

Richard Stallman, Roland Pesch, Stan Shebs, et al.

(Send bugs and comments on GDB to
http://www.intel.com/software/products/support/.)

Debugging with GDB
TEXinfo 2008-04-18.10

Published by the Free Software Foundation
51 Franklin Street, Fifth Floor, Boston, MA 02110-1301, USA
ISBN 978-0-9831592-3-0

Copyright © 1988-2013 Free Software Foundation, Inc.

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.3 or any later version published by the Free Software Foundation; with the Invariant Sections being "Free Software" and "Free Software Needs Free Documentation", with the Front-Cover Texts being "A GNU Manual," and with the Back-Cover Texts as in (a) below.

(a) The FSF's Back-Cover Text is: "You are free to copy and modify this GNU Manual. Buying copies from GNU Press supports the FSF in developing GNU and promoting software freedom."

Table of Contents

Summary of GDB **1**
Free Software 1
Free Software Needs Free Documentation 1
Contributors to GDB 3

1 A Sample GDB Session **7**

2 Getting In and Out of GDB **11**
2.1 Invoking GDB 11
2.1.1 Choosing Files 12
2.1.2 Choosing Modes 13
2.1.3 What GDB Does During Startup 16
2.2 Quitting GDB 17
2.3 Shell Commands 17
2.4 Logging Output 18

3 GDB Commands **19**
3.1 Command Syntax 19
3.2 Command Completion 19
3.3 Getting Help 21

4 Running Programs Under GDB **25**
4.1 Compiling for Debugging 25
4.2 Starting your Program 26
4.3 Your Program's Arguments 28
4.4 Your Program's Environment 29
4.5 Your Program's Working Directory 30
4.6 Your Program's Input and Output 30
4.7 Debugging an Already-running Process 31
4.8 Killing the Child Process 32
4.9 Debugging Multiple Inferiors and Programs 32
4.10 Debugging Programs with Multiple Threads 35
4.11 Debugging Forks 38
4.12 Setting a *Bookmark* to Return to Later 40
4.12.1 A Non-obvious Benefit of Using Checkpoints 42

5 Stopping and Continuing 43

5.1 Breakpoints, Watchpoints, and Catchpoints 43
5.1.1 Setting Breakpoints 44
5.1.2 Setting Watchpoints 50
5.1.3 Setting Catchpoints 53
5.1.4 Deleting Breakpoints 57
5.1.5 Disabling Breakpoints 57
5.1.6 Break Conditions 59
5.1.7 Breakpoint Command Lists 60
5.1.8 Dynamic Printf 61
5.1.9 How to save breakpoints to a file 63
5.1.10 Static Probe Points 63
5.1.11 "Cannot insert breakpoints" 64
5.1.12 "Breakpoint address adjusted..." 64
5.2 Continuing and Stepping 65
5.3 Skipping Over Functions and Files 69
5.4 Signals 70
5.5 Stopping and Starting Multi-thread Programs 72
5.5.1 All-Stop Mode 72
5.5.2 Non-Stop Mode 74
5.5.3 Background Execution 75
5.5.4 Thread-Specific Breakpoints 76
5.5.5 Interrupted System Calls 76
5.5.6 Observer Mode 77

6 Running programs backward 79

7 Recording Inferior's Execution and Replaying It 81

8 Examining the Stack 87

8.1 Stack Frames 87
8.2 Backtraces 88
8.3 Selecting a Frame 90
8.4 Information About a Frame 91

9 Examining Source Files 93

9.1 Printing Source Lines 93
9.2 Specifying a Location 94
9.3 Editing Source Files 95
9.3.1 Choosing your Editor 96
9.4 Searching Source Files 96
9.5 Specifying Source Directories 96
9.6 Source and Machine Code 99

10 Examining Data 103

10.1 Expressions 105
10.2 Ambiguous Expressions 106
10.3 Program Variables 107
10.4 Artificial Arrays 109
10.5 Output Formats 110
10.6 Examining Memory 111
10.7 Automatic Display 113
10.8 Print Settings 115
10.9 Pretty Printing 123
10.9.1 Pretty-Printer Introduction 123
10.9.2 Pretty-Printer Example 123
10.9.3 Pretty-Printer Commands 124
10.10 Value History 125
10.11 Convenience Variables 126
10.12 Convenience Functions 127
10.13 Registers 128
10.14 Floating Point Hardware 130
10.15 Vector Unit 130
10.16 Operating System Auxiliary Information 130
10.17 Memory Region Attributes 132
10.17.1 Attributes 133
10.17.1.1 Memory Access Mode 133
10.17.1.2 Memory Access Size 133
10.17.1.3 Data Cache 133
10.17.2 Memory Access Checking 134
10.18 Copy Between Memory and a File 134
10.19 How to Produce a Core File from Your Program 135
10.20 Character Sets 135
10.21 Caching Data of Remote Targets 138
10.22 Search Memory 139

11 Debugging Optimized Code 141

11.1 Inline Functions 141
11.2 Tail Call Frames 142

12 C Preprocessor Macros 145

13 Tracepoints ... 149
13.1 Commands to Set Tracepoints ... 149
13.1.1 Create and Delete Tracepoints ... 150
13.1.2 Enable and Disable Tracepoints ... 152
13.1.3 Tracepoint Passcounts ... 153
13.1.4 Tracepoint Conditions ... 153
13.1.5 Trace State Variables ... 153
13.1.6 Tracepoint Action Lists ... 154
13.1.7 Listing Tracepoints ... 156
13.1.8 Listing Static Tracepoint Markers ... 157
13.1.9 Starting and Stopping Trace Experiments ... 158
13.1.10 Tracepoint Restrictions ... 160
13.2 Using the Collected Data ... 161
13.2.1 `tfind` *n* ... 161
13.2.2 `tdump` ... 163
13.2.3 `save tracepoints` *filename* ... 164
13.3 Convenience Variables for Tracepoints ... 164
13.4 Using Trace Files ... 165

14 Debugging Programs That Use Overlays ... 167
14.1 How Overlays Work ... 167
14.2 Overlay Commands ... 168
14.3 Automatic Overlay Debugging ... 170
14.4 Overlay Sample Program ... 171

15 Using GDB with Different Languages ... 173
15.1 Switching Between Source Languages ... 173
15.1.1 List of Filename Extensions and Languages ... 173
15.1.2 Setting the Working Language ... 174
15.1.3 Having GDB Infer the Source Language ... 174
15.2 Displaying the Language ... 174
15.3 Type and Range Checking ... 175
15.3.1 An Overview of Type Checking ... 175
15.3.2 An Overview of Range Checking ... 176
15.4 Supported Languages ... 177
15.4.1 C and C++ ... 177
15.4.1.1 C and C++ Operators ... 177
15.4.1.2 C and C++ Constants ... 179
15.4.1.3 C++ Expressions ... 180
15.4.1.4 C and C++ Defaults ... 181
15.4.1.5 C and C++ Type and Range Checks ... 181
15.4.1.6 GDB and C ... 181
15.4.1.7 GDB Features for C++ ... 181
15.4.1.8 Decimal Floating Point format ... 183
15.4.2 D ... 183
15.4.3 Go ... 183

15.4.4 Objective-C 184
15.4.4.1 Method Names in Commands 184
15.4.4.2 The Print Command With Objective-C 184
15.4.5 OpenCL C 185
15.4.5.1 OpenCL C Datatypes 185
15.4.5.2 OpenCL C Expressions 185
15.4.5.3 OpenCL C Operators 185
15.4.6 Fortran 185
15.4.6.1 Fortran Operators and Expressions 185
15.4.6.2 Fortran Defaults 185
15.4.6.3 Special Fortran Commands 186
15.4.7 Pascal 186
15.4.8 Modula-2 186
15.4.8.1 Operators 186
15.4.8.2 Built-in Functions and Procedures 187
15.4.8.3 Constants 188
15.4.8.4 Modula-2 Types 189
15.4.8.5 Modula-2 Defaults 191
15.4.8.6 Deviations from Standard Modula-2 191
15.4.8.7 Modula-2 Type and Range Checks 191
15.4.8.8 The Scope Operators :: and 191
15.4.8.9 GDB and Modula-2 192
15.4.9 Ada 192
15.4.9.1 Introduction 192
15.4.9.2 Omissions from Ada 193
15.4.9.3 Additions to Ada 194
15.4.9.4 Stopping at the Very Beginning 195
15.4.9.5 Extensions for Ada Tasks 196
15.4.9.6 Tasking Support when Debugging Core Files 198
15.4.9.7 Tasking Support when using the Ravenscar Profile 199
15.4.9.8 Known Peculiarities of Ada Mode 199
15.5 Unsupported Languages 200

16 Examining the Symbol Table 201

17 Altering Execution 209

17.1 Assignment to Variables 209
17.2 Continuing at a Different Address 210
17.3 Giving your Program a Signal 211
17.4 Returning from a Function 211
17.5 Calling Program Functions 212
17.6 Patching Programs 213

18 GDB Files ... 215
18.1 Commands to Specify Files ... 215
18.2 Debugging Information in Separate Files ... 223
18.3 Debugging information in a special section ... 227
18.4 Index Files Speed Up GDB ... 227
18.5 Errors Reading Symbol Files ... 228
18.6 GDB Data Files ... 229

19 Specifying a Debugging Target ... 231
19.1 Active Targets ... 231
19.2 Commands for Managing Targets ... 231
19.3 Choosing Target Byte Order ... 234

20 Debugging Remote Programs ... 235
20.1 Connecting to a Remote Target ... 235
20.2 Sending files to a remote system ... 237
20.3 Using the `gdbserver` Program ... 237
20.3.1 Running `gdbserver` ... 237
20.3.1.1 Attaching to a Running Program ... 238
20.3.1.2 Multi-Process Mode for `gdbserver` ... 238
20.3.1.3 TCP port allocation lifecycle of `gdbserver` ... 239
20.3.1.4 Other Command-Line Arguments for `gdbserver` ... 239
20.3.2 Connecting to `gdbserver` ... 240
20.3.3 Monitor Commands for `gdbserver` ... 240
20.3.4 Tracepoints support in `gdbserver` ... 241
20.4 Remote Configuration ... 242
20.5 Implementing a Remote Stub ... 247
20.5.1 What the Stub Can Do for You ... 248
20.5.2 What You Must Do for the Stub ... 248
20.5.3 Putting it All Together ... 250

21 Configuration-Specific Information ... 251
21.1 Native ... 251
21.1.1 HP-UX ... 251
21.1.2 BSD libkvm Interface ... 251
21.1.3 SVR4 Process Information ... 251
21.1.4 Features for Debugging DJGPP Programs ... 253
21.1.5 Features for Debugging MS Windows PE Executables ... 255
21.1.5.1 Support for DLLs without Debugging Symbols ... 257
21.1.5.2 DLL Name Prefixes ... 257
21.1.5.3 Working with Minimal Symbols ... 258
21.1.6 Commands Specific to GNU Hurd Systems ... 258
21.1.7 Darwin ... 261
21.2 Embedded Operating Systems ... 261
21.2.1 Using GDB with VxWorks ... 261
21.2.1.1 Connecting to VxWorks ... 262
21.2.1.2 VxWorks Download ... 262

21.2.1.3 Running Tasks 263
21.3 Embedded Processors 263
21.3.1 ARM 263
21.3.2 Renesas M32R/D and M32R/SDI 265
21.3.3 M68k 266
21.3.4 MicroBlaze 267
21.3.5 MIPS Embedded 267
21.3.6 OpenRISC 1000 269
21.3.7 PowerPC Embedded 271
21.3.8 HP PA Embedded 272
21.3.9 Tsqware Sparclet 273
21.3.9.1 Setting File to Debug 273
21.3.9.2 Connecting to Sparclet 273
21.3.9.3 Sparclet Download 273
21.3.9.4 Running and Debugging 274
21.3.10 Fujitsu Sparclite 274
21.3.11 Zilog Z8000 274
21.3.12 Atmel AVR 275
21.3.13 CRIS 275
21.3.14 Renesas Super-H 275
21.4 Architectures 276
21.4.1 AArch64 276
21.4.2 x86 Architecture-specific Issues 276
21.4.3 Alpha 276
21.4.4 MIPS 276
21.4.5 HPPA 278
21.4.6 Cell Broadband Engine SPU architecture 278
21.4.7 PowerPC 279

22 Controlling GDB 281

22.1 Prompt 281
22.2 Command Editing 281
22.3 Command History 282
22.4 Screen Size 283
22.5 Numbers 284
22.6 Configuring the Current ABI 285
22.7 Automatically loading associated files 286
22.7.1 Automatically loading init file in the current directory 288
22.7.2 Automatically loading thread debugging library 288
22.7.3 The '*objfile*-gdb.gdb' file 288
22.7.4 Security restriction for auto-loading 289
22.7.5 Displaying files tried for auto-load 290
22.8 Optional Warnings and Messages 291
22.9 Optional Messages about Internal Happenings 292
22.10 Other Miscellaneous Settings 296

23 Extending GDB 297
23.1 Canned Sequences of Commands 297
23.1.1 User-defined Commands 297
23.1.2 User-defined Command Hooks 299
23.1.3 Command Files 300
23.1.4 Commands for Controlled Output 301
23.2 Scripting GDB using Python 303
23.2.1 Python Commands 303
23.2.2 Python API 304
23.2.2.1 Basic Python 304
23.2.2.2 Exception Handling 308
23.2.2.3 Values From Inferior 309
23.2.2.4 Types In Python 313
23.2.2.5 Pretty Printing API 317
23.2.2.6 Selecting Pretty-Printers 318
23.2.2.7 Writing a Pretty-Printer 319
23.2.2.8 Type Printing API 321
23.2.2.9 Inferiors In Python 322
23.2.2.10 Events In Python 323
23.2.2.11 Threads In Python 325
23.2.2.12 Commands In Python 326
23.2.2.13 Parameters In Python 329
23.2.2.14 Writing new convenience functions 331
23.2.2.15 Program Spaces In Python 332
23.2.2.16 Objfiles In Python 333
23.2.2.17 Accessing inferior stack frames from Python. 333
23.2.2.18 Accessing frame blocks from Python. 336
23.2.2.19 Python representation of Symbols. 337
23.2.2.20 Symbol table representation in Python. 340
23.2.2.21 Manipulating breakpoints using Python 342
23.2.2.22 Finish Breakpoints 344
23.2.2.23 Python representation of lazy strings. 345
23.2.2.24 Python representation of architectures 346
23.2.3 Python Auto-loading 346
23.2.3.1 The '*objfile*-gdb.py' file 347
23.2.3.2 The .debug_gdb_scripts section 348
23.2.3.3 Which flavor to choose? 348
23.2.4 Python modules 349
23.2.4.1 gdb.printing 349
23.2.4.2 gdb.types 350
23.2.4.3 gdb.prompt 351
23.3 Creating new spellings of existing commands 352

24 Command Interpreters 355

25 GDB Text User Interface 357
25.1 TUI Overview 357
25.2 TUI Key Bindings 358
25.3 TUI Single Key Mode 359
25.4 TUI-specific Commands 359
25.5 TUI Configuration Variables 361

26 Using GDB under GNU Emacs 363

27 The GDB/MI Interface 365
Function and Purpose 365
Notation and Terminology 365
27.3 GDB/MI General Design 365
27.3.1 Context management 366
27.3.2 Asynchronous command execution and non-stop mode 367
27.3.3 Thread groups 367
27.4 GDB/MI Command Syntax 368
27.4.1 GDB/MI Input Syntax 368
27.4.2 GDB/MI Output Syntax 369
27.5 GDB/MI Compatibility with CLI 370
27.6 GDB/MI Development and Front Ends 371
27.7 GDB/MI Output Records 371
27.7.1 GDB/MI Result Records 371
27.7.2 GDB/MI Stream Records 372
27.7.3 GDB/MI Async Records 372
27.7.4 GDB/MI Breakpoint Information 376
27.7.5 GDB/MI Frame Information 377
27.7.6 GDB/MI Thread Information 378
27.7.7 GDB/MI Ada Exception Information 378
27.8 Simple Examples of GDB/MI Interaction 378
27.9 GDB/MI Command Description Format 379
27.10 GDB/MI Breakpoint Commands 380
27.11 GDB/MI Catchpoint Commands 388
27.12 GDB/MI Program Context 389
27.13 GDB/MI Thread Commands 391
27.14 GDB/MI Ada Tasking Commands 393
27.15 GDB/MI Program Execution 394
27.16 GDB/MI Stack Manipulation Commands 401
27.17 GDB/MI Variable Objects 406
27.18 GDB/MI Data Manipulation 416
27.19 GDB/MI Tracepoint Commands 425
27.20 GDB/MI Symbol Query Commands 429
27.21 GDB/MI File Commands 429
27.22 GDB/MI Target Manipulation Commands 431
27.23 GDB/MI File Transfer Commands 434
27.24 Miscellaneous GDB/MI Commands 435

28 GDB Annotations ... 443
28.1 What is an Annotation? ... 443
28.2 The Server Prefix ... 444
28.3 Annotation for GDB Input ... 444
28.4 Errors ... 445
28.5 Invalidation Notices ... 445
28.6 Running the Program ... 445
28.7 Displaying Source ... 446

29 JIT Compilation Interface ... 447
29.1 JIT Declarations ... 447
29.2 Registering Code ... 448
29.3 Unregistering Code ... 448
29.4 Custom Debug Info ... 448
29.4.1 Using JIT Debug Info Readers ... 449
29.4.2 Writing JIT Debug Info Readers ... 449

30 In-Process Agent ... 451
30.1 In-Process Agent Protocol ... 451
30.1.1 IPA Protocol Objects ... 452
30.1.2 IPA Protocol Commands ... 453

31 Reporting Bugs in GDB ... 455
31.1 Have You Found a Bug? ... 455
31.2 How to Report Bugs ... 455

32 Command Line Editing ... 459
32.1 Introduction to Line Editing ... 459
32.2 Readline Interaction ... 459
32.2.1 Readline Bare Essentials ... 459
32.2.2 Readline Movement Commands ... 460
32.2.3 Readline Killing Commands ... 460
32.2.4 Readline Arguments ... 461
32.2.5 Searching for Commands in the History ... 461
32.3 Readline Init File ... 462
32.3.1 Readline Init File Syntax ... 462
32.3.2 Conditional Init Constructs ... 468
32.3.3 Sample Init File ... 469
32.4 Bindable Readline Commands ... 472
32.4.1 Commands For Moving ... 472
32.4.2 Commands For Manipulating The History ... 472
32.4.3 Commands For Changing Text ... 474
32.4.4 Killing And Yanking ... 475
32.4.5 Specifying Numeric Arguments ... 476
32.4.6 Letting Readline Type For You ... 476
32.4.7 Keyboard Macros ... 477
32.4.8 Some Miscellaneous Commands ... 477

32.5 Readline vi Mode 479

33 Using History Interactively 481
33.1 History Expansion 481
33.1.1 Event Designators 481
33.1.2 Word Designators 482
33.1.3 Modifiers 482

Appendix A In Memoriam 485

Appendix B Formatting Documentation 487

Appendix C Installing GDB 489
C.1 Requirements for Building GDB 489
C.2 Invoking the GDB 'configure' Script 490
C.3 Compiling GDB in Another Directory 491
C.4 Specifying Names for Hosts and Targets 492
C.5 'configure' Options 493
C.6 System-wide configuration and settings 494

Appendix D Maintenance Commands 495

Appendix E GDB Remote Serial Protocol 503
E.1 Overview 503
E.2 Packets 504
E.3 Stop Reply Packets 514
E.4 General Query Packets 516
E.5 Architecture-Specific Protocol Details 534
E.5.1 ARM-specific Protocol Details 534
E.5.1.1 ARM Breakpoint Kinds 534
E.5.2 MIPS-specific Protocol Details 534
E.5.2.1 MIPS Register Packet Format 534
E.5.2.2 MIPS Breakpoint Kinds 535
E.6 Tracepoint Packets 535
E.6.1 Relocate instruction reply packet 541
E.7 Host I/O Packets 542
E.8 Interrupts 543
E.9 Notification Packets 544
E.10 Remote Protocol Support for Non-Stop Mode 546
E.11 Packet Acknowledgment 546
E.12 Examples 547
E.13 File-I/O Remote Protocol Extension 547
E.13.1 File-I/O Overview 547
E.13.2 Protocol Basics 548
E.13.3 The F Request Packet 549
E.13.4 The F Reply Packet 549

E.13.5 The 'Ctrl-C' Message ... 549
E.13.6 Console I/O ... 550
E.13.7 List of Supported Calls ... 550
open ... 550
close ... 552
read ... 552
write ... 552
lseek ... 553
rename ... 553
unlink ... 554
stat/fstat ... 554
gettimeofday ... 555
isatty ... 555
system ... 555
E.13.8 Protocol-specific Representation of Datatypes ... 556
Integral Datatypes ... 556
Pointer Values ... 556
Memory Transfer ... 556
struct stat ... 557
struct timeval ... 557
E.13.9 Constants ... 558
Open Flags ... 558
mode_t Values ... 558
Errno Values ... 558
Lseek Flags ... 559
Limits ... 559
E.13.10 File-I/O Examples ... 559
E.14 Library List Format ... 559
E.15 Library List Format for SVR4 Targets ... 560
E.16 Memory Map Format ... 561
E.17 Thread List Format ... 562
E.18 Traceframe Info Format ... 562
E.19 Branch Trace Format ... 563

Appendix F The GDB Agent Expression Mechanism ... 565

F.1 General Bytecode Design ... 565
F.2 Bytecode Descriptions ... 567
F.3 Using Agent Expressions ... 572
F.4 Varying Target Capabilities ... 573
F.5 Rationale ... 573

Appendix G Target Descriptions 577
G.1 Retrieving Descriptions 577
G.2 Target Description Format 577
G.2.1 Inclusion 578
G.2.2 Architecture 578
G.2.3 OS ABI 579
G.2.4 Compatible Architecture 579
G.2.5 Features 579
G.2.6 Types 579
G.2.7 Registers 580
G.3 Predefined Target Types 581
G.4 Standard Target Features 582
G.4.1 AArch64 Features 582
G.4.2 ARM Features 582
G.4.3 i386 Features 583
G.4.4 MIPS Features 583
G.4.5 M68K Features 584
G.4.6 PowerPC Features 584
G.4.7 TMS320C6x Features 584

Appendix H Operating System Information 585
H.1 Process list 585

Appendix I Trace File Format 587

Appendix J `.gdb_index` section format 589

Appendix K GNU GENERAL PUBLIC LICENSE 593

Appendix L GNU Free Documentation License 605

Concept Index 613

Command, Variable, and Function Index 627

Summary of GDB

The purpose of a debugger such as GDB is to allow you to see what is going on "inside" another program while it executes—or what another program was doing at the moment it crashed.

GDB can do four main kinds of things (plus other things in support of these) to help you catch bugs in the act:

- Start your program, specifying anything that might affect its behavior.
- Make your program stop on specified conditions.
- Examine what has happened, when your program has stopped.
- Change things in your program, so you can experiment with correcting the effects of one bug and go on to learn about another.

You can use GDB to debug programs written in C and C++. For more information, see Section 15.4 [Supported Languages], page 177. For more information, see Section 15.4.1 [C and C++], page 177.

Support for D is partial. For information on D, see Section 15.4.2 [D], page 183.

Support for Modula-2 is partial. For information on Modula-2, see Section 15.4.8 [Modula-2], page 186.

Support for OpenCL C is partial. For information on OpenCL C, see Section 15.4.5 [OpenCL C], page 185.

Debugging Pascal programs which use sets, subranges, file variables, or nested functions does not currently work. GDB does not support entering expressions, printing values, or similar features using Pascal syntax.

GDB can be used to debug programs written in Fortran, although it may be necessary to refer to some variables with a trailing underscore.

GDB can be used to debug programs written in Objective-C, using either the Apple/NeXT or the GNU Objective-C runtime.

Free Software

GDB is *free software*, protected by the GNU General Public License (GPL). The GPL gives you the freedom to copy or adapt a licensed program—but every person getting a copy also gets with it the freedom to modify that copy (which means that they must get access to the source code), and the freedom to distribute further copies. Typical software companies use copyrights to limit your freedoms; the Free Software Foundation uses the GPL to preserve these freedoms.

Fundamentally, the General Public License is a license which says that you have these freedoms and that you cannot take these freedoms away from anyone else.

Free Software Needs Free Documentation

The biggest deficiency in the free software community today is not in the software—it is the lack of good free documentation that we can include with the free software. Many of our most important programs do not come with free reference manuals and free introductory

texts. Documentation is an essential part of any software package; when an important free software package does not come with a free manual and a free tutorial, that is a major gap. We have many such gaps today.

Consider Perl, for instance. The tutorial manuals that people normally use are non-free. How did this come about? Because the authors of those manuals published them with restrictive terms—no copying, no modification, source files not available—which exclude them from the free software world.

That wasn't the first time this sort of thing happened, and it was far from the last. Many times we have heard a GNU user eagerly describe a manual that he is writing, his intended contribution to the community, only to learn that he had ruined everything by signing a publication contract to make it non-free.

Free documentation, like free software, is a matter of freedom, not price. The problem with the non-free manual is not that publishers charge a price for printed copies—that in itself is fine. (The Free Software Foundation sells printed copies of manuals, too.) The problem is the restrictions on the use of the manual. Free manuals are available in source code form, and give you permission to copy and modify. Non-free manuals do not allow this.

The criteria of freedom for a free manual are roughly the same as for free software. Redistribution (including the normal kinds of commercial redistribution) must be permitted, so that the manual can accompany every copy of the program, both on-line and on paper.

Permission for modification of the technical content is crucial too. When people modify the software, adding or changing features, if they are conscientious they will change the manual too—so they can provide accurate and clear documentation for the modified program. A manual that leaves you no choice but to write a new manual to document a changed version of the program is not really available to our community.

Some kinds of limits on the way modification is handled are acceptable. For example, requirements to preserve the original author's copyright notice, the distribution terms, or the list of authors, are ok. It is also no problem to require modified versions to include notice that they were modified. Even entire sections that may not be deleted or changed are acceptable, as long as they deal with nontechnical topics (like this one). These kinds of restrictions are acceptable because they don't obstruct the community's normal use of the manual.

However, it must be possible to modify all the *technical* content of the manual, and then distribute the result in all the usual media, through all the usual channels. Otherwise, the restrictions obstruct the use of the manual, it is not free, and we need another manual to replace it.

Please spread the word about this issue. Our community continues to lose manuals to proprietary publishing. If we spread the word that free software needs free reference manuals and free tutorials, perhaps the next person who wants to contribute by writing documentation will realize, before it is too late, that only free manuals contribute to the free software community.

If you are writing documentation, please insist on publishing it under the GNU Free Documentation License or another free documentation license. Remember that this decision requires your approval—you don't have to let the publisher decide. Some commercial publishers will use a free license if you insist, but they will not propose the option; it is up

to you to raise the issue and say firmly that this is what you want. If the publisher you are dealing with refuses, please try other publishers. If you're not sure whether a proposed license is free, write to licensing@gnu.org.

You can encourage commercial publishers to sell more free, copylefted manuals and tutorials by buying them, and particularly by buying copies from the publishers that paid for their writing or for major improvements. Meanwhile, try to avoid buying non-free documentation at all. Check the distribution terms of a manual before you buy it, and insist that whoever seeks your business must respect your freedom. Check the history of the book, and try to reward the publishers that have paid or pay the authors to work on it.

The Free Software Foundation maintains a list of free documentation published by other publishers, at http://www.fsf.org/doc/other-free-books.html.

Contributors to GDB

Richard Stallman was the original author of GDB, and of many other GNU programs. Many others have contributed to its development. This section attempts to credit major contributors. One of the virtues of free software is that everyone is free to contribute to it; with regret, we cannot actually acknowledge everyone here. The file '`ChangeLog`' in the GDB distribution approximates a blow-by-blow account.

Changes much prior to version 2.0 are lost in the mists of time.

> *Plea:* Additions to this section are particularly welcome. If you or your friends (or enemies, to be evenhanded) have been unfairly omitted from this list, we would like to add your names!

So that they may not regard their many labors as thankless, we particularly thank those who shepherded GDB through major releases: Andrew Cagney (releases 6.3, 6.2, 6.1, 6.0, 5.3, 5.2, 5.1 and 5.0); Jim Blandy (release 4.18); Jason Molenda (release 4.17); Stan Shebs (release 4.14); Fred Fish (releases 4.16, 4.15, 4.13, 4.12, 4.11, 4.10, and 4.9); Stu Grossman and John Gilmore (releases 4.8, 4.7, 4.6, 4.5, and 4.4); John Gilmore (releases 4.3, 4.2, 4.1, 4.0, and 3.9); Jim Kingdon (releases 3.5, 3.4, and 3.3); and Randy Smith (releases 3.2, 3.1, and 3.0).

Richard Stallman, assisted at various times by Peter TerMaat, Chris Hanson, and Richard Mlynarik, handled releases through 2.8.

Michael Tiemann is the author of most of the GNU C++ support in GDB, with significant additional contributions from Per Bothner and Daniel Berlin. James Clark wrote the GNU C++ demangler. Early work on C++ was by Peter TerMaat (who also did much general update work leading to release 3.0).

GDB uses the BFD subroutine library to examine multiple object-file formats; BFD was a joint project of David V. Henkel-Wallace, Rich Pixley, Steve Chamberlain, and John Gilmore.

David Johnson wrote the original COFF support; Pace Willison did the original support for encapsulated COFF.

Brent Benson of Harris Computer Systems contributed DWARF 2 support.

Adam de Boor and Bradley Davis contributed the ISI Optimum V support. Per Bothner, Noboyuki Hikichi, and Alessandro Forin contributed MIPS support. Jean-Daniel Fekete contributed Sun 386i support. Chris Hanson improved the HP9000 support. Noboyuki

Hikichi and Tomoyuki Hasei contributed Sony/News OS 3 support. David Johnson contributed Encore Umax support. Jyrki Kuoppala contributed Altos 3068 support. Jeff Law contributed HP PA and SOM support. Keith Packard contributed NS32K support. Doug Rabson contributed Acorn Risc Machine support. Bob Rusk contributed Harris Nighthawk CX-UX support. Chris Smith contributed Convex support (and Fortran debugging). Jonathan Stone contributed Pyramid support. Michael Tiemann contributed SPARC support. Tim Tucker contributed support for the Gould NP1 and Gould Powernode. Pace Willison contributed Intel 386 support. Jay Vosburgh contributed Symmetry support. Marko Mlinar contributed OpenRISC 1000 support.

Andreas Schwab contributed M68K GNU/Linux support.

Rich Schaefer and Peter Schauer helped with support of SunOS shared libraries.

Jay Fenlason and Roland McGrath ensured that GDB and GAS agree about several machine instruction sets.

Patrick Duval, Ted Goldstein, Vikram Koka and Glenn Engel helped develop remote debugging. Intel Corporation, Wind River Systems, AMD, and ARM contributed remote debugging modules for the i960, VxWorks, A29K UDI, and RDI targets, respectively.

Brian Fox is the author of the readline libraries providing command-line editing and command history.

Andrew Beers of SUNY Buffalo wrote the language-switching code, the Modula-2 support, and contributed the Languages chapter of this manual.

Fred Fish wrote most of the support for Unix System Vr4. He also enhanced the command-completion support to cover C++ overloaded symbols.

Hitachi America (now Renesas America), Ltd. sponsored the support for H8/300, H8/500, and Super-H processors.

NEC sponsored the support for the v850, Vr4xxx, and Vr5xxx processors.

Mitsubishi (now Renesas) sponsored the support for D10V, D30V, and M32R/D processors.

Toshiba sponsored the support for the TX39 Mips processor.

Matsushita sponsored the support for the MN10200 and MN10300 processors.

Fujitsu sponsored the support for SPARClite and FR30 processors.

Kung Hsu, Jeff Law, and Rick Sladkey added support for hardware watchpoints.

Michael Snyder added support for tracepoints.

Stu Grossman wrote gdbserver.

Jim Kingdon, Peter Schauer, Ian Taylor, and Stu Grossman made nearly innumerable bug fixes and cleanups throughout GDB.

The following people at the Hewlett-Packard Company contributed support for the PA-RISC 2.0 architecture, HP-UX 10.20, 10.30, and 11.0 (narrow mode), HP's implementation of kernel threads, HP's aC++ compiler, and the Text User Interface (nee Terminal User Interface): Ben Krepp, Richard Title, John Bishop, Susan Macchia, Kathy Mann, Satish Pai, India Paul, Steve Rehrauer, and Elena Zannoni. Kim Haase provided HP-specific information in this manual.

DJ Delorie ported GDB to MS-DOS, for the DJGPP project. Robert Hoehne made significant contributions to the DJGPP port.

Cygnus Solutions has sponsored GDB maintenance and much of its development since 1991. Cygnus engineers who have worked on GDB fulltime include Mark Alexander, Jim Blandy, Per Bothner, Kevin Buettner, Edith Epstein, Chris Faylor, Fred Fish, Martin Hunt, Jim Ingham, John Gilmore, Stu Grossman, Kung Hsu, Jim Kingdon, John Metzler, Fernando Nasser, Geoffrey Noer, Dawn Perchik, Rich Pixley, Zdenek Radouch, Keith Seitz, Stan Shebs, David Taylor, and Elena Zannoni. In addition, Dave Brolley, Ian Carmichael, Steve Chamberlain, Nick Clifton, JT Conklin, Stan Cox, DJ Delorie, Ulrich Drepper, Frank Eigler, Doug Evans, Sean Fagan, David Henkel-Wallace, Richard Henderson, Jeff Holcomb, Jeff Law, Jim Lemke, Tom Lord, Bob Manson, Michael Meissner, Jason Merrill, Catherine Moore, Drew Moseley, Ken Raeburn, Gavin Romig-Koch, Rob Savoye, Jamie Smith, Mike Stump, Ian Taylor, Angela Thomas, Michael Tiemann, Tom Tromey, Ron Unrau, Jim Wilson, and David Zuhn have made contributions both large and small.

Andrew Cagney, Fernando Nasser, and Elena Zannoni, while working for Cygnus Solutions, implemented the original GDB/MI interface.

Jim Blandy added support for preprocessor macros, while working for Red Hat.

Andrew Cagney designed GDB's architecture vector. Many people including Andrew Cagney, Stephane Carrez, Randolph Chung, Nick Duffek, Richard Henderson, Mark Kettenis, Grace Sainsbury, Kei Sakamoto, Yoshinori Sato, Michael Snyder, Andreas Schwab, Jason Thorpe, Corinna Vinschen, Ulrich Weigand, and Elena Zannoni, helped with the migration of old architectures to this new framework.

Andrew Cagney completely re-designed and re-implemented GDB's unwinder framework, this consisting of a fresh new design featuring frame IDs, independent frame sniffers, and the sentinel frame. Mark Kettenis implemented the DWARF 2 unwinder, Jeff Johnston the libunwind unwinder, and Andrew Cagney the dummy, sentinel, tramp, and trad unwinders. The architecture-specific changes, each involving a complete rewrite of the architecture's frame code, were carried out by Jim Blandy, Joel Brobecker, Kevin Buettner, Andrew Cagney, Stephane Carrez, Randolph Chung, Orjan Friberg, Richard Henderson, Daniel Jacobowitz, Jeff Johnston, Mark Kettenis, Theodore A. Roth, Kei Sakamoto, Yoshinori Sato, Michael Snyder, Corinna Vinschen, and Ulrich Weigand.

Christian Zankel, Ross Morley, Bob Wilson, and Maxim Grigoriev from Tensilica, Inc. contributed support for Xtensa processors. Others who have worked on the Xtensa port of GDB in the past include Steve Tjiang, John Newlin, and Scott Foehner.

Michael Eager and staff of Xilinx, Inc., contributed support for the Xilinx MicroBlaze architecture.

1 A Sample GDB Session

You can use this manual at your leisure to read all about GDB. However, a handful of commands are enough to get started using the debugger. This chapter illustrates those commands.

In this sample session, we emphasize user input like this: **input**, to make it easier to pick out from the surrounding output.

One of the preliminary versions of GNU `m4` (a generic macro processor) exhibits the following bug: sometimes, when we change its quote strings from the default, the commands used to capture one macro definition within another stop working. In the following short `m4` session, we define a macro `foo` which expands to `0000`; we then use the `m4` built-in `defn` to define `bar` as the same thing. However, when we change the open quote string to `<QUOTE>` and the close quote string to `<UNQUOTE>`, the same procedure fails to define a new synonym `baz`:

```
$ cd gnu/m4
$ ./m4
define(foo,0000)

foo
0000
define(bar,defn(‘foo’))

bar
0000
changequote(<QUOTE>,<UNQUOTE>)

define(baz,defn(<QUOTE>foo<UNQUOTE>))
baz
Ctrl-d
m4: End of input: 0: fatal error: EOF in string
```

Let us use GDB to try to see what is going on.

```
$ gdb m4
GDB is free software and you are welcome to distribute copies
 of it under certain conditions; type "show copying" to see
 the conditions.
There is absolutely no warranty for GDB; type "show warranty"
 for details.

GDB 7.6-18.0.31, Copyright 1999 Free Software Foundation, Inc...
(gdb)
```

GDB reads only enough symbol data to know where to find the rest when needed; as a result, the first prompt comes up very quickly. We now tell GDB to use a narrower display width than usual, so that examples fit in this manual.

```
(gdb) set width 70
```

We need to see how the `m4` built-in `changequote` works. Having looked at the source, we know the relevant subroutine is `m4_changequote`, so we set a breakpoint there with the GDB `break` command.

```
(gdb) break m4_changequote
Breakpoint 1 at 0x62f4: file builtin.c, line 879.
```

Using the `run` command, we start `m4` running under GDB control; as long as control does not reach the `m4_changequote` subroutine, the program runs as usual:

```
(gdb) run
Starting program: /work/Editorial/gdb/gnu/m4/m4
define(foo,0000)

foo
0000
```

To trigger the breakpoint, we call `changequote`. GDB suspends execution of `m4`, displaying information about the context where it stops.

```
changequote(<QUOTE>,<UNQUOTE>)

Breakpoint 1, m4_changequote (argc=3, argv=0x33c70)
    at builtin.c:879
879         if (bad_argc(TOKEN_DATA_TEXT(argv[0]),argc,1,3))
```

Now we use the command `n` (`next`) to advance execution to the next line of the current function.

```
(gdb) n
882         set_quotes((argc >= 2) ? TOKEN_DATA_TEXT(argv[1])\
 : nil,
```

`set_quotes` looks like a promising subroutine. We can go into it by using the command `s` (`step`) instead of `next`. `step` goes to the next line to be executed in *any* subroutine, so it steps into `set_quotes`.

```
(gdb) s
set_quotes (lq=0x34c78 "<QUOTE>", rq=0x34c88 "<UNQUOTE>")
    at input.c:530
530         if (lquote != def_lquote)
```

The display that shows the subroutine where `m4` is now suspended (and its arguments) is called a stack frame display. It shows a summary of the stack. We can use the `backtrace` command (which can also be spelled `bt`), to see where we are in the stack as a whole: the `backtrace` command displays a stack frame for each active subroutine.

```
(gdb) bt
#0  set_quotes (lq=0x34c78 "<QUOTE>", rq=0x34c88 "<UNQUOTE>")
    at input.c:530
#1  0x6344 in m4_changequote (argc=3, argv=0x33c70)
    at builtin.c:882
#2  0x8174 in expand_macro (sym=0x33320) at macro.c:242
#3  0x7a88 in expand_token (obs=0x0, t=209696, td=0xf7fffa30)
    at macro.c:71
#4  0x79dc in expand_input () at macro.c:40
#5  0x2930 in main (argc=0, argv=0xf7fffb20) at m4.c:195
```

We step through a few more lines to see what happens. The first two times, we can use '`s`'; the next two times we use `n` to avoid falling into the `xstrdup` subroutine.

```
(gdb) s
0x3b5c  532         if (rquote != def_rquote)
(gdb) s
0x3b80  535         lquote = (lq == nil || *lq == '\0') ?  \
def_lquote : xstrdup(lq);
(gdb) n
536         rquote = (rq == nil || *rq == '\0') ? def_rquote\
 : xstrdup(rq);
(gdb) n
538         len_lquote = strlen(rquote);
```

The last line displayed looks a little odd; we can examine the variables `lquote` and `rquote` to see if they are in fact the new left and right quotes we specified. We use the command `p` (`print`) to see their values.

```
(gdb) p lquote
$1 = 0x35d40 "<QUOTE>"
(gdb) p rquote
$2 = 0x35d50 "<UNQUOTE>"
```

`lquote` and `rquote` are indeed the new left and right quotes. To look at some context, we can display ten lines of source surrounding the current line with the `l` (`list`) command.

```
(gdb) l
533             xfree(rquote);
534
535         lquote = (lq == nil || *lq == '\0') ? def_lquote\
 : xstrdup (lq);
536         rquote = (rq == nil || *rq == '\0') ? def_rquote\
 : xstrdup (rq);
537
538         len_lquote = strlen(rquote);
539         len_rquote = strlen(lquote);
540     }
541
542     void
```

Let us step past the two lines that set `len_lquote` and `len_rquote`, and then examine the values of those variables.

```
(gdb) n
539         len_rquote = strlen(lquote);
(gdb) n
540     }
(gdb) p len_lquote
$3 = 9
(gdb) p len_rquote
$4 = 7
```

That certainly looks wrong, assuming `len_lquote` and `len_rquote` are meant to be the lengths of `lquote` and `rquote` respectively. We can set them to better values using the `p` command, since it can print the value of any expression—and that expression can include subroutine calls and assignments.

```
(gdb) p len_lquote=strlen(lquote)
$5 = 7
(gdb) p len_rquote=strlen(rquote)
$6 = 9
```

Is that enough to fix the problem of using the new quotes with the `m4` built-in `defn`? We can allow `m4` to continue executing with the `c` (`continue`) command, and then try the example that caused trouble initially:

```
(gdb) c
Continuing.

define(baz,defn(<QUOTE>foo<UNQUOTE>))

baz
0000
```

Success! The new quotes now work just as well as the default ones. The problem seems to have been just the two typos defining the wrong lengths. We allow `m4` exit by giving it an EOF as input:

```
Ctrl-d
Program exited normally.
```

The message '`Program exited normally.`' is from GDB; it indicates `m4` has finished executing. We can end our GDB session with the GDB `quit` command.

```
(gdb) quit
```

2 Getting In and Out of GDB

This chapter discusses how to start GDB, and how to get out of it. The essentials are:

- type '`gdb`' to start GDB.
- type *`quit`* or *`Ctrl-d`* to exit.

2.1 Invoking GDB

Invoke GDB by running the program `gdb`. Once started, GDB reads commands from the terminal until you tell it to exit.

You can also run `gdb` with a variety of arguments and options, to specify more of your debugging environment at the outset.

The command-line options described here are designed to cover a variety of situations; in some environments, some of these options may effectively be unavailable.

The most usual way to start GDB is with one argument, specifying an executable program:

```
gdb program
```

You can also start with both an executable program and a core file specified:

```
gdb program core
```

You can, instead, specify a process ID as a second argument, if you want to debug a running process:

```
gdb program 1234
```

would attach GDB to process `1234` (unless you also have a file named '`1234`'; GDB does check for a core file first).

Taking advantage of the second command-line argument requires a fairly complete operating system; when you use GDB as a remote debugger attached to a bare board, there may not be any notion of "process", and there is often no way to get a core dump. GDB will warn you if it is unable to attach or to read core dumps.

You can optionally have `gdb` pass any arguments after the executable file to the inferior using `--args`. This option stops option processing.

```
gdb --args gcc -O2 -c foo.c
```

This will cause `gdb` to debug `gcc`, and to set `gcc`'s command-line arguments (see Section 4.3 [Arguments], page 28) to '`-O2 -c foo.c`'.

You can run `gdb` without printing the front material, which describes GDB's non-warranty, by specifying `-silent`:

```
gdb -silent
```

You can further control how GDB starts up by using command-line options. GDB itself can remind you of the options available.

Type

```
gdb -help
```

to display all available options and briefly describe their use ('`gdb -h`' is a shorter equivalent).

All options and command line arguments you give are processed in sequential order. The order makes a difference when the '`-x`' option is used.

2.1.1 Choosing Files

When GDB starts, it reads any arguments other than options as specifying an executable file and core file (or process ID). This is the same as if the arguments were specified by the '`-se`' and '`-c`' (or '`-p`') options respectively. (GDB reads the first argument that does not have an associated option flag as equivalent to the '`-se`' option followed by that argument; and the second argument that does not have an associated option flag, if any, as equivalent to the '`-c`'/'`-p`' option followed by that argument.) If the second argument begins with a decimal digit, GDB will first attempt to attach to it as a process, and if that fails, attempt to open it as a corefile. If you have a corefile whose name begins with a digit, you can prevent GDB from treating it as a pid by prefixing it with '`./`', e.g. '`./12345`'.

If GDB has not been configured to included core file support, such as for most embedded targets, then it will complain about a second argument and ignore it.

Many options have both long and short forms; both are shown in the following list. GDB also recognizes the long forms if you truncate them, so long as enough of the option is present to be unambiguous. (If you prefer, you can flag option arguments with '`--`' rather than '`-`', though we illustrate the more usual convention.)

`-symbols` *file*
`-s` *file* Read symbol table from file *file*.

`-exec` *file*
`-e` *file* Use file *file* as the executable file to execute when appropriate, and for examining pure data in conjunction with a core dump.

`-se` *file* Read symbol table from file *file* and use it as the executable file.

`-core` *file*
`-c` *file* Use file *file* as a core dump to examine.

`-pid` *number*
`-p` *number*
Connect to process ID *number*, as with the `attach` command.

`-command` *file*
`-x` *file* Execute commands from file *file*. The contents of this file is evaluated exactly as the `source` command would. See Section 23.1.3 [Command files], page 300.

`-eval-command` *command*
`-ex` *command*
Execute a single GDB command.

This option may be used multiple times to call multiple commands. It may also be interleaved with '`-command`' as required.

```
gdb -ex 'target sim' -ex 'load' \
   -x setbreakpoints -ex 'run' a.out
```

`-init-command` *file*
`-ix` *file* Execute commands from file *file* before loading the inferior (but after loading gdbinit files). See Section 2.1.3 [Startup], page 16.

`-init-eval-command` *command*
`-iex` *command*
: Execute a single GDB command before loading the inferior (but after loading gdbinit files). See Section 2.1.3 [Startup], page 16.

`-directory` *directory*
`-d` *directory*
: Add *directory* to the path to search for source and script files.

`-r`
`-readnow`
: Read each symbol file's entire symbol table immediately, rather than the default, which is to read it incrementally as it is needed. This makes startup slower, but makes future operations faster.

2.1.2 Choosing Modes

You can run GDB in various alternative modes—for example, in batch mode or quiet mode.

`-nx`
`-n`
: Do not execute commands found in any initialization file. There are three init files, loaded in the following order:

  `'system.gdbinit'`
  : This is the system-wide init file. Its location is specified with the `--with-system-gdbinit` configure option (see Section C.6 [System-wide configuration], page 494). It is loaded first when GDB starts, before command line options have been processed.

  `'~/.gdbinit'`
  : This is the init file in your home directory. It is loaded next, after '`system.gdbinit`', and before command options have been processed.

  `'./.gdbinit'`
  : This is the init file in the current directory. It is loaded last, after command line options other than `-x` and `-ex` have been processed. Command line options `-x` and `-ex` are processed last, after '`./.gdbinit`' has been loaded.

  For further documentation on startup processing, See Section 2.1.3 [Startup], page 16. For documentation on how to write command files, See Section 23.1.3 [Command Files], page 300.

`-nh`
: Do not execute commands found in '`~/.gdbinit`', the init file in your home directory. See Section 2.1.3 [Startup], page 16.

`-quiet`
`-silent`
`-q`
: "Quiet". Do not print the introductory and copyright messages. These messages are also suppressed in batch mode.

`-batch`
: Run in batch mode. Exit with status `0` after processing all the command files specified with '`-x`' (and all commands from initialization files, if not inhibited

with '`-n`'). Exit with nonzero status if an error occurs in executing the GDB commands in the command files. Batch mode also disables pagination, sets unlimited terminal width and height see Section 22.4 [Screen Size], page 283, and acts as if *`set confirm off`* were in effect (see Section 22.8 [Messages/Warnings], page 291).

Batch mode may be useful for running GDB as a filter, for example to download and run a program on another computer; in order to make this more useful, the message

```
Program exited normally.
```

(which is ordinarily issued whenever a program running under GDB control terminates) is not issued when running in batch mode.

`-batch-silent`
: Run in batch mode exactly like '`-batch`', but totally silently. All GDB output to `stdout` is prevented (`stderr` is unaffected). This is much quieter than '`-silent`' and would be useless for an interactive session.

  This is particularly useful when using targets that give '`Loading section`' messages, for example.

  Note that targets that give their output via GDB, as opposed to writing directly to `stdout`, will also be made silent.

`-return-child-result`
: The return code from GDB will be the return code from the child process (the process being debugged), with the following exceptions:

  - GDB exits abnormally. E.g., due to an incorrect argument or an internal error. In this case the exit code is the same as it would have been without '`-return-child-result`'.
  - The user quits with an explicit value. E.g., '`quit 1`'.
  - The child process never runs, or is not allowed to terminate, in which case the exit code will be -1.

  This option is useful in conjunction with '`-batch`' or '`-batch-silent`', when GDB is being used as a remote program loader or simulator interface.

`-nowindows`
`-nw`
: "No windows". If GDB comes with a graphical user interface (GUI) built in, then this option tells GDB to only use the command-line interface. If no GUI is available, this option has no effect.

`-windows`
`-w`
: If GDB includes a GUI, then this option requires it to be used if possible.

`-cd` *`directory`*
: Run GDB using *directory* as its working directory, instead of the current directory.

`-data-directory` *`directory`*
: Run GDB using *directory* as its data directory. The data directory is where GDB searches for its auxiliary files. See Section 18.6 [Data Files], page 229.

`-fullname`
`-f` GNU Emacs sets this option when it runs GDB as a subprocess. It tells GDB to output the full file name and line number in a standard, recognizable fashion each time a stack frame is displayed (which includes each time your program stops). This recognizable format looks like two '`\032`' characters, followed by the file name, line number and character position separated by colons, and a newline. The Emacs-to-GDB interface program uses the two '`\032`' characters as a signal to display the source code for the frame.

`-annotate` *`level`*
This option sets the *annotation level* inside GDB. Its effect is identical to using '`set annotate` *`level`*' (see Chapter 28 [Annotations], page 443). The annotation *level* controls how much information GDB prints together with its prompt, values of expressions, source lines, and other types of output. Level 0 is the normal, level 1 is for use when GDB is run as a subprocess of GNU Emacs, level 3 is the maximum annotation suitable for programs that control GDB, and level 2 has been deprecated.

The annotation mechanism has largely been superseded by GDB/MI (see Chapter 27 [GDB/MI], page 365).

`--args` Change interpretation of command line so that arguments following the executable file are passed as command line arguments to the inferior. This option stops option processing.

`-baud` *`bps`*
`-b` *`bps`* Set the line speed (baud rate or bits per second) of any serial interface used by GDB for remote debugging.

`-l` *`timeout`*
Set the timeout (in seconds) of any communication used by GDB for remote debugging.

`-tty` *`device`*
`-t` *`device`*
Run using *device* for your program's standard input and output.

`-tui` Activate the *Text User Interface* when starting. The Text User Interface manages several text windows on the terminal, showing source, assembly, registers and GDB command outputs (see Chapter 25 [GDB Text User Interface], page 357). Do not use this option if you run GDB from Emacs (see Chapter 26 [Using GDB under GNU Emacs], page 363).

`-interpreter` *`interp`*
Use the interpreter *interp* for interface with the controlling program or device. This option is meant to be set by programs which communicate with GDB using it as a back end. See Chapter 24 [Command Interpreters], page 355.

'`--interpreter=mi`' (or '`--interpreter=mi2`') causes GDB to use the GDB/MI *interface* (see Chapter 27 [The GDB/MI Interface], page 365) included since GDB version 6.0. The previous GDB/MI interface, included in GDB version 5.3 and selected with '`--interpreter=mi1`', is deprecated. Earlier GDB/MI interfaces are no longer supported.

`-write` Open the executable and core files for both reading and writing. This is equivalent to the '`set write on`' command inside GDB (see Section 17.6 [Patching], page 213).

`-statistics`
This option causes GDB to print statistics about time and memory usage after it completes each command and returns to the prompt.

`-version` This option causes GDB to print its version number and no-warranty blurb, and exit.

2.1.3 What GDB Does During Startup

Here's the description of what GDB does during session startup:

1. Sets up the command interpreter as specified by the command line (see Section 2.1.2 [Mode Options], page 13).
2. Reads the system-wide *init file* (if '`--with-system-gdbinit`' was used when building GDB; see Section C.6 [System-wide configuration and settings], page 494) and executes all the commands in that file.
3. Reads the init file (if any) in your home directory[1] and executes all the commands in that file.
4. Executes commands and command files specified by the '`-iex`' and '`-ix`' options in their specified order. Usually you should use the '`-ex`' and '`-x`' options instead, but this way you can apply settings before GDB init files get executed and before inferior gets loaded.
5. Processes command line options and operands.
6. Reads and executes the commands from init file (if any) in the current working directory as long as '`set auto-load local-gdbinit`' is set to '`on`' (see Section 22.7.1 [Init File in the Current Directory], page 288). This is only done if the current directory is different from your home directory. Thus, you can have more than one init file, one generic in your home directory, and another, specific to the program you are debugging, in the directory where you invoke GDB.
7. If the command line specified a program to debug, or a process to attach to, or a core file, GDB loads any auto-loaded scripts provided for the program or for its loaded shared libraries. See Section 22.7 [Auto-loading], page 286.

   If you wish to disable the auto-loading during startup, you must do something like the following:

   ```
   $ gdb -iex "set auto-load python-scripts off" myprogram
   ```

   Option '`-ex`' does not work because the auto-loading is then turned off too late.
8. Executes commands and command files specified by the '`-ex`' and '`-x`' options in their specified order. See Section 23.1.3 [Command Files], page 300, for more details about GDB command files.
9. Reads the command history recorded in the *history file*. See Section 22.3 [Command History], page 282, for more details about the command history and the files where GDB records it.

[1] On DOS/Windows systems, the home directory is the one pointed to by the `HOME` environment variable.

Init files use the same syntax as *command files* (see Section 23.1.3 [Command Files], page 300) and are processed by GDB in the same way. The init file in your home directory can set options (such as '`set complaints`') that affect subsequent processing of command line options and operands. Init files are not executed if you use the '`-nx`' option (see Section 2.1.2 [Choosing Modes], page 13).

To display the list of init files loaded by gdb at startup, you can use *`gdb --help`*.

The GDB init files are normally called '`.gdbinit`'. The DJGPP port of GDB uses the name '`gdb.ini`', due to the limitations of file names imposed by DOS filesystems. The Windows port of GDB uses the standard name, but if it finds a '`gdb.ini`' file in your home directory, it warns you about that and suggests to rename the file to the standard name.

2.2 Quitting GDB

`quit` [*`expression`*]

`q` To exit GDB, use the `quit` command (abbreviated `q`), or type an end-of-file character (usually *`Ctrl-d`*). If you do not supply *expression*, GDB will terminate normally; otherwise it will terminate using the result of *expression* as the error code.

An interrupt (often *`Ctrl-c`*) does not exit from GDB, but rather terminates the action of any GDB command that is in progress and returns to GDB command level. It is safe to type the interrupt character at any time because GDB does not allow it to take effect until a time when it is safe.

If you have been using GDB to control an attached process or device, you can release it with the `detach` command (see Section 4.7 [Debugging an Already-running Process], page 31).

2.3 Shell Commands

If you need to execute occasional shell commands during your debugging session, there is no need to leave or suspend GDB; you can just use the `shell` command.

`shell` *`command-string`*

`!`*`command-string`*

Invoke a standard shell to execute *command-string*. Note that no space is needed between `!` and *command-string*. If it exists, the environment variable `SHELL` determines which shell to run. Otherwise GDB uses the default shell ('`/bin/sh`' on Unix systems, '`COMMAND.COM`' on MS-DOS, etc.).

The utility `make` is often needed in development environments. You do not have to use the `shell` command for this purpose in GDB:

`make` *`make-args`*

Execute the `make` program with the specified arguments. This is equivalent to '`shell make` *`make-args`*'.

2.4 Logging Output

You may want to save the output of GDB commands to a file. There are several commands to control GDB's logging.

`set logging on`
: Enable logging.

`set logging off`
: Disable logging.

`set logging file` *file*
: Change the name of the current logfile. The default logfile is '`gdb.txt`'.

`set logging overwrite [on|off]`
: By default, GDB will append to the logfile. Set `overwrite` if you want `set logging on` to overwrite the logfile instead.

`set logging redirect [on|off]`
: By default, GDB output will go to both the terminal and the logfile. Set `redirect` if you want output to go only to the log file.

`show logging`
: Show the current values of the logging settings.

3 GDB Commands

You can abbreviate a GDB command to the first few letters of the command name, if that abbreviation is unambiguous; and you can repeat certain GDB commands by typing just RET. You can also use the TAB key to get GDB to fill out the rest of a word in a command (or to show you the alternatives available, if there is more than one possibility).

3.1 Command Syntax

A GDB command is a single line of input. There is no limit on how long it can be. It starts with a command name, which is followed by arguments whose meaning depends on the command name. For example, the command `step` accepts an argument which is the number of times to step, as in '`step 5`'. You can also use the `step` command with no arguments. Some commands do not allow any arguments.

GDB command names may always be truncated if that abbreviation is unambiguous. Other possible command abbreviations are listed in the documentation for individual commands. In some cases, even ambiguous abbreviations are allowed; for example, `s` is specially defined as equivalent to `step` even though there are other commands whose names start with `s`. You can test abbreviations by using them as arguments to the `help` command.

A blank line as input to GDB (typing just RET) means to repeat the previous command. Certain commands (for example, `run`) will not repeat this way; these are commands whose unintentional repetition might cause trouble and which you are unlikely to want to repeat. User-defined commands can disable this feature; see Section 23.1.1 [Define], page 297.

The `list` and `x` commands, when you repeat them with RET, construct new arguments rather than repeating exactly as typed. This permits easy scanning of source or memory.

GDB can also use RET in another way: to partition lengthy output, in a way similar to the common utility `more` (see Section 22.4 [Screen Size], page 283). Since it is easy to press one RET too many in this situation, GDB disables command repetition after any command that generates this sort of display.

Any text from a `#` to the end of the line is a comment; it does nothing. This is useful mainly in command files (see Section 23.1.3 [Command Files], page 300).

The *`Ctrl-o`* binding is useful for repeating a complex sequence of commands. This command accepts the current line, like RET, and then fetches the next line relative to the current line from the history for editing.

3.2 Command Completion

GDB can fill in the rest of a word in a command for you, if there is only one possibility; it can also show you what the valid possibilities are for the next word in a command, at any time. This works for GDB commands, GDB subcommands, and the names of symbols in your program.

Press the TAB key whenever you want GDB to fill out the rest of a word. If there is only one possibility, GDB fills in the word, and waits for you to finish the command (or press RET to enter it). For example, if you type

```
(gdb) info bre TAB
```

GDB fills in the rest of the word '`breakpoints`', since that is the only `info` subcommand beginning with '`bre`':

```
(gdb) info breakpoints
```

You can either press RET at this point, to run the `info breakpoints` command, or backspace and enter something else, if '`breakpoints`' does not look like the command you expected. (If you were sure you wanted `info breakpoints` in the first place, you might as well just type RET immediately after '`info bre`', to exploit command abbreviations rather than command completion).

If there is more than one possibility for the next word when you press TAB, GDB sounds a bell. You can either supply more characters and try again, or just press TAB a second time; GDB displays all the possible completions for that word. For example, you might want to set a breakpoint on a subroutine whose name begins with '`make_`', but when you type *`b make_TAB`* GDB just sounds the bell. Typing TAB again displays all the function names in your program that begin with those characters, for example:

```
(gdb) b make_ TAB
```

GDB sounds bell; press TAB again, to see:

```
make_a_section_from_file     make_environ
make_abs_section             make_function_type
make_blockvector             make_pointer_type
make_cleanup                 make_reference_type
make_command                 make_symbol_completion_list
(gdb) b make_
```

After displaying the available possibilities, GDB copies your partial input ('`b make_`' in the example) so you can finish the command.

If you just want to see the list of alternatives in the first place, you can press *`M-?`* rather than pressing TAB twice. *`M-?`* means *`META ?`*. You can type this either by holding down a key designated as the META shift on your keyboard (if there is one) while typing `?`, or as ESC followed by `?`.

Sometimes the string you need, while logically a "word", may contain parentheses or other characters that GDB normally excludes from its notion of a word. To permit word completion to work in this situation, you may enclose words in `'` (single quote marks) in GDB commands.

The most likely situation where you might need this is in typing the name of a C++ function. This is because C++ allows function overloading (multiple definitions of the same function, distinguished by argument type). For example, when you want to set a breakpoint you may need to distinguish whether you mean the version of `name` that takes an `int` parameter, `name(int)`, or the version that takes a `float` parameter, `name(float)`. To use the word-completion facilities in this situation, type a single quote `'` at the beginning of the function name. This alerts GDB that it may need to consider more information than usual when you press TAB or *`M-?`* to request word completion:

```
(gdb) b 'bubble( M-?
bubble(double,double)    bubble(int,int)
(gdb) b 'bubble(
```

In some cases, GDB can tell that completing a name requires using quotes. When this happens, GDB inserts the quote for you (while completing as much as it can) if you do not type the quote in the first place:

```
(gdb) b bub TAB
```

GDB alters your input line to the following, and rings a bell:

```
(gdb) b 'bubble(
```

In general, GDB can tell that a quote is needed (and inserts it) if you have not yet started typing the argument list when you ask for completion on an overloaded symbol.

For more information about overloaded functions, see Section 15.4.1.3 [C++ Expressions], page 180. You can use the command `set overload-resolution off` to disable overload resolution; see Section 15.4.1.7 [GDB Features for C++], page 181.

When completing in an expression which looks up a field in a structure, GDB also tries[1] to limit completions to the field names available in the type of the left-hand-side:

```
(gdb) p gdb_stdout.M-?
magic               to_fputs            to_rewind
to_data             to_isatty           to_write
to_delete           to_put              to_write_async_safe
to_flush            to_read
```

This is because the `gdb_stdout` is a variable of the type `struct ui_file` that is defined in GDB sources as follows:

```
struct ui_file
{
   int *magic;
   ui_file_flush_ftype *to_flush;
   ui_file_write_ftype *to_write;
   ui_file_write_async_safe_ftype *to_write_async_safe;
   ui_file_fputs_ftype *to_fputs;
   ui_file_read_ftype *to_read;
   ui_file_delete_ftype *to_delete;
   ui_file_isatty_ftype *to_isatty;
   ui_file_rewind_ftype *to_rewind;
   ui_file_put_ftype *to_put;
   void *to_data;
}
```

3.3 Getting Help

You can always ask GDB itself for information on its commands, using the command `help`.

`help`
`h`

You can use `help` (abbreviated `h`) with no arguments to display a short list of named classes of commands:

```
(gdb) help
List of classes of commands:

aliases -- Aliases of other commands
breakpoints -- Making program stop at certain points
data -- Examining data
files -- Specifying and examining files
internals -- Maintenance commands
obscure -- Obscure features
running -- Running the program
stack -- Examining the stack
status -- Status inquiries
support -- Support facilities
tracepoints -- Tracing of program execution without
               stopping the program
```

[1] The completer can be confused by certain kinds of invalid expressions. Also, it only examines the static type of the expression, not the dynamic type.

```
user-defined -- User-defined commands

Type "help" followed by a class name for a list of
commands in that class.
Type "help" followed by command name for full
documentation.
Command name abbreviations are allowed if unambiguous.
(gdb)
```

`help` *`class`*

Using one of the general help classes as an argument, you can get a list of the individual commands in that class. For example, here is the help display for the class `status`:

```
(gdb) help status
Status inquiries.

List of commands:

info -- Generic command for showing things
        about the program being debugged
show -- Generic command for showing things
        about the debugger

Type "help" followed by command name for full
documentation.
Command name abbreviations are allowed if unambiguous.
(gdb)
```

`help` *`command`*

With a command name as `help` argument, GDB displays a short paragraph on how to use that command.

`apropos` *`args`*

The `apropos` command searches through all of the GDB commands, and their documentation, for the regular expression specified in *args*. It prints out all matches found. For example:

```
apropos alias
```

results in:

```
alias -- Define a new command that is an alias of an existing command
aliases -- Aliases of other commands
d -- Delete some breakpoints or auto-display expressions
del -- Delete some breakpoints or auto-display expressions
delete -- Delete some breakpoints or auto-display expressions
```

`complete` *`args`*

The `complete` *`args`* command lists all the possible completions for the beginning of a command. Use *args* to specify the beginning of the command you want completed. For example:

```
complete i
```

results in:

```
if
ignore
info
inspect
```

This is intended for use by GNU Emacs.

In addition to `help`, you can use the GDB commands `info` and `show` to inquire about the state of your program, or the state of GDB itself. Each command supports many topics of inquiry; this manual introduces each of them in the appropriate context. The listings under `info` and under `show` in the Command, Variable, and Function Index point to all the sub-commands. See [Command and Variable Index], page 627.

`info` This command (abbreviated `i`) is for describing the state of your program. For example, you can show the arguments passed to a function with `info args`, list the registers currently in use with `info registers`, or list the breakpoints you have set with `info breakpoints`. You can get a complete list of the `info` sub-commands with `help info`.

`set` You can assign the result of an expression to an environment variable with `set`. For example, you can set the GDB prompt to a $-sign with `set prompt $`.

`show` In contrast to `info`, `show` is for describing the state of GDB itself. You can change most of the things you can `show`, by using the related command `set`; for example, you can control what number system is used for displays with `set radix`, or simply inquire which is currently in use with `show radix`.

To display all the settable parameters and their current values, you can use `show` with no arguments; you may also use `info set`. Both commands produce the same display.

Here are three miscellaneous `show` subcommands, all of which are exceptional in lacking corresponding `set` commands:

`show version`
Show what version of GDB is running. You should include this information in GDB bug-reports. If multiple versions of GDB are in use at your site, you may need to determine which version of GDB you are running; as GDB evolves, new commands are introduced, and old ones may wither away. Also, many system vendors ship variant versions of GDB, and there are variant versions of GDB in GNU/Linux distributions as well. The version number is the same as the one announced when you start GDB.

`show copying`
`info copying`
Display information about permission for copying GDB.

`show warranty`
`info warranty`
Display the GNU "NO WARRANTY" statement, or a warranty, if your version of GDB comes with one.

4 Running Programs Under GDB

When you run a program under GDB, you must first generate debugging information when you compile it.

You may start GDB with its arguments, if any, in an environment of your choice. If you are doing native debugging, you may redirect your program's input and output, debug an already running process, or kill a child process.

4.1 Compiling for Debugging

In order to debug a program effectively, you need to generate debugging information when you compile it. This debugging information is stored in the object file; it describes the data type of each variable or function and the correspondence between source line numbers and addresses in the executable code.

To request debugging information, specify the '`-g`' option when you run the compiler.

Programs that are to be shipped to your customers are compiled with optimizations, using the '`-O`' compiler option. However, some compilers are unable to handle the '`-g`' and '`-O`' options together. Using those compilers, you cannot generate optimized executables containing debugging information.

GCC, the GNU C/C++ compiler, supports '`-g`' with or without '`-O`', making it possible to debug optimized code. We recommend that you *always* use '`-g`' whenever you compile a program. You may think your program is correct, but there is no sense in pushing your luck. For more information, see Chapter 11 [Optimized Code], page 141.

Older versions of the GNU C compiler permitted a variant option '`-gg`' for debugging information. GDB no longer supports this format; if your GNU C compiler has this option, do not use it.

GDB knows about preprocessor macros and can show you their expansion (see Chapter 12 [Macros], page 145). Most compilers do not include information about preprocessor macros in the debugging information if you specify the '`-g`' flag alone. Version 3.1 and later of GCC, the GNU C compiler, provides macro information if you are using the DWARF debugging format, and specify the option '`-g3`'.

See Section "Options for Debugging Your Program or GCC" in *Using the GNU Compiler Collection (GCC)*, for more information on GCC options affecting debug information.

You will have the best debugging experience if you use the latest version of the DWARF debugging format that your compiler supports. DWARF is currently the most expressive and best supported debugging format in GDB.

4.2 Starting your Program

`run`
`r`

Use the `run` command to start your program under GDB. You must first specify the program name (except on VxWorks) with an argument to GDB (see Chapter 2 [Getting In and Out of GDB], page 11), or by using the `file` or `exec-file` command (see Section 18.1 [Commands to Specify Files], page 215).

If you are running your program in an execution environment that supports processes, `run` creates an inferior process and makes that process run your program. In some environments without processes, `run` jumps to the start of your program. Other targets, like '`remote`', are always running. If you get an error message like this one:

```
The "remote" target does not support "run".
Try "help target" or "continue".
```

then use `continue` to run your program. You may need `load` first (see [load], page 233).

The execution of a program is affected by certain information it receives from its superior. GDB provides ways to specify this information, which you must do *before* starting your program. (You can change it after starting your program, but such changes only affect your program the next time you start it.) This information may be divided into four categories:

The *arguments.*

Specify the arguments to give your program as the arguments of the `run` command. If a shell is available on your target, the shell is used to pass the arguments, so that you may use normal conventions (such as wildcard expansion or variable substitution) in describing the arguments. In Unix systems, you can control which shell is used with the `SHELL` environment variable. See Section 4.3 [Your Program's Arguments], page 28.

The *environment.*

Your program normally inherits its environment from GDB, but you can use the GDB commands `set environment` and `unset environment` to change parts of the environment that affect your program. See Section 4.4 [Your Program's Environment], page 29.

The *working directory.*

Your program inherits its working directory from GDB. You can set the GDB working directory with the `cd` command in GDB. See Section 4.5 [Your Program's Working Directory], page 30.

The *standard input and output.*

Your program normally uses the same device for standard input and standard output as GDB is using. You can redirect input and output in the `run` command line, or you can use the `tty` command to set a different device for your program. See Section 4.6 [Your Program's Input and Output], page 30.

Warning: While input and output redirection work, you cannot use pipes to pass the output of the program you are debugging to another program; if you attempt this, GDB is likely to wind up debugging the wrong program.

When you issue the `run` command, your program begins to execute immediately. See Chapter 5 [Stopping and Continuing], page 43, for discussion of how to arrange for your program to stop. Once your program has stopped, you may call functions in your program, using the `print` or `call` commands. See Chapter 10 [Examining Data], page 103.

If the modification time of your symbol file has changed since the last time GDB read its symbols, GDB discards its symbol table, and reads it again. When it does this, GDB tries to retain your current breakpoints.

`start` The name of the main procedure can vary from language to language. With C or C++, the main procedure name is always `main`, but other languages such as Ada do not require a specific name for their main procedure. The debugger provides a convenient way to start the execution of the program and to stop at the beginning of the main procedure, depending on the language used.

The '`start`' command does the equivalent of setting a temporary breakpoint at the beginning of the main procedure and then invoking the '`run`' command.

Some programs contain an *elaboration* phase where some startup code is executed before the main procedure is called. This depends on the languages used to write your program. In C++, for instance, constructors for static and global objects are executed before `main` is called. It is therefore possible that the debugger stops before reaching the main procedure. However, the temporary breakpoint will remain to halt execution.

Specify the arguments to give to your program as arguments to the '`start`' command. These arguments will be given verbatim to the underlying '`run`' command. Note that the same arguments will be reused if no argument is provided during subsequent calls to '`start`' or '`run`'.

It is sometimes necessary to debug the program during elaboration. In these cases, using the `start` command would stop the execution of your program too late, as the program would have already completed the elaboration phase. Under these circumstances, insert breakpoints in your elaboration code before running your program.

`set exec-wrapper` *`wrapper`*
`show exec-wrapper`
`unset exec-wrapper`

When '`exec-wrapper`' is set, the specified wrapper is used to launch programs for debugging. GDB starts your program with a shell command of the form *`exec wrapper program`*. Quoting is added to *program* and its arguments, but not to *wrapper*, so you should add quotes if appropriate for your shell. The wrapper runs until it executes your program, and then GDB takes control.

You can use any program that eventually calls `execve` with its arguments as a wrapper. Several standard Unix utilities do this, e.g. `env` and `nohup`. Any Unix shell script ending with `exec "$@"` will also work.

For example, you can use `env` to pass an environment variable to the debugged program, without setting the variable in your shell's environment:

```
(gdb) set exec-wrapper env 'LD_PRELOAD=libtest.so'
(gdb) run
```

This command is available when debugging locally on most targets, excluding DJGPP, Cygwin, MS Windows, and QNX Neutrino.

`set disable-randomization`
`set disable-randomization on`

This option (enabled by default in GDB) will turn off the native randomization of the virtual address space of the started program. This option is useful for multiple debugging sessions to make the execution better reproducible and memory addresses reusable across debugging sessions.

This feature is implemented only on certain targets, including GNU/Linux. On GNU/Linux you can get the same behavior using

```
(gdb) set exec-wrapper setarch ‘uname -m‘ -R
```

`set disable-randomization off`

Leave the behavior of the started executable unchanged. Some bugs rear their ugly heads only when the program is loaded at certain addresses. If your bug disappears when you run the program under GDB, that might be because GDB by default disables the address randomization on platforms, such as GNU/Linux, which do that for stand-alone programs. Use *`set disable-randomization off`* to try to reproduce such elusive bugs.

On targets where it is available, virtual address space randomization protects the programs against certain kinds of security attacks. In these cases the attacker needs to know the exact location of a concrete executable code. Randomizing its location makes it impossible to inject jumps misusing a code at its expected addresses.

Prelinking shared libraries provides a startup performance advantage but it makes addresses in these libraries predictable for privileged processes by having just unprivileged access at the target system. Reading the shared library binary gives enough information for assembling the malicious code misusing it. Still even a prelinked shared library can get loaded at a new random address just requiring the regular relocation process during the startup. Shared libraries not already prelinked are always loaded at a randomly chosen address.

Position independent executables (PIE) contain position independent code similar to the shared libraries and therefore such executables get loaded at a randomly chosen address upon startup. PIE executables always load even already prelinked shared libraries at a random address. You can build such executable using `gcc -fPIE -pie`.

Heap (malloc storage), stack and custom mmap areas are always placed randomly (as long as the randomization is enabled).

`show disable-randomization`

Show the current setting of the explicit disable of the native randomization of the virtual address space of the started program.

4.3 Your Program's Arguments

The arguments to your program can be specified by the arguments of the `run` command. They are passed to a shell, which expands wildcard characters and performs redirection of

I/O, and thence to your program. Your `SHELL` environment variable (if it exists) specifies what shell GDB uses. If you do not define `SHELL`, GDB uses the default shell ('`/bin/sh`' on Unix).

On non-Unix systems, the program is usually invoked directly by GDB, which emulates I/O redirection via the appropriate system calls, and the wildcard characters are expanded by the startup code of the program, not by the shell.

`run` with no arguments uses the same arguments used by the previous `run`, or those set by the `set args` command.

`set args` Specify the arguments to be used the next time your program is run. If `set args` has no arguments, `run` executes your program with no arguments. Once you have run your program with arguments, using `set args` before the next `run` is the only way to run it again without arguments.

`show args` Show the arguments to give your program when it is started.

4.4 Your Program's Environment

The *environment* consists of a set of environment variables and their values. Environment variables conventionally record such things as your user name, your home directory, your terminal type, and your search path for programs to run. Usually you set up environment variables with the shell and they are inherited by all the other programs you run. When debugging, it can be useful to try running your program with a modified environment without having to start GDB over again.

`path` *directory*

Add *directory* to the front of the `PATH` environment variable (the search path for executables) that will be passed to your program. The value of `PATH` used by GDB does not change. You may specify several directory names, separated by whitespace or by a system-dependent separator character ('`:`' on Unix, '`;`' on MS-DOS and MS-Windows). If *directory* is already in the path, it is moved to the front, so it is searched sooner.

You can use the string '`$cwd`' to refer to whatever is the current working directory at the time GDB searches the path. If you use '`.`' instead, it refers to the directory where you executed the `path` command. GDB replaces '`.`' in the *directory* argument (with the current path) before adding *directory* to the search path.

`show paths`

Display the list of search paths for executables (the `PATH` environment variable).

`show environment` [*varname*]

Print the value of environment variable *varname* to be given to your program when it starts. If you do not supply *varname*, print the names and values of all environment variables to be given to your program. You can abbreviate `environment` as `env`.

`set environment` *varname* [`=`*value*]

Set environment variable *varname* to *value*. The value changes for your program only, not for GDB itself. *value* may be any string; the values of environment

variables are just strings, and any interpretation is supplied by your program itself. The *value* parameter is optional; if it is eliminated, the variable is set to a null value.

For example, this command:

```
set env USER = foo
```

tells the debugged program, when subsequently run, that its user is named '`foo`'. (The spaces around '`=`' are used for clarity here; they are not actually required.)

`unset environment` *varname*
: Remove variable *varname* from the environment to be passed to your program. This is different from '`set env` *varname* `=`'; `unset environment` removes the variable from the environment, rather than assigning it an empty value.

Warning: On Unix systems, GDB runs your program using the shell indicated by your `SHELL` environment variable if it exists (or `/bin/sh` if not). If your `SHELL` variable names a shell that runs an initialization file—such as '`.cshrc`' for C-shell, or '`.bashrc`' for BASH—any variables you set in that file affect your program. You may wish to move setting of environment variables to files that are only run when you sign on, such as '`.login`' or '`.profile`'.

4.5 Your Program's Working Directory

Each time you start your program with `run`, it inherits its working directory from the current working directory of GDB. The GDB working directory is initially whatever it inherited from its parent process (typically the shell), but you can specify a new working directory in GDB with the `cd` command.

The GDB working directory also serves as a default for the commands that specify files for GDB to operate on. See Section 18.1 [Commands to Specify Files], page 215.

`cd` [*directory*]
: Set the GDB working directory to *directory*. If not given, *directory* uses '`~`'.

`pwd`
: Print the GDB working directory.

It is generally impossible to find the current working directory of the process being debugged (since a program can change its directory during its run). If you work on a system where GDB is configured with the '`/proc`' support, you can use the `info proc` command (see Section 21.1.3 [SVR4 Process Information], page 251) to find out the current working directory of the debuggee.

4.6 Your Program's Input and Output

By default, the program you run under GDB does input and output to the same terminal that GDB uses. GDB switches the terminal to its own terminal modes to interact with you, but it records the terminal modes your program was using and switches back to them when you continue running your program.

`info terminal`
: Displays information recorded by GDB about the terminal modes your program is using.

You can redirect your program's input and/or output using shell redirection with the `run` command. For example,

```
run > outfile
```

starts your program, diverting its output to the file '`outfile`'.

Another way to specify where your program should do input and output is with the `tty` command. This command accepts a file name as argument, and causes this file to be the default for future `run` commands. It also resets the controlling terminal for the child process, for future `run` commands. For example,

```
tty /dev/ttyb
```

directs that processes started with subsequent `run` commands default to do input and output on the terminal '`/dev/ttyb`' and have that as their controlling terminal.

An explicit redirection in `run` overrides the `tty` command's effect on the input/output device, but not its effect on the controlling terminal.

When you use the `tty` command or redirect input in the `run` command, only the input *for your program* is affected. The input for GDB still comes from your terminal. `tty` is an alias for `set inferior-tty`.

You can use the `show inferior-tty` command to tell GDB to display the name of the terminal that will be used for future runs of your program.

`set inferior-tty /dev/ttyb`
: Set the tty for the program being debugged to /dev/ttyb.

`show inferior-tty`
: Show the current tty for the program being debugged.

4.7 Debugging an Already-running Process

`attach` *process-id*
: This command attaches to a running process—one that was started outside GDB. (`info files` shows your active targets.) The command takes as argument a process ID. The usual way to find out the *process-id* of a Unix process is with the `ps` utility, or with the '`jobs -l`' shell command.

  `attach` does not repeat if you press RET a second time after executing the command.

To use `attach`, your program must be running in an environment which supports processes; for example, `attach` does not work for programs on bare-board targets that lack an operating system. You must also have permission to send the process a signal.

When you use `attach`, the debugger finds the program running in the process first by looking in the current working directory, then (if the program is not found) by using the source file search path (see Section 9.5 [Specifying Source Directories], page 96). You can also use the `file` command to load the program. See Section 18.1 [Commands to Specify Files], page 215.

The first thing GDB does after arranging to debug the specified process is to stop it. You can examine and modify an attached process with all the GDB commands that are ordinarily available when you start processes with `run`. You can insert breakpoints; you can step and

continue; you can modify storage. If you would rather the process continue running, you may use the `continue` command after attaching GDB to the process.

`detach` When you have finished debugging the attached process, you can use the `detach` command to release it from GDB control. Detaching the process continues its execution. After the `detach` command, that process and GDB become completely independent once more, and you are ready to `attach` another process or start one with `run`. `detach` does not repeat if you press RET again after executing the command.

If you exit GDB while you have an attached process, you detach that process. If you use the `run` command, you kill that process. By default, GDB asks for confirmation if you try to do either of these things; you can control whether or not you need to confirm by using the `set confirm` command (see Section 22.8 [Optional Warnings and Messages], page 291).

4.8 Killing the Child Process

`kill` Kill the child process in which your program is running under GDB.

This command is useful if you wish to debug a core dump instead of a running process. GDB ignores any core dump file while your program is running.

On some operating systems, a program cannot be executed outside GDB while you have breakpoints set on it inside GDB. You can use the `kill` command in this situation to permit running your program outside the debugger.

The `kill` command is also useful if you wish to recompile and relink your program, since on many systems it is impossible to modify an executable file while it is running in a process. In this case, when you next type `run`, GDB notices that the file has changed, and reads the symbol table again (while trying to preserve your current breakpoint settings).

4.9 Debugging Multiple Inferiors and Programs

GDB lets you run and debug multiple programs in a single session. In addition, GDB on some systems may let you run several programs simultaneously (otherwise you have to exit from one before starting another). In the most general case, you can have multiple threads of execution in each of multiple processes, launched from multiple executables.

GDB represents the state of each program execution with an object called an *inferior*. An inferior typically corresponds to a process, but is more general and applies also to targets that do not have processes. Inferiors may be created before a process runs, and may be retained after a process exits. Inferiors have unique identifiers that are different from process ids. Usually each inferior will also have its own distinct address space, although some embedded targets may have several inferiors running in different parts of a single address space. Each inferior may in turn have multiple threads running in it.

To find out what inferiors exist at any moment, use `info inferiors`:

`info inferiors`

Print a list of all inferiors currently being managed by GDB.

GDB displays for each inferior (in this order):

1. the inferior number assigned by GDB

2. the target system's inferior identifier
3. the name of the executable the inferior is running.

An asterisk '*' preceding the GDB inferior number indicates the current inferior.

For example,

```
(gdb) info inferiors
  Num  Description       Executable
  2    process 2307      hello
* 1    process 3401      goodbye
```

To switch focus between inferiors, use the `inferior` command:

`inferior` *infno*
: Make inferior number *infno* the current inferior. The argument *infno* is the inferior number assigned by GDB, as shown in the first field of the '`info inferiors`' display.

You can get multiple executables into a debugging session via the `add-inferior` and `clone-inferior` commands. On some systems GDB can add inferiors to the debug session automatically by following calls to `fork` and `exec`. To remove inferiors from the debugging session use the `remove-inferiors` command.

`add-inferior [ -copies` *n* `] [ -exec` *executable* `]`
: Adds *n* inferiors to be run using *executable* as the executable. *n* defaults to 1. If no executable is specified, the inferiors begins empty, with no program. You can still assign or change the program assigned to the inferior at any time by using the `file` command with the executable name as its argument.

`clone-inferior [ -copies` *n* `] [` *infno* `]`
: Adds *n* inferiors ready to execute the same program as inferior *infno*. *n* defaults to 1. *infno* defaults to the number of the current inferior. This is a convenient command when you want to run another instance of the inferior you are debugging.

```
(gdb) info inferiors
  Num  Description       Executable
* 1    process 29964     helloworld
(gdb) clone-inferior
Added inferior 2.
1 inferiors added.
(gdb) info inferiors
  Num  Description       Executable
  2    <null>            helloworld
* 1    process 29964     helloworld
```

You can now simply switch focus to inferior 2 and run it.

`remove-inferiors` *infno*`...`
: Removes the inferior or inferiors *infno*.... It is not possible to remove an inferior that is running with this command. For those, use the `kill` or `detach` command first.

To quit debugging one of the running inferiors that is not the current inferior, you can either detach from it by using the `detach inferior` command (allowing it to run independently), or kill it using the `kill inferiors` command:

`detach inferior` *infno*`...`
: Detach from the inferior or inferiors identified by GDB inferior number(s) *infno*.... Note that the inferior's entry still stays on the list of inferiors shown by `info inferiors`, but its Description will show '`<null>`'.

`kill inferiors` *infno*`...`
: Kill the inferior or inferiors identified by GDB inferior number(s) *infno*.... Note that the inferior's entry still stays on the list of inferiors shown by `info inferiors`, but its Description will show '`<null>`'.

After the successful completion of a command such as `detach`, `detach inferiors`, `kill` or `kill inferiors`, or after a normal process exit, the inferior is still valid and listed with `info inferiors`, ready to be restarted.

To be notified when inferiors are started or exit under GDB's control use `set print inferior-events`:

`set print inferior-events`
`set print inferior-events on`
`set print inferior-events off`
: The `set print inferior-events` command allows you to enable or disable printing of messages when GDB notices that new inferiors have started or that inferiors have exited or have been detached. By default, these messages will not be printed.

`show print inferior-events`
: Show whether messages will be printed when GDB detects that inferiors have started, exited or have been detached.

Many commands will work the same with multiple programs as with a single program: e.g., `print myglobal` will simply display the value of `myglobal` in the current inferior.

Occasionaly, when debugging GDB itself, it may be useful to get more info about the relationship of inferiors, programs, address spaces in a debug session. You can do that with the `maint info program-spaces` command.

`maint info program-spaces`
: Print a list of all program spaces currently being managed by GDB.

  GDB displays for each program space (in this order):

  1. the program space number assigned by GDB
  2. the name of the executable loaded into the program space, with e.g., the `file` command.

  An asterisk '`*`' preceding the GDB program space number indicates the current program space.

  In addition, below each program space line, GDB prints extra information that isn't suitable to display in tabular form. For example, the list of inferiors bound to the program space.

```
(gdb) maint info program-spaces
  Id   Executable
  2    goodbye
       Bound inferiors: ID 1 (process 21561)
```

```
* 1    hello
```

Here we can see that no inferior is running the program `hello`, while `process 21561` is running the program `goodbye`. On some targets, it is possible that multiple inferiors are bound to the same program space. The most common example is that of debugging both the parent and child processes of a `vfork` call. For example,

```
(gdb) maint info program-spaces
  Id   Executable
* 1    vfork-test
       Bound inferiors: ID 2 (process 18050), ID 1 (process 18045)
```

Here, both inferior 2 and inferior 1 are running in the same program space as a result of inferior 1 having executed a `vfork` call.

4.10 Debugging Programs with Multiple Threads

In some operating systems, such as HP-UX and Solaris, a single program may have more than one *thread* of execution. The precise semantics of threads differ from one operating system to another, but in general the threads of a single program are akin to multiple processes—except that they share one address space (that is, they can all examine and modify the same variables). On the other hand, each thread has its own registers and execution stack, and perhaps private memory.

GDB provides these facilities for debugging multi-thread programs:

- automatic notification of new threads
- '`thread` *`threadno`*', a command to switch among threads
- '`info threads`', a command to inquire about existing threads
- '`thread apply [`*`threadno`*`] [`*`all`*`] `*`args`*', a command to apply a command to a list of threads
- thread-specific breakpoints
- '`set print thread-events`', which controls printing of messages on thread start and exit.
- '`set libthread-db-search-path `*`path`*', which lets the user specify which `libthread_db` to use if the default choice isn't compatible with the program.

> *Warning:* These facilities are not yet available on every GDB configuration where the operating system supports threads. If your GDB does not support threads, these commands have no effect. For example, a system without thread support shows no output from '`info threads`', and always rejects the `thread` command, like this:
>
> ```
> (gdb) info threads
> (gdb) thread 1
> Thread ID 1 not known.  Use the "info threads" command to
> see the IDs of currently known threads.
> ```

The GDB thread debugging facility allows you to observe all threads while your program runs—but whenever GDB takes control, one thread in particular is always the focus of debugging. This thread is called the *current thread*. Debugging commands show program information from the perspective of the current thread.

Whenever GDB detects a new thread in your program, it displays the target system's identification for the thread with a message in the form '`[New systag]`'. *systag* is a thread identifier whose form varies depending on the particular system. For example, on GNU/Linux, you might see

```
[New Thread 0x41e02940 (LWP 25582)]
```

when GDB notices a new thread. In contrast, on an SGI system, the *systag* is simply something like '`process 368`', with no further qualifier.

For debugging purposes, GDB associates its own thread number—always a single integer—with each thread in your program.

`info threads` [*id*...]

Display a summary of all threads currently in your program. Optional argument *id*... is one or more thread ids separated by spaces, and means to print information only about the specified thread or threads. GDB displays for each thread (in this order):

1. the thread number assigned by GDB
2. the target system's thread identifier (*systag*)
3. the thread's name, if one is known. A thread can either be named by the user (see `thread name`, below), or, in some cases, by the program itself.
4. the current stack frame summary for that thread

An asterisk '`*`' to the left of the GDB thread number indicates the current thread.

For example,

```
(gdb) info threads
  Id   Target Id         Frame
  3    process 35 thread 27  0x34e5 in sigpause ()
  2    process 35 thread 23  0x34e5 in sigpause ()
* 1    process 35 thread 13  main (argc=1, argv=0x7ffffff8)
    at threadtest.c:68
```

On Solaris, you can display more information about user threads with a Solaris-specific command:

`maint info sol-threads`

Display info on Solaris user threads.

`thread` *threadno*

Make thread number *threadno* the current thread. The command argument *threadno* is the internal GDB thread number, as shown in the first field of the '`info threads`' display. GDB responds by displaying the system identifier of the thread you selected, and its current stack frame summary:

```
(gdb) thread 2
[Switching to thread 2 (Thread 0xb7fdab70 (LWP 12747))]
#0  some_function (ignore=0x0) at example.c:8
8     printf ("hello\n");
```

As with the '`[New ...]`' message, the form of the text after '`Switching to`' depends on your system's conventions for identifying threads.

The debugger convenience variable '`$_thread`' contains the number of the current thread. You may find this useful in writing breakpoint conditional expressions, command scripts, and so forth. See See Section 10.11 [Convenience Variables], page 126, for general information on convenience variables.

`thread apply [threadno | all] command`
: The `thread apply` command allows you to apply the named *command* to one or more threads. Specify the numbers of the threads that you want affected with the command argument *threadno*. It can be a single thread number, one of the numbers shown in the first field of the '`info threads`' display; or it could be a range of thread numbers, as in `2-4`. To apply a command to all threads, type *`thread apply all command`*.

`thread name [name]`
: This command assigns a name to the current thread. If no argument is given, any existing user-specified name is removed. The thread name appears in the '`info threads`' display.

  On some systems, such as GNU/Linux, GDB is able to determine the name of the thread as given by the OS. On these systems, a name specified with '`thread name`' will override the system-give name, and removing the user-specified name will cause GDB to once again display the system-specified name.

`thread find [regexp]`
: Search for and display thread ids whose name or *systag* matches the supplied regular expression.

  As well as being the complement to the '`thread name`' command, this command also allows you to identify a thread by its target *systag*. For instance, on GNU/Linux, the target *systag* is the LWP id.

```
(GDB) thread find 26688
Thread 4 has target id 'Thread 0x41e02940 (LWP 26688)'
(GDB) info thread 4
  Id   Target Id         Frame
  4    Thread 0x41e02940 (LWP 26688) 0x00000031ca6cd372 in select ()
```

`set print thread-events`
`set print thread-events on`
`set print thread-events off`
: The `set print thread-events` command allows you to enable or disable printing of messages when GDB notices that new threads have started or that threads have exited. By default, these messages will be printed if detection of these events is supported by the target. Note that these messages cannot be disabled on all targets.

`show print thread-events`
: Show whether messages will be printed when GDB detects that threads have started and exited.

See Section 5.5 [Stopping and Starting Multi-thread Programs], page 72, for more information about how GDB behaves when you stop and start programs with multiple threads.

See Section 5.1.2 [Setting Watchpoints], page 50, for information about watchpoints in programs with multiple threads.

`set libthread-db-search-path [path]`
: If this variable is set, *path* is a colon-separated list of directories GDB will use to search for `libthread_db`. If you omit *path*, '`libthread-db-search-path`'

will be reset to its default value (`$sdir:$pdir` on GNU/Linux and Solaris systems). Internally, the default value comes from the `LIBTHREAD_DB_SEARCH_PATH` macro.

On GNU/Linux and Solaris systems, GDB uses a "helper" `libthread_db` library to obtain information about threads in the inferior process. GDB will use '`libthread-db-search-path`' to find `libthread_db`. GDB also consults first if inferior specific thread debugging library loading is enabled by '`set auto-load libthread-db`' (see Section 22.7.2 [libthread_db.so.1 file], page 288).

A special entry '`$sdir`' for '`libthread-db-search-path`' refers to the default system directories that are normally searched for loading shared libraries. The '`$sdir`' entry is the only kind not needing to be enabled by '`set auto-load libthread-db`' (see Section 22.7.2 [libthread_db.so.1 file], page 288).

A special entry '`$pdir`' for '`libthread-db-search-path`' refers to the directory from which `libpthread` was loaded in the inferior process.

For any `libthread_db` library GDB finds in above directories, GDB attempts to initialize it with the current inferior process. If this initialization fails (which could happen because of a version mismatch between `libthread_db` and `libpthread`), GDB will unload `libthread_db`, and continue with the next directory. If none of `libthread_db` libraries initialize successfully, GDB will issue a warning and thread debugging will be disabled.

Setting `libthread-db-search-path` is currently implemented only on some platforms.

`show libthread-db-search-path`
: Display current libthread_db search path.

`set debug libthread-db`
`show debug libthread-db`
: Turns on or off display of `libthread_db`-related events. Use `1` to enable, `0` to disable.

4.11 Debugging Forks

On most systems, GDB has no special support for debugging programs which create additional processes using the `fork` function. When a program forks, GDB will continue to debug the parent process and the child process will run unimpeded. If you have set a breakpoint in any code which the child then executes, the child will get a `SIGTRAP` signal which (unless it catches the signal) will cause it to terminate.

However, if you want to debug the child process there is a workaround which isn't too painful. Put a call to `sleep` in the code which the child process executes after the fork. It may be useful to sleep only if a certain environment variable is set, or a certain file exists, so that the delay need not occur when you don't want to run GDB on the child. While the child is sleeping, use the `ps` program to get its process ID. Then tell GDB (a new invocation of GDB if you are also debugging the parent process) to attach to the child process (see Section 4.7 [Attach], page 31). From that point on you can debug the child process just like any other process which you attached to.

On some systems, GDB provides support for debugging programs that create additional processes using the `fork` or `vfork` functions. Currently, the only platforms with this feature are HP-UX (11.x and later only?) and GNU/Linux (kernel version 2.5.60 and later).

By default, when a program forks, GDB will continue to debug the parent process and the child process will run unimpeded.

If you want to follow the child process instead of the parent process, use the command `set follow-fork-mode`.

`set follow-fork-mode` *mode*
: Set the debugger response to a program call of `fork` or `vfork`. A call to `fork` or `vfork` creates a new process. The *mode* argument can be:

  `parent` — The original process is debugged after a fork. The child process runs unimpeded. This is the default.

  `child` — The new process is debugged after a fork. The parent process runs unimpeded.

`show follow-fork-mode`
: Display the current debugger response to a `fork` or `vfork` call.

On Linux, if you want to debug both the parent and child processes, use the command `set detach-on-fork`.

`set detach-on-fork` *mode*
: Tells gdb whether to detach one of the processes after a fork, or retain debugger control over them both.

  `on` — The child process (or parent process, depending on the value of `follow-fork-mode`) will be detached and allowed to run independently. This is the default.

  `off` — Both processes will be held under the control of GDB. One process (child or parent, depending on the value of `follow-fork-mode`) is debugged as usual, while the other is held suspended.

`show detach-on-fork`
: Show whether detach-on-fork mode is on/off.

If you choose to set '`detach-on-fork`' mode off, then GDB will retain control of all forked processes (including nested forks). You can list the forked processes under the control of GDB by using the `info inferiors` command, and switch from one fork to another by using the `inferior` command (see Section 4.9 [Debugging Multiple Inferiors and Programs], page 32).

To quit debugging one of the forked processes, you can either detach from it by using the `detach inferiors` command (allowing it to run independently), or kill it using the `kill inferiors` command. See Section 4.9 [Debugging Multiple Inferiors and Programs], page 32.

If you ask to debug a child process and a `vfork` is followed by an `exec`, GDB executes the new target up to the first breakpoint in the new target. If you have a breakpoint set on `main` in your original program, the breakpoint will also be set on the child process's `main`.

On some systems, when a child process is spawned by `vfork`, you cannot debug the child or parent until an `exec` call completes.

If you issue a `run` command to GDB after an `exec` call executes, the new target restarts. To restart the parent process, use the `file` command with the parent executable name as its argument. By default, after an `exec` call executes, GDB discards the symbols of the previous executable image. You can change this behaviour with the `set follow-exec-mode` command.

`set follow-exec-mode` *mode*

Set debugger response to a program call of `exec`. An `exec` call replaces the program image of a process.

`follow-exec-mode` can be:

`new` GDB creates a new inferior and rebinds the process to this new inferior. The program the process was running before the `exec` call can be restarted afterwards by restarting the original inferior.

For example:

```
(gdb) info inferiors
(gdb) info inferior
  Id   Description   Executable
* 1    <null>        prog1
(gdb) run
process 12020 is executing new program: prog2
Program exited normally.
(gdb) info inferiors
  Id   Description   Executable
* 2    <null>        prog2
  1    <null>        prog1
```

`same` GDB keeps the process bound to the same inferior. The new executable image replaces the previous executable loaded in the inferior. Restarting the inferior after the `exec` call, with e.g., the `run` command, restarts the executable the process was running after the `exec` call. This is the default mode.

For example:

```
(gdb) info inferiors
  Id   Description   Executable
* 1    <null>        prog1
(gdb) run
process 12020 is executing new program: prog2
Program exited normally.
(gdb) info inferiors
  Id   Description   Executable
* 1    <null>        prog2
```

You can use the `catch` command to make GDB stop whenever a `fork`, `vfork`, or `exec` call is made. See Section 5.1.3 [Setting Catchpoints], page 53.

4.12 Setting a *Bookmark* to Return to Later

On certain operating systems[1], GDB is able to save a *snapshot* of a program's state, called a *checkpoint*, and come back to it later.

[1] Currently, only GNU/Linux.

Returning to a checkpoint effectively undoes everything that has happened in the program since the `checkpoint` was saved. This includes changes in memory, registers, and even (within some limits) system state. Effectively, it is like going back in time to the moment when the checkpoint was saved.

Thus, if you're stepping thru a program and you think you're getting close to the point where things go wrong, you can save a checkpoint. Then, if you accidentally go too far and miss the critical statement, instead of having to restart your program from the beginning, you can just go back to the checkpoint and start again from there.

This can be especially useful if it takes a lot of time or steps to reach the point where you think the bug occurs.

To use the `checkpoint`/`restart` method of debugging:

`checkpoint`
: Save a snapshot of the debugged program's current execution state. The `checkpoint` command takes no arguments, but each checkpoint is assigned a small integer id, similar to a breakpoint id.

`info checkpoints`
: List the checkpoints that have been saved in the current debugging session. For each checkpoint, the following information will be listed:

  ```
  Checkpoint ID
  Process ID
  Code Address
  Source line, or label
  ```

`restart` *`checkpoint-id`*
: Restore the program state that was saved as checkpoint number *checkpoint-id*. All program variables, registers, stack frames etc. will be returned to the values that they had when the checkpoint was saved. In essence, gdb will "wind back the clock" to the point in time when the checkpoint was saved.

  Note that breakpoints, GDB variables, command history etc. are not affected by restoring a checkpoint. In general, a checkpoint only restores things that reside in the program being debugged, not in the debugger.

`delete checkpoint` *`checkpoint-id`*
: Delete the previously-saved checkpoint identified by *checkpoint-id*.

Returning to a previously saved checkpoint will restore the user state of the program being debugged, plus a significant subset of the system (OS) state, including file pointers. It won't "un-write" data from a file, but it will rewind the file pointer to the previous location, so that the previously written data can be overwritten. For files opened in read mode, the pointer will also be restored so that the previously read data can be read again.

Of course, characters that have been sent to a printer (or other external device) cannot be "snatched back", and characters received from eg. a serial device can be removed from internal program buffers, but they cannot be "pushed back" into the serial pipeline, ready to be received again. Similarly, the actual contents of files that have been changed cannot be restored (at this time).

However, within those constraints, you actually can "rewind" your program to a previously saved point in time, and begin debugging it again — and you can change the course of events so as to debug a different execution path this time.

Finally, there is one bit of internal program state that will be different when you return to a checkpoint — the program's process id. Each checkpoint will have a unique process id (or *pid*), and each will be different from the program's original *pid*. If your program has saved a local copy of its process id, this could potentially pose a problem.

4.12.1 A Non-obvious Benefit of Using Checkpoints

On some systems such as GNU/Linux, address space randomization is performed on new processes for security reasons. This makes it difficult or impossible to set a breakpoint, or watchpoint, on an absolute address if you have to restart the program, since the absolute location of a symbol will change from one execution to the next.

A checkpoint, however, is an *identical* copy of a process. Therefore if you create a checkpoint at (eg.) the start of main, and simply return to that checkpoint instead of restarting the process, you can avoid the effects of address randomization and your symbols will all stay in the same place.

5 Stopping and Continuing

The principal purposes of using a debugger are so that you can stop your program before it terminates; or so that, if your program runs into trouble, you can investigate and find out why.

Inside GDB, your program may stop for any of several reasons, such as a signal, a breakpoint, or reaching a new line after a GDB command such as `step`. You may then examine and change variables, set new breakpoints or remove old ones, and then continue execution. Usually, the messages shown by GDB provide ample explanation of the status of your program—but you can also explicitly request this information at any time.

`info program`
: Display information about the status of your program: whether it is running or not, what process it is, and why it stopped.

5.1 Breakpoints, Watchpoints, and Catchpoints

A *breakpoint* makes your program stop whenever a certain point in the program is reached. For each breakpoint, you can add conditions to control in finer detail whether your program stops. You can set breakpoints with the `break` command and its variants (see Section 5.1.1 [Setting Breakpoints], page 44), to specify the place where your program should stop by line number, function name or exact address in the program.

On some systems, you can set breakpoints in shared libraries before the executable is run. There is a minor limitation on HP-UX systems: you must wait until the executable is run in order to set breakpoints in shared library routines that are not called directly by the program (for example, routines that are arguments in a `pthread_create` call).

A *watchpoint* is a special breakpoint that stops your program when the value of an expression changes. The expression may be a value of a variable, or it could involve values of one or more variables combined by operators, such as '`a + b`'. This is sometimes called *data breakpoints*. You must use a different command to set watchpoints (see Section 5.1.2 [Setting Watchpoints], page 50), but aside from that, you can manage a watchpoint like any other breakpoint: you enable, disable, and delete both breakpoints and watchpoints using the same commands.

You can arrange to have values from your program displayed automatically whenever GDB stops at a breakpoint. See Section 10.7 [Automatic Display], page 113.

A *catchpoint* is another special breakpoint that stops your program when a certain kind of event occurs, such as the throwing of a C++ exception or the loading of a library. As with watchpoints, you use a different command to set a catchpoint (see Section 5.1.3 [Setting Catchpoints], page 53), but aside from that, you can manage a catchpoint like any other breakpoint. (To stop when your program receives a signal, use the `handle` command; see Section 5.4 [Signals], page 70.)

GDB assigns a number to each breakpoint, watchpoint, or catchpoint when you create it; these numbers are successive integers starting with one. In many of the commands for controlling various features of breakpoints you use the breakpoint number to say which breakpoint you want to change. Each breakpoint may be *enabled* or *disabled*; if disabled, it has no effect on your program until you enable it again.

Some GDB commands accept a range of breakpoints on which to operate. A breakpoint range is either a single breakpoint number, like '`5`', or two such numbers, in increasing order, separated by a hyphen, like '`5-7`'. When a breakpoint range is given to a command, all breakpoints in that range are operated on.

5.1.1 Setting Breakpoints

Breakpoints are set with the `break` command (abbreviated `b`). The debugger convenience variable '`$bpnum`' records the number of the breakpoint you've set most recently; see Section 10.11 [Convenience Variables], page 126, for a discussion of what you can do with convenience variables.

`break` *location*

Set a breakpoint at the given *location*, which can specify a function name, a line number, or an address of an instruction. (See Section 9.2 [Specify Location], page 94, for a list of all the possible ways to specify a *location*.) The breakpoint will stop your program just before it executes any of the code in the specified *location*.

When using source languages that permit overloading of symbols, such as C++, a function name may refer to more than one possible place to break. See Section 10.2 [Ambiguous Expressions], page 106, for a discussion of that situation.

It is also possible to insert a breakpoint that will stop the program only if a specific thread (see Section 5.5.4 [Thread-Specific Breakpoints], page 76) or a specific task (see Section 15.4.9.5 [Ada Tasks], page 196) hits that breakpoint.

`break`

When called without any arguments, `break` sets a breakpoint at the next instruction to be executed in the selected stack frame (see Chapter 8 [Examining the Stack], page 87). In any selected frame but the innermost, this makes your program stop as soon as control returns to that frame. This is similar to the effect of a `finish` command in the frame inside the selected frame—except that `finish` does not leave an active breakpoint. If you use `break` without an argument in the innermost frame, GDB stops the next time it reaches the current location; this may be useful inside loops.

GDB normally ignores breakpoints when it resumes execution, until at least one instruction has been executed. If it did not do this, you would be unable to proceed past a breakpoint without first disabling the breakpoint. This rule applies whether or not the breakpoint already existed when your program stopped.

`break ... if` *cond*

Set a breakpoint with condition *cond*; evaluate the expression *cond* each time the breakpoint is reached, and stop only if the value is nonzero—that is, if *cond* evaluates as true. '`...`' stands for one of the possible arguments described above (or no argument) specifying where to break. See Section 5.1.6 [Break Conditions], page 59, for more information on breakpoint conditions.

`tbreak` *args*

Set a breakpoint enabled only for one stop. *args* are the same as for the `break` command, and the breakpoint is set in the same way, but the breakpoint is auto-

matically deleted after the first time your program stops there. See Section 5.1.5 [Disabling Breakpoints], page 57.

`hbreak` *args*

Set a hardware-assisted breakpoint. *args* are the same as for the `break` command and the breakpoint is set in the same way, but the breakpoint requires hardware support and some target hardware may not have this support. The main purpose of this is EPROM/ROM code debugging, so you can set a breakpoint at an instruction without changing the instruction. This can be used with the new trap-generation provided by SPARClite DSU and most x86-based targets. These targets will generate traps when a program accesses some data or instruction address that is assigned to the debug registers. However the hardware breakpoint registers can take a limited number of breakpoints. For example, on the DSU, only two data breakpoints can be set at a time, and GDB will reject this command if more than two are used. Delete or disable unused hardware breakpoints before setting new ones (see Section 5.1.5 [Disabling Breakpoints], page 57). See Section 5.1.6 [Break Conditions], page 59. For remote targets, you can restrict the number of hardware breakpoints GDB will use, see [set remote hardware-breakpoint-limit], page 243.

`thbreak` *args*

Set a hardware-assisted breakpoint enabled only for one stop. *args* are the same as for the `hbreak` command and the breakpoint is set in the same way. However, like the `tbreak` command, the breakpoint is automatically deleted after the first time your program stops there. Also, like the `hbreak` command, the breakpoint requires hardware support and some target hardware may not have this support. See Section 5.1.5 [Disabling Breakpoints], page 57. See also Section 5.1.6 [Break Conditions], page 59.

`rbreak` *regex*

Set breakpoints on all functions matching the regular expression *regex*. This command sets an unconditional breakpoint on all matches, printing a list of all breakpoints it set. Once these breakpoints are set, they are treated just like the breakpoints set with the `break` command. You can delete them, disable them, or make them conditional the same way as any other breakpoint.

The syntax of the regular expression is the standard one used with tools like '`grep`'. Note that this is different from the syntax used by shells, so for instance `foo*` matches all functions that include an `fo` followed by zero or more `o`s. There is an implicit `.*` leading and trailing the regular expression you supply, so to match only functions that begin with `foo`, use `^foo`.

When debugging C++ programs, `rbreak` is useful for setting breakpoints on overloaded functions that are not members of any special classes.

The `rbreak` command can be used to set breakpoints in **all** the functions in a program, like this:

```
(gdb) rbreak .
```

`rbreak` *file*`:`*regex*

If `rbreak` is called with a filename qualification, it limits the search for functions matching the given regular expression to the specified *file*. This can be used, for example, to set breakpoints on every function in a given file:

```
(gdb) rbreak file.c:.
```

The colon separating the filename qualifier from the regex may optionally be surrounded by spaces.

`info breakpoints` [*n* ...]
`info break` [*n* ...]

Print a table of all breakpoints, watchpoints, and catchpoints set and not deleted. Optional argument *n* means print information only about the specified breakpoint(s) (or watchpoint(s) or catchpoint(s)). For each breakpoint, following columns are printed:

Breakpoint Numbers

Type Breakpoint, watchpoint, or catchpoint.

Disposition

Whether the breakpoint is marked to be disabled or deleted when hit.

Enabled or Disabled

Enabled breakpoints are marked with '`y`'. '`n`' marks breakpoints that are not enabled.

Address Where the breakpoint is in your program, as a memory address. For a pending breakpoint whose address is not yet known, this field will contain '`<PENDING>`'. Such breakpoint won't fire until a shared library that has the symbol or line referred by breakpoint is loaded. See below for details. A breakpoint with several locations will have '`<MULTIPLE>`' in this field—see below for details.

What Where the breakpoint is in the source for your program, as a file and line number. For a pending breakpoint, the original string passed to the breakpoint command will be listed as it cannot be resolved until the appropriate shared library is loaded in the future.

If a breakpoint is conditional, there are two evaluation modes: "host" and "target". If mode is "host", breakpoint condition evaluation is done by GDB on the host's side. If it is "target", then the condition is evaluated by the target. The `info break` command shows the condition on the line following the affected breakpoint, together with its condition evaluation mode in between parentheses.

Breakpoint commands, if any, are listed after that. A pending breakpoint is allowed to have a condition specified for it. The condition is not parsed for validity until a shared library is loaded that allows the pending breakpoint to resolve to a valid location.

`info break` with a breakpoint number *n* as argument lists only that breakpoint. The convenience variable `$_` and the default examining-address for the `x` command are set to the address of the last breakpoint listed (see Section 10.6 [Examining Memory], page 111).

`info break` displays a count of the number of times the breakpoint has been hit. This is especially useful in conjunction with the `ignore` command. You can ignore a large number of breakpoint hits, look at the breakpoint info to see how many times the breakpoint was hit, and then run again, ignoring one less than that number. This will get you quickly to the last hit of that breakpoint.

For a breakpoints with an enable count (xref) greater than 1, `info break` also displays that count.

GDB allows you to set any number of breakpoints at the same place in your program. There is nothing silly or meaningless about this. When the breakpoints are conditional, this is even useful (see Section 5.1.6 [Break Conditions], page 59).

It is possible that a breakpoint corresponds to several locations in your program. Examples of this situation are:

- Multiple functions in the program may have the same name.
- For a C++ constructor, the GCC compiler generates several instances of the function body, used in different cases.
- For a C++ template function, a given line in the function can correspond to any number of instantiations.
- For an inlined function, a given source line can correspond to several places where that function is inlined.

In all those cases, GDB will insert a breakpoint at all the relevant locations.

A breakpoint with multiple locations is displayed in the breakpoint table using several rows—one header row, followed by one row for each breakpoint location. The header row has '`<MULTIPLE>`' in the address column. The rows for individual locations contain the actual addresses for locations, and show the functions to which those locations belong. The number column for a location is of the form *breakpoint-number.location-number*.

For example:

```
Num     Type           Disp Enb  Address    What
1       breakpoint     keep y    <MULTIPLE>
        stop only if i==1
        breakpoint already hit 1 time
1.1                    y    0x080486a2 in void foo<int>() at t.cc:8
1.2                    y    0x080486ca in void foo<double>() at t.cc:8
```

Each location can be individually enabled or disabled by passing *breakpoint-number.location-number* as argument to the `enable` and `disable` commands. Note that you cannot delete the individual locations from the list, you can only delete the entire list of locations that belong to their parent breakpoint (with the *`delete num`* command, where *num* is the number of the parent breakpoint, 1 in the above example). Disabling or enabling the parent breakpoint (see Section 5.1.5 [Disabling], page 57) affects all of the locations that belong to that breakpoint.

It's quite common to have a breakpoint inside a shared library. Shared libraries can be loaded and unloaded explicitly, and possibly repeatedly, as the program is executed. To support this use case, GDB updates breakpoint locations whenever any shared library is loaded or unloaded. Typically, you would set a breakpoint in a shared library at the beginning of your debugging session, when the library is not loaded, and when the symbols

from the library are not available. When you try to set breakpoint, GDB will ask you if you want to set a so called *pending breakpoint*—breakpoint whose address is not yet resolved.

After the program is run, whenever a new shared library is loaded, GDB reevaluates all the breakpoints. When a newly loaded shared library contains the symbol or line referred to by some pending breakpoint, that breakpoint is resolved and becomes an ordinary breakpoint. When a library is unloaded, all breakpoints that refer to its symbols or source lines become pending again.

This logic works for breakpoints with multiple locations, too. For example, if you have a breakpoint in a C++ template function, and a newly loaded shared library has an instantiation of that template, a new location is added to the list of locations for the breakpoint.

Except for having unresolved address, pending breakpoints do not differ from regular breakpoints. You can set conditions or commands, enable and disable them and perform other breakpoint operations.

GDB provides some additional commands for controlling what happens when the '`break`' command cannot resolve breakpoint address specification to an address:

`set breakpoint pending auto`
: This is the default behavior. When GDB cannot find the breakpoint location, it queries you whether a pending breakpoint should be created.

`set breakpoint pending on`
: This indicates that an unrecognized breakpoint location should automatically result in a pending breakpoint being created.

`set breakpoint pending off`
: This indicates that pending breakpoints are not to be created. Any unrecognized breakpoint location results in an error. This setting does not affect any pending breakpoints previously created.

`show breakpoint pending`
: Show the current behavior setting for creating pending breakpoints.

The settings above only affect the `break` command and its variants. Once breakpoint is set, it will be automatically updated as shared libraries are loaded and unloaded.

For some targets, GDB can automatically decide if hardware or software breakpoints should be used, depending on whether the breakpoint address is read-only or read-write. This applies to breakpoints set with the `break` command as well as to internal breakpoints set by commands like `next` and `finish`. For breakpoints set with `hbreak`, GDB will always use hardware breakpoints.

You can control this automatic behaviour with the following commands::

`set breakpoint auto-hw on`
: This is the default behavior. When GDB sets a breakpoint, it will try to use the target memory map to decide if software or hardware breakpoint must be used.

`set breakpoint auto-hw off`
: This indicates GDB should not automatically select breakpoint type. If the target provides a memory map, GDB will warn when trying to set software breakpoint at a read-only address.

GDB normally implements breakpoints by replacing the program code at the breakpoint address with a special instruction, which, when executed, given control to the debugger. By default, the program code is so modified only when the program is resumed. As soon as the program stops, GDB restores the original instructions. This behaviour guards against leaving breakpoints inserted in the target should gdb abrubptly disconnect. However, with slow remote targets, inserting and removing breakpoint can reduce the performance. This behavior can be controlled with the following commands::

`set breakpoint always-inserted off`
: All breakpoints, including newly added by the user, are inserted in the target only when the target is resumed. All breakpoints are removed from the target when it stops.

`set breakpoint always-inserted on`
: Causes all breakpoints to be inserted in the target at all times. If the user adds a new breakpoint, or changes an existing breakpoint, the breakpoints in the target are updated immediately. A breakpoint is removed from the target only when breakpoint itself is removed.

`set breakpoint always-inserted auto`
: This is the default mode. If GDB is controlling the inferior in non-stop mode (see Section 5.5.2 [Non-Stop Mode], page 74), gdb behaves as if `breakpoint always-inserted` mode is on. If GDB is controlling the inferior in all-stop mode, GDB behaves as if `breakpoint always-inserted` mode is off.

GDB handles conditional breakpoints by evaluating these conditions when a breakpoint breaks. If the condition is true, then the process being debugged stops, otherwise the process is resumed.

If the target supports evaluating conditions on its end, GDB may download the breakpoint, together with its conditions, to it.

This feature can be controlled via the following commands:

`set breakpoint condition-evaluation host`
: This option commands GDB to evaluate the breakpoint conditions on the host's side. Unconditional breakpoints are sent to the target which in turn receives the triggers and reports them back to GDB for condition evaluation. This is the standard evaluation mode.

`set breakpoint condition-evaluation target`
: This option commands GDB to download breakpoint conditions to the target at the moment of their insertion. The target is responsible for evaluating the conditional expression and reporting breakpoint stop events back to GDB whenever the condition is true. Due to limitations of target-side evaluation, some conditions cannot be evaluated there, e.g., conditions that depend on local data that is only known to the host. Examples include conditional expressions involving convenience variables, complex types that cannot be handled by the agent expression parser and expressions that are too long to be sent over to the target, specially when the target is a remote system. In these cases, the conditions will be evaluated by GDB.

`set breakpoint condition-evaluation auto`
: This is the default mode. If the target supports evaluating breakpoint conditions on its end, GDB will download breakpoint conditions to the target (limitations mentioned previously apply). If the target does not support breakpoint condition evaluation, then GDB will fallback to evaluating all these conditions on the host's side.

GDB itself sometimes sets breakpoints in your program for special purposes, such as proper handling of `longjmp` (in C programs). These internal breakpoints are assigned negative numbers, starting with `-1`; '`info breakpoints`' does not display them. You can see these breakpoints with the GDB maintenance command '`maint info breakpoints`' (see [maint info breakpoints], page 495).

5.1.2 Setting Watchpoints

You can use a watchpoint to stop execution whenever the value of an expression changes, without having to predict a particular place where this may happen. (This is sometimes called a *data breakpoint*.) The expression may be as simple as the value of a single variable, or as complex as many variables combined by operators. Examples include:

- A reference to the value of a single variable.
- An address cast to an appropriate data type. For example, '`*(int *)0x12345678`' will watch a 4-byte region at the specified address (assuming an `int` occupies 4 bytes).
- An arbitrarily complex expression, such as '`a*b + c/d`'. The expression can use any operators valid in the program's native language (see Chapter 15 [Languages], page 173).

You can set a watchpoint on an expression even if the expression can not be evaluated yet. For instance, you can set a watchpoint on '`*global_ptr`' before '`global_ptr`' is initialized. GDB will stop when your program sets '`global_ptr`' and the expression produces a valid value. If the expression becomes valid in some other way than changing a variable (e.g. if the memory pointed to by '`*global_ptr`' becomes readable as the result of a `malloc` call), GDB may not stop until the next time the expression changes.

Depending on your system, watchpoints may be implemented in software or hardware. GDB does software watchpointing by single-stepping your program and testing the variable's value each time, which is hundreds of times slower than normal execution. (But this may still be worth it, to catch errors where you have no clue what part of your program is the culprit.)

On some systems, such as HP-UX, PowerPC, GNU/Linux and most other x86-based targets, GDB includes support for hardware watchpoints, which do not slow down the running of your program.

`watch` [`-l`|`-location`] *`expr`* [`thread` *`threadnum`*] [`mask` *`maskvalue`*]
: Set a watchpoint for an expression. GDB will break when the expression *expr* is written into by the program and its value changes. The simplest (and the most popular) use of this command is to watch the value of a single variable:

```
(gdb) watch foo
```

: If the command includes a [`thread` *`threadnum`*] argument, GDB breaks only when the thread identified by *threadnum* changes the value of *expr*. If any other

threads change the value of *expr*, GDB will not break. Note that watchpoints restricted to a single thread in this way only work with Hardware Watchpoints.

Ordinarily a watchpoint respects the scope of variables in *expr* (see below). The `-location` argument tells GDB to instead watch the memory referred to by *expr*. In this case, GDB will evaluate *expr*, take the address of the result, and watch the memory at that address. The type of the result is used to determine the size of the watched memory. If the expression's result does not have an address, then GDB will print an error.

The [`mask` *`maskvalue`*] argument allows creation of masked watchpoints, if the current architecture supports this feature (e.g., PowerPC Embedded architecture, see Section 21.3.7 [PowerPC Embedded], page 271.) A *masked watchpoint* specifies a mask in addition to an address to watch. The mask specifies that some bits of an address (the bits which are reset in the mask) should be ignored when matching the address accessed by the inferior against the watchpoint address. Thus, a masked watchpoint watches many addresses simultaneously—those addresses whose unmasked bits are identical to the unmasked bits in the watchpoint address. The `mask` argument implies `-location`. Examples:

```
(gdb) watch foo mask 0xffff00ff
(gdb) watch *0xdeadbeef mask 0xffffff00
```

`rwatch` [`-l`|`-location`] *`expr`* [`thread` *`threadnum`*] [`mask` *`maskvalue`*]
Set a watchpoint that will break when the value of *expr* is read by the program.

`awatch` [`-l`|`-location`] *`expr`* [`thread` *`threadnum`*] [`mask` *`maskvalue`*]
Set a watchpoint that will break when *expr* is either read from or written into by the program.

`info watchpoints` [*`n`*`...`]
This command prints a list of watchpoints, using the same format as `info break` (see Section 5.1.1 [Set Breaks], page 44).

If you watch for a change in a numerically entered address you need to dereference it, as the address itself is just a constant number which will never change. GDB refuses to create a watchpoint that watches a never-changing value:

```
(gdb) watch 0x600850
Cannot watch constant value 0x600850.
(gdb) watch *(int *) 0x600850
Watchpoint 1: *(int *) 6293584
```

GDB sets a *hardware watchpoint* if possible. Hardware watchpoints execute very quickly, and the debugger reports a change in value at the exact instruction where the change occurs. If GDB cannot set a hardware watchpoint, it sets a software watchpoint, which executes more slowly and reports the change in value at the next *statement*, not the instruction, after the change occurs.

You can force GDB to use only software watchpoints with the *`set can-use-hw-watchpoints 0`* command. With this variable set to zero, GDB will never try to use hardware watchpoints, even if the underlying system supports them. (Note that hardware-assisted watchpoints that were set *before* setting `can-use-hw-watchpoints` to zero will still use the hardware mechanism of watching expression values.)

`set can-use-hw-watchpoints`
: Set whether or not to use hardware watchpoints.

`show can-use-hw-watchpoints`
: Show the current mode of using hardware watchpoints.

For remote targets, you can restrict the number of hardware watchpoints GDB will use, see [set remote hardware-breakpoint-limit], page 243.

When you issue the `watch` command, GDB reports

```
Hardware watchpoint num: expr
```

if it was able to set a hardware watchpoint.

Currently, the `awatch` and `rwatch` commands can only set hardware watchpoints, because accesses to data that don't change the value of the watched expression cannot be detected without examining every instruction as it is being executed, and GDB does not do that currently. If GDB finds that it is unable to set a hardware breakpoint with the `awatch` or `rwatch` command, it will print a message like this:

```
Expression cannot be implemented with read/access watchpoint.
```

Sometimes, GDB cannot set a hardware watchpoint because the data type of the watched expression is wider than what a hardware watchpoint on the target machine can handle. For example, some systems can only watch regions that are up to 4 bytes wide; on such systems you cannot set hardware watchpoints for an expression that yields a double-precision floating-point number (which is typically 8 bytes wide). As a work-around, it might be possible to break the large region into a series of smaller ones and watch them with separate watchpoints.

If you set too many hardware watchpoints, GDB might be unable to insert all of them when you resume the execution of your program. Since the precise number of active watchpoints is unknown until such time as the program is about to be resumed, GDB might not be able to warn you about this when you set the watchpoints, and the warning will be printed only when the program is resumed:

```
Hardware watchpoint num: Could not insert watchpoint
```

If this happens, delete or disable some of the watchpoints.

Watching complex expressions that reference many variables can also exhaust the resources available for hardware-assisted watchpoints. That's because GDB needs to watch every variable in the expression with separately allocated resources.

If you call a function interactively using `print` or `call`, any watchpoints you have set will be inactive until GDB reaches another kind of breakpoint or the call completes.

GDB automatically deletes watchpoints that watch local (automatic) variables, or expressions that involve such variables, when they go out of scope, that is, when the execution leaves the block in which these variables were defined. In particular, when the program being debugged terminates, *all* local variables go out of scope, and so only watchpoints that watch global variables remain set. If you rerun the program, you will need to set all such watchpoints again. One way of doing that would be to set a code breakpoint at the entry to the `main` function and when it breaks, set all the watchpoints.

In multi-threaded programs, watchpoints will detect changes to the watched expression from every thread.

Warning: In multi-threaded programs, software watchpoints have only limited usefulness. If GDB creates a software watchpoint, it can only watch the value of an expression *in a single thread*. If you are confident that the expression can only change due to the current thread's activity (and if you are also confident that no other thread can become current), then you can use software watchpoints as usual. However, GDB may not notice when a non-current thread's activity changes the expression. (Hardware watchpoints, in contrast, watch an expression in all threads.)

See [set remote hardware-watchpoint-limit], page 243.

5.1.3 Setting Catchpoints

You can use *catchpoints* to cause the debugger to stop for certain kinds of program events, such as C++ exceptions or the loading of a shared library. Use the `catch` command to set a catchpoint.

`catch` *event*

Stop when *event* occurs. *event* can be any of the following:

`throw` The throwing of a C++ exception.

`catch` The catching of a C++ exception.

`exception`

An Ada exception being raised. If an exception name is specified at the end of the command (eg `catch exception Program_Error`), the debugger will stop only when this specific exception is raised. Otherwise, the debugger stops execution when any Ada exception is raised.

When inserting an exception catchpoint on a user-defined exception whose name is identical to one of the exceptions defined by the language, the fully qualified name must be used as the exception name. Otherwise, GDB will assume that it should stop on the pre-defined exception rather than the user-defined one. For instance, assuming an exception called `Constraint_Error` is defined in package `Pck`, then the command to use to catch such exceptions is *`catch exception Pck.Constraint_Error`*.

`exception unhandled`

An exception that was raised but is not handled by the program.

`assert` A failed Ada assertion.

`exec` A call to `exec`. This is currently only available for HP-UX and GNU/Linux.

`syscall`
`syscall` [*name* | *number*] `...`

A call to or return from a system call, a.k.a. *syscall*. A syscall is a mechanism for application programs to request a service from the operating system (OS) or one of the OS system services. GDB can catch some or all of the syscalls issued by the debuggee, and show

the related information for each syscall. If no argument is specified, calls to and returns from all system calls will be caught.

name can be any system call name that is valid for the underlying OS. Just what syscalls are valid depends on the OS. On GNU and Unix systems, you can find the full list of valid syscall names on '`/usr/include/asm/unistd.h`'.

Normally, GDB knows in advance which syscalls are valid for each OS, so you can use the GDB command-line completion facilities (see Section 3.2 [command completion], page 19) to list the available choices.

You may also specify the system call numerically. A syscall's number is the value passed to the OS's syscall dispatcher to identify the requested service. When you specify the syscall by its name, GDB uses its database of syscalls to convert the name into the corresponding numeric code, but using the number directly may be useful if GDB's database does not have the complete list of syscalls on your system (e.g., because GDB lags behind the OS upgrades).

The example below illustrates how this command works if you don't provide arguments to it:

```
(gdb) catch syscall
Catchpoint 1 (syscall)
(gdb) r
Starting program: /tmp/catch-syscall

Catchpoint 1 (call to syscall 'close'), \
   0xffffe424 in __kernel_vsyscall ()
(gdb) c
Continuing.

Catchpoint 1 (returned from syscall 'close'), \
0xffffe424 in __kernel_vsyscall ()
(gdb)
```

Here is an example of catching a system call by name:

```
(gdb) catch syscall chroot
Catchpoint 1 (syscall 'chroot' [61])
(gdb) r
Starting program: /tmp/catch-syscall

Catchpoint 1 (call to syscall 'chroot'), \
   0xffffe424 in __kernel_vsyscall ()
(gdb) c
Continuing.

Catchpoint 1 (returned from syscall 'chroot'), \
0xffffe424 in __kernel_vsyscall ()
(gdb)
```

An example of specifying a system call numerically. In the case below, the syscall number has a corresponding entry in the XML file, so GDB finds its name and prints it:

```
(gdb) catch syscall 252
Catchpoint 1 (syscall(s) 'exit_group')
```

```
(gdb) r
Starting program: /tmp/catch-syscall

Catchpoint 1 (call to syscall 'exit_group'), \
   0xffffe424 in __kernel_vsyscall ()
(gdb) c
Continuing.

Program exited normally.
(gdb)
```

However, there can be situations when there is no corresponding name in XML file for that syscall number. In this case, GDB prints a warning message saying that it was not able to find the syscall name, but the catchpoint will be set anyway. See the example below:

```
(gdb) catch syscall 764
warning: The number '764' does not represent a known syscall.
Catchpoint 2 (syscall 764)
(gdb)
```

If you configure GDB using the '`--without-expat`' option, it will not be able to display syscall names. Also, if your architecture does not have an XML file describing its system calls, you will not be able to see the syscall names. It is important to notice that these two features are used for accessing the syscall name database. In either case, you will see a warning like this:

```
(gdb) catch syscall
warning: Could not open "syscalls/i386-linux.xml"
warning: Could not load the syscall XML file 'syscalls/i386-linux.xml'.
GDB will not be able to display syscall names.
Catchpoint 1 (syscall)
(gdb)
```

Of course, the file name will change depending on your architecture and system.

Still using the example above, you can also try to catch a syscall by its number. In this case, you would see something like:

```
(gdb) catch syscall 252
Catchpoint 1 (syscall(s) 252)
```

Again, in this case GDB would not be able to display syscall's names.

`fork` A call to `fork`. This is currently only available for HP-UX and GNU/Linux.

`vfork` A call to `vfork`. This is currently only available for HP-UX and GNU/Linux.

`load` [`regexp`]
`unload` [`regexp`]
The loading or unloading of a shared library. If *regexp* is given, then the catchpoint will stop only if the regular expression matches one of the affected libraries.

`signal` [*signal*... | 'all']

The delivery of a signal.

With no arguments, this catchpoint will catch any signal that is not used internally by GDB, specifically, all signals except 'SIGTRAP' and 'SIGINT'.

With the argument 'all', all signals, including those used by GDB, will be caught. This argument cannot be used with other signal names.

Otherwise, the arguments are a list of signal names as given to `handle` (see Section 5.4 [Signals], page 70). Only signals specified in this list will be caught.

One reason that `catch signal` can be more useful than `handle` is that you can attach commands and conditions to the catchpoint.

When a signal is caught by a catchpoint, the signal's `stop` and `print` settings, as specified by `handle`, are ignored. However, whether the signal is still delivered to the inferior depends on the `pass` setting; this can be changed in the catchpoint's commands.

`tcatch` *event*

Set a catchpoint that is enabled only for one stop. The catchpoint is automatically deleted after the first time the event is caught.

Use the `info break` command to list the current catchpoints.

There are currently some limitations to C++ exception handling (`catch throw` and `catch catch`) in GDB:

- If you call a function interactively, GDB normally returns control to you when the function has finished executing. If the call raises an exception, however, the call may bypass the mechanism that returns control to you and cause your program either to abort or to simply continue running until it hits a breakpoint, catches a signal that GDB is listening for, or exits. This is the case even if you set a catchpoint for the exception; catchpoints on exceptions are disabled within interactive calls.
- You cannot raise an exception interactively.
- You cannot install an exception handler interactively.

Sometimes `catch` is not the best way to debug exception handling: if you need to know exactly where an exception is raised, it is better to stop *before* the exception handler is called, since that way you can see the stack before any unwinding takes place. If you set a breakpoint in an exception handler instead, it may not be easy to find out where the exception was raised.

To stop just before an exception handler is called, you need some knowledge of the implementation. In the case of GNU C++, exceptions are raised by calling a library function named `__raise_exception` which has the following ANSI C interface:

```
/* addr is where the exception identifier is stored.
   id is the exception identifier.  */
void __raise_exception (void **addr, void *id);
```

To make the debugger catch all exceptions before any stack unwinding takes place, set a breakpoint on `__raise_exception` (see Section 5.1 [Breakpoints; Watchpoints; and Exceptions], page 43).

With a conditional breakpoint (see Section 5.1.6 [Break Conditions], page 59) that depends on the value of *id*, you can stop your program when a specific exception is raised. You can use multiple conditional breakpoints to stop your program when any of a number of exceptions are raised.

5.1.4 Deleting Breakpoints

It is often necessary to eliminate a breakpoint, watchpoint, or catchpoint once it has done its job and you no longer want your program to stop there. This is called *deleting* the breakpoint. A breakpoint that has been deleted no longer exists; it is forgotten.

With the `clear` command you can delete breakpoints according to where they are in your program. With the `delete` command you can delete individual breakpoints, watchpoints, or catchpoints by specifying their breakpoint numbers.

It is not necessary to delete a breakpoint to proceed past it. GDB automatically ignores breakpoints on the first instruction to be executed when you continue execution without changing the execution address.

`clear`
: Delete any breakpoints at the next instruction to be executed in the selected stack frame (see Section 8.3 [Selecting a Frame], page 90). When the innermost frame is selected, this is a good way to delete a breakpoint where your program just stopped.

`clear` *location*
: Delete any breakpoints set at the specified *location*. See Section 9.2 [Specify Location], page 94, for the various forms of *location*; the most useful ones are listed below:

  `clear` *function*
  `clear` *filename*`:`*function*
  : Delete any breakpoints set at entry to the named *function*.

  `clear` *linenum*
  `clear` *filename*`:`*linenum*
  : Delete any breakpoints set at or within the code of the specified *linenum* of the specified *filename*.

`delete` [`breakpoints`] [*range*`...`]
: Delete the breakpoints, watchpoints, or catchpoints of the breakpoint ranges specified as arguments. If no argument is specified, delete all breakpoints (GDB asks confirmation, unless you have `set confirm off`). You can abbreviate this command as `d`.

5.1.5 Disabling Breakpoints

Rather than deleting a breakpoint, watchpoint, or catchpoint, you might prefer to *disable* it. This makes the breakpoint inoperative as if it had been deleted, but remembers the information on the breakpoint so that you can *enable* it again later.

You disable and enable breakpoints, watchpoints, and catchpoints with the `enable` and `disable` commands, optionally specifying one or more breakpoint numbers as arguments. Use `info break` to print a list of all breakpoints, watchpoints, and catchpoints if you do not know which numbers to use.

Disabling and enabling a breakpoint that has multiple locations affects all of its locations.

A breakpoint, watchpoint, or catchpoint can have any of several different states of enablement:

- Enabled. The breakpoint stops your program. A breakpoint set with the `break` command starts out in this state.
- Disabled. The breakpoint has no effect on your program.
- Enabled once. The breakpoint stops your program, but then becomes disabled.
- Enabled for a count. The breakpoint stops your program for the next N times, then becomes disabled.
- Enabled for deletion. The breakpoint stops your program, but immediately after it does so it is deleted permanently. A breakpoint set with the `tbreak` command starts out in this state.

You can use the following commands to enable or disable breakpoints, watchpoints, and catchpoints:

`disable` [`breakpoints`] [*`range`*`...`]
: Disable the specified breakpoints—or all breakpoints, if none are listed. A disabled breakpoint has no effect but is not forgotten. All options such as ignore-counts, conditions and commands are remembered in case the breakpoint is enabled again later. You may abbreviate `disable` as `dis`.

`enable` [`breakpoints`] [*`range`*`...`]
: Enable the specified breakpoints (or all defined breakpoints). They become effective once again in stopping your program.

`enable` [`breakpoints`] `once` *`range`*`...`
: Enable the specified breakpoints temporarily. GDB disables any of these breakpoints immediately after stopping your program.

`enable` [`breakpoints`] `count` *`count range`*`...`
: Enable the specified breakpoints temporarily. GDB records *count* with each of the specified breakpoints, and decrements a breakpoint's count when it is hit. When any count reaches 0, GDB disables that breakpoint. If a breakpoint has an ignore count (see Section 5.1.6 [Break Conditions], page 59), that will be decremented to 0 before *count* is affected.

`enable` [`breakpoints`] `delete` *`range`*`...`
: Enable the specified breakpoints to work once, then die. GDB deletes any of these breakpoints as soon as your program stops there. Breakpoints set by the `tbreak` command start out in this state.

Except for a breakpoint set with `tbreak` (see Section 5.1.1 [Setting Breakpoints], page 44), breakpoints that you set are initially enabled; subsequently, they become disabled or enabled only when you use one of the commands above. (The command `until`

can set and delete a breakpoint of its own, but it does not change the state of your other breakpoints; see Section 5.2 [Continuing and Stepping], page 65.)

5.1.6 Break Conditions

The simplest sort of breakpoint breaks every time your program reaches a specified place. You can also specify a *condition* for a breakpoint. A condition is just a Boolean expression in your programming language (see Section 10.1 [Expressions], page 105). A breakpoint with a condition evaluates the expression each time your program reaches it, and your program stops only if the condition is *true*.

This is the converse of using assertions for program validation; in that situation, you want to stop when the assertion is violated—that is, when the condition is false. In C, if you want to test an assertion expressed by the condition *assert*, you should set the condition '`! assert`' on the appropriate breakpoint.

Conditions are also accepted for watchpoints; you may not need them, since a watchpoint is inspecting the value of an expression anyhow—but it might be simpler, say, to just set a watchpoint on a variable name, and specify a condition that tests whether the new value is an interesting one.

Break conditions can have side effects, and may even call functions in your program. This can be useful, for example, to activate functions that log program progress, or to use your own print functions to format special data structures. The effects are completely predictable unless there is another enabled breakpoint at the same address. (In that case, GDB might see the other breakpoint first and stop your program without checking the condition of this one.) Note that breakpoint commands are usually more convenient and flexible than break conditions for the purpose of performing side effects when a breakpoint is reached (see Section 5.1.7 [Breakpoint Command Lists], page 60).

Breakpoint conditions can also be evaluated on the target's side if the target supports it. Instead of evaluating the conditions locally, GDB encodes the expression into an agent expression (see Appendix F [Agent Expressions], page 565) suitable for execution on the target, independently of GDB. Global variables become raw memory locations, locals become stack accesses, and so forth.

In this case, GDB will only be notified of a breakpoint trigger when its condition evaluates to true. This mechanism may provide faster response times depending on the performance characteristics of the target since it does not need to keep GDB informed about every breakpoint trigger, even those with false conditions.

Break conditions can be specified when a breakpoint is set, by using '`if`' in the arguments to the `break` command. See Section 5.1.1 [Setting Breakpoints], page 44. They can also be changed at any time with the `condition` command.

You can also use the `if` keyword with the `watch` command. The `catch` command does not recognize the `if` keyword; `condition` is the only way to impose a further condition on a catchpoint.

`condition` *bnum expression*

Specify *expression* as the break condition for breakpoint, watchpoint, or catchpoint number *bnum*. After you set a condition, breakpoint *bnum* stops your program only if the value of *expression* is true (nonzero, in C). When you use `condition`, GDB checks *expression* immediately for syntactic correctness,

and to determine whether symbols in it have referents in the context of your breakpoint. If *expression* uses symbols not referenced in the context of the breakpoint, GDB prints an error message:

```
No symbol "foo" in current context.
```

GDB does not actually evaluate *expression* at the time the `condition` command (or a command that sets a breakpoint with a condition, like `break if ...`) is given, however. See Section 10.1 [Expressions], page 105.

`condition` *bnum*
: Remove the condition from breakpoint number *bnum*. It becomes an ordinary unconditional breakpoint.

A special case of a breakpoint condition is to stop only when the breakpoint has been reached a certain number of times. This is so useful that there is a special way to do it, using the *ignore count* of the breakpoint. Every breakpoint has an ignore count, which is an integer. Most of the time, the ignore count is zero, and therefore has no effect. But if your program reaches a breakpoint whose ignore count is positive, then instead of stopping, it just decrements the ignore count by one and continues. As a result, if the ignore count value is *n*, the breakpoint does not stop the next *n* times your program reaches it.

`ignore` *bnum count*
: Set the ignore count of breakpoint number *bnum* to *count*. The next *count* times the breakpoint is reached, your program's execution does not stop; other than to decrement the ignore count, GDB takes no action.

  To make the breakpoint stop the next time it is reached, specify a count of zero.

  When you use `continue` to resume execution of your program from a breakpoint, you can specify an ignore count directly as an argument to `continue`, rather than using `ignore`. See Section 5.2 [Continuing and Stepping], page 65.

  If a breakpoint has a positive ignore count and a condition, the condition is not checked. Once the ignore count reaches zero, GDB resumes checking the condition.

  You could achieve the effect of the ignore count with a condition such as '`$foo-- <= 0`' using a debugger convenience variable that is decremented each time. See Section 10.11 [Convenience Variables], page 126.

Ignore counts apply to breakpoints, watchpoints, and catchpoints.

5.1.7 Breakpoint Command Lists

You can give any breakpoint (or watchpoint or catchpoint) a series of commands to execute when your program stops due to that breakpoint. For example, you might want to print the values of certain expressions, or enable other breakpoints.

`commands` [*range*`...`]
`... command-list ...`
`end`
: Specify a list of commands for the given breakpoints. The commands themselves appear on the following lines. Type a line containing just `end` to terminate the commands.

  To remove all commands from a breakpoint, type `commands` and follow it immediately with `end`; that is, give no commands.

> With no argument, `commands` refers to the last breakpoint, watchpoint, or catchpoint set (not to the breakpoint most recently encountered). If the most recent breakpoints were set with a single command, then the `commands` will apply to all the breakpoints set by that command. This applies to breakpoints set by `rbreak`, and also applies when a single `break` command creates multiple breakpoints (see Section 10.2 [Ambiguous Expressions], page 106).

Pressing RET as a means of repeating the last GDB command is disabled within a *command-list*.

You can use breakpoint commands to start your program up again. Simply use the `continue` command, or `step`, or any other command that resumes execution.

Any other commands in the command list, after a command that resumes execution, are ignored. This is because any time you resume execution (even with a simple `next` or `step`), you may encounter another breakpoint—which could have its own command list, leading to ambiguities about which list to execute.

If the first command you specify in a command list is `silent`, the usual message about stopping at a breakpoint is not printed. This may be desirable for breakpoints that are to print a specific message and then continue. If none of the remaining commands print anything, you see no sign that the breakpoint was reached. `silent` is meaningful only at the beginning of a breakpoint command list.

The commands `echo`, `output`, and `printf` allow you to print precisely controlled output, and are often useful in silent breakpoints. See Section 23.1.4 [Commands for Controlled Output], page 301.

For example, here is how you could use breakpoint commands to print the value of `x` at entry to `foo` whenever `x` is positive.

```
break foo if x>0
commands
silent
printf "x is %d\n",x
cont
end
```

One application for breakpoint commands is to compensate for one bug so you can test for another. Put a breakpoint just after the erroneous line of code, give it a condition to detect the case in which something erroneous has been done, and give it commands to assign correct values to any variables that need them. End with the `continue` command so that your program does not stop, and start with the `silent` command so that no output is produced. Here is an example:

```
break 403
commands
silent
set x = y + 4
cont
end
```

5.1.8 Dynamic Printf

The dynamic printf command `dprintf` combines a breakpoint with formatted printing of your program's data to give you the effect of inserting `printf` calls into your program on-the-fly, without having to recompile it.

In its most basic form, the output goes to the GDB console. However, you can set the variable `dprintf-style` for alternate handling. For instance, you can ask to format the output by calling your program's `printf` function. This has the advantage that the characters go to the program's output device, so they can recorded in redirects to files and so forth.

If you are doing remote debugging with a stub or agent, you can also ask to have the printf handled by the remote agent. In addition to ensuring that the output goes to the remote program's device along with any other output the program might produce, you can also ask that the dprintf remain active even after disconnecting from the remote target. Using the stub/agent is also more efficient, as it can do everything without needing to communicate with GDB.

`dprintf` *`location`*`,`*`template`*`,`*`expression`*`[,`*`expression`*`...]`
: Whenever execution reaches *location*, print the values of one or more *expressions* under the control of the string *template*. To print several values, separate them with commas.

`set dprintf-style` *`style`*
: Set the dprintf output to be handled in one of several different styles enumerated below. A change of style affects all existing dynamic printfs immediately. (If you need individual control over the print commands, simply define normal breakpoints with explicitly-supplied command lists.)

`gdb`
: Handle the output using the GDB `printf` command.

`call`
: Handle the output by calling a function in your program (normally `printf`).

`agent`
: Have the remote debugging agent (such as `gdbserver`) handle the output itself. This style is only available for agents that support running commands on the target.

`set dprintf-function` *`function`*
: Set the function to call if the dprintf style is `call`. By default its value is `printf`. You may set it to any expression. that GDB can evaluate to a function, as per the `call` command.

`set dprintf-channel` *`channel`*
: Set a "channel" for dprintf. If set to a non-empty value, GDB will evaluate it as an expression and pass the result as a first argument to the `dprintf-function`, in the manner of `fprintf` and similar functions. Otherwise, the dprintf format string will be the first argument, in the manner of `printf`.

  As an example, if you wanted `dprintf` output to go to a logfile that is a standard I/O stream assigned to the variable `mylog`, you could do the following:

```
(gdb) set dprintf-style call
(gdb) set dprintf-function fprintf
(gdb) set dprintf-channel mylog
(gdb) dprintf 25,"at line 25, glob=%d\n",glob
Dprintf 1 at 0x123456: file main.c, line 25.
(gdb) info break
1       dprintf        keep y   0x00123456 in main at main.c:25
```

```
                call (void) fprintf (mylog,"at line 25, glob=%d\n",glob)
                continue
        (gdb)
```

Note that the `info break` displays the dynamic printf commands as normal breakpoint commands; you can thus easily see the effect of the variable settings.

`set disconnected-dprintf on`
`set disconnected-dprintf off`
Choose whether `dprintf` commands should continue to run if GDB has disconnected from the target. This only applies if the `dprintf-style` is `agent`.

`show disconnected-dprintf off`
Show the current choice for disconnected `dprintf`.

GDB does not check the validity of function and channel, relying on you to supply values that are meaningful for the contexts in which they are being used. For instance, the function and channel may be the values of local variables, but if that is the case, then all enabled dynamic prints must be at locations within the scope of those locals. If evaluation fails, GDB will report an error.

5.1.9 How to save breakpoints to a file

To save breakpoint definitions to a file use the `save breakpoints` command.

`save breakpoints [`*`filename`*`]`
This command saves all current breakpoint definitions together with their commands and ignore counts, into a file '*`filename`*' suitable for use in a later debugging session. This includes all types of breakpoints (breakpoints, watchpoints, catchpoints, tracepoints). To read the saved breakpoint definitions, use the `source` command (see Section 23.1.3 [Command Files], page 300). Note that watchpoints with expressions involving local variables may fail to be recreated because it may not be possible to access the context where the watchpoint is valid anymore. Because the saved breakpoint definitions are simply a sequence of GDB commands that recreate the breakpoints, you can edit the file in your favorite editing program, and remove the breakpoint definitions you're not interested in, or that can no longer be recreated.

5.1.10 Static Probe Points

GDB supports *SDT* probes in the code. SDT stands for Statically Defined Tracing, and the probes are designed to have a tiny runtime code and data footprint, and no dynamic relocations. They are usable from assembly, C and C++ languages. See http://sourceware.org/systemtap/wiki/UserSpaceProbeImplementation for a good reference on how the SDT probes are implemented.

Currently, `SystemTap` (http://sourceware.org/systemtap/) SDT probes are supported on ELF-compatible systems. See http://sourceware.org/systemtap/wiki/AddingUserSpaceProbin for more information on how to add `SystemTap` SDT probes in your applications.

Some probes have an associated semaphore variable; for instance, this happens automatically if you defined your probe using a DTrace-style '`.d`' file. If your probe has a semaphore, GDB will automatically enable it when you specify a breakpoint using the '`-probe-stap`'

notation. But, if you put a breakpoint at a probe's location by some other method (e.g., `break file:line`), then GDB will not automatically set the semaphore.

You can examine the available static static probes using `info probes`, with optional arguments:

`info probes stap` [*provider* [*name* [*objfile*]]]
: If given, *provider* is a regular expression used to match against provider names when selecting which probes to list. If omitted, probes by all probes from all providers are listed.

  If given, *name* is a regular expression to match against probe names when selecting which probes to list. If omitted, probe names are not considered when deciding whether to display them.

  If given, *objfile* is a regular expression used to select which object files (executable or shared libraries) to examine. If not given, all object files are considered.

`info probes all`
: List the available static probes, from all types.

A probe may specify up to twelve arguments. These are available at the point at which the probe is defined—that is, when the current PC is at the probe's location. The arguments are available using the convenience variables (see Section 10.11 [Convenience Vars], page 126) `$_probe_arg0...$_probe_arg11`. Each probe argument is an integer of the appropriate size; types are not preserved. The convenience variable `$_probe_argc` holds the number of arguments at the current probe point.

These variables are always available, but attempts to access them at any location other than a probe point will cause GDB to give an error message.

5.1.11 "Cannot insert breakpoints"

If you request too many active hardware-assisted breakpoints and watchpoints, you will see this error message:

```
Stopped; cannot insert breakpoints.
You may have requested too many hardware breakpoints and watchpoints.
```

This message is printed when you attempt to resume the program, since only then GDB knows exactly how many hardware breakpoints and watchpoints it needs to insert.

When this message is printed, you need to disable or remove some of the hardware-assisted breakpoints and watchpoints, and then continue.

5.1.12 "Breakpoint address adjusted..."

Some processor architectures place constraints on the addresses at which breakpoints may be placed. For architectures thus constrained, GDB will attempt to adjust the breakpoint's address to comply with the constraints dictated by the architecture.

One example of such an architecture is the Fujitsu FR-V. The FR-V is a VLIW architecture in which a number of RISC-like instructions may be bundled together for parallel execution. The FR-V architecture constrains the location of a breakpoint instruction within such a bundle to the instruction with the lowest address. GDB honors this constraint by adjusting a breakpoint's address to the first in the bundle.

It is not uncommon for optimized code to have bundles which contain instructions from different source statements, thus it may happen that a breakpoint's address will be adjusted from one source statement to another. Since this adjustment may significantly alter GDB's breakpoint related behavior from what the user expects, a warning is printed when the breakpoint is first set and also when the breakpoint is hit.

A warning like the one below is printed when setting a breakpoint that's been subject to address adjustment:

```
warning: Breakpoint address adjusted from 0x00010414 to 0x00010410.
```

Such warnings are printed both for user settable and GDB's internal breakpoints. If you see one of these warnings, you should verify that a breakpoint set at the adjusted address will have the desired affect. If not, the breakpoint in question may be removed and other breakpoints may be set which will have the desired behavior. E.g., it may be sufficient to place the breakpoint at a later instruction. A conditional breakpoint may also be useful in some cases to prevent the breakpoint from triggering too often.

GDB will also issue a warning when stopping at one of these adjusted breakpoints:

```
warning: Breakpoint 1 address previously adjusted from 0x00010414
to 0x00010410.
```

When this warning is encountered, it may be too late to take remedial action except in cases where the breakpoint is hit earlier or more frequently than expected.

5.2 Continuing and Stepping

Continuing means resuming program execution until your program completes normally. In contrast, *stepping* means executing just one more "step" of your program, where "step" may mean either one line of source code, or one machine instruction (depending on what particular command you use). Either when continuing or when stepping, your program may stop even sooner, due to a breakpoint or a signal. (If it stops due to a signal, you may want to use `handle`, or use '`signal 0`' to resume execution. See Section 5.4 [Signals], page 70.)

`continue` [*ignore-count*]
`c` [*ignore-count*]
`fg` [*ignore-count*]

Resume program execution, at the address where your program last stopped; any breakpoints set at that address are bypassed. The optional argument *ignore-count* allows you to specify a further number of times to ignore a breakpoint at this location; its effect is like that of `ignore` (see Section 5.1.6 [Break Conditions], page 59).

The argument *ignore-count* is meaningful only when your program stopped due to a breakpoint. At other times, the argument to `continue` is ignored.

The synonyms `c` and `fg` (for *foreground*, as the debugged program is deemed to be the foreground program) are provided purely for convenience, and have exactly the same behavior as `continue`.

To resume execution at a different place, you can use `return` (see Section 17.4 [Returning from a Function], page 211) to go back to the calling function; or `jump` (see Section 17.2 [Continuing at a Different Address], page 210) to go to an arbitrary location in your program.

A typical technique for using stepping is to set a breakpoint (see Section 5.1 [Breakpoints; Watchpoints; and Catchpoints], page 43) at the beginning of the function or the section of your program where a problem is believed to lie, run your program until it stops at that breakpoint, and then step through the suspect area, examining the variables that are interesting, until you see the problem happen.

`step` Continue running your program until control reaches a different source line, then stop it and return control to GDB. This command is abbreviated `s`.

> *Warning:* If you use the `step` command while control is within a function that was compiled without debugging information, execution proceeds until control reaches a function that does have debugging information. Likewise, it will not step into a function which is compiled without debugging information. To step through functions without debugging information, use the `stepi` command, described below.

The `step` command only stops at the first instruction of a source line. This prevents the multiple stops that could otherwise occur in `switch` statements, `for` loops, etc. `step` continues to stop if a function that has debugging information is called within the line. In other words, `step` *steps inside* any functions called within the line.

Also, the `step` command only enters a function if there is line number information for the function. Otherwise it acts like the `next` command. This avoids problems when using `cc -gl` on MIPS machines. Previously, `step` entered subroutines if there was any debugging information about the routine.

`step` *count*

Continue running as in `step`, but do so *count* times. If a breakpoint is reached, or a signal not related to stepping occurs before *count* steps, stepping stops right away.

`next` [*count*]

Continue to the next source line in the current (innermost) stack frame. This is similar to `step`, but function calls that appear within the line of code are executed without stopping. Execution stops when control reaches a different line of code at the original stack level that was executing when you gave the `next` command. This command is abbreviated `n`.

An argument *count* is a repeat count, as for `step`.

The `next` command only stops at the first instruction of a source line. This prevents multiple stops that could otherwise occur in `switch` statements, `for` loops, etc.

`set step-mode`
`set step-mode on`

The `set step-mode on` command causes the `step` command to stop at the first instruction of a function which contains no debug line information rather than stepping over it.

This is useful in cases where you may be interested in inspecting the machine instructions of a function which has no symbolic info and do not want GDB to automatically skip over this function.

`set step-mode off`
: Causes the `step` command to step over any functions which contains no debug information. This is the default.

`show step-mode`
: Show whether GDB will stop in or step over functions without source line debug information.

`finish`
: Continue running until just after function in the selected stack frame returns. Print the returned value (if any). This command can be abbreviated as `fin`.

  Contrast this with the `return` command (see Section 17.4 [Returning from a Function], page 211).

`until`
`u`
: Continue running until a source line past the current line, in the current stack frame, is reached. This command is used to avoid single stepping through a loop more than once. It is like the `next` command, except that when `until` encounters a jump, it automatically continues execution until the program counter is greater than the address of the jump.

  This means that when you reach the end of a loop after single stepping though it, `until` makes your program continue execution until it exits the loop. In contrast, a `next` command at the end of a loop simply steps back to the beginning of the loop, which forces you to step through the next iteration.

  `until` always stops your program if it attempts to exit the current stack frame.

  `until` may produce somewhat counterintuitive results if the order of machine code does not match the order of the source lines. For example, in the following excerpt from a debugging session, the `f` (`frame`) command shows that execution is stopped at line `206`; yet when we use `until`, we get to line `195`:

```
(gdb) f
#0  main (argc=4, argv=0xf7fffae8) at m4.c:206
206                 expand_input();
(gdb) until
195             for ( ; argc > 0; NEXTARG) {
```

  This happened because, for execution efficiency, the compiler had generated code for the loop closure test at the end, rather than the start, of the loop—even though the test in a C `for`-loop is written before the body of the loop. The `until` command appeared to step back to the beginning of the loop when it advanced to this expression; however, it has not really gone to an earlier statement—not in terms of the actual machine code.

  `until` with no argument works by means of single instruction stepping, and hence is slower than `until` with an argument.

`until` *location*
`u` *location*
: Continue running your program until either the specified location is reached, or the current stack frame returns. *location* is any of the forms described

in Section 9.2 [Specify Location], page 94. This form of the command uses temporary breakpoints, and hence is quicker than `until` without an argument. The specified location is actually reached only if it is in the current frame. This implies that `until` can be used to skip over recursive function invocations. For instance in the code below, if the current location is line `96`, issuing `until 99` will execute the program up to line `99` in the same invocation of factorial, i.e., after the inner invocations have returned.

```
94 int factorial (int value)
95 {
96     if (value > 1) {
97            value *= factorial (value - 1);
98     }
99     return (value);
100     }
```

`advance` *location*
: Continue running the program up to the given *location*. An argument is required, which should be of one of the forms described in Section 9.2 [Specify Location], page 94. Execution will also stop upon exit from the current stack frame. This command is similar to `until`, but `advance` will not skip over recursive function calls, and the target location doesn't have to be in the same frame as the current one.

`stepi`
`stepi` *arg*
`si`
: Execute one machine instruction, then stop and return to the debugger.

  It is often useful to do '`display/i $pc`' when stepping by machine instructions. This makes GDB automatically display the next instruction to be executed, each time your program stops. See Section 10.7 [Automatic Display], page 113.

  An argument is a repeat count, as in `step`.

`nexti`
`nexti` *arg*
`ni`
: Execute one machine instruction, but if it is a function call, proceed until the function returns.

  An argument is a repeat count, as in `next`.

By default, and if available, GDB makes use of target-assisted *range stepping*. In other words, whenever you use a stepping command (e.g., `step`, `next`), GDB tells the target to step the corresponding range of instruction addresses instead of issuing multiple single-steps. This speeds up line stepping, particularly for remote targets. Ideally, there should be no reason you would want to turn range stepping off. However, it's possible that a bug in the debug info, a bug in the remote stub (for remote targets), or even a bug in GDB could make line stepping behave incorrectly when target-assisted range stepping is enabled. You can use the following command to turn off range stepping if necessary:

`set range-stepping`
`show range-stepping`
: Control whether range stepping is enabled.

If `on`, and the target supports it, GDB tells the target to step a range of addresses itself, instead of issuing multiple single-steps. If `off`, GDB always issues single-steps, even if range stepping is supported by the target. The default is `on`.

5.3 Skipping Over Functions and Files

The program you are debugging may contain some functions which are uninteresting to debug. The `skip` comand lets you tell GDB to skip a function or all functions in a file when stepping.

For example, consider the following C function:

```
101     int func()
102     {
103         foo(boring());
104         bar(boring());
105     }
```

Suppose you wish to step into the functions `foo` and `bar`, but you are not interested in stepping through `boring`. If you run `step` at line 103, you'll enter `boring()`, but if you run `next`, you'll step over both `foo` and `boring`!

One solution is to `step` into `boring` and use the `finish` command to immediately exit it. But this can become tedious if `boring` is called from many places.

A more flexible solution is to execute *`skip boring`*. This instructs GDB never to step into `boring`. Now when you execute `step` at line 103, you'll step over `boring` and directly into `foo`.

You can also instruct GDB to skip all functions in a file, with, for example, `skip file boring.c`.

`skip` [*`linespec`*]
`skip function` [*`linespec`*]

After running this command, the function named by *linespec* or the function containing the line named by *linespec* will be skipped over when stepping. See Section 9.2 [Specify Location], page 94.

If you do not specify *linespec*, the function you're currently debugging will be skipped.

(If you have a function called `file` that you want to skip, use *`skip function file`*.)

`skip file` [*`filename`*]

After running this command, any function whose source lives in *filename* will be skipped over when stepping.

If you do not specify *filename*, functions whose source lives in the file you're currently debugging will be skipped.

Skips can be listed, deleted, disabled, and enabled, much like breakpoints. These are the commands for managing your list of skips:

`info skip` [*`range`*]

Print details about the specified skip(s). If *range* is not specified, print a table with details about all functions and files marked for skipping. `info skip` prints the following information about each skip:

Identifier A number identifying this skip.

Type The type of this skip, either '`function`' or '`file`'.

Enabled or Disabled
Enabled skips are marked with '`y`'. Disabled skips are marked with '`n`'.

Address For function skips, this column indicates the address in memory of the function being skipped. If you've set a function skip on a function which has not yet been loaded, this field will contain '`<PENDING>`'. Once a shared library which has the function is loaded, `info skip` will show the function's address here.

What For file skips, this field contains the filename being skipped. For functions skips, this field contains the function name and its line number in the file where it is defined.

`skip delete` [*range*]
Delete the specified skip(s). If *range* is not specified, delete all skips.

`skip enable` [*range*]
Enable the specified skip(s). If *range* is not specified, enable all skips.

`skip disable` [*range*]
Disable the specified skip(s). If *range* is not specified, disable all skips.

5.4 Signals

A signal is an asynchronous event that can happen in a program. The operating system defines the possible kinds of signals, and gives each kind a name and a number. For example, in Unix `SIGINT` is the signal a program gets when you type an interrupt character (often *Ctrl-c*); `SIGSEGV` is the signal a program gets from referencing a place in memory far away from all the areas in use; `SIGALRM` occurs when the alarm clock timer goes off (which happens only if your program has requested an alarm).

Some signals, including `SIGALRM`, are a normal part of the functioning of your program. Others, such as `SIGSEGV`, indicate errors; these signals are *fatal* (they kill your program immediately) if the program has not specified in advance some other way to handle the signal. `SIGINT` does not indicate an error in your program, but it is normally fatal so it can carry out the purpose of the interrupt: to kill the program.

GDB has the ability to detect any occurrence of a signal in your program. You can tell GDB in advance what to do for each kind of signal.

Normally, GDB is set up to let the non-erroneous signals like `SIGALRM` be silently passed to your program (so as not to interfere with their role in the program's functioning) but to stop your program immediately whenever an error signal happens. You can change these settings with the `handle` command.

`info signals`
`info handle`
Print a table of all the kinds of signals and how GDB has been told to handle each one. You can use this to see the signal numbers of all the defined types of signals.

`info signals` *sig*
: Similar, but print information only about the specified signal number.

  `info handle` is an alias for `info signals`.

`catch signal` [*signal* ... | 'all']
: Set a catchpoint for the indicated signals. See Section 5.1.3 [Set Catchpoints], page 53, for details about this command.

`handle` *signal* [*keywords*...]
: Change the way GDB handles signal *signal*. *signal* can be the number of a signal or its name (with or without the 'SIG' at the beginning); a list of signal numbers of the form '*low-high*'; or the word 'all', meaning all the known signals. Optional arguments *keywords*, described below, say what change to make.

The keywords allowed by the `handle` command can be abbreviated. Their full names are:

`nostop`
: GDB should not stop your program when this signal happens. It may still print a message telling you that the signal has come in.

`stop`
: GDB should stop your program when this signal happens. This implies the `print` keyword as well.

`print`
: GDB should print a message when this signal happens.

`noprint`
: GDB should not mention the occurrence of the signal at all. This implies the `nostop` keyword as well.

`pass`
`noignore`
: GDB should allow your program to see this signal; your program can handle the signal, or else it may terminate if the signal is fatal and not handled. `pass` and `noignore` are synonyms.

`nopass`
`ignore`
: GDB should not allow your program to see this signal. `nopass` and `ignore` are synonyms.

When a signal stops your program, the signal is not visible to the program until you continue. Your program sees the signal then, if `pass` is in effect for the signal in question *at that time*. In other words, after GDB reports a signal, you can use the `handle` command with `pass` or `nopass` to control whether your program sees that signal when you continue.

The default is set to `nostop`, `noprint`, `pass` for non-erroneous signals such as `SIGALRM`, `SIGWINCH` and `SIGCHLD`, and to `stop`, `print`, `pass` for the erroneous signals.

You can also use the `signal` command to prevent your program from seeing a signal, or cause it to see a signal it normally would not see, or to give it any signal at any time. For example, if your program stopped due to some sort of memory reference error, you might store correct values into the erroneous variables and continue, hoping to see more execution; but your program would probably terminate immediately as a result of the fatal signal once it saw the signal. To prevent this, you can continue with '`signal 0`'. See Section 17.3 [Giving your Program a Signal], page 211.

On some targets, GDB can inspect extra signal information associated with the intercepted signal, before it is actually delivered to the program being debugged. This information is exported by the convenience variable `$_siginfo`, and consists of data that is passed by the kernel to the signal handler at the time of the receipt of a signal. The data type of the information itself is target dependent. You can see the data type using the `ptype $_siginfo` command. On Unix systems, it typically corresponds to the standard `siginfo_t` type, as defined in the '`signal.h`' system header.

Here's an example, on a GNU/Linux system, printing the stray referenced address that raised a segmentation fault.

```
(gdb) continue
Program received signal SIGSEGV, Segmentation fault.
0x0000000000400766 in main ()
69        *(int *)p = 0;
(gdb) ptype $_siginfo
type = struct {
    int si_signo;
    int si_errno;
    int si_code;
    union {
        int _pad[28];
        struct {...} _kill;
        struct {...} _timer;
        struct {...} _rt;
        struct {...} _sigchld;
        struct {...} _sigfault;
        struct {...} _sigpoll;
    } _sifields;
}
(gdb) ptype $_siginfo._sifields._sigfault
type = struct {
    void *si_addr;
}
(gdb) p $_siginfo._sifields._sigfault.si_addr
$1 = (void *) 0x7ffff7ff7000
```

Depending on target support, `$_siginfo` may also be writable.

5.5 Stopping and Starting Multi-thread Programs

GDB supports debugging programs with multiple threads (see Section 4.10 [Debugging Programs with Multiple Threads], page 35). There are two modes of controlling execution of your program within the debugger. In the default mode, referred to as *all-stop mode*, when any thread in your program stops (for example, at a breakpoint or while being stepped), all other threads in the program are also stopped by GDB. On some targets, GDB also supports *non-stop mode*, in which other threads can continue to run freely while you examine the stopped thread in the debugger.

5.5.1 All-Stop Mode

In all-stop mode, whenever your program stops under GDB for any reason, *all* threads of execution stop, not just the current thread. This allows you to examine the overall state of the program, including switching between threads, without worrying that things may change underfoot.

Conversely, whenever you restart the program, *all* threads start executing. *This is true even when single-stepping* with commands like `step` or `next`.

In particular, GDB cannot single-step all threads in lockstep. Since thread scheduling is up to your debugging target's operating system (not controlled by GDB), other threads may execute more than one statement while the current thread completes a single step. Moreover, in general other threads stop in the middle of a statement, rather than at a clean statement boundary, when the program stops.

You might even find your program stopped in another thread after continuing or even single-stepping. This happens whenever some other thread runs into a breakpoint, a signal, or an exception before the first thread completes whatever you requested.

Whenever GDB stops your program, due to a breakpoint or a signal, it automatically selects the thread where that breakpoint or signal happened. GDB alerts you to the context switch with a message such as '`[Switching to Thread n]`' to identify the thread.

On some OSes, you can modify GDB's default behavior by locking the OS scheduler to allow only a single thread to run.

`set scheduler-locking` *mode*
: Set the scheduler locking mode. If it is `off`, then there is no locking and any thread may run at any time. If `on`, then only the current thread may run when the inferior is resumed. The `step` mode optimizes for single-stepping; it prevents other threads from preempting the current thread while you are stepping, so that the focus of debugging does not change unexpectedly. Other threads only rarely (or never) get a chance to run when you step. They are more likely to run when you '`next`' over a function call, and they are completely free to run when you use commands like '`continue`', '`until`', or '`finish`'. However, unless another thread hits a breakpoint during its timeslice, GDB does not change the current thread away from the thread that you are debugging.

`show scheduler-locking`
: Display the current scheduler locking mode.

By default, when you issue one of the execution commands such as `continue`, `next` or `step`, GDB allows only threads of the current inferior to run. For example, if GDB is attached to two inferiors, each with two threads, the `continue` command resumes only the two threads of the current inferior. This is useful, for example, when you debug a program that forks and you want to hold the parent stopped (so that, for instance, it doesn't run to exit), while you debug the child. In other situations, you may not be interested in inspecting the current state of any of the processes GDB is attached to, and you may want to resume them all until some breakpoint is hit. In the latter case, you can instruct GDB to allow all threads of all the inferiors to run with the `set schedule-multiple` command.

`set schedule-multiple`
: Set the mode for allowing threads of multiple processes to be resumed when an execution command is issued. When `on`, all threads of all processes are allowed to run. When `off`, only the threads of the current process are resumed. The default is `off`. The `scheduler-locking` mode takes precedence when set to `on`, or while you are stepping and set to `step`.

`show schedule-multiple`
: Display the current mode for resuming the execution of threads of multiple processes.

5.5.2 Non-Stop Mode

For some multi-threaded targets, GDB supports an optional mode of operation in which you can examine stopped program threads in the debugger while other threads continue to execute freely. This minimizes intrusion when debugging live systems, such as programs where some threads have real-time constraints or must continue to respond to external events. This is referred to as *non-stop* mode.

In non-stop mode, when a thread stops to report a debugging event, *only* that thread is stopped; GDB does not stop other threads as well, in contrast to the all-stop mode behavior. Additionally, execution commands such as `continue` and `step` apply by default only to the current thread in non-stop mode, rather than all threads as in all-stop mode. This allows you to control threads explicitly in ways that are not possible in all-stop mode — for example, stepping one thread while allowing others to run freely, stepping one thread while holding all others stopped, or stepping several threads independently and simultaneously.

To enter non-stop mode, use this sequence of commands before you run or attach to your program:

```
# Enable the async interface.
set target-async 1

# If using the CLI, pagination breaks non-stop.
set pagination off

# Finally, turn it on!
set non-stop on
```

You can use these commands to manipulate the non-stop mode setting:

`set non-stop on`
: Enable selection of non-stop mode.

`set non-stop off`
: Disable selection of non-stop mode.

`show non-stop`
: Show the current non-stop enablement setting.

Note these commands only reflect whether non-stop mode is enabled, not whether the currently-executing program is being run in non-stop mode. In particular, the `set non-stop` preference is only consulted when GDB starts or connects to the target program, and it is generally not possible to switch modes once debugging has started. Furthermore, since not all targets support non-stop mode, even when you have enabled non-stop mode, GDB may still fall back to all-stop operation by default.

In non-stop mode, all execution commands apply only to the current thread by default. That is, `continue` only continues one thread. To continue all threads, issue `continue -a` or `c -a`.

You can use GDB's background execution commands (see Section 5.5.3 [Background Execution], page 75) to run some threads in the background while you continue to examine

or step others from GDB. The MI execution commands (see Section 27.15 [GDB/MI Program Execution], page 394) are always executed asynchronously in non-stop mode.

Suspending execution is done with the `interrupt` command when running in the background, or *`Ctrl-c`* during foreground execution. In all-stop mode, this stops the whole process; but in non-stop mode the interrupt applies only to the current thread. To stop the whole program, use `interrupt -a`.

Other execution commands do not currently support the `-a` option.

In non-stop mode, when a thread stops, GDB doesn't automatically make that thread current, as it does in all-stop mode. This is because the thread stop notifications are asynchronous with respect to GDB's command interpreter, and it would be confusing if GDB unexpectedly changed to a different thread just as you entered a command to operate on the previously current thread.

5.5.3 Background Execution

GDB's execution commands have two variants: the normal foreground (synchronous) behavior, and a background (asynchronous) behavior. In foreground execution, GDB waits for the program to report that some thread has stopped before prompting for another command. In background execution, GDB immediately gives a command prompt so that you can issue other commands while your program runs.

You need to explicitly enable asynchronous mode before you can use background execution commands. You can use these commands to manipulate the asynchronous mode setting:

`set target-async on`
: Enable asynchronous mode.

`set target-async off`
: Disable asynchronous mode.

`show target-async`
: Show the current target-async setting.

If the target doesn't support async mode, GDB issues an error message if you attempt to use the background execution commands.

To specify background execution, add a `&` to the command. For example, the background form of the `continue` command is `continue&`, or just `c&`. The execution commands that accept background execution are:

`run` See Section 4.2 [Starting your Program], page 26.

`attach` See Section 4.7 [Debugging an Already-running Process], page 31.

`step` See Section 5.2 [Continuing and Stepping], page 65.

`stepi` See Section 5.2 [Continuing and Stepping], page 65.

`next` See Section 5.2 [Continuing and Stepping], page 65.

`nexti` See Section 5.2 [Continuing and Stepping], page 65.

`continue` See Section 5.2 [Continuing and Stepping], page 65.

`finish` See Section 5.2 [Continuing and Stepping], page 65.

`until` See Section 5.2 [Continuing and Stepping], page 65.

Background execution is especially useful in conjunction with non-stop mode for debugging programs with multiple threads; see Section 5.5.2 [Non-Stop Mode], page 74. However, you can also use these commands in the normal all-stop mode with the restriction that you cannot issue another execution command until the previous one finishes. Examples of commands that are valid in all-stop mode while the program is running include `help` and `info break`.

You can interrupt your program while it is running in the background by using the `interrupt` command.

`interrupt`
`interrupt -a`

Suspend execution of the running program. In all-stop mode, `interrupt` stops the whole process, but in non-stop mode, it stops only the current thread. To stop the whole program in non-stop mode, use `interrupt -a`.

5.5.4 Thread-Specific Breakpoints

When your program has multiple threads (see Section 4.10 [Debugging Programs with Multiple Threads], page 35), you can choose whether to set breakpoints on all threads, or on a particular thread.

`break` *`linespec`* `thread` *`threadno`*
`break` *`linespec`* `thread` *`threadno`* `if ...`

linespec specifies source lines; there are several ways of writing them (see Section 9.2 [Specify Location], page 94), but the effect is always to specify some source line.

Use the qualifier '`thread` *`threadno`*' with a breakpoint command to specify that you only want GDB to stop the program when a particular thread reaches this breakpoint. *threadno* is one of the numeric thread identifiers assigned by GDB, shown in the first column of the '`info threads`' display.

If you do not specify '`thread` *`threadno`*' when you set a breakpoint, the breakpoint applies to *all* threads of your program.

You can use the `thread` qualifier on conditional breakpoints as well; in this case, place '`thread` *`threadno`*' before or after the breakpoint condition, like this:

```
(gdb) break frik.c:13 thread 28 if bartab > lim
```

5.5.5 Interrupted System Calls

There is an unfortunate side effect when using GDB to debug multi-threaded programs. If one thread stops for a breakpoint, or for some other reason, and another thread is blocked in a system call, then the system call may return prematurely. This is a consequence of the interaction between multiple threads and the signals that GDB uses to implement breakpoints and other events that stop execution.

To handle this problem, your program should check the return value of each system call and react appropriately. This is good programming style anyways.

For example, do not write code like this:

```
sleep (10);
```

The call to `sleep` will return early if a different thread stops at a breakpoint or for some other reason.

Instead, write this:

```
int unslept = 10;
while (unslept > 0)
  unslept = sleep (unslept);
```

A system call is allowed to return early, so the system is still conforming to its specification. But GDB does cause your multi-threaded program to behave differently than it would without GDB.

Also, GDB uses internal breakpoints in the thread library to monitor certain events such as thread creation and thread destruction. When such an event happens, a system call in another thread may return prematurely, even though your program does not appear to stop.

5.5.6 Observer Mode

If you want to build on non-stop mode and observe program behavior without any chance of disruption by GDB, you can set variables to disable all of the debugger's attempts to modify state, whether by writing memory, inserting breakpoints, etc. These operate at a low level, intercepting operations from all commands.

When all of these are set to `off`, then GDB is said to be *observer mode*. As a convenience, the variable `observer` can be set to disable these, plus enable non-stop mode.

Note that GDB will not prevent you from making nonsensical combinations of these settings. For instance, if you have enabled `may-insert-breakpoints` but disabled `may-write-memory`, then breakpoints that work by writing trap instructions into the code stream will still not be able to be placed.

`set observer on`
`set observer off`
: When set to `on`, this disables all the permission variables below (except for `insert-fast-tracepoints`), plus enables non-stop debugging. Setting this to `off` switches back to normal debugging, though remaining in non-stop mode.

`show observer`
: Show whether observer mode is on or off.

`set may-write-registers on`
`set may-write-registers off`
: This controls whether GDB will attempt to alter the values of registers, such as with assignment expressions in `print`, or the `jump` command. It defaults to `on`.

`show may-write-registers`
: Show the current permission to write registers.

`set may-write-memory on`
`set may-write-memory off`
: This controls whether GDB will attempt to alter the contents of memory, such as with assignment expressions in `print`. It defaults to `on`.

`show may-write-memory`
: Show the current permission to write memory.

`set may-insert-breakpoints on`
`set may-insert-breakpoints off`
: This controls whether GDB will attempt to insert breakpoints. This affects all breakpoints, including internal breakpoints defined by GDB. It defaults to `on`.

`show may-insert-breakpoints`
: Show the current permission to insert breakpoints.

`set may-insert-tracepoints on`
`set may-insert-tracepoints off`
: This controls whether GDB will attempt to insert (regular) tracepoints at the beginning of a tracing experiment. It affects only non-fast tracepoints, fast tracepoints being under the control of `may-insert-fast-tracepoints`. It defaults to `on`.

`show may-insert-tracepoints`
: Show the current permission to insert tracepoints.

`set may-insert-fast-tracepoints on`
`set may-insert-fast-tracepoints off`
: This controls whether GDB will attempt to insert fast tracepoints at the beginning of a tracing experiment. It affects only fast tracepoints, regular (non-fast) tracepoints being under the control of `may-insert-tracepoints`. It defaults to `on`.

`show may-insert-fast-tracepoints`
: Show the current permission to insert fast tracepoints.

`set may-interrupt on`
`set may-interrupt off`
: This controls whether GDB will attempt to interrupt or stop program execution. When this variable is `off`, the `interrupt` command will have no effect, nor will *`Ctrl-c`*. It defaults to `on`.

`show may-interrupt`
: Show the current permission to interrupt or stop the program.

6 Running programs backward

When you are debugging a program, it is not unusual to realize that you have gone too far, and some event of interest has already happened. If the target environment supports it, GDB can allow you to "rewind" the program by running it backward.

A target environment that supports reverse execution should be able to "undo" the changes in machine state that have taken place as the program was executing normally. Variables, registers etc. should revert to their previous values. Obviously this requires a great deal of sophistication on the part of the target environment; not all target environments can support reverse execution.

When a program is executed in reverse, the instructions that have most recently been executed are "un-executed", in reverse order. The program counter runs backward, following the previous thread of execution in reverse. As each instruction is "un-executed", the values of memory and/or registers that were changed by that instruction are reverted to their previous states. After executing a piece of source code in reverse, all side effects of that code should be "undone", and all variables should be returned to their prior values[1].

If you are debugging in a target environment that supports reverse execution, GDB provides the following commands.

`reverse-continue` [*ignore-count*]
`rc` [*ignore-count*]
: Beginning at the point where your program last stopped, start executing in reverse. Reverse execution will stop for breakpoints and synchronous exceptions (signals), just like normal execution. Behavior of asynchronous signals depends on the target environment.

`reverse-step` [*count*]
: Run the program backward until control reaches the start of a different source line; then stop it, and return control to GDB.

  Like the `step` command, `reverse-step` will only stop at the beginning of a source line. It "un-executes" the previously executed source line. If the previous source line included calls to debuggable functions, `reverse-step` will step (backward) into the called function, stopping at the beginning of the *last* statement in the called function (typically a return statement).

  Also, as with the `step` command, if non-debuggable functions are called, `reverse-step` will run thru them backward without stopping.

`reverse-stepi` [*count*]
: Reverse-execute one machine instruction. Note that the instruction to be reverse-executed is *not* the one pointed to by the program counter, but the

[1] Note that some side effects are easier to undo than others. For instance, memory and registers are relatively easy, but device I/O is hard. Some targets may be able undo things like device I/O, and some may not.

The contract between GDB and the reverse executing target requires only that the target do something reasonable when GDB tells it to execute backwards, and then report the results back to GDB. Whatever the target reports back to GDB, GDB will report back to the user. GDB assumes that the memory and registers that the target reports are in a consistant state, but GDB accepts whatever it is given.

instruction executed prior to that one. For instance, if the last instruction was a jump, `reverse-stepi` will take you back from the destination of the jump to the jump instruction itself.

`reverse-next` [*count*]
: Run backward to the beginning of the previous line executed in the current (innermost) stack frame. If the line contains function calls, they will be "un-executed" without stopping. Starting from the first line of a function, `reverse-next` will take you back to the caller of that function, *before* the function was called, just as the normal `next` command would take you from the last line of a function back to its return to its caller[2].

`reverse-nexti` [*count*]
: Like `nexti`, `reverse-nexti` executes a single instruction in reverse, except that called functions are "un-executed" atomically. That is, if the previously executed instruction was a return from another function, `reverse-nexti` will continue to execute in reverse until the call to that function (from the current stack frame) is reached.

`reverse-finish`
: Just as the `finish` command takes you to the point where the current function returns, `reverse-finish` takes you to the point where it was called. Instead of ending up at the end of the current function invocation, you end up at the beginning.

`set exec-direction`
: Set the direction of target execution.

`set exec-direction reverse`
: GDB will perform all execution commands in reverse, until the exec-direction mode is changed to "forward". Affected commands include `step, stepi, next, nexti, continue, and finish`. The `return` command cannot be used in reverse mode.

`set exec-direction forward`
: GDB will perform all execution commands in the normal fashion. This is the default.

[2] Unless the code is too heavily optimized.

7 Recording Inferior's Execution and Replaying It

On some platforms, GDB provides a special *process record and replay* target that can record a log of the process execution, and replay it later with both forward and reverse execution commands.

When this target is in use, if the execution log includes the record for the next instruction, GDB will debug in *replay mode*. In the replay mode, the inferior does not really execute code instructions. Instead, all the events that normally happen during code execution are taken from the execution log. While code is not really executed in replay mode, the values of registers (including the program counter register) and the memory of the inferior are still changed as they normally would. Their contents are taken from the execution log.

If the record for the next instruction is not in the execution log, GDB will debug in *record mode*. In this mode, the inferior executes normally, and GDB records the execution log for future replay.

The process record and replay target supports reverse execution (see Chapter 6 [Reverse Execution], page 79), even if the platform on which the inferior runs does not. However, the reverse execution is limited in this case by the range of the instructions recorded in the execution log. In other words, reverse execution on platforms that don't support it directly can only be done in the replay mode.

When debugging in the reverse direction, GDB will work in replay mode as long as the execution log includes the record for the previous instruction; otherwise, it will work in record mode, if the platform supports reverse execution, or stop if not.

For architecture environments that support process record and replay, GDB provides the following commands:

`record` *`method`*

This command starts the process record and replay target. The recording method can be specified as parameter. Without a parameter the command uses the `full` recording method. The following recording methods are available:

`full` Full record/replay recording using GDB's software record and replay implementation. This method allows replaying and reverse execution.

`btrace` Hardware-supported instruction recording. This method does not allow replaying and reverse execution.

This recording method may not be available on all processors.

The process record and replay target can only debug a process that is already running. Therefore, you need first to start the process with the *`run`* or *`start`* commands, and then start the recording with the *`record method`* command.

Both `record` *`method`* and `rec` *`method`* are aliases of `target record-`*`method`*.

Displaced stepping (see Appendix D [displaced stepping], page 495) will be automatically disabled when process record and replay target is started. That's because the process record and replay target doesn't support displaced stepping.

If the inferior is in the non-stop mode (see Section 5.5.2 [Non-Stop Mode], page 74) or in the asynchronous execution mode (see Section 5.5.3 [Background Execution], page 75), not all recording methods are available. The `full` recording method does not support these two modes.

`record stop`
Stop the process record and replay target. When process record and replay target stops, the entire execution log will be deleted and the inferior will either be terminated, or will remain in its final state.

When you stop the process record and replay target in record mode (at the end of the execution log), the inferior will be stopped at the next instruction that would have been recorded. In other words, if you record for a while and then stop recording, the inferior process will be left in the same state as if the recording never happened.

On the other hand, if the process record and replay target is stopped while in replay mode (that is, not at the end of the execution log, but at some earlier point), the inferior process will become "live" at that earlier state, and it will then be possible to continue the usual "live" debugging of the process from that state.

When the inferior process exits, or GDB detaches from it, process record and replay target will automatically stop itself.

`record save` *`filename`*
Save the execution log to a file '*`filename`*'. Default filename is '`gdb_record.`*`process_id`*', where *process_id* is the process ID of the inferior.

This command may not be available for all recording methods.

`record restore` *`filename`*
Restore the execution log from a file '*`filename`*'. File must have been created with `record save`.

`set record full insn-number-max` *`limit`*
Set the limit of instructions to be recorded for the `full` recording method. Default value is 200000.

If *limit* is a positive number, then GDB will start deleting instructions from the log once the number of the record instructions becomes greater than *limit*. For every new recorded instruction, GDB will delete the earliest recorded instruction to keep the number of recorded instructions at the limit. (Since deleting recorded instructions loses information, GDB lets you control what happens when the limit is reached, by means of the `stop-at-limit` option, described below.)

If *limit* is zero, GDB will never delete recorded instructions from the execution log. The number of recorded instructions is unlimited in this case.

`show record full insn-number-max`
Show the limit of instructions to be recorded with the `full` recording method.

`set record full stop-at-limit`
Control the behavior of the `full` recording method when the number of recorded instructions reaches the limit. If ON (the default), GDB will stop when the limit

is reached for the first time and ask you whether you want to stop the inferior or continue running it and recording the execution log. If you decide to continue recording, each new recorded instruction will cause the oldest one to be deleted.

If this option is OFF, GDB will automatically delete the oldest record to make room for each new one, without asking.

`show record full stop-at-limit`
Show the current setting of `stop-at-limit`.

`set record full memory-query`
Control the behavior when GDB is unable to record memory changes caused by an instruction for the `full` recording method. If ON, GDB will query whether to stop the inferior in that case.

If this option is OFF (the default), GDB will automatically ignore the effect of such instructions on memory. Later, when GDB replays this execution log, it will mark the log of this instruction as not accessible, and it will not affect the replay results.

`show record full memory-query`
Show the current setting of `memory-query`.

`info record`
Show various statistics about the recording depending on the recording method:

`full` For the `full` recording method, it shows the state of process record and its in-memory execution log buffer, including:

- Whether in record mode or replay mode.
- Lowest recorded instruction number (counting from when the current execution log started recording instructions).
- Highest recorded instruction number.
- Current instruction about to be replayed (if in replay mode).
- Number of instructions contained in the execution log.
- Maximum number of instructions that may be contained in the execution log.

`btrace` For the `btrace` recording method, it shows the number of instructions that have been recorded and the number of blocks of sequential control-flow that is formed by the recorded instructions.

`record delete`
When record target runs in replay mode ("in the past"), delete the subsequent execution log and begin to record a new execution log starting from the current address. This means you will abandon the previously recorded "future" and begin recording a new "future".

`record instruction-history`
Disassembles instructions from the recorded execution log. By default, ten instructions are disassembled. This can be changed using the `set record instruction-history-size` command. Instructions are printed in execution order. There are several ways to specify what part of the execution log to disassemble:

`record instruction-history` *`insn`*
: Disassembles ten instructions starting from instruction number *insn*.

`record instruction-history` *`insn`*`, +/-`*`n`*
: Disassembles *n* instructions around instruction number *insn*. If *n* is preceded with `+`, disassembles *n* instructions after instruction number *insn*. If *n* is preceded with `-`, disassembles *n* instructions before instruction number *insn*.

`record instruction-history`
: Disassembles ten more instructions after the last disassembly.

`record instruction-history -`
: Disassembles ten more instructions before the last disassembly.

`record instruction-history` *`begin end`*
: Disassembles instructions beginning with instruction number *begin* until instruction number *end*. The instruction number *end* is not included.

This command may not be available for all recording methods.

`set record instruction-history-size`
: Define how many instructions to disassemble in the `record instruction-history` command. The default value is 10.

`show record instruction-history-size`
: Show how many instructions to disassemble in the `record instruction-history` command.

`record function-call-history`
: Prints the execution history at function granularity. It prints one line for each sequence of instructions that belong to the same function giving the name of that function, the source lines for this instruction sequence (if the `/l` modifier is specified), and the instructions numbers that form the sequence (if the `/i` modifier is specified).

```
(gdb) list 1, 10
1   void foo (void)
2   {
3   }
4
5   void bar (void)
6   {
7     ...
8     foo ();
9     ...
10  }
(gdb) record function-call-history /l
1  foo.c:6-8   bar
2  foo.c:2-3   foo
3  foo.c:9-10  bar
```

By default, ten lines are printed. This can be changed using the `set record function-call-history-size` command. Functions are printed in execution order. There are several ways to specify what to print:

`record function-call-history` *`func`*
: Prints ten functions starting from function number *func*.

`record function-call-history` *`func`*`, +/-`*`n`*
: Prints *n* functions around function number *func*. If *n* is preceded with `+`, prints *n* functions after function number *func*. If *n* is preceded with `-`, prints *n* functions before function number *func*.

`record function-call-history`
: Prints ten more functions after the last ten-line print.

`record function-call-history -`
: Prints ten more functions before the last ten-line print.

`record function-call-history` *`begin end`*
: Prints functions beginning with function number *begin* until function number *end*. The function number *end* is not included.

This command may not be available for all recording methods.

`set record function-call-history-size`
: Define how many lines to print in the `record function-call-history` command. The default value is 10.

`show record function-call-history-size`
: Show how many lines to print in the `record function-call-history` command.

8 Examining the Stack

When your program has stopped, the first thing you need to know is where it stopped and how it got there.

Each time your program performs a function call, information about the call is generated. That information includes the location of the call in your program, the arguments of the call, and the local variables of the function being called. The information is saved in a block of data called a *stack frame*. The stack frames are allocated in a region of memory called the *call stack*.

When your program stops, the GDB commands for examining the stack allow you to see all of this information.

One of the stack frames is *selected* by GDB and many GDB commands refer implicitly to the selected frame. In particular, whenever you ask GDB for the value of a variable in your program, the value is found in the selected frame. There are special GDB commands to select whichever frame you are interested in. See Section 8.3 [Selecting a Frame], page 90.

When your program stops, GDB automatically selects the currently executing frame and describes it briefly, similar to the `frame` command (see Section 8.4 [Information about a Frame], page 91).

8.1 Stack Frames

The call stack is divided up into contiguous pieces called *stack frames*, or *frames* for short; each frame is the data associated with one call to one function. The frame contains the arguments given to the function, the function's local variables, and the address at which the function is executing.

When your program is started, the stack has only one frame, that of the function `main`. This is called the *initial* frame or the *outermost* frame. Each time a function is called, a new frame is made. Each time a function returns, the frame for that function invocation is eliminated. If a function is recursive, there can be many frames for the same function. The frame for the function in which execution is actually occurring is called the *innermost* frame. This is the most recently created of all the stack frames that still exist.

Inside your program, stack frames are identified by their addresses. A stack frame consists of many bytes, each of which has its own address; each kind of computer has a convention for choosing one byte whose address serves as the address of the frame. Usually this address is kept in a register called the *frame pointer register* (see Section 10.13 [Registers], page 128) while execution is going on in that frame.

GDB assigns numbers to all existing stack frames, starting with zero for the innermost frame, one for the frame that called it, and so on upward. These numbers do not really exist in your program; they are assigned by GDB to give you a way of designating stack frames in GDB commands.

Some compilers provide a way to compile functions so that they operate without stack frames. (For example, the GCC option

```
'-fomit-frame-pointer'
```

generates functions without a frame.) This is occasionally done with heavily used library functions to save the frame setup time. GDB has limited facilities for dealing with

these function invocations. If the innermost function invocation has no stack frame, GDB nevertheless regards it as though it had a separate frame, which is numbered zero as usual, allowing correct tracing of the function call chain. However, GDB has no provision for frameless functions elsewhere in the stack.

`frame` *args*
: The `frame` command allows you to move from one stack frame to another, and to print the stack frame you select. *args* may be either the address of the frame or the stack frame number. Without an argument, `frame` prints the current stack frame.

`select-frame`
: The `select-frame` command allows you to move from one stack frame to another without printing the frame. This is the silent version of `frame`.

8.2 Backtraces

A backtrace is a summary of how your program got where it is. It shows one line per frame, for many frames, starting with the currently executing frame (frame zero), followed by its caller (frame one), and on up the stack.

`backtrace`
`bt`
: Print a backtrace of the entire stack: one line per frame for all frames in the stack.

  You can stop the backtrace at any time by typing the system interrupt character, normally *Ctrl-c*.

`backtrace` *n*
`bt` *n*
: Similar, but print only the innermost *n* frames.

`backtrace -`*n*
`bt -`*n*
: Similar, but print only the outermost *n* frames.

`backtrace full`
`bt full`
`bt full` *n*
`bt full -`*n*
: Print the values of the local variables also. *n* specifies the number of frames to print, as described above.

The names `where` and `info stack` (abbreviated `info s`) are additional aliases for `backtrace`.

In a multi-threaded program, GDB by default shows the backtrace only for the current thread. To display the backtrace for several or all of the threads, use the command `thread apply` (see Section 4.10 [Threads], page 35). For example, if you type *thread apply all backtrace*, GDB will display the backtrace for all the threads; this is handy when you debug a core dump of a multi-threaded program.

Each line in the backtrace shows the frame number and the function name. The program counter value is also shown—unless you use `set print address off`. The backtrace also shows the source file name and line number, as well as the arguments to the function. The program counter value is omitted if it is at the beginning of the code for that line number.

Here is an example of a backtrace. It was made with the command '`bt 3`', so it shows the innermost three frames.

```
#0  m4_traceon (obs=0x24eb0, argc=1, argv=0x2b8c8)
    at builtin.c:993
#1  0x6e38 in expand_macro (sym=0x2b600, data=...) at macro.c:242
#2  0x6840 in expand_token (obs=0x0, t=177664, td=0xf7fffb08)
    at macro.c:71
(More stack frames follow...)
```

The display for frame zero does not begin with a program counter value, indicating that your program has stopped at the beginning of the code for line `993` of `builtin.c`.

The value of parameter `data` in frame 1 has been replaced by `...`. By default, GDB prints the value of a parameter only if it is a scalar (integer, pointer, enumeration, etc). See command *`set print frame-arguments`* in Section 10.8 [Print Settings], page 115 for more details on how to configure the way function parameter values are printed.

If your program was compiled with optimizations, some compilers will optimize away arguments passed to functions if those arguments are never used after the call. Such optimizations generate code that passes arguments through registers, but doesn't store those arguments in the stack frame. GDB has no way of displaying such arguments in stack frames other than the innermost one. Here's what such a backtrace might look like:

```
#0  m4_traceon (obs=0x24eb0, argc=1, argv=0x2b8c8)
    at builtin.c:993
#1  0x6e38 in expand_macro (sym=<optimized out>) at macro.c:242
#2  0x6840 in expand_token (obs=0x0, t=<optimized out>, td=0xf7fffb08)
    at macro.c:71
(More stack frames follow...)
```

The values of arguments that were not saved in their stack frames are shown as '`<optimized out>`'.

If you need to display the values of such optimized-out arguments, either deduce that from other variables whose values depend on the one you are interested in, or recompile without optimizations.

Most programs have a standard user entry point—a place where system libraries and startup code transition into user code. For C this is `main`[1]. When GDB finds the entry function in a backtrace it will terminate the backtrace, to avoid tracing into highly system-specific (and generally uninteresting) code.

If you need to examine the startup code, or limit the number of levels in a backtrace, you can change this behavior:

`set backtrace past-main`
`set backtrace past-main on`
: Backtraces will continue past the user entry point.

`set backtrace past-main off`
: Backtraces will stop when they encounter the user entry point. This is the default.

`show backtrace past-main`
: Display the current user entry point backtrace policy.

[1] Note that embedded programs (the so-called "free-standing" environment) are not required to have a `main` function as the entry point. They could even have multiple entry points.

`set backtrace past-entry`
`set backtrace past-entry on`
: Backtraces will continue past the internal entry point of an application. This entry point is encoded by the linker when the application is built, and is likely before the user entry point `main` (or equivalent) is called.

`set backtrace past-entry off`
: Backtraces will stop when they encounter the internal entry point of an application. This is the default.

`show backtrace past-entry`
: Display the current internal entry point backtrace policy.

`set backtrace limit` *n*
`set backtrace limit 0`
: Limit the backtrace to *n* levels. A value of zero means unlimited.

`show backtrace limit`
: Display the current limit on backtrace levels.

You can control how file names are displayed.

`set filename-display`
`set filename-display relative`
: Display file names relative to the compilation directory. This is the default.

`set filename-display basename`
: Display only basename of a filename.

`set filename-display absolute`
: Display an absolute filename.

`show filename-display`
: Show the current way to display filenames.

8.3 Selecting a Frame

Most commands for examining the stack and other data in your program work on whichever stack frame is selected at the moment. Here are the commands for selecting a stack frame; all of them finish by printing a brief description of the stack frame just selected.

`frame` *n*
`f` *n*
: Select frame number *n*. Recall that frame zero is the innermost (currently executing) frame, frame one is the frame that called the innermost one, and so on. The highest-numbered frame is the one for `main`.

`frame` *addr*
`f` *addr*
: Select the frame at address *addr*. This is useful mainly if the chaining of stack frames has been damaged by a bug, making it impossible for GDB to assign numbers properly to all frames. In addition, this can be useful when your program has multiple stacks and switches between them.

  On the SPARC architecture, `frame` needs two addresses to select an arbitrary frame: a frame pointer and a stack pointer.

On the MIPS and Alpha architecture, it needs two addresses: a stack pointer and a program counter.

On the 29k architecture, it needs three addresses: a register stack pointer, a program counter, and a memory stack pointer.

`up` *n* Move *n* frames up the stack. For positive numbers *n*, this advances toward the outermost frame, to higher frame numbers, to frames that have existed longer. *n* defaults to one.

`down` *n* Move *n* frames down the stack. For positive numbers *n*, this advances toward the innermost frame, to lower frame numbers, to frames that were created more recently. *n* defaults to one. You may abbreviate `down` as `do`.

All of these commands end by printing two lines of output describing the frame. The first line shows the frame number, the function name, the arguments, and the source file and line number of execution in that frame. The second line shows the text of that source line.

For example:

```
(gdb) up
#1  0x22f0 in main (argc=1, argv=0xf7fffbf4, env=0xf7fffbfc)
    at env.c:10
10              read_input_file (argv[i]);
```

After such a printout, the `list` command with no arguments prints ten lines centered on the point of execution in the frame. You can also edit the program at the point of execution with your favorite editing program by typing `edit`. See Section 9.1 [Printing Source Lines], page 93, for details.

`up-silently` *n*
`down-silently` *n*

These two commands are variants of `up` and `down`, respectively; they differ in that they do their work silently, without causing display of the new frame. They are intended primarily for use in GDB command scripts, where the output might be unnecessary and distracting.

8.4 Information About a Frame

There are several other commands to print information about the selected stack frame.

`frame`
`f` When used without any argument, this command does not change which frame is selected, but prints a brief description of the currently selected stack frame. It can be abbreviated `f`. With an argument, this command is used to select a stack frame. See Section 8.3 [Selecting a Frame], page 90.

`info frame`
`info f` This command prints a verbose description of the selected stack frame, including:

- the address of the frame
- the address of the next frame down (called by this frame)
- the address of the next frame up (caller of this frame)

- the language in which the source code corresponding to this frame is written
- the address of the frame's arguments
- the address of the frame's local variables
- the program counter saved in it (the address of execution in the caller frame)
- which registers were saved in the frame

The verbose description is useful when something has gone wrong that has made the stack format fail to fit the usual conventions.

`info frame` *addr*
`info f` *addr*

Print a verbose description of the frame at address *addr*, without selecting that frame. The selected frame remains unchanged by this command. This requires the same kind of address (more than one for some architectures) that you specify in the `frame` command. See Section 8.3 [Selecting a Frame], page 90.

`info args` Print the arguments of the selected frame, each on a separate line.

`info locals`

Print the local variables of the selected frame, each on a separate line. These are all variables (declared either static or automatic) accessible at the point of execution of the selected frame.

9 Examining Source Files

GDB can print parts of your program's source, since the debugging information recorded in the program tells GDB what source files were used to build it. When your program stops, GDB spontaneously prints the line where it stopped. Likewise, when you select a stack frame (see Section 8.3 [Selecting a Frame], page 90), GDB prints the line where execution in that frame has stopped. You can print other portions of source files by explicit command.

If you use GDB through its GNU Emacs interface, you may prefer to use Emacs facilities to view source; see Chapter 26 [Using GDB under GNU Emacs], page 363.

9.1 Printing Source Lines

To print lines from a source file, use the `list` command (abbreviated `l`). By default, ten lines are printed. There are several ways to specify what part of the file you want to print; see Section 9.2 [Specify Location], page 94, for the full list.

Here are the forms of the `list` command most commonly used:

`list` *linenum*
: Print lines centered around line number *linenum* in the current source file.

`list` *function*
: Print lines centered around the beginning of function *function*.

`list`
: Print more lines. If the last lines printed were printed with a `list` command, this prints lines following the last lines printed; however, if the last line printed was a solitary line printed as part of displaying a stack frame (see Chapter 8 [Examining the Stack], page 87), this prints lines centered around that line.

`list -`
: Print lines just before the lines last printed.

By default, GDB prints ten source lines with any of these forms of the `list` command. You can change this using `set listsize`:

`set listsize` *count*
: Make the `list` command display *count* source lines (unless the `list` argument explicitly specifies some other number). Setting *count* to 0 means there's no limit.

`show listsize`
: Display the number of lines that `list` prints.

Repeating a `list` command with RET discards the argument, so it is equivalent to typing just `list`. This is more useful than listing the same lines again. An exception is made for an argument of '`-`'; that argument is preserved in repetition so that each repetition moves up in the source file.

In general, the `list` command expects you to supply zero, one or two *linespecs*. Linespecs specify source lines; there are several ways of writing them (see Section 9.2 [Specify Location], page 94), but the effect is always to specify some source line.

Here is a complete description of the possible arguments for `list`:

`list` *linespec*
: Print lines centered around the line specified by *linespec*.

`list` *first*`,`*last*
: Print lines from *first* to *last*. Both arguments are linespecs. When a `list` command has two linespecs, and the source file of the second linespec is omitted, this refers to the same source file as the first linespec.

`list ,`*last*
: Print lines ending with *last*.

`list` *first*`,`
: Print lines starting with *first*.

`list +`
: Print lines just after the lines last printed.

`list -`
: Print lines just before the lines last printed.

`list`
: As described in the preceding table.

9.2 Specifying a Location

Several GDB commands accept arguments that specify a location of your program's code. Since GDB is a source-level debugger, a location usually specifies some line in the source code; for that reason, locations are also known as *linespecs*.

Here are all the different ways of specifying a code location that GDB understands:

linenum
: Specifies the line number *linenum* of the current source file.

-offset
+offset
: Specifies the line *offset* lines before or after the *current line*. For the `list` command, the current line is the last one printed; for the breakpoint commands, this is the line at which execution stopped in the currently selected *stack frame* (see Section 8.1 [Frames], page 87, for a description of stack frames.) When used as the second of the two linespecs in a `list` command, this specifies the line *offset* lines up or down from the first linespec.

filename`:`*linenum*
: Specifies the line *linenum* in the source file *filename*. If *filename* is a relative file name, then it will match any source file name with the same trailing components. For example, if *filename* is '`gcc/expr.c`', then it will match source file name of '`/build/trunk/gcc/expr.c`', but not '`/build/trunk/libcpp/expr.c`' or '`/build/trunk/gcc/x-expr.c`'.

function
: Specifies the line that begins the body of the function *function*. For example, in C, this is the line with the open brace.

function`:`*label*
: Specifies the line where *label* appears in *function*.

filename`:`*function*
: Specifies the line that begins the body of the function *function* in the file *filename*. You only need the file name with a function name to avoid ambiguity when there are identically named functions in different source files.

label
: Specifies the line at which the label named *label* appears. GDB searches for the label in the function corresponding to the currently selected stack frame.

If there is no current selected stack frame (for instance, if the inferior is not running), then GDB will not search for a label.

`*address` Specifies the program address *address*. For line-oriented commands, such as `list` and `edit`, this specifies a source line that contains *address*. For `break` and other breakpoint oriented commands, this can be used to set breakpoints in parts of your program which do not have debugging information or source files.

Here *address* may be any expression valid in the current working language (see Chapter 15 [Languages], page 173) that specifies a code address. In addition, as a convenience, GDB extends the semantics of expressions used in locations to cover the situations that frequently happen during debugging. Here are the various forms of *address*:

expression
Any expression valid in the current working language.

funcaddr An address of a function or procedure derived from its name. In C, C++, Java, Objective-C, Fortran, minimal, and assembly, this is simply the function's name *function* (and actually a special case of a valid expression). In Pascal and Modula-2, this is `&`*function*. In Ada, this is *function*`'Address` (although the Pascal form also works).

This form specifies the address of the function's first instruction, before the stack frame and arguments have been set up.

'filename'`::`*funcaddr*
Like *funcaddr* above, but also specifies the name of the source file explicitly. This is useful if the name of the function does not specify the function unambiguously, e.g., if there are several functions with identical names in different source files.

`-pstap|-probe-stap` [*objfile*`:`[*provider*`:`]]*name*
The GNU/Linux tool `SystemTap` provides a way for applications to embed static probes. See Section 5.1.10 [Static Probe Points], page 63, for more information on finding and using static probes. This form of linespec specifies the location of such a static probe.

If *objfile* is given, only probes coming from that shared library or executable matching *objfile* as a regular expression are considered. If *provider* is given, then only probes from that provider are considered. If several probes match the spec, GDB will insert a breakpoint at each one of those probes.

9.3 Editing Source Files

To edit the lines in a source file, use the `edit` command. The editing program of your choice is invoked with the current line set to the active line in the program. Alternatively, there are several ways to specify what part of the file you want to print if you want to see other parts of the program:

`edit` *location*
: Edit the source file specified by `location`. Editing starts at that *location*, e.g., at the specified source line of the specified file. See Section 9.2 [Specify Location], page 94, for all the possible forms of the *location* argument; here are the forms of the `edit` command most commonly used:

  `edit` *number*
  : Edit the current source file with *number* as the active line number.

  `edit` *function*
  : Edit the file containing *function* at the beginning of its definition.

9.3.1 Choosing your Editor

You can customize GDB to use any editor you want[1]. By default, it is '`/bin/ex`', but you can change this by setting the environment variable `EDITOR` before using GDB. For example, to configure GDB to use the `vi` editor, you could use these commands with the `sh` shell:

```
EDITOR=/usr/bin/vi
export EDITOR
gdb ...
```

or in the `csh` shell,

```
setenv EDITOR /usr/bin/vi
gdb ...
```

9.4 Searching Source Files

There are two commands for searching through the current source file for a regular expression.

`forward-search` *regexp*
`search` *regexp*
: The command '`forward-search` *regexp*' checks each line, starting with the one following the last line listed, for a match for *regexp*. It lists the line that is found. You can use the synonym '`search` *regexp*' or abbreviate the command name as `fo`.

`reverse-search` *regexp*
: The command '`reverse-search` *regexp*' checks each line, starting with the one before the last line listed and going backward, for a match for *regexp*. It lists the line that is found. You can abbreviate this command as `rev`.

9.5 Specifying Source Directories

Executable programs sometimes do not record the directories of the source files from which they were compiled, just the names. Even when they do, the directories could be moved between the compilation and your debugging session. GDB has a list of directories to search for source files; this is called the *source path*. Each time GDB wants a source file, it tries all

[1] The only restriction is that your editor (say `ex`), recognizes the following command-line syntax:

```
ex +number file
```

The optional numeric value `+`*number* specifies the number of the line in the file where to start editing.

the directories in the list, in the order they are present in the list, until it finds a file with the desired name.

For example, suppose an executable references the file '`/usr/src/foo-1.0/lib/foo.c`', and our source path is '`/mnt/cross`'. The file is first looked up literally; if this fails, '`/mnt/cross/usr/src/foo-1.0/lib/foo.c`' is tried; if this fails, '`/mnt/cross/foo.c`' is opened; if this fails, an error message is printed. GDB does not look up the parts of the source file name, such as '`/mnt/cross/src/foo-1.0/lib/foo.c`'. Likewise, the subdirectories of the source path are not searched: if the source path is '`/mnt/cross`', and the binary refers to '`foo.c`', GDB would not find it under '`/mnt/cross/usr/src/foo-1.0/lib`'.

Plain file names, relative file names with leading directories, file names containing dots, etc. are all treated as described above; for instance, if the source path is '`/mnt/cross`', and the source file is recorded as '`../lib/foo.c`', GDB would first try '`../lib/foo.c`', then '`/mnt/cross/../lib/foo.c`', and after that—'`/mnt/cross/foo.c`'.

Note that the executable search path is *not* used to locate the source files.

Whenever you reset or rearrange the source path, GDB clears out any information it has cached about where source files are found and where each line is in the file.

When you start GDB, its source path includes only '`cdir`' and '`cwd`', in that order. To add other directories, use the `directory` command.

The search path is used to find both program source files and GDB script files (read using the '`-command`' option and '`source`' command).

In addition to the source path, GDB provides a set of commands that manage a list of source path substitution rules. A *substitution rule* specifies how to rewrite source directories stored in the program's debug information in case the sources were moved to a different directory between compilation and debugging. A rule is made of two strings, the first specifying what needs to be rewritten in the path, and the second specifying how it should be rewritten. In [set substitute-path], page 98, we name these two parts *from* and *to* respectively. GDB does a simple string replacement of *from* with *to* at the start of the directory part of the source file name, and uses that result instead of the original file name to look up the sources.

Using the previous example, suppose the '`foo-1.0`' tree has been moved from '`/usr/src`' to '`/mnt/cross`', then you can tell GDB to replace '`/usr/src`' in all source path names with '`/mnt/cross`'. The first lookup will then be '`/mnt/cross/foo-1.0/lib/foo.c`' in place of the original location of '`/usr/src/foo-1.0/lib/foo.c`'. To define a source path substitution rule, use the `set substitute-path` command (see [set substitute-path], page 98).

To avoid unexpected substitution results, a rule is applied only if the *from* part of the directory name ends at a directory separator. For instance, a rule substituting '`/usr/source`' into '`/mnt/cross`' will be applied to '`/usr/source/foo-1.0`' but not to '`/usr/sourceware/foo-2.0`'. And because the substitution is applied only at the beginning of the directory name, this rule will not be applied to '`/root/usr/source/baz.c`' either.

In many cases, you can achieve the same result using the `directory` command. However, `set substitute-path` can be more efficient in the case where the sources are organized in a complex tree with multiple subdirectories. With the `directory` command, you need to add each subdirectory of your project. If you moved the entire tree while preserving its

internal organization, then `set substitute-path` allows you to direct the debugger to all the sources with one single command.

`set substitute-path` is also more than just a shortcut command. The source path is only used if the file at the original location no longer exists. On the other hand, `set substitute-path` modifies the debugger behavior to look at the rewritten location instead. So, if for any reason a source file that is not relevant to your executable is located at the original location, a substitution rule is the only method available to point GDB at the new location.

You can configure a default source path substitution rule by configuring GDB with the '`--with-relocated-sources=dir`' option. The *dir* should be the name of a directory under GDB's configured prefix (set with '`--prefix`' or '`--exec-prefix`'), and directory names in debug information under *dir* will be adjusted automatically if the installed GDB is moved to a new location. This is useful if GDB, libraries or executables with debug information and corresponding source code are being moved together.

`directory` *dirname ...*
`dir` *dirname ...*

Add directory *dirname* to the front of the source path. Several directory names may be given to this command, separated by '`:`' ('`;`' on MS-DOS and MS-Windows, where '`:`' usually appears as part of absolute file names) or white-space. You may specify a directory that is already in the source path; this moves it forward, so GDB searches it sooner.

You can use the string '`$cdir`' to refer to the compilation directory (if one is recorded), and '`$cwd`' to refer to the current working directory. '`$cwd`' is not the same as '`.`'—the former tracks the current working directory as it changes during your GDB session, while the latter is immediately expanded to the current directory at the time you add an entry to the source path.

`directory`

Reset the source path to its default value ('`$cdir:$cwd`' on Unix systems). This requires confirmation.

`set directories` *path-list*

Set the source path to *path-list*. '`$cdir:$cwd`' are added if missing.

`show directories`

Print the source path: show which directories it contains.

`set substitute-path` *from to*

Define a source path substitution rule, and add it at the end of the current list of existing substitution rules. If a rule with the same *from* was already defined, then the old rule is also deleted.

For example, if the file '`/foo/bar/baz.c`' was moved to '`/mnt/cross/baz.c`', then the command

```
(gdb) set substitute-path /usr/src /mnt/cross
```

will tell GDB to replace '`/usr/src`' with '`/mnt/cross`', which will allow GDB to find the file '`baz.c`' even though it was moved.

In the case when more than one substitution rule have been defined, the rules are evaluated one by one in the order where they have been defined. The first one matching, if any, is selected to perform the substitution.

For instance, if we had entered the following commands:

```
(gdb) set substitute-path /usr/src/include /mnt/include
(gdb) set substitute-path /usr/src /mnt/src
```

GDB would then rewrite '`/usr/src/include/defs.h`' into '`/mnt/include/defs.h`' by using the first rule. However, it would use the second rule to rewrite '`/usr/src/lib/foo.c`' into '`/mnt/src/lib/foo.c`'.

`unset substitute-path [path]`

If a path is specified, search the current list of substitution rules for a rule that would rewrite that path. Delete that rule if found. A warning is emitted by the debugger if no rule could be found.

If no path is specified, then all substitution rules are deleted.

`show substitute-path [path]`

If a path is specified, then print the source path substitution rule which would rewrite that path, if any.

If no path is specified, then print all existing source path substitution rules.

If your source path is cluttered with directories that are no longer of interest, GDB may sometimes cause confusion by finding the wrong versions of source. You can correct the situation as follows:

1. Use `directory` with no argument to reset the source path to its default value.
2. Use `directory` with suitable arguments to reinstall the directories you want in the source path. You can add all the directories in one command.

9.6 Source and Machine Code

You can use the command `info line` to map source lines to program addresses (and vice versa), and the command `disassemble` to display a range of addresses as machine instructions. You can use the command `set disassemble-next-line` to set whether to disassemble next source line when execution stops. When run under GNU Emacs mode, the `info line` command causes the arrow to point to the line specified. Also, `info line` prints addresses in symbolic form as well as hex.

`info line` *linespec*

Print the starting and ending addresses of the compiled code for source line *linespec*. You can specify source lines in any of the ways documented in Section 9.2 [Specify Location], page 94.

For example, we can use `info line` to discover the location of the object code for the first line of function `m4_changequote`:

```
(gdb) info line m4_changequote
Line 895 of "builtin.c" starts at pc 0x634c and ends at 0x6350.
```

We can also inquire (using `*`*`addr`* as the form for *linespec*) what source line covers a particular address:

```
(gdb) info line *0x63ff
Line 926 of "builtin.c" starts at pc 0x63e4 and ends at 0x6404.
```

After `info line`, the default address for the `x` command is changed to the starting address of the line, so that '`x/i`' is sufficient to begin examining the machine code (see Section 10.6 [Examining Memory], page 111). Also, this address is saved as the value of the convenience variable `$_` (see Section 10.11 [Convenience Variables], page 126).

`disassemble`
`disassemble /m`
`disassemble /r`

This specialized command dumps a range of memory as machine instructions. It can also print mixed source+disassembly by specifying the `/m` modifier and print the raw instructions in hex as well as in symbolic form by specifying the `/r`. The default memory range is the function surrounding the program counter of the selected frame. A single argument to this command is a program counter value; GDB dumps the function surrounding this value. When two arguments are given, they should be separated by a comma, possibly surrounded by whitespace. The arguments specify a range of addresses to dump, in one of two forms:

`start,end`
the addresses from *start* (inclusive) to *end* (exclusive)

`start,+length`
the addresses from *start* (inclusive) to *`start+length`* (exclusive).

When 2 arguments are specified, the name of the function is also printed (since there could be several functions in the given range).

The argument(s) can be any expression yielding a numeric value, such as '`0x32c4`', '`&main+10`' or '`$pc - 8`'.

If the range of memory being disassembled contains current program counter, the instruction at that location is shown with a `=>` marker.

The following example shows the disassembly of a range of addresses of HP PA-RISC 2.0 code:

```
(gdb) disas 0x32c4, 0x32e4
Dump of assembler code from 0x32c4 to 0x32e4:
   0x32c4 <main+204>:      addil 0,dp
   0x32c8 <main+208>:      ldw 0x22c(sr0,r1),r26
   0x32cc <main+212>:      ldil 0x3000,r31
   0x32d0 <main+216>:      ble 0x3f8(sr4,r31)
   0x32d4 <main+220>:      ldo 0(r31),rp
   0x32d8 <main+224>:      addil -0x800,dp
   0x32dc <main+228>:      ldo 0x588(r1),r26
   0x32e0 <main+232>:      ldil 0x3000,r31
End of assembler dump.
```

Here is an example showing mixed source+assembly for Intel x86, when the program is stopped just after function prologue:

```
(gdb) disas /m main
Dump of assembler code for function main:
5       {
   0x08048330 <+0>:    push   %ebp
   0x08048331 <+1>:    mov    %esp,%ebp
```

```
   0x08048333 <+3>:    sub    $0x8,%esp
   0x08048336 <+6>:    and    $0xfffffff0,%esp
   0x08048339 <+9>:    sub    $0x10,%esp

6         printf ("Hello.\n");
=> 0x0804833c <+12>:   movl   $0x8048440,(%esp)
   0x08048343 <+19>:   call   0x8048284 <puts@plt>

7         return 0;
8       }
   0x08048348 <+24>:   mov    $0x0,%eax
   0x0804834d <+29>:   leave
   0x0804834e <+30>:   ret

End of assembler dump.
```

Here is another example showing raw instructions in hex for AMD x86-64,

```
(gdb) disas /r 0x400281,+10
Dump of assembler code from 0x400281 to 0x40028b:
   0x0000000000400281:  38 36  cmp    %dh,(%rsi)
   0x0000000000400283:  2d 36 34 2e 73 sub    $0x732e3436,%eax
   0x0000000000400288:  6f     outsl  %ds:(%rsi),(%dx)
   0x0000000000400289:  2e 32 00       xor    %cs:(%rax),%al
End of assembler dump.
```

Addresses cannot be specified as a linespec (see Section 9.2 [Specify Location], page 94). So, for example, if you want to disassemble function `bar` in file '`foo.c`', you must type '`disassemble 'foo.c'::bar`' and not '`disassemble foo.c:bar`'.

Some architectures have more than one commonly-used set of instruction mnemonics or other syntax.

For programs that were dynamically linked and use shared libraries, instructions that call functions or branch to locations in the shared libraries might show a seemingly bogus location—it's actually a location of the relocation table. On some architectures, GDB might be able to resolve these to actual function names.

`set disassembly-flavor` *instruction-set*
: Select the instruction set to use when disassembling the program via the `disassemble` or `x/i` commands.

  Currently this command is only defined for the Intel x86 family. You can set *instruction-set* to either `intel` or `att`. The default is `att`, the AT&T flavor used by default by Unix assemblers for x86-based targets.

`show disassembly-flavor`
: Show the current setting of the disassembly flavor.

`set disassemble-next-line`
`show disassemble-next-line`
: Control whether or not GDB will disassemble the next source line or instruction when execution stops. If ON, GDB will display disassembly of the next source line when execution of the program being debugged stops. This is *in addition* to displaying the source line itself, which GDB always does if possible. If the next source line cannot be displayed for some reason (e.g., if GDB cannot find the source file, or there's no line info in the debug info), GDB will display

disassembly of the next *instruction* instead of showing the next source line. If AUTO, GDB will display disassembly of next instruction only if the source line cannot be displayed. This setting causes GDB to display some feedback when you step through a function with no line info or whose source file is unavailable. The default is OFF, which means never display the disassembly of the next line or instruction.

10 Examining Data

The usual way to examine data in your program is with the `print` command (abbreviated `p`), or its synonym `inspect`. It evaluates and prints the value of an expression of the language your program is written in (see Chapter 15 [Using GDB with Different Languages], page 173). It may also print the expression using a Python-based pretty-printer (see Section 10.9 [Pretty Printing], page 123).

`print` *expr*
`print /f` *expr*
: *expr* is an expression (in the source language). By default the value of *expr* is printed in a format appropriate to its data type; you can choose a different format by specifying '`/f`', where *f* is a letter specifying the format; see Section 10.5 [Output Formats], page 110.

`print`
`print /f`
: If you omit *expr*, GDB displays the last value again (from the *value history*; see Section 10.10 [Value History], page 125). This allows you to conveniently inspect the same value in an alternative format.

A more low-level way of examining data is with the `x` command. It examines data in memory at a specified address and prints it in a specified format. See Section 10.6 [Examining Memory], page 111.

If you are interested in information about types, or about how the fields of a struct or a class are declared, use the `ptype` *exp* command rather than `print`. See Chapter 16 [Examining the Symbol Table], page 201.

Another way of examining values of expressions and type information is through the Python extension command `explore` (available only if the GDB build is configured with `--with-python`). It offers an interactive way to start at the highest level (or, the most abstract level) of the data type of an expression (or, the data type itself) and explore all the way down to leaf scalar values/fields embedded in the higher level data types.

`explore` *arg*
: *arg* is either an expression (in the source language), or a type visible in the current context of the program being debugged.

The working of the `explore` command can be illustrated with an example. If a data type `struct ComplexStruct` is defined in your C program as

```
struct SimpleStruct
{
  int i;
  double d;
};

struct ComplexStruct
{
  struct SimpleStruct *ss_p;
  int arr[10];
};
```

followed by variable declarations as

```
struct SimpleStruct ss = { 10, 1.11 };
struct ComplexStruct cs = { &ss, { 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 } };
```

then, the value of the variable `cs` can be explored using the `explore` command as follows.

```
(gdb) explore cs
The value of ‘cs’ is a struct/class of type ‘struct ComplexStruct’ with
the following fields:

  ss_p = <Enter 0 to explore this field of type ‘struct SimpleStruct *’>
   arr = <Enter 1 to explore this field of type ‘int [10]’>

Enter the field number of choice:
```

Since the fields of `cs` are not scalar values, you are being prompted to chose the field you want to explore. Let's say you choose the field `ss_p` by entering `0`. Then, since this field is a pointer, you will be asked if it is pointing to a single value. From the declaration of `cs` above, it is indeed pointing to a single value, hence you enter `y`. If you enter `n`, then you will be asked if it were pointing to an array of values, in which case this field will be explored as if it were an array.

```
‘cs.ss_p’ is a pointer to a value of type ‘struct SimpleStruct’
Continue exploring it as a pointer to a single value [y/n]: y
The value of ‘*(cs.ss_p)’ is a struct/class of type ‘struct
SimpleStruct’ with the following fields:

  i = 10 .. (Value of type ‘int’)
  d = 1.1100000000000001 .. (Value of type ‘double’)

Press enter to return to parent value:
```

If the field `arr` of `cs` was chosen for exploration by entering `1` earlier, then since it is as array, you will be prompted to enter the index of the element in the array that you want to explore.

```
‘cs.arr’ is an array of ‘int’.
Enter the index of the element you want to explore in ‘cs.arr’: 5

‘(cs.arr)[5]’ is a scalar value of type ‘int’.

(cs.arr)[5] = 4

Press enter to return to parent value:
```

In general, at any stage of exploration, you can go deeper towards the leaf values by responding to the prompts appropriately, or hit the return key to return to the enclosing data structure (the *higher* level data structure).

Similar to exploring values, you can use the `explore` command to explore types. Instead of specifying a value (which is typically a variable name or an expression valid in the current context of the program being debugged), you specify a type name. If you consider the same example as above, your can explore the type `struct ComplexStruct` by passing the argument `struct ComplexStruct` to the `explore` command.

```
(gdb) explore struct ComplexStruct
```

By responding to the prompts appropriately in the subsequent interactive session, you can explore the type `struct ComplexStruct` in a manner similar to how the value `cs` was explored in the above example.

The `explore` command also has two sub-commands, `explore value` and `explore type`. The former sub-command is a way to explicitly specify that value exploration of the argument is being invoked, while the latter is a way to explicitly specify that type exploration of the argument is being invoked.

`explore value` *expr*
: This sub-command of `explore` explores the value of the expression *expr* (if *expr* is an expression valid in the current context of the program being debugged). The behavior of this command is identical to that of the behavior of the `explore` command being passed the argument *expr*.

`explore type` *arg*
: This sub-command of `explore` explores the type of *arg* (if *arg* is a type visible in the current context of program being debugged), or the type of the value/expression *arg* (if *arg* is an expression valid in the current context of the program being debugged). If *arg* is a type, then the behavior of this command is identical to that of the `explore` command being passed the argument *arg*. If *arg* is an expression, then the behavior of this command will be identical to that of the `explore` command being passed the type of *arg* as the argument.

10.1 Expressions

`print` and many other GDB commands accept an expression and compute its value. Any kind of constant, variable or operator defined by the programming language you are using is valid in an expression in GDB. This includes conditional expressions, function calls, casts, and string constants. It also includes preprocessor macros, if you compiled your program to include this information; see Section 4.1 [Compilation], page 25.

GDB supports array constants in expressions input by the user. The syntax is `{`*element*, *element*`...}`. For example, you can use the command `print {1, 2, 3}` to create an array of three integers. If you pass an array to a function or assign it to a program variable, GDB copies the array to memory that is `malloc`ed in the target program.

Because C is so widespread, most of the expressions shown in examples in this manual are in C. See Chapter 15 [Using GDB with Different Languages], page 173, for information on how to use expressions in other languages.

In this section, we discuss operators that you can use in GDB expressions regardless of your programming language.

Casts are supported in all languages, not just in C, because it is so useful to cast a number into a pointer in order to examine a structure at that address in memory.

GDB supports these operators, in addition to those common to programming languages:

`@`
: '`@`' is a binary operator for treating parts of memory as arrays. See Section 10.4 [Artificial Arrays], page 109, for more information.

`::`
: '`::`' allows you to specify a variable in terms of the file or function where it is defined. See Section 10.3 [Program Variables], page 107.

`{`*type*`}` *addr*
: Refers to an object of type *type* stored at address *addr* in memory. *addr* may be any expression whose value is an integer or pointer (but parentheses are

required around binary operators, just as in a cast). This construct is allowed regardless of what kind of data is normally supposed to reside at *addr*.

10.2 Ambiguous Expressions

Expressions can sometimes contain some ambiguous elements. For instance, some programming languages (notably Ada, C++ and Objective-C) permit a single function name to be defined several times, for application in different contexts. This is called *overloading*. Another example involving Ada is generics. A *generic package* is similar to C++ templates and is typically instantiated several times, resulting in the same function name being defined in different contexts.

In some cases and depending on the language, it is possible to adjust the expression to remove the ambiguity. For instance in C++, you can specify the signature of the function you want to break on, as in *`break function(types)`*. In Ada, using the fully qualified name of your function often makes the expression unambiguous as well.

When an ambiguity that needs to be resolved is detected, the debugger has the capability to display a menu of numbered choices for each possibility, and then waits for the selection with the prompt '`>`'. The first option is always '`[0] cancel`', and typing *`0 RET`* aborts the current command. If the command in which the expression was used allows more than one choice to be selected, the next option in the menu is '`[1] all`', and typing *`1 RET`* selects all possible choices.

For example, the following session excerpt shows an attempt to set a breakpoint at the overloaded symbol `String::after`. We choose three particular definitions of that function name:

```
(gdb) b String::after
[0] cancel
[1] all
[2] file:String.cc; line number:867
[3] file:String.cc; line number:860
[4] file:String.cc; line number:875
[5] file:String.cc; line number:853
[6] file:String.cc; line number:846
[7] file:String.cc; line number:735
> 2 4 6
Breakpoint 1 at 0xb26c: file String.cc, line 867.
Breakpoint 2 at 0xb344: file String.cc, line 875.
Breakpoint 3 at 0xafcc: file String.cc, line 846.
Multiple breakpoints were set.
Use the "delete" command to delete unwanted
 breakpoints.
(gdb)
```

`set multiple-symbols` *`mode`*

This option allows you to adjust the debugger behavior when an expression is ambiguous.

By default, *mode* is set to `all`. If the command with which the expression is used allows more than one choice, then GDB automatically selects all possible choices. For instance, inserting a breakpoint on a function using an ambiguous name results in a breakpoint inserted on each possible match. However, if a unique choice must be made, then GDB uses the menu to help you disambiguate

the expression. For instance, printing the address of an overloaded function will result in the use of the menu.

When *mode* is set to `ask`, the debugger always uses the menu when an ambiguity is detected.

Finally, when *mode* is set to `cancel`, the debugger reports an error due to the ambiguity and the command is aborted.

`show multiple-symbols`
: Show the current value of the `multiple-symbols` setting.

10.3 Program Variables

The most common kind of expression to use is the name of a variable in your program.

Variables in expressions are understood in the selected stack frame (see Section 8.3 [Selecting a Frame], page 90); they must be either:

- global (or file-static)

or

- visible according to the scope rules of the programming language from the point of execution in that frame

This means that in the function

```
foo (a)
     int a;
{
  bar (a);
  {
    int b = test ();
    bar (b);
  }
}
```

you can examine and use the variable `a` whenever your program is executing within the function `foo`, but you can only use or examine the variable `b` while your program is executing inside the block where `b` is declared.

There is an exception: you can refer to a variable or function whose scope is a single source file even if the current execution point is not in this file. But it is possible to have more than one such variable or function with the same name (in different source files). If that happens, referring to that name has unpredictable effects. If you wish, you can specify a static variable in a particular function or file by using the colon-colon (`::`) notation:

```
file::variable
function::variable
```

Here *file* or *function* is the name of the context for the static *variable*. In the case of file names, you can use quotes to make sure GDB parses the file name as a single word—for example, to print a global value of `x` defined in '`f2.c`':

```
(gdb) p 'f2.c'::x
```

The `::` notation is normally used for referring to static variables, since you typically disambiguate uses of local variables in functions by selecting the appropriate frame and using the simple name of the variable. However, you may also use this notation to refer to local variables in frames enclosing the selected frame:

```
void
foo (int a)
{
  if (a < 10)
    bar (a);
  else
    process (a);    /* Stop here */
}

int
bar (int a)
{
  foo (a + 5);
}
```

For example, if there is a breakpoint at the commented line, here is what you might see when the program stops after executing the call `bar(0)`:

```
(gdb) p a
$1 = 10
(gdb) p bar::a
$2 = 5
(gdb) up 2
#2  0x080483d0 in foo (a=5) at foobar.c:12
(gdb) p a
$3 = 5
(gdb) p bar::a
$4 = 0
```

These uses of '`::`' are very rarely in conflict with the very similar use of the same notation in C++. GDB also supports use of the C++ scope resolution operator in GDB expressions.

> *Warning:* Occasionally, a local variable may appear to have the wrong value at certain points in a function—just after entry to a new scope, and just before exit.

You may see this problem when you are stepping by machine instructions. This is because, on most machines, it takes more than one instruction to set up a stack frame (including local variable definitions); if you are stepping by machine instructions, variables may appear to have the wrong values until the stack frame is completely built. On exit, it usually also takes more than one machine instruction to destroy a stack frame; after you begin stepping through that group of instructions, local variable definitions may be gone.

This may also happen when the compiler does significant optimizations. To be sure of always seeing accurate values, turn off all optimization when compiling.

Another possible effect of compiler optimizations is to optimize unused variables out of existence, or assign variables to registers (as opposed to memory addresses). Depending on the support for such cases offered by the debug info format used by the compiler, GDB might not be able to display values for such local variables. If that happens, GDB will print a message like this:

```
No symbol "foo" in current context.
```

To solve such problems, either recompile without optimizations, or use a different debug info format, if the compiler supports several such formats. See Section 4.1 [Compilation], page 25, for more information on choosing compiler options. See Section 15.4.1 [C and C++], page 177, for more information about debug info formats that are best suited to C++ programs.

If you ask to print an object whose contents are unknown to GDB, e.g., because its data type is not completely specified by the debug information, GDB will say '`<incomplete type>`'. See Chapter 16 [Symbols], page 201, for more about this.

If you append `@entry` string to a function parameter name you get its value at the time the function got called. If the value is not available an error message is printed. Entry values are available only with some compilers. Entry values are normally also printed at the function parameter list according to [set print entry-values], page 118.

```
Breakpoint 1, d (i=30) at gdb.base/entry-value.c:29
29   i++;
(gdb) next
30   e (i);
(gdb) print i
$1 = 31
(gdb) print i@entry
$2 = 30
```

Strings are identified as arrays of `char` values without specified signedness. Arrays of either `signed char` or `unsigned char` get printed as arrays of 1 byte sized integers. `-fsigned-char` or `-funsigned-char` GCC options have no effect as GDB defines literal string type `"char"` as `char` without a sign. For program code

```
char var0[] = "A";
signed char var1[] = "A";
```

You get during debugging

```
(gdb) print var0
$1 = "A"
(gdb) print var1
$2 = {65 'A', 0 '\0'}
```

10.4 Artificial Arrays

It is often useful to print out several successive objects of the same type in memory; a section of an array, or an array of dynamically determined size for which only a pointer exists in the program.

You can do this by referring to a contiguous span of memory as an *artificial array*, using the binary operator '`@`'. The left operand of '`@`' should be the first element of the desired array and be an individual object. The right operand should be the desired length of the array. The result is an array value whose elements are all of the type of the left argument. The first element is actually the left argument; the second element comes from bytes of memory immediately following those that hold the first element, and so on. Here is an example. If a program says

```
int *array = (int *) malloc (len * sizeof (int));
```

you can print the contents of `array` with

```
p *array@len
```

The left operand of '`@`' must reside in memory. Array values made with '`@`' in this way behave just like other arrays in terms of subscripting, and are coerced to pointers when used in expressions. Artificial arrays most often appear in expressions via the value history (see Section 10.10 [Value History], page 125), after printing one out.

Another way to create an artificial array is to use a cast. This re-interprets a value as if it were an array. The value need not be in memory:

```
(gdb) p/x (short[2])0x12345678
$1 = {0x1234, 0x5678}
```

As a convenience, if you leave the array length out (as in '`(`*`type`*`[])`*`value`') GDB calculates the size to fill the value (as '`sizeof(`*`value`*`)/sizeof(`*`type`*`)`':

```
(gdb) p/x (short[])0x12345678
$2 = {0x1234, 0x5678}
```

Sometimes the artificial array mechanism is not quite enough; in moderately complex data structures, the elements of interest may not actually be adjacent—for example, if you are interested in the values of pointers in an array. One useful work-around in this situation is to use a convenience variable (see Section 10.11 [Convenience Variables], page 126) as a counter in an expression that prints the first interesting value, and then repeat that expression via RET. For instance, suppose you have an array `dtab` of pointers to structures, and you are interested in the values of a field `fv` in each structure. Here is an example of what you might type:

```
set $i = 0
p dtab[$i++]->fv
RET
RET
...
```

10.5 Output Formats

By default, GDB prints a value according to its data type. Sometimes this is not what you want. For example, you might want to print a number in hex, or a pointer in decimal. Or you might want to view data in memory at a certain address as a character string or as an instruction. To do these things, specify an *output format* when you print a value.

The simplest use of output formats is to say how to print a value already computed. This is done by starting the arguments of the `print` command with a slash and a format letter. The format letters supported are:

`x` Regard the bits of the value as an integer, and print the integer in hexadecimal.

`d` Print as integer in signed decimal.

`u` Print as integer in unsigned decimal.

`o` Print as integer in octal.

`t` Print as integer in binary. The letter '`t`' stands for "two".[1]

`a` Print as an address, both absolute in hexadecimal and as an offset from the nearest preceding symbol. You can use this format used to discover where (in what function) an unknown address is located:

```
(gdb) p/a 0x54320
$3 = 0x54320 <_initialize_vx+396>
```

The command `info symbol 0x54320` yields similar results. See Chapter 16 [Symbols], page 201.

[1] '`b`' cannot be used because these format letters are also used with the `x` command, where '`b`' stands for "byte"; see Section 10.6 [Examining Memory], page 111.

`c` Regard as an integer and print it as a character constant. This prints both the numerical value and its character representation. The character representation is replaced with the octal escape '`\nnn`' for characters outside the 7-bit ASCII range.

Without this format, GDB displays `char`, `unsigned char`, and `signed char` data as character constants. Single-byte members of vectors are displayed as integer data.

`f` Regard the bits of the value as a floating point number and print using typical floating point syntax.

`s` Regard as a string, if possible. With this format, pointers to single-byte data are displayed as null-terminated strings and arrays of single-byte data are displayed as fixed-length strings. Other values are displayed in their natural types.

Without this format, GDB displays pointers to and arrays of `char`, `unsigned char`, and `signed char` as strings. Single-byte members of a vector are displayed as an integer array.

`r` Print using the '`raw`' formatting. By default, GDB will use a Python-based pretty-printer, if one is available (see Section 10.9 [Pretty Printing], page 123). This typically results in a higher-level display of the value's contents. The '`r`' format bypasses any Python pretty-printer which might exist.

For example, to print the program counter in hex (see Section 10.13 [Registers], page 128), type

```
p/x $pc
```

Note that no space is required before the slash; this is because command names in GDB cannot contain a slash.

To reprint the last value in the value history with a different format, you can use the `print` command with just a format and no expression. For example, '`p/x`' reprints the last value in hex.

10.6 Examining Memory

You can use the command `x` (for "examine") to examine memory in any of several formats, independently of your program's data types.

`x/`*`nfu addr`*
`x` *`addr`*
`x` Use the `x` command to examine memory.

n, *f*, and *u* are all optional parameters that specify how much memory to display and how to format it; *addr* is an expression giving the address where you want to start displaying memory. If you use defaults for *nfu*, you need not type the slash '`/`'. Several commands set convenient defaults for *addr*.

n, the repeat count
The repeat count is a decimal integer; the default is 1. It specifies how much memory (counting by units *u*) to display.

f, the display format
: The display format is one of the formats used by `print` (‘`x`’, ‘`d`’, ‘`u`’, ‘`o`’, ‘`t`’, ‘`a`’, ‘`c`’, ‘`f`’, ‘`s`’), and in addition ‘`i`’ (for machine instructions). The default is ‘`x`’ (hexadecimal) initially. The default changes each time you use either `x` or `print`.

u, the unit size
: The unit size is any of

  `b` Bytes.

  `h` Halfwords (two bytes).

  `w` Words (four bytes). This is the initial default.

  `g` Giant words (eight bytes).

  Each time you specify a unit size with `x`, that size becomes the default unit the next time you use `x`. For the ‘`i`’ format, the unit size is ignored and is normally not written. For the ‘`s`’ format, the unit size defaults to ‘`b`’, unless it is explicitly given. Use ***x /hs*** to display 16-bit char strings and ***x /ws*** to display 32-bit strings. The next use of ***x /s*** will again display 8-bit strings. Note that the results depend on the programming language of the current compilation unit. If the language is C, the ‘`s`’ modifier will use the UTF-16 encoding while ‘`w`’ will use UTF-32. The encoding is set by the programming language and cannot be altered.

addr, starting display address
: *addr* is the address where you want GDB to begin displaying memory. The expression need not have a pointer value (though it may); it is always interpreted as an integer address of a byte of memory. See Section 10.1 [Expressions], page 105, for more information on expressions. The default for *addr* is usually just after the last address examined—but several other commands also set the default address: `info breakpoints` (to the address of the last breakpoint listed), `info line` (to the starting address of a line), and `print` (if you use it to display a value from memory).

For example, ‘`x/3uh 0x54320`’ is a request to display three halfwords (`h`) of memory, formatted as unsigned decimal integers (‘`u`’), starting at address `0x54320`. ‘`x/4xw $sp`’ prints the four words (‘`w`’) of memory above the stack pointer (here, ‘`$sp`’; see Section 10.13 [Registers], page 128) in hexadecimal (‘`x`’).

Since the letters indicating unit sizes are all distinct from the letters specifying output formats, you do not have to remember whether unit size or format comes first; either order works. The output specifications ‘`4xw`’ and ‘`4wx`’ mean exactly the same thing. (However, the count *n* must come first; ‘`wx4`’ does not work.)

Even though the unit size *u* is ignored for the formats ‘`s`’ and ‘`i`’, you might still want to use a count *n*; for example, ‘`3i`’ specifies that you want to see three machine instructions, including any operands. For convenience, especially when used with the `display` command, the ‘`i`’ format also prints branch delay slot instructions, if any, beyond the count specified, which immediately follow the last instruction that is within the count. The command

`disassemble` gives an alternative way of inspecting machine instructions; see Section 9.6 [Source and Machine Code], page 99.

All the defaults for the arguments to `x` are designed to make it easy to continue scanning memory with minimal specifications each time you use `x`. For example, after you have inspected three machine instructions with '`x/3i addr`', you can inspect the next seven with just '`x/7`'. If you use RET to repeat the `x` command, the repeat count *n* is used again; the other arguments default as for successive uses of `x`.

When examining machine instructions, the instruction at current program counter is shown with a `=>` marker. For example:

```
(gdb) x/5i $pc-6
   0x804837f <main+11>: mov    %esp,%ebp
   0x8048381 <main+13>: push   %ecx
   0x8048382 <main+14>: sub    $0x4,%esp
=> 0x8048385 <main+17>: movl   $0x8048460,(%esp)
   0x804838c <main+24>: call   0x80482d4 <puts@plt>
```

The addresses and contents printed by the `x` command are not saved in the value history because there is often too much of them and they would get in the way. Instead, GDB makes these values available for subsequent use in expressions as values of the convenience variables `$_` and `$__`. After an `x` command, the last address examined is available for use in expressions in the convenience variable `$_`. The contents of that address, as examined, are available in the convenience variable `$__`.

If the `x` command has a repeat count, the address and contents saved are from the last memory unit printed; this is not the same as the last address printed if several units were printed on the last line of output.

When you are debugging a program running on a remote target machine (see Chapter 20 [Remote Debugging], page 235), you may wish to verify the program's image in the remote machine's memory against the executable file you downloaded to the target. The `compare-sections` command is provided for such situations.

`compare-sections` [*section-name*]

> Compare the data of a loadable section *section-name* in the executable file of the program being debugged with the same section in the remote machine's memory, and report any mismatches. With no arguments, compares all loadable sections. This command's availability depends on the target's support for the `"qCRC"` remote request.

10.7 Automatic Display

If you find that you want to print the value of an expression frequently (to see how it changes), you might want to add it to the *automatic display list* so that GDB prints its value each time your program stops. Each expression added to the list is given a number to identify it; to remove an expression from the list, you specify that number. The automatic display looks like this:

```
2: foo = 38
3: bar[5] = (struct hack *) 0x3804
```

This display shows item numbers, expressions and their current values. As with displays you request manually using `x` or `print`, you can specify the output format you prefer; in

fact, `display` decides whether to use `print` or `x` depending your format specification—it uses `x` if you specify either the '`i`' or '`s`' format, or a unit size; otherwise it uses `print`.

`display` *expr*
: Add the expression *expr* to the list of expressions to display each time your program stops. See Section 10.1 [Expressions], page 105.

  `display` does not repeat if you press RET again after using it.

`display/`*fmt expr*
: For *fmt* specifying only a display format and not a size or count, add the expression *expr* to the auto-display list but arrange to display it each time in the specified format *fmt*. See Section 10.5 [Output Formats], page 110.

`display/`*fmt addr*
: For *fmt* '`i`' or '`s`', or including a unit-size or a number of units, add the expression *addr* as a memory address to be examined each time your program stops. Examining means in effect doing '`x/`*fmt addr*'. See Section 10.6 [Examining Memory], page 111.

For example, '`display/i $pc`' can be helpful, to see the machine instruction about to be executed each time execution stops ('`$pc`' is a common name for the program counter; see Section 10.13 [Registers], page 128).

`undisplay` *dnums*`...`
`delete display` *dnums*`...`
: Remove items from the list of expressions to display. Specify the numbers of the displays that you want affected with the command argument *dnums*. It can be a single display number, one of the numbers shown in the first field of the '`info display`' display; or it could be a range of display numbers, as in `2-4`.

  `undisplay` does not repeat if you press RET after using it. (Otherwise you would just get the error '`No display number ...`'.)

`disable display` *dnums*`...`
: Disable the display of item numbers *dnums*. A disabled display item is not printed automatically, but is not forgotten. It may be enabled again later. Specify the numbers of the displays that you want affected with the command argument *dnums*. It can be a single display number, one of the numbers shown in the first field of the '`info display`' display; or it could be a range of display numbers, as in `2-4`.

`enable display` *dnums*`...`
: Enable display of item numbers *dnums*. It becomes effective once again in auto display of its expression, until you specify otherwise. Specify the numbers of the displays that you want affected with the command argument *dnums*. It can be a single display number, one of the numbers shown in the first field of the '`info display`' display; or it could be a range of display numbers, as in `2-4`.

`display`
: Display the current values of the expressions on the list, just as is done when your program stops.

`info display`
: Print the list of expressions previously set up to display automatically, each one with its item number, but without showing the values. This includes disabled expressions, which are marked as such. It also includes expressions which would not be displayed right now because they refer to automatic variables not currently available.

If a display expression refers to local variables, then it does not make sense outside the lexical context for which it was set up. Such an expression is disabled when execution enters a context where one of its variables is not defined. For example, if you give the command `display last_char` while inside a function with an argument `last_char`, GDB displays this argument while your program continues to stop inside that function. When it stops elsewhere—where there is no variable `last_char`—the display is disabled automatically. The next time your program stops where `last_char` is meaningful, you can enable the display expression once again.

10.8 Print Settings

GDB provides the following ways to control how arrays, structures, and symbols are printed.

These settings are useful for debugging programs in any language:

`set print address`
`set print address on`
: GDB prints memory addresses showing the location of stack traces, structure values, pointer values, breakpoints, and so forth, even when it also displays the contents of those addresses. The default is `on`. For example, this is what a stack frame display looks like with `set print address on`:

```
(gdb) f
#0  set_quotes (lq=0x34c78 "<<", rq=0x34c88 ">>")
    at input.c:530
530         if (lquote != def_lquote)
```

`set print address off`
: Do not print addresses when displaying their contents. For example, this is the same stack frame displayed with `set print address off`:

```
(gdb) set print addr off
(gdb) f
#0  set_quotes (lq="<<", rq=">>") at input.c:530
530         if (lquote != def_lquote)
```

You can use '`set print address off`' to eliminate all machine dependent displays from the GDB interface. For example, with `print address off`, you should get the same text for backtraces on all machines—whether or not they involve pointer arguments.

`show print address`
: Show whether or not addresses are to be printed.

When GDB prints a symbolic address, it normally prints the closest earlier symbol plus an offset. If that symbol does not uniquely identify the address (for example, it is a name whose scope is a single source file), you may need to clarify. One way to do this is with `info`

`line`, for example '`info line *0x4537`'. Alternately, you can set GDB to print the source file and line number when it prints a symbolic address:

`set print symbol-filename on`
: Tell GDB to print the source file name and line number of a symbol in the symbolic form of an address.

`set print symbol-filename off`
: Do not print source file name and line number of a symbol. This is the default.

`show print symbol-filename`
: Show whether or not GDB will print the source file name and line number of a symbol in the symbolic form of an address.

Another situation where it is helpful to show symbol filenames and line numbers is when disassembling code; GDB shows you the line number and source file that corresponds to each instruction.

Also, you may wish to see the symbolic form only if the address being printed is reasonably close to the closest earlier symbol:

`set print max-symbolic-offset` *`max-offset`*
: Tell GDB to only display the symbolic form of an address if the offset between the closest earlier symbol and the address is less than *max-offset*. The default is 0, which tells GDB to always print the symbolic form of an address if any symbol precedes it.

`show print max-symbolic-offset`
: Ask how large the maximum offset is that GDB prints in a symbolic address.

If you have a pointer and you are not sure where it points, try '`set print symbol-filename on`'. Then you can determine the name and source file location of the variable where it points, using '`p/a` *`pointer`*'. This interprets the address in symbolic form. For example, here GDB shows that a variable `ptt` points at another variable `t`, defined in '`hi2.c`':

```
(gdb) set print symbol-filename on
(gdb) p/a ptt
$4 = 0xe008 <t in hi2.c>
```

Warning: For pointers that point to a local variable, '`p/a`' does not show the symbol name and filename of the referent, even with the appropriate `set print` options turned on.

You can also enable '`/a`'-like formatting all the time using '`set print symbol on`':

`set print symbol on`
: Tell GDB to print the symbol corresponding to an address, if one exists.

`set print symbol off`
: Tell GDB not to print the symbol corresponding to an address. In this mode, GDB will still print the symbol corresponding to pointers to functions. This is the default.

`show print symbol`
: Show whether GDB will display the symbol corresponding to an address.

Other settings control how different kinds of objects are printed:

`set print array`
`set print array on`
: Pretty print arrays. This format is more convenient to read, but uses more space. The default is off.

`set print array off`
: Return to compressed format for arrays.

`show print array`
: Show whether compressed or pretty format is selected for displaying arrays.

`set print array-indexes`
`set print array-indexes on`
: Print the index of each element when displaying arrays. May be more convenient to locate a given element in the array or quickly find the index of a given element in that printed array. The default is off.

`set print array-indexes off`
: Stop printing element indexes when displaying arrays.

`show print array-indexes`
: Show whether the index of each element is printed when displaying arrays.

`set print elements` *number-of-elements*
: Set a limit on how many elements of an array GDB will print. If GDB is printing a large array, it stops printing after it has printed the number of elements set by the `set print elements` command. This limit also applies to the display of strings. When GDB starts, this limit is set to 200. Setting *number-of-elements* to zero means that the printing is unlimited.

`show print elements`
: Display the number of elements of a large array that GDB will print. If the number is 0, then the printing is unlimited.

`set print frame-arguments` *value*
: This command allows to control how the values of arguments are printed when the debugger prints a frame (see Section 8.1 [Frames], page 87). The possible values are:

  `all` The values of all arguments are printed.

  `scalars` Print the value of an argument only if it is a scalar. The value of more complex arguments such as arrays, structures, unions, etc, is replaced by `...`. This is the default. Here is an example where only scalar arguments are shown:

```
#1  0x08048361 in call_me (i=3, s=..., ss=0xbf8d508c, u=..., e=green)
  at frame-args.c:23
```

  `none` None of the argument values are printed. Instead, the value of each argument is replaced by `...`. In this case, the example above now becomes:

```
#1  0x08048361 in call_me (i=..., s=..., ss=..., u=..., e=...)
  at frame-args.c:23
```

By default, only scalar arguments are printed. This command can be used to configure the debugger to print the value of all arguments, regardless of their type. However, it is often advantageous to not print the value of more complex parameters. For instance, it reduces the amount of information printed in each frame, making the backtrace more readable. Also, it improves performance when displaying Ada frames, because the computation of large arguments can sometimes be CPU-intensive, especially in large applications. Setting `print frame-arguments` to `scalars` (the default) or `none` avoids this computation, thus speeding up the display of each Ada frame.

`show print frame-arguments`
Show how the value of arguments should be displayed when printing a frame.

`set print entry-values` *value*
Set printing of frame argument values at function entry. In some cases GDB can determine the value of function argument which was passed by the function caller, even if the value was modified inside the called function and therefore is different. With optimized code, the current value could be unavailable, but the entry value may still be known.

The default value is `default` (see below for its description). Older GDB behaved as with the setting `no`. Compilers not supporting this feature will behave in the `default` setting the same way as with the `no` setting.

This functionality is currently supported only by DWARF 2 debugging format and the compiler has to produce '`DW_TAG_GNU_call_site`' tags. With GCC, you need to specify '`-O -g`' during compilation, to get this information.

The *value* parameter can be one of the following:

`no` Print only actual parameter values, never print values from function entry point.

```
#0  equal (val=5)
#0  different (val=6)
#0  lost (val=<optimized out>)
#0  born (val=10)
#0  invalid (val=<optimized out>)
```

`only` Print only parameter values from function entry point. The actual parameter values are never printed.

```
#0  equal (val@entry=5)
#0  different (val@entry=5)
#0  lost (val@entry=5)
#0  born (val@entry=<optimized out>)
#0  invalid (val@entry=<optimized out>)
```

`preferred`
Print only parameter values from function entry point. If value from function entry point is not known while the actual value is known, print the actual value for such parameter.

```
#0  equal (val@entry=5)
```

```
#0  different (val@entry=5)
#0  lost (val@entry=5)
#0  born (val=10)
#0  invalid (val@entry=<optimized out>)
```

`if-needed`
: Print actual parameter values. If actual parameter value is not known while value from function entry point is known, print the entry point value for such parameter.

```
#0  equal (val=5)
#0  different (val=6)
#0  lost (val@entry=5)
#0  born (val=10)
#0  invalid (val=<optimized out>)
```

`both`
: Always print both the actual parameter value and its value from function entry point, even if values of one or both are not available due to compiler optimizations.

```
#0  equal (val=5, val@entry=5)
#0  different (val=6, val@entry=5)
#0  lost (val=<optimized out>, val@entry=5)
#0  born (val=10, val@entry=<optimized out>)
#0  invalid (val=<optimized out>, val@entry=<optimized out>)
```

`compact`
: Print the actual parameter value if it is known and also its value from function entry point if it is known. If neither is known, print for the actual value `<optimized out>`. If not in MI mode (see Chapter 27 [GDB/MI], page 365) and if both values are known and identical, print the shortened `param=param@entry=VALUE` notation.

```
#0  equal (val=val@entry=5)
#0  different (val=6, val@entry=5)
#0  lost (val@entry=5)
#0  born (val=10)
#0  invalid (val=<optimized out>)
```

`default`
: Always print the actual parameter value. Print also its value from function entry point, but only if it is known. If not in MI mode (see Chapter 27 [GDB/MI], page 365) and if both values are known and identical, print the shortened `param=param@entry=VALUE` notation.

```
#0  equal (val=val@entry=5)
#0  different (val=6, val@entry=5)
#0  lost (val=<optimized out>, val@entry=5)
#0  born (val=10)
#0  invalid (val=<optimized out>)
```

For analysis messages on possible failures of frame argument values at function entry resolution see [set debug entry-values], page 142.

`show print entry-values`
: Show the method being used for printing of frame argument values at function entry.

`set print repeats`
: Set the threshold for suppressing display of repeated array elements. When the number of consecutive identical elements of an array exceeds the threshold,

GDB prints the string `"<repeats n times>"`, where *n* is the number of identical repetitions, instead of displaying the identical elements themselves. Setting the threshold to zero will cause all elements to be individually printed. The default threshold is 10.

`show print repeats`
: Display the current threshold for printing repeated identical elements.

`set print null-stop`
: Cause GDB to stop printing the characters of an array when the first NULL is encountered. This is useful when large arrays actually contain only short strings. The default is off.

`show print null-stop`
: Show whether GDB stops printing an array on the first NULL character.

`set print pretty on`
: Cause GDB to print structures in an indented format with one member per line, like this:

```
$1 = {
  next = 0x0,
  flags = {
    sweet = 1,
    sour = 1
  },
  meat = 0x54 "Pork"
}
```

`set print pretty off`
: Cause GDB to print structures in a compact format, like this:

```
$1 = {next = 0x0, flags = {sweet = 1, sour = 1}, \
meat = 0x54 "Pork"}
```

This is the default format.

`show print pretty`
: Show which format GDB is using to print structures.

`set print sevenbit-strings on`
: Print using only seven-bit characters; if this option is set, GDB displays any eight-bit characters (in strings or character values) using the notation *nnn*. This setting is best if you are working in English (ASCII) and you use the high-order bit of characters as a marker or "meta" bit.

`set print sevenbit-strings off`
: Print full eight-bit characters. This allows the use of more international character sets, and is the default.

`show print sevenbit-strings`
: Show whether or not GDB is printing only seven-bit characters.

`set print union on`
: Tell GDB to print unions which are contained in structures and other unions. This is the default setting.

`set print union off`
: Tell GDB not to print unions which are contained in structures and other unions. GDB will print `"{...}"` instead.

`show print union`
: Ask GDB whether or not it will print unions which are contained in structures and other unions.

  For example, given the declarations

```
typedef enum {Tree, Bug} Species;
typedef enum {Big_tree, Acorn, Seedling} Tree_forms;
typedef enum {Caterpillar, Cocoon, Butterfly}
              Bug_forms;

struct thing {
  Species it;
  union {
    Tree_forms tree;
    Bug_forms bug;
  } form;
};

struct thing foo = {Tree, {Acorn}};
```

  with `set print union on` in effect '`p foo`' would print

```
$1 = {it = Tree, form = {tree = Acorn, bug = Cocoon}}
```

  and with `set print union off` in effect it would print

```
$1 = {it = Tree, form = {...}}
```

  `set print union` affects programs written in C-like languages and in Pascal.

These settings are of interest when debugging C++ programs:

`set print demangle`
`set print demangle on`
: Print C++ names in their source form rather than in the encoded ("mangled") form passed to the assembler and linker for type-safe linkage. The default is on.

`show print demangle`
: Show whether C++ names are printed in mangled or demangled form.

`set print asm-demangle`
`set print asm-demangle on`
: Print C++ names in their source form rather than their mangled form, even in assembler code printouts such as instruction disassemblies. The default is off.

`show print asm-demangle`
: Show whether C++ names in assembly listings are printed in mangled or demangled form.

`set demangle-style` *style*
: Choose among several encoding schemes used by different compilers to represent C++ names. The choices for *style* are currently:

  `auto`
  : Allow GDB to choose a decoding style by inspecting your program. This is the default.

`gnu` Decode based on the GNU C++ compiler (`g++`) encoding algorithm.

`hp` Decode based on the HP ANSI C++ (`aCC`) encoding algorithm.

`lucid` Decode based on the Lucid C++ compiler (`lcc`) encoding algorithm.

`arm` Decode using the algorithm in the *C++ Annotated Reference Manual*. **Warning:** this setting alone is not sufficient to allow debugging `cfront`-generated executables. GDB would require further enhancement to permit that.

If you omit *style*, you will see a list of possible formats.

`show demangle-style`
Display the encoding style currently in use for decoding C++ symbols.

`set print object`
`set print object on`
When displaying a pointer to an object, identify the *actual* (derived) type of the object rather than the *declared* type, using the virtual function table. Note that the virtual function table is required—this feature can only work for objects that have run-time type identification; a single virtual method in the object's declared type is sufficient. Note that this setting is also taken into account when working with variable objects via MI (see Chapter 27 [GDB/MI], page 365).

`set print object off`
Display only the declared type of objects, without reference to the virtual function table. This is the default setting.

`show print object`
Show whether actual, or declared, object types are displayed.

`set print static-members`
`set print static-members on`
Print static members when displaying a C++ object. The default is on.

`set print static-members off`
Do not print static members when displaying a C++ object.

`show print static-members`
Show whether C++ static members are printed or not.

`set print pascal_static-members`
`set print pascal_static-members on`
Print static members when displaying a Pascal object. The default is on.

`set print pascal_static-members off`
Do not print static members when displaying a Pascal object.

`show print pascal_static-members`
Show whether Pascal static members are printed or not.

`set print vtbl`
`set print vtbl on`
Pretty print C++ virtual function tables. The default is off. (The `vtbl` commands do not work on programs compiled with the HP ANSI C++ compiler (`aCC`).)

`set print vtbl off`
: Do not pretty print C++ virtual function tables.

`show print vtbl`
: Show whether C++ virtual function tables are pretty printed, or not.

10.9 Pretty Printing

GDB provides a mechanism to allow pretty-printing of values using Python code. It greatly simplifies the display of complex objects. This mechanism works for both MI and the CLI.

10.9.1 Pretty-Printer Introduction

When GDB prints a value, it first sees if there is a pretty-printer registered for the value. If there is then GDB invokes the pretty-printer to print the value. Otherwise the value is printed normally.

Pretty-printers are normally named. This makes them easy to manage. The '`info pretty-printer`' command will list all the installed pretty-printers with their names. If a pretty-printer can handle multiple data types, then its *subprinters* are the printers for the individual data types. Each such subprinter has its own name. The format of the name is *printer-name*;*subprinter-name*.

Pretty-printers are installed by *registering* them with GDB. Typically they are automatically loaded and registered when the corresponding debug information is loaded, thus making them available without having to do anything special.

There are three places where a pretty-printer can be registered.

- Pretty-printers registered globally are available when debugging all inferiors.
- Pretty-printers registered with a program space are available only when debugging that program. See Section 23.2.2.15 [Progspaces In Python], page 332, for more details on program spaces in Python.
- Pretty-printers registered with an objfile are loaded and unloaded with the corresponding objfile (e.g., shared library). See Section 23.2.2.16 [Objfiles In Python], page 333, for more details on objfiles in Python.

See Section 23.2.2.6 [Selecting Pretty-Printers], page 318, for further information on how pretty-printers are selected,

See Section 23.2.2.7 [Writing a Pretty-Printer], page 319, for implementing pretty printers for new types.

10.9.2 Pretty-Printer Example

Here is how a C++ `std::string` looks without a pretty-printer:

```
(gdb) print s
$1 = {
  static npos = 4294967295,
  _M_dataplus = {
    <std::allocator<char>> = {
      <__gnu_cxx::new_allocator<char>> = {
        <No data fields>}, <No data fields>
      },
    members of std::basic_string<char, std::char_traits<char>,
```

```
        std::allocator<char> >::_Alloc_hider:
      _M_p = 0x804a014 "abcd"
  }
}
```

With a pretty-printer for `std::string` only the contents are printed:

```
(gdb) print s
$2 = "abcd"
```

10.9.3 Pretty-Printer Commands

`info pretty-printer [`*`object-regexp`* `[`*`name-regexp`*`]]`

Print the list of installed pretty-printers. This includes disabled pretty-printers, which are marked as such.

object-regexp is a regular expression matching the objects whose pretty-printers to list. Objects can be `global`, the program space's file (see Section 23.2.2.15 [Progspaces In Python], page 332), and the object files within that program space (see Section 23.2.2.16 [Objfiles In Python], page 333). See Section 23.2.2.6 [Selecting Pretty-Printers], page 318, for details on how GDB looks up a printer from these three objects.

name-regexp is a regular expression matching the name of the printers to list.

`disable pretty-printer [`*`object-regexp`* `[`*`name-regexp`*`]]`

Disable pretty-printers matching *object-regexp* and *name-regexp*. A disabled pretty-printer is not forgotten, it may be enabled again later.

`enable pretty-printer [`*`object-regexp`* `[`*`name-regexp`*`]]`

Enable pretty-printers matching *object-regexp* and *name-regexp*.

Example:

Suppose we have three pretty-printers installed: one from library1.so named `foo` that prints objects of type `foo`, and another from library2.so named `bar` that prints two types of objects, `bar1` and `bar2`.

```
(gdb) info pretty-printer
library1.so:
  foo
library2.so:
  bar
    bar1
    bar2
(gdb) info pretty-printer library2
library2.so:
  bar
    bar1
    bar2
(gdb) disable pretty-printer library1
1 printer disabled
2 of 3 printers enabled
(gdb) info pretty-printer
library1.so:
  foo [disabled]
library2.so:
  bar
    bar1
```

```
    bar2
(gdb) disable pretty-printer library2 bar:bar1
1 printer disabled
1 of 3 printers enabled
(gdb) info pretty-printer library2
library1.so:
  foo [disabled]
library2.so:
  bar
    bar1 [disabled]
    bar2
(gdb) disable pretty-printer library2 bar
1 printer disabled
0 of 3 printers enabled
(gdb) info pretty-printer library2
library1.so:
  foo [disabled]
library2.so:
  bar [disabled]
    bar1 [disabled]
    bar2
```

Note that for `bar` the entire printer can be disabled, as can each individual subprinter.

10.10 Value History

Values printed by the `print` command are saved in the GDB *value history*. This allows you to refer to them in other expressions. Values are kept until the symbol table is re-read or discarded (for example with the `file` or `symbol-file` commands). When the symbol table changes, the value history is discarded, since the values may contain pointers back to the types defined in the symbol table.

The values printed are given *history numbers* by which you can refer to them. These are successive integers starting with one. `print` shows you the history number assigned to a value by printing '`$`*num* `= `' before the value; here *num* is the history number.

To refer to any previous value, use '`$`' followed by the value's history number. The way `print` labels its output is designed to remind you of this. Just `$` refers to the most recent value in the history, and `$$` refers to the value before that. `$$`*n* refers to the *n*th value from the end; `$$2` is the value just prior to `$$`, `$$1` is equivalent to `$$`, and `$$0` is equivalent to `$`.

For example, suppose you have just printed a pointer to a structure and want to see the contents of the structure. It suffices to type

```
p *$
```

If you have a chain of structures where the component `next` points to the next one, you can print the contents of the next one with this:

```
p *$.next
```

You can print successive links in the chain by repeating this command—which you can do by just typing RET.

Note that the history records values, not expressions. If the value of `x` is 4 and you type these commands:

```
print x
set x=5
```

then the value recorded in the value history by the `print` command remains 4 even though the value of `x` has changed.

`show values`
: Print the last ten values in the value history, with their item numbers. This is like '`p $$9`' repeated ten times, except that `show values` does not change the history.

`show values` *n*
: Print ten history values centered on history item number *n*.

`show values +`
: Print ten history values just after the values last printed. If no more values are available, `show values +` produces no display.

Pressing RET to repeat `show values` *n* has exactly the same effect as '`show values +`'.

10.11 Convenience Variables

GDB provides *convenience variables* that you can use within GDB to hold on to a value and refer to it later. These variables exist entirely within GDB; they are not part of your program, and setting a convenience variable has no direct effect on further execution of your program. That is why you can use them freely.

Convenience variables are prefixed with '`$`'. Any name preceded by '`$`' can be used for a convenience variable, unless it is one of the predefined machine-specific register names (see Section 10.13 [Registers], page 128). (Value history references, in contrast, are *numbers* preceded by '`$`'. See Section 10.10 [Value History], page 125.)

You can save a value in a convenience variable with an assignment expression, just as you would set a variable in your program. For example:

```
set $foo = *object_ptr
```

would save in `$foo` the value contained in the object pointed to by `object_ptr`.

Using a convenience variable for the first time creates it, but its value is `void` until you assign a new value. You can alter the value with another assignment at any time.

Convenience variables have no fixed types. You can assign a convenience variable any type of value, including structures and arrays, even if that variable already has a value of a different type. The convenience variable, when used as an expression, has the type of its current value.

`show convenience`
: Print a list of convenience variables used so far, and their values, as well as a list of the convenience functions. Abbreviated `show conv`.

`init-if-undefined` `$`*variable* `=` *expression*
: Set a convenience variable if it has not already been set. This is useful for user-defined commands that keep some state. It is similar, in concept, to using local static variables with initializers in C (except that convenience variables are global). It can also be used to allow users to override default values used in a command script.

  If the variable is already defined then the expression is not evaluated so any side-effects do not occur.

One of the ways to use a convenience variable is as a counter to be incremented or a pointer to be advanced. For example, to print a field from successive elements of an array of structures:

```
set $i = 0
print bar[$i++]->contents
```

Repeat that command by typing RET.

Some convenience variables are created automatically by GDB and given values likely to be useful.

`$_` The variable `$_` is automatically set by the `x` command to the last address examined (see Section 10.6 [Examining Memory], page 111). Other commands which provide a default address for `x` to examine also set `$_` to that address; these commands include `info line` and `info breakpoint`. The type of `$_` is `void *` except when set by the `x` command, in which case it is a pointer to the type of `$__`.

`$__` The variable `$__` is automatically set by the `x` command to the value found in the last address examined. Its type is chosen to match the format in which the data was printed.

`$_exitcode`
The variable `$_exitcode` is automatically set to the exit code when the program being debugged terminates.

`$_probe_argc`
`$_probe_arg0...$_probe_arg11`
Arguments to a static probe. See Section 5.1.10 [Static Probe Points], page 63.

`$_sdata` The variable `$_sdata` contains extra collected static tracepoint data. See Section 13.1.6 [Tracepoint Action Lists], page 154. Note that `$_sdata` could be empty, if not inspecting a trace buffer, or if extra static tracepoint data has not been collected.

`$_siginfo`
The variable `$_siginfo` contains extra signal information (see [extra signal information], page 71). Note that `$_siginfo` could be empty, if the application has not yet received any signals. For example, it will be empty before you execute the `run` command.

`$_tlb` The variable `$_tlb` is automatically set when debugging applications running on MS-Windows in native mode or connected to gdbserver that supports the `qGetTIBAddr` request. See Section E.4 [General Query Packets], page 516. This variable contains the address of the thread information block.

On HP-UX systems, if you refer to a function or variable name that begins with a dollar sign, GDB searches for a user or system name first, before it searches for a convenience variable.

10.12 Convenience Functions

GDB also supplies some *convenience functions*. These have a syntax similar to convenience variables. A convenience function can be used in an expression just like an ordinary function; however, a convenience function is implemented internally to GDB.

These functions require GDB to be configured with `Python` support.

`$_memeq(`*buf1*`, `*buf2*`, `*length*`)`
: Returns one if the *length* bytes at the addresses given by *buf1* and *buf2* are equal. Otherwise it returns zero.

`$_regex(`*str*`, `*regex*`)`
: Returns one if the string *str* matches the regular expression *regex*. Otherwise it returns zero. The syntax of the regular expression is that specified by `Python`'s regular expression support.

`$_streq(`*str1*`, `*str2*`)`
: Returns one if the strings *str1* and *str2* are equal. Otherwise it returns zero.

`$_strlen(`*str*`)`
: Returns the length of string *str*.

GDB provides the ability to list and get help on convenience functions.

`help function`
: Print a list of all convenience functions.

10.13 Registers

You can refer to machine register contents, in expressions, as variables with names starting with '`$`'. The names of registers are different for each machine; use `info registers` to see the names used on your machine.

`info registers`
: Print the names and values of all registers except floating-point and vector registers (in the selected stack frame).

`info all-registers`
: Print the names and values of all registers, including floating-point and vector registers (in the selected stack frame).

`info registers `*regname* `...`
: Print the *relativized* value of each specified register *regname*. As discussed in detail below, register values are normally relative to the selected stack frame. *regname* may be any register name valid on the machine you are using, with or without the initial '`$`'.

GDB has four "standard" register names that are available (in expressions) on most machines—whenever they do not conflict with an architecture's canonical mnemonics for registers. The register names `$pc` and `$sp` are used for the program counter register and the stack pointer. `$fp` is used for a register that contains a pointer to the current stack frame, and `$ps` is used for a register that contains the processor status. For example, you could print the program counter in hex with

```
p/x $pc
```

or print the instruction to be executed next with

```
x/i $pc
```

or add four to the stack pointer[2] with

```
set $sp += 4
```

Whenever possible, these four standard register names are available on your machine even though the machine has different canonical mnemonics, so long as there is no conflict. The `info registers` command shows the canonical names. For example, on the SPARC, `info registers` displays the processor status register as `$psr` but you can also refer to it as `$ps`; and on x86-based machines `$ps` is an alias for the EFLAGS register.

GDB always considers the contents of an ordinary register as an integer when the register is examined in this way. Some machines have special registers which can hold nothing but floating point; these registers are considered to have floating point values. There is no way to refer to the contents of an ordinary register as floating point value (although you can *print* it as a floating point value with '`print/f $regname`').

Some registers have distinct "raw" and "virtual" data formats. This means that the data format in which the register contents are saved by the operating system is not the same one that your program normally sees. For example, the registers of the 68881 floating point coprocessor are always saved in "extended" (raw) format, but all C programs expect to work with "double" (virtual) format. In such cases, GDB normally works with the virtual format only (the format that makes sense for your program), but the `info registers` command prints the data in both formats.

Some machines have special registers whose contents can be interpreted in several different ways. For example, modern x86-based machines have SSE and MMX registers that can hold several values packed together in several different formats. GDB refers to such registers in `struct` notation:

```
(gdb) print $xmm1
$1 = {
  v4_float = {0, 3.43859137e-038, 1.54142831e-044, 1.821688e-044},
  v2_double = {9.92129282474342e-303, 2.7585945287983262e-313},
  v16_int8 = "\000\000\000\000\3706;\001\v\000\000\000\r\000\000",
  v8_int16 = {0, 0, 14072, 315, 11, 0, 13, 0},
  v4_int32 = {0, 20657912, 11, 13},
  v2_int64 = {88725056443645952, 55834574859},
  uint128 = 0x0000000d0000000b013b36f800000000
}
```

To set values of such registers, you need to tell GDB which view of the register you wish to change, as if you were assigning value to a `struct` member:

```
(gdb) set $xmm1.uint128 = 0x00000000000000000000000FFFFFFFF
```

Normally, register values are relative to the selected stack frame (see Section 8.3 [Selecting a Frame], page 90). This means that you get the value that the register would contain if all stack frames farther in were exited and their saved registers restored. In order to see the true contents of hardware registers, you must select the innermost frame (with '`frame 0`').

However, GDB must deduce where registers are saved, from the machine code generated by your compiler. If some registers are not saved, or if GDB is unable to locate the saved registers, the selected stack frame makes no difference.

[2] This is a way of removing one word from the stack, on machines where stacks grow downward in memory (most machines, nowadays). This assumes that the innermost stack frame is selected; setting `$sp` is not allowed when other stack frames are selected. To pop entire frames off the stack, regardless of machine architecture, use `return`; see Section 17.4 [Returning from a Function], page 211.

10.14 Floating Point Hardware

Depending on the configuration, GDB may be able to give you more information about the status of the floating point hardware.

`info float`
: Display hardware-dependent information about the floating point unit. The exact contents and layout vary depending on the floating point chip. Currently, '`info float`' is supported on the ARM and x86 machines.

10.15 Vector Unit

Depending on the configuration, GDB may be able to give you more information about the status of the vector unit.

`info vector`
: Display information about the vector unit. The exact contents and layout vary depending on the hardware.

10.16 Operating System Auxiliary Information

GDB provides interfaces to useful OS facilities that can help you debug your program.

Some operating systems supply an *auxiliary vector* to programs at startup. This is akin to the arguments and environment that you specify for a program, but contains a system-dependent variety of binary values that tell system libraries important details about the hardware, operating system, and process. Each value's purpose is identified by an integer tag; the meanings are well-known but system-specific. Depending on the configuration and operating system facilities, GDB may be able to show you this information. For remote targets, this functionality may further depend on the remote stub's support of the '`qXfer:auxv:read`' packet, see [qXfer auxiliary vector read], page 530.

`info auxv` Display the auxiliary vector of the inferior, which can be either a live process or a core dump file. GDB prints each tag value numerically, and also shows names and text descriptions for recognized tags. Some values in the vector are numbers, some bit masks, and some pointers to strings or other data. GDB displays each value in the most appropriate form for a recognized tag, and in hexadecimal for an unrecognized tag.

On some targets, GDB can access operating system-specific information and show it to you. The types of information available will differ depending on the type of operating system running on the target. The mechanism used to fetch the data is described in Appendix H [Operating System Information], page 585. For remote targets, this functionality depends on the remote stub's support of the '`qXfer:osdata:read`' packet, see [qXfer osdata read], page 532.

`info os` *infotype*
: Display OS information of the requested type.

  On GNU/Linux, the following values of *infotype* are valid:

  `processes`
  : Display the list of processes on the target. For each process, GDB prints the process identifier, the name of the user, the command

corresponding to the process, and the list of processor cores that the process is currently running on. (To understand what these properties mean, for this and the following info types, please consult the general GNU/Linux documentation.)

`procgroups`
: Display the list of process groups on the target. For each process, GDB prints the identifier of the process group that it belongs to, the command corresponding to the process group leader, the process identifier, and the command line of the process. The list is sorted first by the process group identifier, then by the process identifier, so that processes belonging to the same process group are grouped together and the process group leader is listed first.

`threads`
: Display the list of threads running on the target. For each thread, GDB prints the identifier of the process that the thread belongs to, the command of the process, the thread identifier, and the processor core that it is currently running on. The main thread of a process is not listed.

`files`
: Display the list of open file descriptors on the target. For each file descriptor, GDB prints the identifier of the process owning the descriptor, the command of the owning process, the value of the descriptor, and the target of the descriptor.

`sockets`
: Display the list of Internet-domain sockets on the target. For each socket, GDB prints the address and port of the local and remote endpoints, the current state of the connection, the creator of the socket, the IP address family of the socket, and the type of the connection.

`shm`
: Display the list of all System V shared-memory regions on the target. For each shared-memory region, GDB prints the region key, the shared-memory identifier, the access permissions, the size of the region, the process that created the region, the process that last attached to or detached from the region, the current number of live attaches to the region, and the times at which the region was last attached to, detach from, and changed.

`semaphores`
: Display the list of all System V semaphore sets on the target. For each semaphore set, GDB prints the semaphore set key, the semaphore set identifier, the access permissions, the number of semaphores in the set, the user and group of the owner and creator of the semaphore set, and the times at which the semaphore set was operated upon and changed.

`msg`
: Display the list of all System V message queues on the target. For each message queue, GDB prints the message queue key, the message queue identifier, the access permissions, the current number of bytes on the queue, the current number of messages on the queue, the

processes that last sent and received a message on the queue, the user and group of the owner and creator of the message queue, the times at which a message was last sent and received on the queue, and the time at which the message queue was last changed.

`modules` Display the list of all loaded kernel modules on the target. For each module, GDB prints the module name, the size of the module in bytes, the number of times the module is used, the dependencies of the module, the status of the module, and the address of the loaded module in memory.

`info os` If *infotype* is omitted, then list the possible values for *infotype* and the kind of OS information available for each *infotype*. If the target does not return a list of possible types, this command will report an error.

10.17 Memory Region Attributes

Memory region attributes allow you to describe special handling required by regions of your target's memory. GDB uses attributes to determine whether to allow certain types of memory accesses; whether to use specific width accesses; and whether to cache target memory. By default the description of memory regions is fetched from the target (if the current target supports this), but the user can override the fetched regions.

Defined memory regions can be individually enabled and disabled. When a memory region is disabled, GDB uses the default attributes when accessing memory in that region. Similarly, if no memory regions have been defined, GDB uses the default attributes when accessing all memory.

When a memory region is defined, it is given a number to identify it; to enable, disable, or remove a memory region, you specify that number.

`mem` *lower upper attributes...*
Define a memory region bounded by *lower* and *upper* with attributes *attributes*..., and add it to the list of regions monitored by GDB. Note that *upper* == 0 is a special case: it is treated as the target's maximum memory address. (0xffff on 16 bit targets, 0xffffffff on 32 bit targets, etc.)

`mem auto` Discard any user changes to the memory regions and use target-supplied regions, if available, or no regions if the target does not support.

`delete mem` *nums...*
Remove memory regions *nums*... from the list of regions monitored by GDB.

`disable mem` *nums...*
Disable monitoring of memory regions *nums*.... A disabled memory region is not forgotten. It may be enabled again later.

`enable mem` *nums...*
Enable monitoring of memory regions *nums*....

`info mem` Print a table of all defined memory regions, with the following columns for each region:

Memory Region Number
Enabled or Disabled.
: Enabled memory regions are marked with '`y`'. Disabled memory regions are marked with '`n`'.

Lo Address
: The address defining the inclusive lower bound of the memory region.

Hi Address
: The address defining the exclusive upper bound of the memory region.

Attributes
: The list of attributes set for this memory region.

10.17.1 Attributes

10.17.1.1 Memory Access Mode

The access mode attributes set whether GDB may make read or write accesses to a memory region.

While these attributes prevent GDB from performing invalid memory accesses, they do nothing to prevent the target system, I/O DMA, etc. from accessing memory.

`ro`
: Memory is read only.

`wo`
: Memory is write only.

`rw`
: Memory is read/write. This is the default.

10.17.1.2 Memory Access Size

The access size attribute tells GDB to use specific sized accesses in the memory region. Often memory mapped device registers require specific sized accesses. If no access size attribute is specified, GDB may use accesses of any size.

`8`
: Use 8 bit memory accesses.

`16`
: Use 16 bit memory accesses.

`32`
: Use 32 bit memory accesses.

`64`
: Use 64 bit memory accesses.

10.17.1.3 Data Cache

The data cache attributes set whether GDB will cache target memory. While this generally improves performance by reducing debug protocol overhead, it can lead to incorrect results because GDB does not know about volatile variables or memory mapped device registers.

`cache`
: Enable GDB to cache target memory.

`nocache`
: Disable GDB from caching target memory. This is the default.

10.17.2 Memory Access Checking

GDB can be instructed to refuse accesses to memory that is not explicitly described. This can be useful if accessing such regions has undesired effects for a specific target, or to provide better error checking. The following commands control this behaviour.

`set mem inaccessible-by-default [on|off]`
: If `on` is specified, make GDB treat memory not explicitly described by the memory ranges as non-existent and refuse accesses to such memory. The checks are only performed if there's at least one memory range defined. If `off` is specified, make GDB treat the memory not explicitly described by the memory ranges as RAM. The default value is `on`.

`show mem inaccessible-by-default`
: Show the current handling of accesses to unknown memory.

10.18 Copy Between Memory and a File

You can use the commands `dump`, `append`, and `restore` to copy data between target memory and a file. The `dump` and `append` commands write data to a file, and the `restore` command reads data from a file back into the inferior's memory. Files may be in binary, Motorola S-record, Intel hex, or Tektronix Hex format; however, GDB can only append to binary files.

`dump` [*format*] `memory` *filename start_addr end_addr*
`dump` [*format*] `value` *filename expr*
: Dump the contents of memory from *start_addr* to *end_addr*, or the value of *expr*, to *filename* in the given format.

  The *format* parameter may be any one of:

  `binary` Raw binary form.

  `ihex` Intel hex format.

  `srec` Motorola S-record format.

  `tekhex` Tektronix Hex format.

  GDB uses the same definitions of these formats as the GNU binary utilities, like '`objdump`' and '`objcopy`'. If *format* is omitted, GDB dumps the data in raw binary form.

`append` [`binary`] `memory` *filename start_addr end_addr*
`append` [`binary`] `value` *filename expr*
: Append the contents of memory from *start_addr* to *end_addr*, or the value of *expr*, to the file *filename*, in raw binary form. (GDB can only append data to files in raw binary form.)

`restore` *filename* [`binary`] *bias start end*
: Restore the contents of file *filename* into memory. The `restore` command can automatically recognize any known BFD file format, except for raw binary. To restore a raw binary file you must specify the optional keyword `binary` after the filename.

  If *bias* is non-zero, its value will be added to the addresses contained in the file. Binary files always start at address zero, so they will be restored at address

bias. Other bfd files have a built-in location; they will be restored at offset *bias* from that location.

If *start* and/or *end* are non-zero, then only data between file offset *start* and file offset *end* will be restored. These offsets are relative to the addresses in the file, before the *bias* argument is applied.

10.19 How to Produce a Core File from Your Program

A *core file* or *core dump* is a file that records the memory image of a running process and its process status (register values etc.). Its primary use is post-mortem debugging of a program that crashed while it ran outside a debugger. A program that crashes automatically produces a core file, unless this feature is disabled by the user. See Section 18.1 [Files], page 215, for information on invoking GDB in the post-mortem debugging mode.

Occasionally, you may wish to produce a core file of the program you are debugging in order to preserve a snapshot of its state. GDB has a special command for that.

`generate-core-file [file]`
`gcore [file]`

Produce a core dump of the inferior process. The optional argument *file* specifies the file name where to put the core dump. If not specified, the file name defaults to '`core.pid`', where *pid* is the inferior process ID.

Note that this command is implemented only for some systems (as of this writing, GNU/Linux, FreeBSD, Solaris, and S390).

10.20 Character Sets

If the program you are debugging uses a different character set to represent characters and strings than the one GDB uses itself, GDB can automatically translate between the character sets for you. The character set GDB uses we call the *host character set*; the one the inferior program uses we call the *target character set*.

For example, if you are running GDB on a GNU/Linux system, which uses the ISO Latin 1 character set, but you are using GDB's remote protocol (see Chapter 20 [Remote Debugging], page 235) to debug a program running on an IBM mainframe, which uses the EBCDIC character set, then the host character set is Latin-1, and the target character set is EBCDIC. If you give GDB the command `set target-charset EBCDIC-US`, then GDB translates between EBCDIC and Latin 1 as you print character or string values, or use character and string literals in expressions.

GDB has no way to automatically recognize which character set the inferior program uses; you must tell it, using the `set target-charset` command, described below.

Here are the commands for controlling GDB's character set support:

`set target-charset charset`

Set the current target character set to *charset*. To display the list of supported target character sets, type `set target-charset TABTAB`.

`set host-charset charset`

Set the current host character set to *charset*.

By default, GDB uses a host character set appropriate to the system it is running on; you can override that default using the `set host-charset` command. On some systems, GDB cannot automatically determine the appropriate host character set. In this case, GDB uses '`UTF-8`'.

GDB can only use certain character sets as its host character set. If you type *`set host-charset TABTAB`*, GDB will list the host character sets it supports.

`set charset` *`charset`*
: Set the current host and target character sets to *charset*. As above, if you type *`set charset TABTAB`*, GDB will list the names of the character sets that can be used for both host and target.

`show charset`
: Show the names of the current host and target character sets.

`show host-charset`
: Show the name of the current host character set.

`show target-charset`
: Show the name of the current target character set.

`set target-wide-charset` *`charset`*
: Set the current target's wide character set to *charset*. This is the character set used by the target's `wchar_t` type. To display the list of supported wide character sets, type *`set target-wide-charset TABTAB`*.

`show target-wide-charset`
: Show the name of the current target's wide character set.

Here is an example of GDB's character set support in action. Assume that the following source code has been placed in the file '`charset-test.c`':

```
#include <stdio.h>

char ascii_hello[]
  = {72, 101, 108, 108, 111, 44, 32, 119,
     111, 114, 108, 100, 33, 10, 0};
char ibm1047_hello[]
  = {200, 133, 147, 147, 150, 107, 64, 166,
     150, 153, 147, 132, 90, 37, 0};

main ()
{
  printf ("Hello, world!\n");
}
```

In this program, `ascii_hello` and `ibm1047_hello` are arrays containing the string '`Hello, world!`' followed by a newline, encoded in the ASCII and IBM1047 character sets.

We compile the program, and invoke the debugger on it:

```
$ gcc -g charset-test.c -o charset-test
$ gdb -nw charset-test
GNU gdb 2001-12-19-cvs
Copyright 2001 Free Software Foundation, Inc.
...
(gdb)
```

We can use the `show charset` command to see what character sets GDB is currently using to interpret and display characters and strings:

```
(gdb) show charset
The current host and target character set is ‘ISO-8859-1’.
(gdb)
```

For the sake of printing this manual, let's use ASCII as our initial character set:

```
(gdb) set charset ASCII
(gdb) show charset
The current host and target character set is ‘ASCII’.
(gdb)
```

Let's assume that ASCII is indeed the correct character set for our host system — in other words, let's assume that if GDB prints characters using the ASCII character set, our terminal will display them properly. Since our current target character set is also ASCII, the contents of `ascii_hello` print legibly:

```
(gdb) print ascii_hello
$1 = 0x401698 "Hello, world!\n"
(gdb) print ascii_hello[0]
$2 = 72 'H'
(gdb)
```

GDB uses the target character set for character and string literals you use in expressions:

```
(gdb) print '+'
$3 = 43 '+'
(gdb)
```

The ASCII character set uses the number 43 to encode the '+' character.

GDB relies on the user to tell it which character set the target program uses. If we print `ibm1047_hello` while our target character set is still ASCII, we get jibberish:

```
(gdb) print ibm1047_hello
$4 = 0x4016a8 "\310\205\223\223\226k@\246\226\231\223\204Z%"
(gdb) print ibm1047_hello[0]
$5 = 200 '\310'
(gdb)
```

If we invoke the `set target-charset` followed by TABTAB, GDB tells us the character sets it supports:

```
(gdb) set target-charset
ASCII       EBCDIC-US   IBM1047     ISO-8859-1
(gdb) set target-charset
```

We can select IBM1047 as our target character set, and examine the program's strings again. Now the ASCII string is wrong, but GDB translates the contents of `ibm1047_hello` from the target character set, IBM1047, to the host character set, ASCII, and they display correctly:

```
(gdb) set target-charset IBM1047
(gdb) show charset
The current host character set is ‘ASCII’.
The current target character set is ‘IBM1047’.
(gdb) print ascii_hello
$6 = 0x401698 "\110\145%%?\054\040\167?\162%\144\041\012"
(gdb) print ascii_hello[0]
$7 = 72 '\110'
(gdb) print ibm1047_hello
$8 = 0x4016a8 "Hello, world!\n"
(gdb) print ibm1047_hello[0]
```

```
$9 = 200 'H'
(gdb)
```

As above, GDB uses the target character set for character and string literals you use in expressions:

```
(gdb) print '+'
$10 = 78 '+'
(gdb)
```

The IBM1047 character set uses the number 78 to encode the '+' character.

10.21 Caching Data of Remote Targets

GDB caches data exchanged between the debugger and a remote target (see Chapter 20 [Remote Debugging], page 235). Such caching generally improves performance, because it reduces the overhead of the remote protocol by bundling memory reads and writes into large chunks. Unfortunately, simply caching everything would lead to incorrect results, since GDB does not necessarily know anything about volatile values, memory-mapped I/O addresses, etc. Furthermore, in non-stop mode (see Section 5.5.2 [Non-Stop Mode], page 74) memory can be changed *while* a gdb command is executing. Therefore, by default, GDB only caches data known to be on the stack[3]. Other regions of memory can be explicitly marked as cacheable; see see Section 10.17 [Memory Region Attributes], page 132.

`set remotecache on`
`set remotecache off`
: This option no longer does anything; it exists for compatibility with old scripts.

`show remotecache`
: Show the current state of the obsolete remotecache flag.

`set stack-cache on`
`set stack-cache off`
: Enable or disable caching of stack accesses. When `ON`, use caching. By default, this option is `ON`.

`show stack-cache`
: Show the current state of data caching for memory accesses.

`info dcache` [`line`]
: Print the information about the data cache performance. The information displayed includes the dcache width and depth, and for each cache line, its number, address, and how many times it was referenced. This command is useful for debugging the data cache operation.

  If a line number is specified, the contents of that line will be printed in hex.

`set dcache size` *`size`*
: Set maximum number of entries in dcache (dcache depth above).

`set dcache line-size` *`line-size`*
: Set number of bytes each dcache entry caches (dcache width above). Must be a power of 2.

[3] In non-stop mode, it is moderately rare for a running thread to modify the stack of a stopped thread in a way that would interfere with a backtrace, and caching of stack reads provides a significant speed up of remote backtraces.

`show dcache size`
: Show maximum number of dcache entries. See also Section 10.21 [Caching Remote Data], page 138.

`show dcache line-size`
: Show default size of dcache lines. See also Section 10.21 [Caching Remote Data], page 138.

10.22 Search Memory

Memory can be searched for a particular sequence of bytes with the `find` command.

`find` [`/`*sn*] *start_addr*`, +`*len*`,` *val1* [`,` *val2*`, ...`]
`find` [`/`*sn*] *start_addr*`,` *end_addr*`,` *val1* [`,` *val2*`, ...`]
: Search memory for the sequence of bytes specified by *val1*, *val2*, etc. The search begins at address *start_addr* and continues for either *len* bytes or through to *end_addr* inclusive.

s and *n* are optional parameters. They may be specified in either order, apart or together.

s, search query size
: The size of each search query value.

  `b` bytes

  `h` halfwords (two bytes)

  `w` words (four bytes)

  `g` giant words (eight bytes)

  All values are interpreted in the current language. This means, for example, that if the current source language is C/C++ then searching for the string "hello" includes the trailing '\0'.

  If the value size is not specified, it is taken from the value's type in the current language. This is useful when one wants to specify the search pattern as a mixture of types. Note that this means, for example, that in the case of C-like languages a search for an untyped 0x42 will search for '`(int) 0x42`' which is typically four bytes.

n, maximum number of finds
: The maximum number of matches to print. The default is to print all finds.

You can use strings as search values. Quote them with double-quotes (`"`). The string value is copied into the search pattern byte by byte, regardless of the endianness of the target and the size specification.

The address of each match found is printed as well as a count of the number of matches found.

The address of the last value found is stored in convenience variable '`$_`'. A count of the number of matches is stored in '`$numfound`'.

For example, if stopped at the `printf` in this function:

```
void
hello ()
{
  static char hello[] = "hello-hello";
  static struct { char c; short s; int i; }
    __attribute__ ((packed)) mixed
    = { 'c', 0x1234, 0x87654321 };
  printf ("%s\n", hello);
}
```

you get during debugging:

```
(gdb) find &hello[0], +sizeof(hello), "hello"
0x804956d <hello.1620+6>
1 pattern found
(gdb) find &hello[0], +sizeof(hello), 'h', 'e', 'l', 'l', 'o'
0x8049567 <hello.1620>
0x804956d <hello.1620+6>
2 patterns found
(gdb) find /b1 &hello[0], +sizeof(hello), 'h', 0x65, 'l'
0x8049567 <hello.1620>
1 pattern found
(gdb) find &mixed, +sizeof(mixed), (char) 'c', (short) 0x1234, (int) 0x87654321
0x8049560 <mixed.1625>
1 pattern found
(gdb) print $numfound
$1 = 1
(gdb) print $_
$2 = (void *) 0x8049560
```

11 Debugging Optimized Code

Almost all compilers support optimization. With optimization disabled, the compiler generates assembly code that corresponds directly to your source code, in a simplistic way. As the compiler applies more powerful optimizations, the generated assembly code diverges from your original source code. With help from debugging information generated by the compiler, GDB can map from the running program back to constructs from your original source.

GDB is more accurate with optimization disabled. If you can recompile without optimization, it is easier to follow the progress of your program during debugging. But, there are many cases where you may need to debug an optimized version.

When you debug a program compiled with '`-g -O`', remember that the optimizer has rearranged your code; the debugger shows you what is really there. Do not be too surprised when the execution path does not exactly match your source file! An extreme example: if you define a variable, but never use it, GDB never sees that variable—because the compiler optimizes it out of existence.

Some things do not work as well with '`-g -O`' as with just '`-g`', particularly on machines with instruction scheduling. If in doubt, recompile with '`-g`' alone, and if this fixes the problem, please report it to us as a bug (including a test case!). See Section 10.3 [Variables], page 107, for more information about debugging optimized code.

11.1 Inline Functions

Inlining is an optimization that inserts a copy of the function body directly at each call site, instead of jumping to a shared routine. GDB displays inlined functions just like non-inlined functions. They appear in backtraces. You can view their arguments and local variables, step into them with `step`, skip them with `next`, and escape from them with `finish`. You can check whether a function was inlined by using the `info frame` command.

For GDB to support inlined functions, the compiler must record information about inlining in the debug information — GCC using the DWARF 2 format does this, and several other compilers do also. GDB only supports inlined functions when using DWARF 2. Versions of GCC before 4.1 do not emit two required attributes ('`DW_AT_call_file`' and '`DW_AT_call_line`'); GDB does not display inlined function calls with earlier versions of GCC. It instead displays the arguments and local variables of inlined functions as local variables in the caller.

The body of an inlined function is directly included at its call site; unlike a non-inlined function, there are no instructions devoted to the call. GDB still pretends that the call site and the start of the inlined function are different instructions. Stepping to the call site shows the call site, and then stepping again shows the first line of the inlined function, even though no additional instructions are executed.

This makes source-level debugging much clearer; you can see both the context of the call and then the effect of the call. Only stepping by a single instruction using `stepi` or `nexti` does not do this; single instruction steps always show the inlined body.

There are some ways that GDB does not pretend that inlined function calls are the same as normal calls:

- Setting breakpoints at the call site of an inlined function may not work, because the call site does not contain any code. GDB may incorrectly move the breakpoint to the next line of the enclosing function, after the call. This limitation will be removed in a future version of GDB; until then, set a breakpoint on an earlier line or inside the inlined function instead.
- GDB cannot locate the return value of inlined calls after using the `finish` command. This is a limitation of compiler-generated debugging information; after `finish`, you can step to the next line and print a variable where your program stored the return value.

11.2 Tail Call Frames

Function `B` can call function `C` in its very last statement. In unoptimized compilation the call of `C` is immediately followed by return instruction at the end of `B` code. Optimizing compiler may replace the call and return in function `B` into one jump to function `C` instead. Such use of a jump instruction is called *tail call*.

During execution of function `C`, there will be no indication in the function call stack frames that it was tail-called from `B`. If function `A` regularly calls function `B` which tail-calls function `C`, then GDB will see `A` as the caller of `C`. However, in some cases GDB can determine that `C` was tail-called from `B`, and it will then create fictitious call frame for that, with the return address set up as if `B` called `C` normally.

This functionality is currently supported only by DWARF 2 debugging format and the compiler has to produce '`DW_TAG_GNU_call_site`' tags. With GCC, you need to specify '`-O -g`' during compilation, to get this information.

`info frame` command (see Section 8.4 [Frame Info], page 91) will indicate the tail call frame kind by text `tail call frame` such as in this sample GDB output:

```
(gdb) x/i $pc - 2
   0x40066b <b(int, double)+11>: jmp 0x400640 <c(int, double)>
(gdb) info frame
Stack level 1, frame at 0x7fffffffda30:
 rip = 0x40066d in b (amd64-entry-value.cc:59); saved rip 0x4004c5
 tail call frame, caller of frame at 0x7fffffffda30
 source language c++.
 Arglist at unknown address.
 Locals at unknown address, Previous frame's sp is 0x7fffffffda30
```

The detection of all the possible code path executions can find them ambiguous. There is no execution history stored (possible Chapter 6 [Reverse Execution], page 79 is never used for this purpose) and the last known caller could have reached the known callee by multiple different jump sequences. In such case GDB still tries to show at least all the unambiguous top tail callers and all the unambiguous bottom tail calees, if any.

`set debug entry-values`

When set to on, enables printing of analysis messages for both frame argument values at function entry and tail calls. It will show all the possible valid tail calls code paths it has considered. It will also print the intersection of them with the final unambiguous (possibly partial or even empty) code path result.

`show debug entry-values`
: Show the current state of analysis messages printing for both frame argument values at function entry and tail calls.

The analysis messages for tail calls can for example show why the virtual tail call frame for function `c` has not been recognized (due to the indirect reference by variable `x`):

```
static void __attribute__((noinline, noclone)) c (void);
void (*x) (void) = c;
static void __attribute__((noinline, noclone)) a (void) { x++; }
static void __attribute__((noinline, noclone)) c (void) { a (); }
int main (void) { x (); return 0; }

Breakpoint 1, DW_OP_GNU_entry_value resolving cannot find
DW_TAG_GNU_call_site 0x40039a in main
a () at t.c:3
3 static void __attribute__((noinline, noclone)) a (void) { x++; }
(gdb) bt
#0  a () at t.c:3
#1  0x000000000040039a in main () at t.c:5
```

Another possibility is an ambiguous virtual tail call frames resolution:

```
int i;
static void __attribute__((noinline, noclone)) f (void) { i++; }
static void __attribute__((noinline, noclone)) e (void) { f (); }
static void __attribute__((noinline, noclone)) d (void) { f (); }
static void __attribute__((noinline, noclone)) c (void) { d (); }
static void __attribute__((noinline, noclone)) b (void)
{ if (i) c (); else e (); }
static void __attribute__((noinline, noclone)) a (void) { b (); }
int main (void) { a (); return 0; }

tailcall: initial: 0x4004d2(a) 0x4004ce(b) 0x4004b2(c) 0x4004a2(d)
tailcall: compare: 0x4004d2(a) 0x4004cc(b) 0x400492(e)
tailcall: reduced: 0x4004d2(a) |
(gdb) bt
#0  f () at t.c:2
#1  0x00000000004004d2 in a () at t.c:8
#2  0x0000000000400395 in main () at t.c:9
```

Frames #0 and #2 are real, #1 is a virtual tail call frame. The code can have possible execution paths `main->a->b->c->d->f` or `main->a->b->e->f`, GDB cannot find which one from the inferior state.

`initial:` state shows some random possible calling sequence GDB has found. It then finds another possible calling sequcen - that one is prefixed by `compare:`. The non-ambiguous intersection of these two is printed as the `reduced:` calling sequence. That one could have many futher `compare:` and `reduced:` statements as long as there remain any non-ambiguous sequence entries.

For the frame of function `b` in both cases there are different possible `$pc` values (`0x4004cc` or `0x4004ce`), therefore this frame is also ambigous. The only non-ambiguous frame is the one for function `a`, therefore this one is displayed to the user while the ambiguous frames are omitted.

There can be also reasons why printing of frame argument values at function entry may fail:

```
int v;
```

```
static void __attribute__((noinline, noclone)) c (int i) { v++; }
static void __attribute__((noinline, noclone)) a (int i);
static void __attribute__((noinline, noclone)) b (int i) { a (i); }
static void __attribute__((noinline, noclone)) a (int i)
{ if (i) b (i - 1); else c (0); }
int main (void) { a (5); return 0; }

(gdb) bt
#0  c (i=i@entry=0) at t.c:2
#1  0x0000000000400428 in a (DW_OP_GNU_entry_value resolving has found
function "a" at 0x400420 can call itself via tail calls
i=<optimized out>) at t.c:6
#2  0x000000000040036e in main () at t.c:7
```

GDB cannot find out from the inferior state if and how many times did function `a` call itself (via function `b`) as these calls would be tail calls. Such tail calls would modify thue `i` variable, therefore GDB cannot be sure the value it knows would be right - GDB prints `<optimized out>` instead.

12 C Preprocessor Macros

Some languages, such as C and C++, provide a way to define and invoke "preprocessor macros" which expand into strings of tokens. GDB can evaluate expressions containing macro invocations, show the result of macro expansion, and show a macro's definition, including where it was defined.

You may need to compile your program specially to provide GDB with information about preprocessor macros. Most compilers do not include macros in their debugging information, even when you compile with the '`-g`' flag. See Section 4.1 [Compilation], page 25.

A program may define a macro at one point, remove that definition later, and then provide a different definition after that. Thus, at different points in the program, a macro may have different definitions, or have no definition at all. If there is a current stack frame, GDB uses the macros in scope at that frame's source code line. Otherwise, GDB uses the macros in scope at the current listing location; see Section 9.1 [List], page 93.

Whenever GDB evaluates an expression, it always expands any macro invocations present in the expression. GDB also provides the following commands for working with macros explicitly.

`macro expand` *`expression`*
`macro exp` *`expression`*
: Show the results of expanding all preprocessor macro invocations in *expression*. Since GDB simply expands macros, but does not parse the result, *expression* need not be a valid expression; it can be any string of tokens.

`macro expand-once` *`expression`*
`macro exp1` *`expression`*
: *(This command is not yet implemented.)* Show the results of expanding those preprocessor macro invocations that appear explicitly in *expression*. Macro invocations appearing in that expansion are left unchanged. This command allows you to see the effect of a particular macro more clearly, without being confused by further expansions. Since GDB simply expands macros, but does not parse the result, *expression* need not be a valid expression; it can be any string of tokens.

`info macro [-a|-all] [--]` *`macro`*
: Show the current definition or all definitions of the named *macro*, and describe the source location or compiler command-line where that definition was established. The optional double dash is to signify the end of argument processing and the beginning of *macro* for non C-like macros where the macro may begin with a hyphen.

`info macros` *`linespec`*
: Show all macro definitions that are in effect at the location specified by *linespec*, and describe the source location or compiler command-line where those definitions were established.

`macro define` *`macro replacement-list`*
`macro define` *`macro`*`(`*`arglist`*`)` *`replacement-list`*
: Introduce a definition for a preprocessor macro named *macro*, invocations of which are replaced by the tokens given in *replacement-list*. The first form of

this command defines an "object-like" macro, which takes no arguments; the second form defines a "function-like" macro, which takes the arguments given in *arglist*.

A definition introduced by this command is in scope in every expression evaluated in GDB, until it is removed with the `macro undef` command, described below. The definition overrides all definitions for *macro* present in the program being debugged, as well as any previous user-supplied definition.

`macro undef` *macro*

Remove any user-supplied definition for the macro named *macro*. This command only affects definitions provided with the `macro define` command, described above; it cannot remove definitions present in the program being debugged.

`macro list`

List all the macros defined using the `macro define` command.

Here is a transcript showing the above commands in action. First, we show our source files:

```
$ cat sample.c
#include <stdio.h>
#include "sample.h"

#define M 42
#define ADD(x) (M + x)

main ()
{
#define N 28
  printf ("Hello, world!\n");
#undef N
  printf ("We're so creative.\n");
#define N 1729
  printf ("Goodbye, world!\n");
}
$ cat sample.h
#define Q <
$
```

Now, we compile the program using the GNU C compiler, GCC. We pass the '`-gdwarf-2`'[1] *and* '`-g3`' flags to ensure the compiler includes information about preprocessor macros in the debugging information.

```
$ gcc -gdwarf-2 -g3 sample.c -o sample
$
```

Now, we start GDB on our sample program:

```
$ gdb -nw sample
GNU gdb 2002-05-06-cvs
Copyright 2002 Free Software Foundation, Inc.
GDB is free software, ...
(gdb)
```

[1] This is the minimum. Recent versions of GCC support '`-gdwarf-3`' and '`-gdwarf-4`'; we recommend always choosing the most recent version of DWARF.

We can expand macros and examine their definitions, even when the program is not running. GDB uses the current listing position to decide which macro definitions are in scope:

```
(gdb) list main
3
4       #define M 42
5       #define ADD(x) (M + x)
6
7       main ()
8       {
9       #define N 28
10        printf ("Hello, world!\n");
11      #undef N
12        printf ("We're so creative.\n");
(gdb) info macro ADD
Defined at /home/jimb/gdb/macros/play/sample.c:5
#define ADD(x) (M + x)
(gdb) info macro Q
Defined at /home/jimb/gdb/macros/play/sample.h:1
  included at /home/jimb/gdb/macros/play/sample.c:2
#define Q <
(gdb) macro expand ADD(1)
expands to: (42 + 1)
(gdb) macro expand-once ADD(1)
expands to: once (M + 1)
(gdb)
```

In the example above, note that `macro expand-once` expands only the macro invocation explicit in the original text — the invocation of `ADD` — but does not expand the invocation of the macro `M`, which was introduced by `ADD`.

Once the program is running, GDB uses the macro definitions in force at the source line of the current stack frame:

```
(gdb) break main
Breakpoint 1 at 0x8048370: file sample.c, line 10.
(gdb) run
Starting program: /home/jimb/gdb/macros/play/sample

Breakpoint 1, main () at sample.c:10
10        printf ("Hello, world!\n");
(gdb)
```

At line 10, the definition of the macro `N` at line 9 is in force:

```
(gdb) info macro N
Defined at /home/jimb/gdb/macros/play/sample.c:9
#define N 28
(gdb) macro expand N Q M
expands to: 28 < 42
(gdb) print N Q M
$1 = 1
(gdb)
```

As we step over directives that remove `N`'s definition, and then give it a new definition, GDB finds the definition (or lack thereof) in force at each point:

```
(gdb) next
Hello, world!
12        printf ("We're so creative.\n");
(gdb) info macro N
```

```
The symbol 'N' has no definition as a C/C++ preprocessor macro
at /home/jimb/gdb/macros/play/sample.c:12
(gdb) next
We're so creative.
14        printf ("Goodbye, world!\n");
(gdb) info macro N
Defined at /home/jimb/gdb/macros/play/sample.c:13
#define N 1729
(gdb) macro expand N Q M
expands to: 1729 < 42
(gdb) print N Q M
$2 = 0
(gdb)
```

In addition to source files, macros can be defined on the compilation command line using the '`-D`*`name`*`=`*`value`*' syntax. For macros defined in such a way, GDB displays the location of their definition as line zero of the source file submitted to the compiler.

```
(gdb) info macro __STDC__
Defined at /home/jimb/gdb/macros/play/sample.c:0
-D__STDC__=1
(gdb)
```

13 Tracepoints

In some applications, it is not feasible for the debugger to interrupt the program's execution long enough for the developer to learn anything helpful about its behavior. If the program's correctness depends on its real-time behavior, delays introduced by a debugger might cause the program to change its behavior drastically, or perhaps fail, even when the code itself is correct. It is useful to be able to observe the program's behavior without interrupting it.

Using GDB's `trace` and `collect` commands, you can specify locations in the program, called *tracepoints*, and arbitrary expressions to evaluate when those tracepoints are reached. Later, using the `tfind` command, you can examine the values those expressions had when the program hit the tracepoints. The expressions may also denote objects in memory—structures or arrays, for example—whose values GDB should record; while visiting a particular tracepoint, you may inspect those objects as if they were in memory at that moment. However, because GDB records these values without interacting with you, it can do so quickly and unobtrusively, hopefully not disturbing the program's behavior.

The tracepoint facility is currently available only for remote targets. See Chapter 19 [Targets], page 231. In addition, your remote target must know how to collect trace data. This functionality is implemented in the remote stub; however, none of the stubs distributed with GDB support tracepoints as of this writing. The format of the remote packets used to implement tracepoints are described in Section E.6 [Tracepoint Packets], page 535.

It is also possible to get trace data from a file, in a manner reminiscent of corefiles; you specify the filename, and use `tfind` to search through the file. See Section 13.4 [Trace Files], page 165, for more details.

This chapter describes the tracepoint commands and features.

13.1 Commands to Set Tracepoints

Before running such a *trace experiment*, an arbitrary number of tracepoints can be set. A tracepoint is actually a special type of breakpoint (see Section 5.1.1 [Set Breaks], page 44), so you can manipulate it using standard breakpoint commands. For instance, as with breakpoints, tracepoint numbers are successive integers starting from one, and many of the commands associated with tracepoints take the tracepoint number as their argument, to identify which tracepoint to work on.

For each tracepoint, you can specify, in advance, some arbitrary set of data that you want the target to collect in the trace buffer when it hits that tracepoint. The collected data can include registers, local variables, or global data. Later, you can use GDB commands to examine the values these data had at the time the tracepoint was hit.

Tracepoints do not support every breakpoint feature. Ignore counts on tracepoints have no effect, and tracepoints cannot run GDB commands when they are hit. Tracepoints may not be thread-specific either.

Some targets may support *fast tracepoints*, which are inserted in a different way (such as with a jump instead of a trap), that is faster but possibly restricted in where they may be installed.

Regular and fast tracepoints are dynamic tracing facilities, meaning that they can be used to insert tracepoints at (almost) any location in the target. Some targets may also support controlling *static tracepoints* from GDB. With static tracing, a set of instrumentation

points, also known as *markers*, are embedded in the target program, and can be activated or deactivated by name or address. These are usually placed at locations which facilitate investigating what the target is actually doing. GDB's support for static tracing includes being able to list instrumentation points, and attach them with GDB defined high level tracepoints that expose the whole range of convenience of GDB's tracepoints support. Namely, support for collecting registers values and values of global or local (to the instrumentation point) variables; tracepoint conditions and trace state variables. The act of installing a GDB static tracepoint on an instrumentation point, or marker, is referred to as *probing* a static tracepoint marker.

`gdbserver` supports tracepoints on some target systems. See Section 20.3 [Tracepoints support in gdbserver], page 237.

This section describes commands to set tracepoints and associated conditions and actions.

13.1.1 Create and Delete Tracepoints

`trace` *location*

The `trace` command is very similar to the `break` command. Its argument *location* can be a source line, a function name, or an address in the target program. See Section 9.2 [Specify Location], page 94. The `trace` command defines a tracepoint, which is a point in the target program where the debugger will briefly stop, collect some data, and then allow the program to continue. Setting a tracepoint or changing its actions takes effect immediately if the remote stub supports the '`InstallInTrace`' feature (see [install tracepoint in tracing], page 527). If remote stub doesn't support the '`InstallInTrace`' feature, all these changes don't take effect until the next `tstart` command, and once a trace experiment is running, further changes will not have any effect until the next trace experiment starts. In addition, GDB supports *pending tracepoints*—tracepoints whose address is not yet resolved. (This is similar to pending breakpoints.) Pending tracepoints are not downloaded to the target and not installed until they are resolved. The resolution of pending tracepoints requires GDB support—when debugging with the remote target, and GDB disconnects from the remote stub (see [disconnected tracing], page 158), pending tracepoints can not be resolved (and downloaded to the remote stub) while GDB is disconnected.

Here are some examples of using the `trace` command:

```
(gdb) trace foo.c:121     // a source file and line number

(gdb) trace +2            // 2 lines forward

(gdb) trace my_function   // first source line of function

(gdb) trace *my_function // EXACT start address of function

(gdb) trace *0x2117c4     // an address
```

You can abbreviate `trace` as `tr`.

`trace` *`location`* `if` *`cond`*

Set a tracepoint with condition *cond*; evaluate the expression *cond* each time the tracepoint is reached, and collect data only if the value is nonzero—that is, if *cond* evaluates as true. See Section 13.1.4 [Tracepoint Conditions], page 153, for more information on tracepoint conditions.

`ftrace` *`location`* `[ if` *`cond`* `]`

The `ftrace` command sets a fast tracepoint. For targets that support them, fast tracepoints will use a more efficient but possibly less general technique to trigger data collection, such as a jump instruction instead of a trap, or some sort of hardware support. It may not be possible to create a fast tracepoint at the desired location, in which case the command will exit with an explanatory message.

GDB handles arguments to `ftrace` exactly as for `trace`.

On 32-bit x86-architecture systems, fast tracepoints normally need to be placed at an instruction that is 5 bytes or longer, but can be placed at 4-byte instructions if the low 64K of memory of the target program is available to install trampolines. Some Unix-type systems, such as GNU/Linux, exclude low addresses from the program's address space; but for instance with the Linux kernel it is possible to let GDB use this area by doing a `sysctl` command to set the `mmap_min_addr` kernel parameter, as in

```
sudo sysctl -w vm.mmap_min_addr=32768
```

which sets the low address to 32K, which leaves plenty of room for trampolines. The minimum address should be set to a page boundary.

`strace` *`location`* `[ if` *`cond`* `]`

The `strace` command sets a static tracepoint. For targets that support it, setting a static tracepoint probes a static instrumentation point, or marker, found at *location*. It may not be possible to set a static tracepoint at the desired location, in which case the command will exit with an explanatory message.

GDB handles arguments to `strace` exactly as for `trace`, with the addition that the user can also specify `-m` *`marker`* as *location*. This probes the marker identified by the *marker* string identifier. This identifier depends on the static tracepoint backend library your program is using. You can find all the marker identifiers in the '`ID`' field of the `info static-tracepoint-markers` command output. See Section 13.1.8 [Listing Static Tracepoint Markers], page 157. For example, in the following small program using the UST tracing engine:

```
main ()
{
  trace_mark(ust, bar33, "str %s", "FOOBAZ");
}
```

the marker id is composed of joining the first two arguments to the `trace_mark` call with a slash, which translates to:

```
(gdb) info static-tracepoint-markers
Cnt Enb ID         Address            What
1   n   ust/bar33  0x0000000000400ddc in main at stexample.c:22
         Data: "str %s"
```

```
[etc...]
```

so you may probe the marker above with:

```
(gdb) strace -m ust/bar33
```

Static tracepoints accept an extra collect action — `collect $_sdata`. This collects arbitrary user data passed in the probe point call to the tracing library. In the UST example above, you'll see that the third argument to `trace_mark` is a printf-like format string. The user data is then the result of running that formating string against the following arguments. Note that `info static-tracepoint-markers` command output lists that format string in the '`Data:`' field.

You can inspect this data when analyzing the trace buffer, by printing the $_sdata variable like any other variable available to GDB. See Section 13.1.6 [Tracepoint Action Lists], page 154.

The convenience variable `$tpnum` records the tracepoint number of the most recently set tracepoint.

`delete tracepoint` [*num*]

Permanently delete one or more tracepoints. With no argument, the default is to delete all tracepoints. Note that the regular `delete` command can remove tracepoints also.

Examples:

```
(gdb) delete trace 1 2 3 // remove three tracepoints

(gdb) delete trace       // remove all tracepoints
```

You can abbreviate this command as `del tr`.

13.1.2 Enable and Disable Tracepoints

These commands are deprecated; they are equivalent to plain `disable` and `enable`.

`disable tracepoint` [*num*]

Disable tracepoint *num*, or all tracepoints if no argument *num* is given. A disabled tracepoint will have no effect during a trace experiment, but it is not forgotten. You can re-enable a disabled tracepoint using the `enable tracepoint` command. If the command is issued during a trace experiment and the debug target has support for disabling tracepoints during a trace experiment, then the change will be effective immediately. Otherwise, it will be applied to the next trace experiment.

`enable tracepoint` [*num*]

Enable tracepoint *num*, or all tracepoints. If this command is issued during a trace experiment and the debug target supports enabling tracepoints during a trace experiment, then the enabled tracepoints will become effective immediately. Otherwise, they will become effective the next time a trace experiment is run.

13.1.3 Tracepoint Passcounts

`passcount` [*n* [*num*]]

Set the *passcount* of a tracepoint. The passcount is a way to automatically stop a trace experiment. If a tracepoint's passcount is *n*, then the trace experiment will be automatically stopped on the *n*'th time that tracepoint is hit. If the tracepoint number *num* is not specified, the `passcount` command sets the passcount of the most recently defined tracepoint. If no passcount is given, the trace experiment will run until stopped explicitly by the user.

Examples:

```
(gdb) passcount 5 2 // Stop on the 5th execution of
                    // tracepoint 2

(gdb) passcount 12  // Stop on the 12th execution of the
                    // most recently defined tracepoint.
(gdb) trace foo
(gdb) pass 3
(gdb) trace bar
(gdb) pass 2
(gdb) trace baz
(gdb) pass 1          // Stop tracing when foo has been
                      // executed 3 times OR when bar has
                      // been executed 2 times
                      // OR when baz has been executed 1 time.
```

13.1.4 Tracepoint Conditions

The simplest sort of tracepoint collects data every time your program reaches a specified place. You can also specify a *condition* for a tracepoint. A condition is just a Boolean expression in your programming language (see Section 10.1 [Expressions], page 105). A tracepoint with a condition evaluates the expression each time your program reaches it, and data collection happens only if the condition is true.

Tracepoint conditions can be specified when a tracepoint is set, by using '`if`' in the arguments to the `trace` command. See Section 13.1.1 [Setting Tracepoints], page 150. They can also be set or changed at any time with the `condition` command, just as with breakpoints.

Unlike breakpoint conditions, GDB does not actually evaluate the conditional expression itself. Instead, GDB encodes the expression into an agent expression (see Appendix F [Agent Expressions], page 565) suitable for execution on the target, independently of GDB. Global variables become raw memory locations, locals become stack accesses, and so forth.

For instance, suppose you have a function that is usually called frequently, but should not be called after an error has occurred. You could use the following tracepoint command to collect data about calls of that function that happen while the error code is propagating through the program; an unconditional tracepoint could end up collecting thousands of useless trace frames that you would have to search through.

```
(gdb) trace normal_operation if errcode > 0
```

13.1.5 Trace State Variables

A *trace state variable* is a special type of variable that is created and managed by target-side code. The syntax is the same as that for GDB's convenience variables (a string prefixed

with "$"), but they are stored on the target. They must be created explicitly, using a `tvariable` command. They are always 64-bit signed integers.

Trace state variables are remembered by GDB, and downloaded to the target along with tracepoint information when the trace experiment starts. There are no intrinsic limits on the number of trace state variables, beyond memory limitations of the target.

Although trace state variables are managed by the target, you can use them in print commands and expressions as if they were convenience variables; GDB will get the current value from the target while the trace experiment is running. Trace state variables share the same namespace as other "$" variables, which means that you cannot have trace state variables with names like `$23` or `$pc`, nor can you have a trace state variable and a convenience variable with the same name.

`tvariable $`*`name`* `[ =` *`expression`* `]`

The `tvariable` command creates a new trace state variable named `$`*`name`*, and optionally gives it an initial value of *expression*. *expression* is evaluated when this command is entered; the result will be converted to an integer if possible, otherwise GDB will report an error. A subsequent `tvariable` command specifying the same name does not create a variable, but instead assigns the supplied initial value to the existing variable of that name, overwriting any previous initial value. The default initial value is 0.

`info tvariables`

List all the trace state variables along with their initial values. Their current values may also be displayed, if the trace experiment is currently running.

`delete tvariable` [`$`*`name ...`*]

Delete the given trace state variables, or all of them if no arguments are specified.

13.1.6 Tracepoint Action Lists

`actions` [*`num`*]

This command will prompt for a list of actions to be taken when the tracepoint is hit. If the tracepoint number *num* is not specified, this command sets the actions for the one that was most recently defined (so that you can define a tracepoint and then say `actions` without bothering about its number). You specify the actions themselves on the following lines, one action at a time, and terminate the actions list with a line containing just `end`. So far, the only defined actions are `collect`, `teval`, and `while-stepping`.

`actions` is actually equivalent to `commands` (see Section 5.1.7 [Breakpoint Command Lists], page 60), except that only the defined actions are allowed; any other GDB command is rejected.

To remove all actions from a tracepoint, type '`actions` *`num`*' and follow it immediately with '`end`'.

```
(gdb) collect data // collect some data

(gdb) while-stepping 5 // single-step 5 times, collect data

(gdb) end              // signals the end of actions.
```

In the following example, the action list begins with `collect` commands indicating the things to be collected when the tracepoint is hit. Then, in order to single-step and collect additional data following the tracepoint, a `while-stepping` command is used, followed by the list of things to be collected after each step in a sequence of single steps. The `while-stepping` command is terminated by its own separate `end` command. Lastly, the action list is terminated by an `end` command.

```
(gdb) trace foo
(gdb) actions
Enter actions for tracepoint 1, one per line:
> collect bar,baz
> collect $regs
> while-stepping 12
  > collect $pc, arr[i]
  > end
end
```

`collect`[`/`*mods*] *expr1*`,` *expr2*`, ...`

Collect values of the given expressions when the tracepoint is hit. This command accepts a comma-separated list of any valid expressions. In addition to global, static, or local variables, the following special arguments are supported:

`$regs` Collect all registers.

`$args` Collect all function arguments.

`$locals` Collect all local variables.

`$_ret` Collect the return address. This is helpful if you want to see more of a backtrace.

`$_probe_argc`
Collects the number of arguments from the static probe at which the tracepoint is located. See Section 5.1.10 [Static Probe Points], page 63.

`$_probe_arg`*n*
n is an integer between 0 and 11. Collects the *n*th argument from the static probe at which the tracepoint is located. See Section 5.1.10 [Static Probe Points], page 63.

`$_sdata` Collect static tracepoint marker specific data. Only available for static tracepoints. See Section 13.1.6 [Tracepoint Action Lists], page 154. On the UST static tracepoints library backend, an instrumentation point resembles a `printf` function call. The tracing library is able to collect user specified data formatted to a character string using the format provided by the programmer that instrumented the program. Other backends have similar mechanisms. Here's an example of a UST marker call:

```
const char master_name[] = "$your_name";
trace_mark(channel1, marker1, "hello %s", master_name)
```

In this case, collecting `$_sdata` collects the string '`hello $yourname`'. When analyzing the trace buffer, you can inspect '`$_sdata`' like any other variable available to GDB.

You can give several consecutive `collect` commands, each one with a single argument, or one `collect` command with several arguments separated by commas; the effect is the same.

The optional *mods* changes the usual handling of the arguments. `s` requests that pointers to chars be handled as strings, in particular collecting the contents of the memory being pointed at, up to the first zero. The upper bound is by default the value of the `print elements` variable; if `s` is followed by a decimal number, that is the upper bound instead. So for instance '`collect/s25 mystr`' collects as many as 25 characters at '`mystr`'.

The command `info scope` (see Chapter 16 [Symbols], page 201) is particularly useful for figuring out what data to collect.

`teval` *expr1, expr2, ...*

Evaluate the given expressions when the tracepoint is hit. This command accepts a comma-separated list of expressions. The results are discarded, so this is mainly useful for assigning values to trace state variables (see Section 13.1.5 [Trace State Variables], page 153) without adding those values to the trace buffer, as would be the case if the `collect` action were used.

`while-stepping` *n*

Perform *n* single-step instruction traces after the tracepoint, collecting new data after each step. The `while-stepping` command is followed by the list of what to collect while stepping (followed by its own `end` command):

```
> while-stepping 12
  > collect $regs, myglobal
  > end
>
```

Note that `$pc` is not automatically collected by `while-stepping`; you need to explicitly collect that register if you need it. You may abbreviate `while-stepping` as `ws` or `stepping`.

`set default-collect` *expr1, expr2, ...*

This variable is a list of expressions to collect at each tracepoint hit. It is effectively an additional `collect` action prepended to every tracepoint action list. The expressions are parsed individually for each tracepoint, so for instance a variable named `xyz` may be interpreted as a global for one tracepoint, and a local for another, as appropriate to the tracepoint's location.

`show default-collect`

Show the list of expressions that are collected by default at each tracepoint hit.

13.1.7 Listing Tracepoints

`info tracepoints` [*num* ...]

Display information about the tracepoint *num*. If you don't specify a tracepoint number, displays information about all the tracepoints defined so far. The format is similar to that used for `info breakpoints`; in fact, `info tracepoints` is the same command, simply restricting itself to tracepoints.

A tracepoint's listing may include additional information specific to tracing:

- its passcount as given by the `passcount n` command
- the state about installed on target of each location

```
(gdb) info trace
Num     Type           Disp Enb Address    What
1       tracepoint     keep y   0x0804ab57 in foo() at main.cxx:7
        while-stepping 20
          collect globfoo, $regs
        end
        collect globfoo2
        end
        pass count 1200
2       tracepoint     keep y   <MULTIPLE>
        collect $eip
2.1                         y     0x0804859c in func4 at change-loc.h:35
        installed on target
2.2                         y     0xb7ffc480 in func4 at change-loc.h:35
        installed on target
2.3                         y     <PENDING>  set_tracepoint
3       tracepoint     keep y   0x080485b1 in foo at change-loc.c:29
        not installed on target
(gdb)
```

This command can be abbreviated `info tp`.

13.1.8 Listing Static Tracepoint Markers

`info static-tracepoint-markers`

Display information about all static tracepoint markers defined in the program.

For each marker, the following columns are printed:

Count An incrementing counter, output to help readability. This is not a stable identifier.

ID The marker ID, as reported by the target.

Enabled or Disabled
Probed markers are tagged with '`y`'. '`n`' identifies marks that are not enabled.

Address Where the marker is in your program, as a memory address.

What Where the marker is in the source for your program, as a file and line number. If the debug information included in the program does not allow GDB to locate the source of the marker, this column will be left blank.

In addition, the following information may be printed for each marker:

Data User data passed to the tracing library by the marker call. In the UST backend, this is the format string passed as argument to the marker call.

Static tracepoints probing the marker
The list of static tracepoints attached to the marker.

```
(gdb) info static-tracepoint-markers
Cnt ID         Enb Address            What
```

```
1   ust/bar2   y   0x0000000000400e1a in main at stexample.c:25
     Data: number1 %d number2 %d
     Probed by static tracepoints: #2
2   ust/bar33  n   0x0000000000400c87 in main at stexample.c:24
     Data: str %s
(gdb)
```

13.1.9 Starting and Stopping Trace Experiments

`tstart` This command starts the trace experiment, and begins collecting data. It has the side effect of discarding all the data collected in the trace buffer during the previous trace experiment. If any arguments are supplied, they are taken as a note and stored with the trace experiment's state. The notes may be arbitrary text, and are especially useful with disconnected tracing in a multi-user context; the notes can explain what the trace is doing, supply user contact information, and so forth.

`tstop` This command stops the trace experiment. If any arguments are supplied, they are recorded with the experiment as a note. This is useful if you are stopping a trace started by someone else, for instance if the trace is interfering with the system's behavior and needs to be stopped quickly.

Note: a trace experiment and data collection may stop automatically if any tracepoint's passcount is reached (see Section 13.1.3 [Tracepoint Passcounts], page 153), or if the trace buffer becomes full.

`tstatus` This command displays the status of the current trace data collection.

Here is an example of the commands we described so far:

```
(gdb) trace gdb_c_test
(gdb) actions
Enter actions for tracepoint #1, one per line.
> collect $regs,$locals,$args
> while-stepping 11
  > collect $regs
  > end
> end
(gdb) tstart
[time passes ...]
(gdb) tstop
```

You can choose to continue running the trace experiment even if GDB disconnects from the target, voluntarily or involuntarily. For commands such as `detach`, the debugger will ask what you want to do with the trace. But for unexpected terminations (GDB crash, network outage), it would be unfortunate to lose hard-won trace data, so the variable `disconnected-tracing` lets you decide whether the trace should continue running without GDB.

`set disconnected-tracing on`
`set disconnected-tracing off`

Choose whether a tracing run should continue to run if GDB has disconnected from the target. Note that `detach` or `quit` will ask you directly what to do about a running trace no matter what this variable's setting, so the variable is mainly useful for handling unexpected situations, such as loss of the network.

`show disconnected-tracing`
: Show the current choice for disconnected tracing.

When you reconnect to the target, the trace experiment may or may not still be running; it might have filled the trace buffer in the meantime, or stopped for one of the other reasons. If it is running, it will continue after reconnection.

Upon reconnection, the target will upload information about the tracepoints in effect. GDB will then compare that information to the set of tracepoints currently defined, and attempt to match them up, allowing for the possibility that the numbers may have changed due to creation and deletion in the meantime. If one of the target's tracepoints does not match any in GDB, the debugger will create a new tracepoint, so that you have a number with which to specify that tracepoint. This matching-up process is necessarily heuristic, and it may result in useless tracepoints being created; you may simply delete them if they are of no use.

If your target agent supports a *circular trace buffer*, then you can run a trace experiment indefinitely without filling the trace buffer; when space runs out, the agent deletes already-collected trace frames, oldest first, until there is enough room to continue collecting. This is especially useful if your tracepoints are being hit too often, and your trace gets terminated prematurely because the buffer is full. To ask for a circular trace buffer, simply set '`circular-trace-buffer`' to on. You can set this at any time, including during tracing; if the agent can do it, it will change buffer handling on the fly, otherwise it will not take effect until the next run.

`set circular-trace-buffer on`
`set circular-trace-buffer off`
: Choose whether a tracing run should use a linear or circular buffer for trace data. A linear buffer will not lose any trace data, but may fill up prematurely, while a circular buffer will discard old trace data, but it will have always room for the latest tracepoint hits.

`show circular-trace-buffer`
: Show the current choice for the trace buffer. Note that this may not match the agent's current buffer handling, nor is it guaranteed to match the setting that might have been in effect during a past run, for instance if you are looking at frames from a trace file.

`set trace-buffer-size` *n*
: Request that the target use a trace buffer of *n* bytes. Not all targets will honor the request; they may have a compiled-in size for the trace buffer, or some other limitation. Set to a value of `-1` to let the target use whatever size it likes. This is also the default.

`show trace-buffer-size`
: Show the current requested size for the trace buffer. Note that this will only match the actual size if the target supports size-setting, and was able to handle the requested size. For instance, if the target can only change buffer size between runs, this variable will not reflect the change until the next run starts. Use `tstatus` to get a report of the actual buffer size.

`set trace-user` *text*
`show trace-user`
`set trace-notes` *text*
: Set the trace run's notes.

`show trace-notes`
: Show the trace run's notes.

`set trace-stop-notes` *text*
: Set the trace run's stop notes. The handling of the note is as for `tstop` arguments; the set command is convenient way to fix a stop note that is mistaken or incomplete.

`show trace-stop-notes`
: Show the trace run's stop notes.

13.1.10 Tracepoint Restrictions

There are a number of restrictions on the use of tracepoints. As described above, tracepoint data gathering occurs on the target without interaction from GDB. Thus the full capabilities of the debugger are not available during data gathering, and then at data examination time, you will be limited by only having what was collected. The following items describe some common problems, but it is not exhaustive, and you may run into additional difficulties not mentioned here.

- Tracepoint expressions are intended to gather objects (lvalues). Thus the full flexibility of GDB's expression evaluator is not available. You cannot call functions, cast objects to aggregate types, access convenience variables or modify values (except by assignment to trace state variables). Some language features may implicitly call functions (for instance Objective-C fields with accessors), and therefore cannot be collected either.
- Collection of local variables, either individually or in bulk with `$locals` or `$args`, during `while-stepping` may behave erratically. The stepping action may enter a new scope (for instance by stepping into a function), or the location of the variable may change (for instance it is loaded into a register). The tracepoint data recorded uses the location information for the variables that is correct for the tracepoint location. When the tracepoint is created, it is not possible, in general, to determine where the steps of a `while-stepping` sequence will advance the program—particularly if a conditional branch is stepped.
- Collection of an incompletely-initialized or partially-destroyed object may result in something that GDB cannot display, or displays in a misleading way.
- When GDB displays a pointer to character it automatically dereferences the pointer to also display characters of the string being pointed to. However, collecting the pointer during tracing does not automatically collect the string. You need to explicitly dereference the pointer and provide size information if you want to collect not only the pointer, but the memory pointed to. For example, `*ptr@50` can be used to collect the 50 element array pointed to by `ptr`.
- It is not possible to collect a complete stack backtrace at a tracepoint. Instead, you may collect the registers and a few hundred bytes from the stack pointer with something like `*(unsigned char *)$esp@300` (adjust to use the name of the actual stack pointer

register on your target architecture, and the amount of stack you wish to capture). Then the `backtrace` command will show a partial backtrace when using a trace frame. The number of stack frames that can be examined depends on the sizes of the frames in the collected stack. Note that if you ask for a block so large that it goes past the bottom of the stack, the target agent may report an error trying to read from an invalid address.

- If you do not collect registers at a tracepoint, GDB can infer that the value of `$pc` must be the same as the address of the tracepoint and use that when you are looking at a trace frame for that tracepoint. However, this cannot work if the tracepoint has multiple locations (for instance if it was set in a function that was inlined), or if it has a `while-stepping` loop. In those cases GDB will warn you that it can't infer `$pc`, and default it to zero.

13.2 Using the Collected Data

After the tracepoint experiment ends, you use GDB commands for examining the trace data. The basic idea is that each tracepoint collects a trace *snapshot* every time it is hit and another snapshot every time it single-steps. All these snapshots are consecutively numbered from zero and go into a buffer, and you can examine them later. The way you examine them is to *focus* on a specific trace snapshot. When the remote stub is focused on a trace snapshot, it will respond to all GDB requests for memory and registers by reading from the buffer which belongs to that snapshot, rather than from *real* memory or registers of the program being debugged. This means that **all** GDB commands (`print`, `info registers`, `backtrace`, etc.) will behave as if we were currently debugging the program state as it was when the tracepoint occurred. Any requests for data that are not in the buffer will fail.

13.2.1 `tfind` *n*

The basic command for selecting a trace snapshot from the buffer is `tfind` *n*, which finds trace snapshot number *n*, counting from zero. If no argument *n* is given, the next snapshot is selected.

Here are the various forms of using the `tfind` command.

`tfind start`
: Find the first snapshot in the buffer. This is a synonym for `tfind 0` (since 0 is the number of the first snapshot).

`tfind none`
: Stop debugging trace snapshots, resume *live* debugging.

`tfind end`
: Same as '`tfind none`'.

`tfind`
: No argument means find the next trace snapshot.

`tfind -`
: Find the previous trace snapshot before the current one. This permits retracing earlier steps.

`tfind tracepoint` *num*
: Find the next snapshot associated with tracepoint *num*. Search proceeds forward from the last examined trace snapshot. If no argument *num* is given, it means find the next snapshot collected for the same tracepoint as the current snapshot.

`tfind pc` *addr*
: Find the next snapshot associated with the value *addr* of the program counter. Search proceeds forward from the last examined trace snapshot. If no argument *addr* is given, it means find the next snapshot with the same value of PC as the current snapshot.

`tfind outside` *addr1*`,` *addr2*
: Find the next snapshot whose PC is outside the given range of addresses (exclusive).

`tfind range` *addr1*`,` *addr2*
: Find the next snapshot whose PC is between *addr1* and *addr2* (inclusive).

`tfind line` [*file*`:`]*n*
: Find the next snapshot associated with the source line *n*. If the optional argument *file* is given, refer to line *n* in that source file. Search proceeds forward from the last examined trace snapshot. If no argument *n* is given, it means find the next line other than the one currently being examined; thus saying `tfind line` repeatedly can appear to have the same effect as stepping from line to line in a *live* debugging session.

The default arguments for the `tfind` commands are specifically designed to make it easy to scan through the trace buffer. For instance, `tfind` with no argument selects the next trace snapshot, and `tfind -` with no argument selects the previous trace snapshot. So, by giving one `tfind` command, and then simply hitting RET repeatedly you can examine all the trace snapshots in order. Or, by saying `tfind -` and then hitting RET repeatedly you can examine the snapshots in reverse order. The `tfind line` command with no argument selects the snapshot for the next source line executed. The `tfind pc` command with no argument selects the next snapshot with the same program counter (PC) as the current frame. The `tfind tracepoint` command with no argument selects the next trace snapshot collected by the same tracepoint as the current one.

In addition to letting you scan through the trace buffer manually, these commands make it easy to construct GDB scripts that scan through the trace buffer and print out whatever collected data you are interested in. Thus, if we want to examine the PC, FP, and SP registers from each trace frame in the buffer, we can say this:

```
(gdb) tfind start
(gdb) while ($trace_frame != -1)
> printf "Frame %d, PC = %08X, SP = %08X, FP = %08X\n", \
          $trace_frame, $pc, $sp, $fp
> tfind
> end

Frame 0, PC = 0020DC64, SP = 0030BF3C, FP = 0030BF44
Frame 1, PC = 0020DC6C, SP = 0030BF38, FP = 0030BF44
Frame 2, PC = 0020DC70, SP = 0030BF34, FP = 0030BF44
Frame 3, PC = 0020DC74, SP = 0030BF30, FP = 0030BF44
Frame 4, PC = 0020DC78, SP = 0030BF2C, FP = 0030BF44
Frame 5, PC = 0020DC7C, SP = 0030BF28, FP = 0030BF44
Frame 6, PC = 0020DC80, SP = 0030BF24, FP = 0030BF44
Frame 7, PC = 0020DC84, SP = 0030BF20, FP = 0030BF44
Frame 8, PC = 0020DC88, SP = 0030BF1C, FP = 0030BF44
Frame 9, PC = 0020DC8E, SP = 0030BF18, FP = 0030BF44
```

```
Frame 10, PC = 00203F6C, SP = 0030BE3C, FP = 0030BF14
```

Or, if we want to examine the variable `X` at each source line in the buffer:

```
(gdb) tfind start
(gdb) while ($trace_frame != -1)
> printf "Frame %d, X == %d\n", $trace_frame, X
> tfind line
> end

Frame 0, X = 1
Frame 7, X = 2
Frame 13, X = 255
```

13.2.2 `tdump`

This command takes no arguments. It prints all the data collected at the current trace snapshot.

```
(gdb) trace 444
(gdb) actions
Enter actions for tracepoint #2, one per line:
> collect $regs, $locals, $args, gdb_long_test
> end

(gdb) tstart

(gdb) tfind line 444
#0  gdb_test (p1=0x11, p2=0x22, p3=0x33, p4=0x44, p5=0x55, p6=0x66)
at gdb_test.c:444
444         printp( "%s: arguments = 0x%X 0x%X 0x%X 0x%X 0x%X 0x%X\n", )

(gdb) tdump
Data collected at tracepoint 2, trace frame 1:
d0              0xc4aa0085       -995491707
d1              0x18     24
d2              0x80     128
d3              0x33     51
d4              0x71aea3d        119204413
d5              0x22     34
d6              0xe0     224
d7              0x380035 3670069
a0              0x19e24a 1696330
a1              0x3000668        50333288
a2              0x100    256
a3              0x322000 3284992
a4              0x3000698        50333336
a5              0x1ad3cc 1758156
fp              0x30bf3c 0x30bf3c
sp              0x30bf34 0x30bf34
ps              0x0      0
pc              0x20b2c8 0x20b2c8
fpcontrol       0x0      0
fpstatus        0x0      0
fpiaddr         0x0      0
p = 0x20e5b4 "gdb-test"
p1 = (void *) 0x11
p2 = (void *) 0x22
p3 = (void *) 0x33
p4 = (void *) 0x44
```

```
p5 = (void *) 0x55
p6 = (void *) 0x66
gdb_long_test = 17 '\021'

(gdb)
```

`tdump` works by scanning the tracepoint's current collection actions and printing the value of each expression listed. So `tdump` can fail, if after a run, you change the tracepoint's actions to mention variables that were not collected during the run.

Also, for tracepoints with `while-stepping` loops, `tdump` uses the collected value of `$pc` to distinguish between trace frames that were collected at the tracepoint hit, and frames that were collected while stepping. This allows it to correctly choose whether to display the basic list of collections, or the collections from the body of the while-stepping loop. However, if `$pc` was not collected, then `tdump` will always attempt to dump using the basic collection list, and may fail if a while-stepping frame does not include all the same data that is collected at the tracepoint hit.

13.2.3 `save tracepoints` *filename*

This command saves all current tracepoint definitions together with their actions and pass-counts, into a file '*filename*' suitable for use in a later debugging session. To read the saved tracepoint definitions, use the `source` command (see Section 23.1.3 [Command Files], page 300). The `save-tracepoints` command is a deprecated alias for `save tracepoints`

13.3 Convenience Variables for Tracepoints

`(int) $trace_frame`
: The current trace snapshot (a.k.a. *frame*) number, or -1 if no snapshot is selected.

`(int) $tracepoint`
: The tracepoint for the current trace snapshot.

`(int) $trace_line`
: The line number for the current trace snapshot.

`(char []) $trace_file`
: The source file for the current trace snapshot.

`(char []) $trace_func`
: The name of the function containing `$tracepoint`.

Note: `$trace_file` is not suitable for use in `printf`, use `output` instead.

Here's a simple example of using these convenience variables for stepping through all the trace snapshots and printing some of their data. Note that these are not the same as trace state variables, which are managed by the target.

```
(gdb) tfind start

(gdb) while $trace_frame != -1
> output $trace_file
> printf ", line %d (tracepoint #%d)\n", $trace_line, $tracepoint
> tfind
> end
```

13.4 Using Trace Files

In some situations, the target running a trace experiment may no longer be available; perhaps it crashed, or the hardware was needed for a different activity. To handle these cases, you can arrange to dump the trace data into a file, and later use that file as a source of trace data, via the `target tfile` command.

`tsave [ -r ] filename`
: Save the trace data to *filename*. By default, this command assumes that *filename* refers to the host filesystem, so if necessary GDB will copy raw trace data up from the target and then save it. If the target supports it, you can also supply the optional argument `-r` ("remote") to direct the target to save the data directly into *filename* in its own filesystem, which may be more efficient if the trace buffer is very large. (Note, however, that `target tfile` can only read from files accessible to the host.)

`target tfile filename`
: Use the file named *filename* as a source of trace data. Commands that examine data work as they do with a live target, but it is not possible to run any new trace experiments. `tstatus` will report the state of the trace run at the moment the data was saved, as well as the current trace frame you are examining. *filename* must be on a filesystem accessible to the host.

14 Debugging Programs That Use Overlays

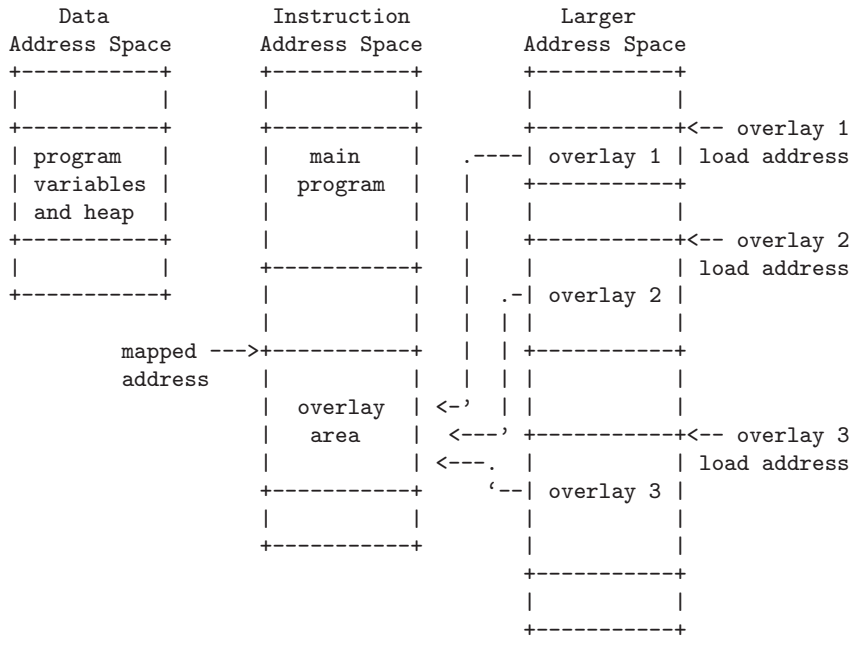
If your program is too large to fit completely in your target system's memory, you can sometimes use *overlays* to work around this problem. GDB provides some support for debugging programs that use overlays.

14.1 How Overlays Work

Suppose you have a computer whose instruction address space is only 64 kilobytes long, but which has much more memory which can be accessed by other means: special instructions, segment registers, or memory management hardware, for example. Suppose further that you want to adapt a program which is larger than 64 kilobytes to run on this system.

One solution is to identify modules of your program which are relatively independent, and need not call each other directly; call these modules *overlays*. Separate the overlays from the main program, and place their machine code in the larger memory. Place your main program in instruction memory, but leave at least enough space there to hold the largest overlay as well.

Now, to call a function located in an overlay, you must first copy that overlay's machine code from the large memory into the space set aside for it in the instruction memory, and then jump to its entry point there.



A code overlay

The diagram (see [A code overlay], page 167) shows a system with separate data and instruction address spaces. To map an overlay, the program copies its code from the larger address space to the instruction address space. Since the overlays shown here all use the same mapped address, only one may be mapped at a time. For a system with a single address space for data and instructions, the diagram would be similar, except that the program variables and heap would share an address space with the main program and the overlay area.

An overlay loaded into instruction memory and ready for use is called a *mapped* overlay; its *mapped address* is its address in the instruction memory. An overlay not present (or only partially present) in instruction memory is called *unmapped*; its *load address* is its address in the larger memory. The mapped address is also called the *virtual memory address*, or *VMA*; the load address is also called the *load memory address*, or *LMA*.

Unfortunately, overlays are not a completely transparent way to adapt a program to limited instruction memory. They introduce a new set of global constraints you must keep in mind as you design your program:

- Before calling or returning to a function in an overlay, your program must make sure that overlay is actually mapped. Otherwise, the call or return will transfer control to the right address, but in the wrong overlay, and your program will probably crash.
- If the process of mapping an overlay is expensive on your system, you will need to choose your overlays carefully to minimize their effect on your program's performance.
- The executable file you load onto your system must contain each overlay's instructions, appearing at the overlay's load address, not its mapped address. However, each overlay's instructions must be relocated and its symbols defined as if the overlay were at its mapped address. You can use GNU linker scripts to specify different load and relocation addresses for pieces of your program; see Section "Overlay Description" in *Using ld: the GNU linker*.
- The procedure for loading executable files onto your system must be able to load their contents into the larger address space as well as the instruction and data spaces.

The overlay system described above is rather simple, and could be improved in many ways:

- If your system has suitable bank switch registers or memory management hardware, you could use those facilities to make an overlay's load area contents simply appear at their mapped address in instruction space. This would probably be faster than copying the overlay to its mapped area in the usual way.
- If your overlays are small enough, you could set aside more than one overlay area, and have more than one overlay mapped at a time.
- You can use overlays to manage data, as well as instructions. In general, data overlays are even less transparent to your design than code overlays: whereas code overlays only require care when you call or return to functions, data overlays require care every time you access the data. Also, if you change the contents of a data overlay, you must copy its contents back out to its load address before you can copy a different data overlay into the same mapped area.

14.2 Overlay Commands

To use GDB's overlay support, each overlay in your program must correspond to a separate section of the executable file. The section's virtual memory address and load memory address must be the overlay's mapped and load addresses. Identifying overlays with sections allows GDB to determine the appropriate address of a function or variable, depending on whether the overlay is mapped or not.

GDB's overlay commands all start with the word `overlay`; you can abbreviate this as `ov` or `ovly`. The commands are:

`overlay off`
: Disable GDB's overlay support. When overlay support is disabled, GDB assumes that all functions and variables are always present at their mapped addresses. By default, GDB's overlay support is disabled.

`overlay manual`
: Enable *manual* overlay debugging. In this mode, GDB relies on you to tell it which overlays are mapped, and which are not, using the `overlay map-overlay` and `overlay unmap-overlay` commands described below.

`overlay map-overlay` *`overlay`*
`overlay map` *`overlay`*
: Tell GDB that *overlay* is now mapped; *overlay* must be the name of the object file section containing the overlay. When an overlay is mapped, GDB assumes it can find the overlay's functions and variables at their mapped addresses. GDB assumes that any other overlays whose mapped ranges overlap that of *overlay* are now unmapped.

`overlay unmap-overlay` *`overlay`*
`overlay unmap` *`overlay`*
: Tell GDB that *overlay* is no longer mapped; *overlay* must be the name of the object file section containing the overlay. When an overlay is unmapped, GDB assumes it can find the overlay's functions and variables at their load addresses.

`overlay auto`
: Enable *automatic* overlay debugging. In this mode, GDB consults a data structure the overlay manager maintains in the inferior to see which overlays are mapped. For details, see Section 14.3 [Automatic Overlay Debugging], page 170.

`overlay load-target`
`overlay load`
: Re-read the overlay table from the inferior. Normally, GDB re-reads the table GDB automatically each time the inferior stops, so this command should only be necessary if you have changed the overlay mapping yourself using GDB. This command is only useful when using automatic overlay debugging.

`overlay list-overlays`
`overlay list`
: Display a list of the overlays currently mapped, along with their mapped addresses, load addresses, and sizes.

Normally, when GDB prints a code address, it includes the name of the function the address falls in:

```
(gdb) print main
$3 = {int ()} 0x11a0 <main>
```

When overlay debugging is enabled, GDB recognizes code in unmapped overlays, and prints the names of unmapped functions with asterisks around them. For example, if `foo` is a function in an unmapped overlay, GDB prints it this way:

```
(gdb) overlay list
No sections are mapped.
(gdb) print foo
```

```
$5 = {int (int)} 0x100000 <*foo*>
```

When `foo`'s overlay is mapped, GDB prints the function's name normally:

```
(gdb) overlay list
Section .ov.foo.text, loaded at 0x100000 - 0x100034,
        mapped at 0x1016 - 0x104a
(gdb) print foo
$6 = {int (int)} 0x1016 <foo>
```

When overlay debugging is enabled, GDB can find the correct address for functions and variables in an overlay, whether or not the overlay is mapped. This allows most GDB commands, like `break` and `disassemble`, to work normally, even on unmapped code. However, GDB's breakpoint support has some limitations:

- You can set breakpoints in functions in unmapped overlays, as long as GDB can write to the overlay at its load address.
- GDB can not set hardware or simulator-based breakpoints in unmapped overlays. However, if you set a breakpoint at the end of your overlay manager (and tell GDB which overlays are now mapped, if you are using manual overlay management), GDB will re-set its breakpoints properly.

14.3 Automatic Overlay Debugging

GDB can automatically track which overlays are mapped and which are not, given some simple co-operation from the overlay manager in the inferior. If you enable automatic overlay debugging with the `overlay auto` command (see Section 14.2 [Overlay Commands], page 168), GDB looks in the inferior's memory for certain variables describing the current state of the overlays.

Here are the variables your overlay manager must define to support GDB's automatic overlay debugging:

`_ovly_table`:
: This variable must be an array of the following structures:

```
struct
{
  /* The overlay's mapped address.  */
  unsigned long vma;

  /* The size of the overlay, in bytes.  */
  unsigned long size;

  /* The overlay's load address.  */
  unsigned long lma;

  /* Non-zero if the overlay is currently mapped;
     zero otherwise.  */
  unsigned long mapped;
}
```

`_novlys`:
: This variable must be a four-byte signed integer, holding the total number of elements in `_ovly_table`.

To decide whether a particular overlay is mapped or not, GDB looks for an entry in `_ovly_table` whose `vma` and `lma` members equal the VMA and LMA of the overlay's section

in the executable file. When GDB finds a matching entry, it consults the entry's `mapped` member to determine whether the overlay is currently mapped.

In addition, your overlay manager may define a function called `_ovly_debug_event`. If this function is defined, GDB will silently set a breakpoint there. If the overlay manager then calls this function whenever it has changed the overlay table, this will enable GDB to accurately keep track of which overlays are in program memory, and update any breakpoints that may be set in overlays. This will allow breakpoints to work even if the overlays are kept in ROM or other non-writable memory while they are not being executed.

14.4 Overlay Sample Program

When linking a program which uses overlays, you must place the overlays at their load addresses, while relocating them to run at their mapped addresses. To do this, you must write a linker script (see Section "Overlay Description" in *Using ld: the GNU linker*). Unfortunately, since linker scripts are specific to a particular host system, target architecture, and target memory layout, this manual cannot provide portable sample code demonstrating GDB's overlay support.

However, the GDB source distribution does contain an overlaid program, with linker scripts for a few systems, as part of its test suite. The program consists of the following files from '`gdb/testsuite/gdb.base`':

'`overlays.c`'
: The main program file.

'`ovlymgr.c`'
: A simple overlay manager, used by '`overlays.c`'.

'`foo.c`'
'`bar.c`'
'`baz.c`'
'`grbx.c`'
: Overlay modules, loaded and used by '`overlays.c`'.

'`d10v.ld`'
'`m32r.ld`'
: Linker scripts for linking the test program on the `d10v-elf` and `m32r-elf` targets.

You can build the test program using the `d10v-elf` GCC cross-compiler like this:

```
$ d10v-elf-gcc -g -c overlays.c
$ d10v-elf-gcc -g -c ovlymgr.c
$ d10v-elf-gcc -g -c foo.c
$ d10v-elf-gcc -g -c bar.c
$ d10v-elf-gcc -g -c baz.c
$ d10v-elf-gcc -g -c grbx.c
$ d10v-elf-gcc -g overlays.o ovlymgr.o foo.o bar.o \
                  baz.o grbx.o -Wl,-Td10v.ld -o overlays
```

The build process is identical for any other architecture, except that you must substitute the appropriate compiler and linker script for the target system for `d10v-elf-gcc` and `d10v.ld`.

15 Using GDB with Different Languages

Although programming languages generally have common aspects, they are rarely expressed in the same manner. For instance, in ANSI C, dereferencing a pointer `p` is accomplished by `*p`, but in Modula-2, it is accomplished by `p^`. Values can also be represented (and displayed) differently. Hex numbers in C appear as '`0x1ae`', while in Modula-2 they appear as '`1AEH`'.

Language-specific information is built into GDB for some languages, allowing you to express operations like the above in your program's native language, and allowing GDB to output values in a manner consistent with the syntax of your program's native language. The language you use to build expressions is called the *working language*.

15.1 Switching Between Source Languages

There are two ways to control the working language—either have GDB set it automatically, or select it manually yourself. You can use the `set language` command for either purpose. On startup, GDB defaults to setting the language automatically. The working language is used to determine how expressions you type are interpreted, how values are printed, etc.

In addition to the working language, every source file that GDB knows about has its own working language. For some object file formats, the compiler might indicate which language a particular source file is in. However, most of the time GDB infers the language from the name of the file. The language of a source file controls whether C++ names are demangled—this way `backtrace` can show each frame appropriately for its own language. There is no way to set the language of a source file from within GDB, but you can set the language associated with a filename extension. See Section 15.2 [Displaying the Language], page 174.

This is most commonly a problem when you use a program, such as `cfront` or `f2c`, that generates C but is written in another language. In that case, make the program use `#line` directives in its C output; that way GDB will know the correct language of the source code of the original program, and will display that source code, not the generated C code.

15.1.1 List of Filename Extensions and Languages

If a source file name ends in one of the following extensions, then GDB infers that its language is the one indicated.

'`.ada`'
'`.ads`'
'`.adb`'
'`.a`' Ada source file.

'`.c`' C source file

'`.C`'
'`.cc`'
'`.cp`'
'`.cpp`'
'`.cxx`'
'`.c++`' C++ source file

‘.d’ D source file

‘.m’ Objective-C source file

‘.f’
‘.F’ Fortran source file

‘.mod’ Modula-2 source file

‘.s’
‘.S’ Assembler source file. This actually behaves almost like C, but GDB does not skip over function prologues when stepping.

In addition, you may set the language associated with a filename extension. See Section 15.2 [Displaying the Language], page 174.

15.1.2 Setting the Working Language

If you allow GDB to set the language automatically, expressions are interpreted the same way in your debugging session and your program.

If you wish, you may set the language manually. To do this, issue the command ‘`set language` *lang*’, where *lang* is the name of a language, such as `c` or `modula-2`. For a list of the supported languages, type ‘`set language`’.

Setting the language manually prevents GDB from updating the working language automatically. This can lead to confusion if you try to debug a program when the working language is not the same as the source language, when an expression is acceptable to both languages—but means different things. For instance, if the current source file were written in C, and GDB was parsing Modula-2, a command such as:

```
print a = b + c
```

might not have the effect you intended. In C, this means to add `b` and `c` and place the result in `a`. The result printed would be the value of `a`. In Modula-2, this means to compare `a` to the result of `b+c`, yielding a `BOOLEAN` value.

15.1.3 Having GDB Infer the Source Language

To have GDB set the working language automatically, use ‘`set language local`’ or ‘`set language auto`’. GDB then infers the working language. That is, when your program stops in a frame (usually by encountering a breakpoint), GDB sets the working language to the language recorded for the function in that frame. If the language for a frame is unknown (that is, if the function or block corresponding to the frame was defined in a source file that does not have a recognized extension), the current working language is not changed, and GDB issues a warning.

This may not seem necessary for most programs, which are written entirely in one source language. However, program modules and libraries written in one source language can be used by a main program written in a different source language. Using ‘`set language auto`’ in this case frees you from having to set the working language manually.

15.2 Displaying the Language

The following commands help you find out which language is the working language, and also what language source files were written in.

`show language`
: Display the current working language. This is the language you can use with commands such as `print` to build and compute expressions that may involve variables in your program.

`info frame`
: Display the source language for this frame. This language becomes the working language if you use an identifier from this frame. See Section 8.4 [Information about a Frame], page 91, to identify the other information listed here.

`info source`
: Display the source language of this source file. See Chapter 16 [Examining the Symbol Table], page 201, to identify the other information listed here.

In unusual circumstances, you may have source files with extensions not in the standard list. You can then set the extension associated with a language explicitly:

`set extension-language` *`ext language`*
: Tell GDB that source files with extension *ext* are to be assumed as written in the source language *language*.

`info extensions`
: List all the filename extensions and the associated languages.

15.3 Type and Range Checking

Some languages are designed to guard you against making seemingly common errors through a series of compile- and run-time checks. These include checking the type of arguments to functions and operators and making sure mathematical overflows are caught at run time. Checks such as these help to ensure a program's correctness once it has been compiled by eliminating type mismatches and providing active checks for range errors when your program is running.

By default GDB checks for these errors according to the rules of the current source language. Although GDB does not check the statements in your program, it can check expressions entered directly into GDB for evaluation via the `print` command, for example.

15.3.1 An Overview of Type Checking

Some languages, such as C and C++, are strongly typed, meaning that the arguments to operators and functions have to be of the correct type, otherwise an error occurs. These checks prevent type mismatch errors from ever causing any run-time problems. For example,

```
int klass::my_method(char *b) { return  b ? 1 : 2; }

(gdb) print obj.my_method (0)
$1 = 2
```

but

```
(gdb) print obj.my_method (0x1234)
Cannot resolve method klass::my_method to any overloaded instance
```

The second example fails because in C++ the integer constant '`0x1234`' is not type-compatible with the pointer parameter type.

For the expressions you use in GDB commands, you can tell GDB to not enforce strict type checking or to treat any mismatches as errors and abandon the expression; When type checking is disabled, GDB successfully evaluates expressions like the second example above.

Even if type checking is off, there may be other reasons related to type that prevent GDB from evaluating an expression. For instance, GDB does not know how to add an `int` and a `struct foo`. These particular type errors have nothing to do with the language in use and usually arise from expressions which make little sense to evaluate anyway.

GDB provides some additional commands for controlling type checking:

`set check type on`
`set check type off`
: Set strict type checking on or off. If any type mismatches occur in evaluating an expression while type checking is on, GDB prints a message and aborts evaluation of the expression.

`show check type`
: Show the current setting of type checking and whether GDB is enforcing strict type checking rules.

15.3.2 An Overview of Range Checking

In some languages (such as Modula-2), it is an error to exceed the bounds of a type; this is enforced with run-time checks. Such range checking is meant to ensure program correctness by making sure computations do not overflow, or indices on an array element access do not exceed the bounds of the array.

For expressions you use in GDB commands, you can tell GDB to treat range errors in one of three ways: ignore them, always treat them as errors and abandon the expression, or issue warnings but evaluate the expression anyway.

A range error can result from numerical overflow, from exceeding an array index bound, or when you type a constant that is not a member of any type. Some languages, however, do not treat overflows as an error. In many implementations of C, mathematical overflow causes the result to "wrap around" to lower values—for example, if m is the largest integer value, and s is the smallest, then

$$m + 1 \Rightarrow s$$

This, too, is specific to individual languages, and in some cases specific to individual compilers or machines. See Section 15.4 [Supported Languages], page 177, for further details on specific languages.

GDB provides some additional commands for controlling the range checker:

`set check range auto`
: Set range checking on or off based on the current working language. See Section 15.4 [Supported Languages], page 177, for the default settings for each language.

`set check range on`
`set check range off`
: Set range checking on or off, overriding the default setting for the current working language. A warning is issued if the setting does not match the language

default. If a range error occurs and range checking is on, then a message is printed and evaluation of the expression is aborted.

`set check range warn`
: Output messages when the GDB range checker detects a range error, but attempt to evaluate the expression anyway. Evaluating the expression may still be impossible for other reasons, such as accessing memory that the process does not own (a typical example from many Unix systems).

`show range`
: Show the current setting of the range checker, and whether or not it is being set automatically by GDB.

15.4 Supported Languages

GDB supports C, C++, D, Go, Objective-C, Fortran, Java, OpenCL C, Pascal, assembly, Modula-2, and Ada. Some GDB features may be used in expressions regardless of the language you use: the GDB `@` and `::` operators, and the '`{type}addr`' construct (see Section 10.1 [Expressions], page 105) can be used with the constructs of any supported language.

The following sections detail to what degree each source language is supported by GDB. These sections are not meant to be language tutorials or references, but serve only as a reference guide to what the GDB expression parser accepts, and what input and output formats should look like for different languages. There are many good books written on each of these languages; please look to these for a language reference or tutorial.

15.4.1 C and C++

Since C and C++ are so closely related, many features of GDB apply to both languages. Whenever this is the case, we discuss those languages together.

The C++ debugging facilities are jointly implemented by the C++ compiler and GDB. Therefore, to debug your C++ code effectively, you must compile your C++ programs with a supported C++ compiler, such as GNU `g++`, or the HP ANSI C++ compiler (`aCC`).

15.4.1.1 C and C++ Operators

Operators must be defined on values of specific types. For instance, `+` is defined on numbers, but not on structures. Operators are often defined on groups of types.

For the purposes of C and C++, the following definitions hold:

- *Integral types* include `int` with any of its storage-class specifiers; `char`; `enum`; and, for C++, `bool`.
- *Floating-point types* include `float`, `double`, and `long double` (if supported by the target platform).
- *Pointer types* include all types defined as `(type *)`.
- *Scalar types* include all of the above.

The following operators are supported. They are listed here in order of increasing precedence:

`,`
: The comma or sequencing operator. Expressions in a comma-separated list are evaluated from left to right, with the result of the entire expression being the last expression evaluated.

`=` Assignment. The value of an assignment expression is the value assigned. Defined on scalar types.

`op=` Used in an expression of the form `a op= b`, and translated to `a = a op b`. `op=` and `=` have the same precedence. *op* is any one of the operators `|`, `^`, `&`, `<<`, `>>`, `+`, `-`, `*`, `/`, `%`.

`?:` The ternary operator. `a ? b : c` can be thought of as: if *a* then *b* else *c*. *a* should be of an integral type.

`||` Logical OR. Defined on integral types.

`&&` Logical AND. Defined on integral types.

`|` Bitwise OR. Defined on integral types.

`^` Bitwise exclusive-OR. Defined on integral types.

`&` Bitwise AND. Defined on integral types.

`==`, `!=` Equality and inequality. Defined on scalar types. The value of these expressions is 0 for false and non-zero for true.

`<`, `>`, `<=`, `>=`
Less than, greater than, less than or equal, greater than or equal. Defined on scalar types. The value of these expressions is 0 for false and non-zero for true.

`<<`, `>>` left shift, and right shift. Defined on integral types.

`@` The GDB "artificial array" operator (see Section 10.1 [Expressions], page 105).

`+`, `-` Addition and subtraction. Defined on integral types, floating-point types and pointer types.

`*`, `/`, `%` Multiplication, division, and modulus. Multiplication and division are defined on integral and floating-point types. Modulus is defined on integral types.

`++`, `--` Increment and decrement. When appearing before a variable, the operation is performed before the variable is used in an expression; when appearing after it, the variable's value is used before the operation takes place.

`*` Pointer dereferencing. Defined on pointer types. Same precedence as `++`.

`&` Address operator. Defined on variables. Same precedence as `++`.

For debugging C++, GDB implements a use of '`&`' beyond what is allowed in the C++ language itself: you can use '`&(&ref)`' to examine the address where a C++ reference variable (declared with '`&ref`') is stored.

`-` Negative. Defined on integral and floating-point types. Same precedence as `++`.

`!` Logical negation. Defined on integral types. Same precedence as `++`.

`~` Bitwise complement operator. Defined on integral types. Same precedence as `++`.

`.`, `->` Structure member, and pointer-to-structure member. For convenience, GDB regards the two as equivalent, choosing whether to dereference a pointer based on the stored type information. Defined on `struct` and `union` data.

`.*`, `->*` Dereferences of pointers to members.

`[]` Array indexing. `a[i]` is defined as `*(a+i)`. Same precedence as `->`.

`()` Function parameter list. Same precedence as `->`.

`::` C++ scope resolution operator. Defined on `struct`, `union`, and `class` types.

`::` Doubled colons also represent the GDB scope operator (see Section 10.1 [Expressions], page 105). Same precedence as `::`, above.

If an operator is redefined in the user code, GDB usually attempts to invoke the redefined version instead of using the operator's predefined meaning.

15.4.1.2 C and C++ Constants

GDB allows you to express the constants of C and C++ in the following ways:

- Integer constants are a sequence of digits. Octal constants are specified by a leading '`0`' (i.e. zero), and hexadecimal constants by a leading '`0x`' or '`0X`'. Constants may also end with a letter '`l`', specifying that the constant should be treated as a `long` value.
- Floating point constants are a sequence of digits, followed by a decimal point, followed by a sequence of digits, and optionally followed by an exponent. An exponent is of the form: '`e`[[`+`]|`-`]*nnn*', where *nnn* is another sequence of digits. The '`+`' is optional for positive exponents. A floating-point constant may also end with a letter '`f`' or '`F`', specifying that the constant should be treated as being of the `float` (as opposed to the default `double`) type; or with a letter '`l`' or '`L`', which specifies a `long double` constant.
- Enumerated constants consist of enumerated identifiers, or their integral equivalents.
- Character constants are a single character surrounded by single quotes (`'`), or a number—the ordinal value of the corresponding character (usually its ASCII value). Within quotes, the single character may be represented by a letter or by *escape sequences*, which are of the form '`\`*nnn*', where *nnn* is the octal representation of the character's ordinal value; or of the form '`\x`', where '`x`' is a predefined special character—for example, '`\n`' for newline.

  Wide character constants can be written by prefixing a character constant with '`L`', as in C. For example, '`L'x'`' is the wide form of '`x`'. The target wide character set is used when computing the value of this constant (see Section 10.20 [Character Sets], page 135).
- String constants are a sequence of character constants surrounded by double quotes (`"`). Any valid character constant (as described above) may appear. Double quotes within the string must be preceded by a backslash, so for instance '`"a\"b'c"`' is a string of five characters.

  Wide string constants can be written by prefixing a string constant with '`L`', as in C. The target wide character set is used when computing the value of this constant (see Section 10.20 [Character Sets], page 135).
- Pointer constants are an integral value. You can also write pointers to constants using the C operator '`&`'.
- Array constants are comma-separated lists surrounded by braces '`{`' and '`}`'; for example, '`{1,2,3}`' is a three-element array of integers, '`{{1,2}, {3,4}, {5,6}}`' is a

three-by-two array, and '`{&"hi", &"there", &"fred"}`' is a three-element array of pointers.

15.4.1.3 C++ Expressions

GDB expression handling can interpret most C++ expressions.

> *Warning:* GDB can only debug C++ code if you use the proper compiler and the proper debug format. Currently, GDB works best when debugging C++ code that is compiled with the most recent version of GCC possible. The DWARF debugging format is preferred; GCC defaults to this on most popular platforms. Other compilers and/or debug formats are likely to work badly or not at all when using GDB to debug C++ code. See Section 4.1 [Compilation], page 25.

1. Member function calls are allowed; you can use expressions like

   ```
   count = aml->GetOriginal(x, y)
   ```

2. While a member function is active (in the selected stack frame), your expressions have the same namespace available as the member function; that is, GDB allows implicit references to the class instance pointer `this` following the same rules as C++. `using` declarations in the current scope are also respected by GDB.

3. You can call overloaded functions; GDB resolves the function call to the right definition, with some restrictions. GDB does not perform overload resolution involving user-defined type conversions, calls to constructors, or instantiations of templates that do not exist in the program. It also cannot handle ellipsis argument lists or default arguments.

   It does perform integral conversions and promotions, floating-point promotions, arithmetic conversions, pointer conversions, conversions of class objects to base classes, and standard conversions such as those of functions or arrays to pointers; it requires an exact match on the number of function arguments.

   Overload resolution is always performed, unless you have specified `set overload-resolution off`. See Section 15.4.1.7 [GDB Features for C++], page 181.

   You must specify `set overload-resolution off` in order to use an explicit function signature to call an overloaded function, as in

   ```
   p 'foo(char,int)'('x', 13)
   ```

   The GDB command-completion facility can simplify this; see Section 3.2 [Command Completion], page 19.

4. GDB understands variables declared as C++ references; you can use them in expressions just as you do in C++ source—they are automatically dereferenced.

   In the parameter list shown when GDB displays a frame, the values of reference variables are not displayed (unlike other variables); this avoids clutter, since references are often used for large structures. The *address* of a reference variable is always shown, unless you have specified '`set print address off`'.

5. GDB supports the C++ name resolution operator `::`—your expressions can use it just as expressions in your program do. Since one scope may be defined in another, you can use `::` repeatedly if necessary, for example in an expression like '*`scope1`*`::`*`scope2`*`::`*`name`*'. GDB also allows resolving name scope by reference to source files, in both C and C++ debugging (see Section 10.3 [Program Variables], page 107).

6. GDB performs argument-dependent lookup, following the C++ specification.

15.4.1.4 C and C++ Defaults

If you allow GDB to set range checking automatically, it defaults to `off` whenever the working language changes to C or C++. This happens regardless of whether you or GDB selects the working language.

If you allow GDB to set the language automatically, it recognizes source files whose names end with '`.c`', '`.C`', or '`.cc`', etc, and when GDB enters code compiled from one of these files, it sets the working language to C or C++. See Section 15.1.3 [Having GDB Infer the Source Language], page 174, for further details.

15.4.1.5 C and C++ Type and Range Checks

By default, when GDB parses C or C++ expressions, strict type checking is used. However, if you turn type checking off, GDB will allow certain non-standard conversions, such as promoting integer constants to pointers.

Range checking, if turned on, is done on mathematical operations. Array indices are not checked, since they are often used to index a pointer that is not itself an array.

15.4.1.6 GDB and C

The `set print union` and `show print union` commands apply to the `union` type. When set to '`on`', any `union` that is inside a `struct` or `class` is also printed. Otherwise, it appears as '`{...}`'.

The `@` operator aids in the debugging of dynamic arrays, formed with pointers and a memory allocation function. See Section 10.1 [Expressions], page 105.

15.4.1.7 GDB Features for C++

Some GDB commands are particularly useful with C++, and some are designed specifically for use with C++. Here is a summary:

breakpoint menus
: When you want a breakpoint in a function whose name is overloaded, GDB has the capability to display a menu of possible breakpoint locations to help you specify which function definition you want. See Section 10.2 [Ambiguous Expressions], page 106.

`rbreak` *regex*
: Setting breakpoints using regular expressions is helpful for setting breakpoints on overloaded functions that are not members of any special classes. See Section 5.1.1 [Setting Breakpoints], page 44.

`catch throw`
`catch catch`
: Debug C++ exception handling using these commands. See Section 5.1.3 [Setting Catchpoints], page 53.

`ptype` *typename*
: Print inheritance relationships as well as other information for type *typename*. See Chapter 16 [Examining the Symbol Table], page 201.

`info vtbl` *expression*.
: The `info vtbl` command can be used to display the virtual method tables of the object computed by *expression*. This shows one entry per virtual table; there may be multiple virtual tables when multiple inheritance is in use.

`set print demangle`
`show print demangle`
`set print asm-demangle`
`show print asm-demangle`
: Control whether C++ symbols display in their source form, both when displaying code as C++ source and when displaying disassemblies. See Section 10.8 [Print Settings], page 115.

`set print object`
`show print object`
: Choose whether to print derived (actual) or declared types of objects. See Section 10.8 [Print Settings], page 115.

`set print vtbl`
`show print vtbl`
: Control the format for printing virtual function tables. See Section 10.8 [Print Settings], page 115. (The `vtbl` commands do not work on programs compiled with the HP ANSI C++ compiler (`aCC`).)

`set overload-resolution on`
: Enable overload resolution for C++ expression evaluation. The default is on. For overloaded functions, GDB evaluates the arguments and searches for a function whose signature matches the argument types, using the standard C++ conversion rules (see Section 15.4.1.3 [C++ Expressions], page 180, for details). If it cannot find a match, it emits a message.

`set overload-resolution off`
: Disable overload resolution for C++ expression evaluation. For overloaded functions that are not class member functions, GDB chooses the first function of the specified name that it finds in the symbol table, whether or not its arguments are of the correct type. For overloaded functions that are class member functions, GDB searches for a function whose signature *exactly* matches the argument types.

`show overload-resolution`
: Show the current setting of overload resolution.

Overloaded symbol names
: You can specify a particular definition of an overloaded symbol, using the same notation that is used to declare such symbols in C++: type *`symbol(types)`* rather than just *symbol*. You can also use the GDB command-line word completion facilities to list the available choices, or to finish the type list for you. See Section 3.2 [Command Completion], page 19, for details on how to do this.

15.4.1.8 Decimal Floating Point format

GDB can examine, set and perform computations with numbers in decimal floating point format, which in the C language correspond to the `_Decimal32`, `_Decimal64` and `_Decimal128` types as specified by the extension to support decimal floating-point arithmetic.

There are two encodings in use, depending on the architecture: BID (Binary Integer Decimal) for x86 and x86-64, and DPD (Densely Packed Decimal) for PowerPC. GDB will use the appropriate encoding for the configured target.

Because of a limitation in '`libdecnumber`', the library used by GDB to manipulate decimal floating point numbers, it is not possible to convert (using a cast, for example) integers wider than 32-bit to decimal float.

In addition, in order to imitate GDB's behaviour with binary floating point computations, error checking in decimal float operations ignores underflow, overflow and divide by zero exceptions.

In the PowerPC architecture, GDB provides a set of pseudo-registers to inspect `_Decimal128` values stored in floating point registers. See Section 21.4.7 [PowerPC], page 279 for more details.

15.4.2 D

GDB can be used to debug programs written in D and compiled with GDC, LDC or DMD compilers. Currently GDB supports only one D specific feature — dynamic arrays.

15.4.3 Go

GDB can be used to debug programs written in Go and compiled with '`gccgo`' or '`6g`' compilers.

Here is a summary of the Go-specific features and restrictions:

`The current Go package`
: The name of the current package does not need to be specified when specifying global variables and functions.

  For example, given the program:

  ```
  package main
  var myglob = "Shall we?"
  func main () {
    // ...
  }
  ```

  When stopped inside `main` either of these work:

  ```
  (gdb) p myglob
  (gdb) p main.myglob
  ```

`Builtin Go types`
: The `string` type is recognized by GDB and is printed as a string.

`Builtin Go functions`
: The GDB expression parser recognizes the `unsafe.Sizeof` function and handles it internally.

`Restrictions on Go expressions`
: All Go operators are supported except `&^`. The Go `_` "blank identifier" is not supported. Automatic dereferencing of pointers is not supported.

15.4.4 Objective-C

This section provides information about some commands and command options that are useful for debugging Objective-C code. See also Chapter 16 [Symbols], page 201, and Chapter 16 [Symbols], page 201, for a few more commands specific to Objective-C support.

15.4.4.1 Method Names in Commands

The following commands have been extended to accept Objective-C method names as line specifications:

- `clear`
- `break`
- `info line`
- `jump`
- `list`

A fully qualified Objective-C method name is specified as

```
-[Class methodName]
```

where the minus sign is used to indicate an instance method and a plus sign (not shown) is used to indicate a class method. The class name *Class* and method name *methodName* are enclosed in brackets, similar to the way messages are specified in Objective-C source code. For example, to set a breakpoint at the `create` instance method of class `Fruit` in the program currently being debugged, enter:

```
break -[Fruit create]
```

To list ten program lines around the `initialize` class method, enter:

```
list +[NSText initialize]
```

In the current version of GDB, the plus or minus sign is required. In future versions of GDB, the plus or minus sign will be optional, but you can use it to narrow the search. It is also possible to specify just a method name:

```
break create
```

You must specify the complete method name, including any colons. If your program's source files contain more than one `create` method, you'll be presented with a numbered list of classes that implement that method. Indicate your choice by number, or type '`0`' to exit if none apply.

As another example, to clear a breakpoint established at the `makeKeyAndOrderFront:` method of the `NSWindow` class, enter:

```
clear -[NSWindow makeKeyAndOrderFront:]
```

15.4.4.2 The Print Command With Objective-C

The print command has also been extended to accept methods. For example:

```
print -[object hash]
```

will tell GDB to send the `hash` message to *object* and print the result. Also, an additional command has been added, `print-object` or `po` for short, which is meant to print the

description of an object. However, this command may only work with certain Objective-C libraries that have a particular hook function, `_NSPrintForDebugger`, defined.

15.4.5 OpenCL C

This section provides information about GDBs OpenCL C support.

15.4.5.1 OpenCL C Datatypes

GDB supports the builtin scalar and vector datatypes specified by OpenCL 1.1. In addition the half- and double-precision floating point data types of the `cl_khr_fp16` and `cl_khr_fp64` OpenCL extensions are also known to GDB.

15.4.5.2 OpenCL C Expressions

GDB supports accesses to vector components including the access as lvalue where possible. Since OpenCL C is based on C99 most C expressions supported by GDB can be used as well.

15.4.5.3 OpenCL C Operators

GDB supports the operators specified by OpenCL 1.1 for scalar and vector data types.

15.4.6 Fortran

GDB can be used to debug programs written in Fortran, but it currently supports only the features of Fortran 77 language.

Some Fortran compilers (GNU Fortran 77 and Fortran 95 compilers among them) append an underscore to the names of variables and functions. When you debug programs compiled by those compilers, you will need to refer to variables and functions with a trailing underscore.

15.4.6.1 Fortran Operators and Expressions

Operators must be defined on values of specific types. For instance, `+` is defined on numbers, but not on characters or other non- arithmetic types. Operators are often defined on groups of types.

`**` The exponentiation operator. It raises the first operand to the power of the second one.

`:` The range operator. Normally used in the form of array(low:high) to represent a section of array.

`%` The access component operator. Normally used to access elements in derived types. Also suitable for unions. As unions aren't part of regular Fortran, this can only happen when accessing a register that uses a gdbarch-defined union type.

15.4.6.2 Fortran Defaults

Fortran symbols are usually case-insensitive, so GDB by default uses case-insensitive matches for Fortran symbols. You can change that with the '`set case-insensitive`' command, see Chapter 16 [Symbols], page 201, for the details.

15.4.6.3 Special Fortran Commands

GDB has some commands to support Fortran-specific features, such as displaying common blocks.

`info common` [*common-name*]
: This command prints the values contained in the Fortran `COMMON` block whose name is *common-name*. With no argument, the names of all `COMMON` blocks visible at the current program location are printed.

15.4.7 Pascal

Debugging Pascal programs which use sets, subranges, file variables, or nested functions does not currently work. GDB does not support entering expressions, printing values, or similar features using Pascal syntax.

The Pascal-specific command `set print pascal_static-members` controls whether static members of Pascal objects are displayed. See Section 10.8 [Print Settings], page 115.

15.4.8 Modula-2

The extensions made to GDB to support Modula-2 only support output from the GNU Modula-2 compiler (which is currently being developed). Other Modula-2 compilers are not currently supported, and attempting to debug executables produced by them is most likely to give an error as GDB reads in the executable's symbol table.

15.4.8.1 Operators

Operators must be defined on values of specific types. For instance, `+` is defined on numbers, but not on structures. Operators are often defined on groups of types. For the purposes of Modula-2, the following definitions hold:

- *Integral types* consist of `INTEGER`, `CARDINAL`, and their subranges.
- *Character types* consist of `CHAR` and its subranges.
- *Floating-point types* consist of `REAL`.
- *Pointer types* consist of anything declared as `POINTER TO` *type*.
- *Scalar types* consist of all of the above.
- *Set types* consist of `SET` and `BITSET` types.
- *Boolean types* consist of `BOOLEAN`.

The following operators are supported, and appear in order of increasing precedence:

`,`
: Function argument or array index separator.

`:=`
: Assignment. The value of *var* `:=` *value* is *value*.

`<`, `>`
: Less than, greater than on integral, floating-point, or enumerated types.

`<=`, `>=`
: Less than or equal to, greater than or equal to on integral, floating-point and enumerated types, or set inclusion on set types. Same precedence as `<`.

`=`, `<>`, `#`
: Equality and two ways of expressing inequality, valid on scalar types. Same precedence as `<`. In GDB scripts, only `<>` is available for inequality, since `#` conflicts with the script comment character.

`IN` Set membership. Defined on set types and the types of their members. Same precedence as `<`.

`OR` Boolean disjunction. Defined on boolean types.

`AND`, `&` Boolean conjunction. Defined on boolean types.

`@` The GDB "artificial array" operator (see Section 10.1 [Expressions], page 105).

`+`, `-` Addition and subtraction on integral and floating-point types, or union and difference on set types.

`*` Multiplication on integral and floating-point types, or set intersection on set types.

`/` Division on floating-point types, or symmetric set difference on set types. Same precedence as `*`.

`DIV`, `MOD` Integer division and remainder. Defined on integral types. Same precedence as `*`.

`-` Negative. Defined on `INTEGER` and `REAL` data.

`^` Pointer dereferencing. Defined on pointer types.

`NOT` Boolean negation. Defined on boolean types. Same precedence as `^`.

`.` `RECORD` field selector. Defined on `RECORD` data. Same precedence as `^`.

`[]` Array indexing. Defined on `ARRAY` data. Same precedence as `^`.

`()` Procedure argument list. Defined on `PROCEDURE` objects. Same precedence as `^`.

`::`, `.` GDB and Modula-2 scope operators.

Warning: Set expressions and their operations are not yet supported, so GDB treats the use of the operator `IN`, or the use of operators `+`, `-`, `*`, `/`, `=`, , `<>`, `#`, `<=`, and `>=` on sets as an error.

15.4.8.2 Built-in Functions and Procedures

Modula-2 also makes available several built-in procedures and functions. In describing these, the following metavariables are used:

a represents an `ARRAY` variable.

c represents a `CHAR` constant or variable.

i represents a variable or constant of integral type.

m represents an identifier that belongs to a set. Generally used in the same function with the metavariable *s*. The type of *s* should be `SET OF` *mtype* (where *mtype* is the type of *m*).

n represents a variable or constant of integral or floating-point type.

r represents a variable or constant of floating-point type.

t represents a type.

v represents a variable.

x represents a variable or constant of one of many types. See the explanation of the function for details.

All Modula-2 built-in procedures also return a result, described below.

`ABS(n)` Returns the absolute value of *n*.

`CAP(c)` If *c* is a lower case letter, it returns its upper case equivalent, otherwise it returns its argument.

`CHR(i)` Returns the character whose ordinal value is *i*.

`DEC(v)` Decrements the value in the variable *v* by one. Returns the new value.

`DEC(v,i)` Decrements the value in the variable *v* by *i*. Returns the new value.

`EXCL(m,s)`
Removes the element *m* from the set *s*. Returns the new set.

`FLOAT(i)` Returns the floating point equivalent of the integer *i*.

`HIGH(a)` Returns the index of the last member of *a*.

`INC(v)` Increments the value in the variable *v* by one. Returns the new value.

`INC(v,i)` Increments the value in the variable *v* by *i*. Returns the new value.

`INCL(m,s)`
Adds the element *m* to the set *s* if it is not already there. Returns the new set.

`MAX(t)` Returns the maximum value of the type *t*.

`MIN(t)` Returns the minimum value of the type *t*.

`ODD(i)` Returns boolean TRUE if *i* is an odd number.

`ORD(x)` Returns the ordinal value of its argument. For example, the ordinal value of a character is its ASCII value (on machines supporting the ASCII character set). *x* must be of an ordered type, which include integral, character and enumerated types.

`SIZE(x)` Returns the size of its argument. *x* can be a variable or a type.

`TRUNC(r)` Returns the integral part of *r*.

`TSIZE(x)` Returns the size of its argument. *x* can be a variable or a type.

`VAL(t,i)` Returns the member of the type *t* whose ordinal value is *i*.

Warning: Sets and their operations are not yet supported, so GDB treats the use of procedures `INCL` and `EXCL` as an error.

15.4.8.3 Constants

GDB allows you to express the constants of Modula-2 in the following ways:

- Integer constants are simply a sequence of digits. When used in an expression, a constant is interpreted to be type-compatible with the rest of the expression. Hexadecimal integers are specified by a trailing '`H`', and octal integers by a trailing '`B`'.

- Floating point constants appear as a sequence of digits, followed by a decimal point and another sequence of digits. An optional exponent can then be specified, in the form '`E[+|-]`*nnn*', where '`[+|-]`*nnn*' is the desired exponent. All of the digits of the floating point constant must be valid decimal (base 10) digits.
- Character constants consist of a single character enclosed by a pair of like quotes, either single (') or double ("). They may also be expressed by their ordinal value (their ASCII value, usually) followed by a '`C`'.
- String constants consist of a sequence of characters enclosed by a pair of like quotes, either single (') or double ("). Escape sequences in the style of C are also allowed. See Section 15.4.1.2 [C and C++ Constants], page 179, for a brief explanation of escape sequences.
- Enumerated constants consist of an enumerated identifier.
- Boolean constants consist of the identifiers `TRUE` and `FALSE`.
- Pointer constants consist of integral values only.
- Set constants are not yet supported.

15.4.8.4 Modula-2 Types

Currently GDB can print the following data types in Modula-2 syntax: array types, record types, set types, pointer types, procedure types, enumerated types, subrange types and base types. You can also print the contents of variables declared using these type. This section gives a number of simple source code examples together with sample GDB sessions.

The first example contains the following section of code:

```
VAR
   s: SET OF CHAR ;
   r: [20..40] ;
```

and you can request GDB to interrogate the type and value of `r` and `s`.

```
(gdb) print s
{'A'..'C', 'Z'}
(gdb) ptype s
SET OF CHAR
(gdb) print r
21
(gdb) ptype r
[20..40]
```

Likewise if your source code declares `s` as:

```
VAR
   s: SET ['A'..'Z'] ;
```

then you may query the type of `s` by:

```
(gdb) ptype s
type = SET ['A'..'Z']
```

Note that at present you cannot interactively manipulate set expressions using the debugger.

The following example shows how you might declare an array in Modula-2 and how you can interact with GDB to print its type and contents:

```
VAR
   s: ARRAY [-10..10] OF CHAR ;
```

```
(gdb) ptype s
ARRAY [-10..10] OF CHAR
```

Note that the array handling is not yet complete and although the type is printed correctly, expression handling still assumes that all arrays have a lower bound of zero and not `-10` as in the example above.

Here are some more type related Modula-2 examples:

```
TYPE
   colour = (blue, red, yellow, green) ;
   t = [blue..yellow] ;
VAR
   s: t ;
BEGIN
   s := blue ;
```

The GDB interaction shows how you can query the data type and value of a variable.

```
(gdb) print s
$1 = blue
(gdb) ptype t
type = [blue..yellow]
```

In this example a Modula-2 array is declared and its contents displayed. Observe that the contents are written in the same way as their `C` counterparts.

```
VAR
   s: ARRAY [1..5] OF CARDINAL ;
BEGIN
   s[1] := 1 ;
(gdb) print s
$1 = {1, 0, 0, 0, 0}
(gdb) ptype s
type = ARRAY [1..5] OF CARDINAL
```

The Modula-2 language interface to GDB also understands pointer types as shown in this example:

```
VAR
   s: POINTER TO ARRAY [1..5] OF CARDINAL ;
BEGIN
   NEW(s) ;
   s^[1] := 1 ;
```

and you can request that GDB describes the type of `s`.

```
(gdb) ptype s
type = POINTER TO ARRAY [1..5] OF CARDINAL
```

GDB handles compound types as we can see in this example. Here we combine array types, record types, pointer types and subrange types:

```
TYPE
   foo = RECORD
            f1: CARDINAL ;
            f2: CHAR ;
            f3: myarray ;
         END ;

   myarray = ARRAY myrange OF CARDINAL ;
   myrange = [-2..2] ;
VAR
   s: POINTER TO ARRAY myrange OF foo ;
```

and you can ask GDB to describe the type of `s` as shown below.

```
(gdb) ptype s
type = POINTER TO ARRAY [-2..2] OF foo = RECORD
    f1 : CARDINAL;
    f2 : CHAR;
    f3 : ARRAY [-2..2] OF CARDINAL;
END
```

15.4.8.5 Modula-2 Defaults

If type and range checking are set automatically by GDB, they both default to `on` whenever the working language changes to Modula-2. This happens regardless of whether you or GDB selected the working language.

If you allow GDB to set the language automatically, then entering code compiled from a file whose name ends with '`.mod`' sets the working language to Modula-2. See Section 15.1.3 [Having GDB Infer the Source Language], page 174, for further details.

15.4.8.6 Deviations from Standard Modula-2

A few changes have been made to make Modula-2 programs easier to debug. This is done primarily via loosening its type strictness:

- Unlike in standard Modula-2, pointer constants can be formed by integers. This allows you to modify pointer variables during debugging. (In standard Modula-2, the actual address contained in a pointer variable is hidden from you; it can only be modified through direct assignment to another pointer variable or expression that returned a pointer.)
- C escape sequences can be used in strings and characters to represent non-printable characters. GDB prints out strings with these escape sequences embedded. Single non-printable characters are printed using the '`CHR(`*nnn*`)`' format.
- The assignment operator (`:=`) returns the value of its right-hand argument.
- All built-in procedures both modify *and* return their argument.

15.4.8.7 Modula-2 Type and Range Checks

Warning: in this release, GDB does not yet perform type or range checking.

GDB considers two Modula-2 variables type equivalent if:

- They are of types that have been declared equivalent via a `TYPE` *t1* `=` *t2* statement
- They have been declared on the same line. (Note: This is true of the GNU Modula-2 compiler, but it may not be true of other compilers.)

As long as type checking is enabled, any attempt to combine variables whose types are not equivalent is an error.

Range checking is done on all mathematical operations, assignment, array index bounds, and all built-in functions and procedures.

15.4.8.8 The Scope Operators `::` and `.`

There are a few subtle differences between the Modula-2 scope operator (`.`) and the GDB scope operator (`::`). The two have similar syntax:

```
module . id
```

```
scope :: id
```

where *scope* is the name of a module or a procedure, *module* the name of a module, and *id* is any declared identifier within your program, except another module.

Using the `::` operator makes GDB search the scope specified by *scope* for the identifier *id*. If it is not found in the specified scope, then GDB searches all scopes enclosing the one specified by *scope*.

Using the `.` operator makes GDB search the current scope for the identifier specified by *id* that was imported from the definition module specified by *module*. With this operator, it is an error if the identifier *id* was not imported from definition module *module*, or if *id* is not an identifier in *module*.

15.4.8.9 GDB and Modula-2

Some GDB commands have little use when debugging Modula-2 programs. Five subcommands of `set print` and `show print` apply specifically to C and C++: '`vtbl`', '`demangle`', '`asm-demangle`', '`object`', and '`union`'. The first four apply to C++, and the last to the C `union` type, which has no direct analogue in Modula-2.

The `@` operator (see Section 10.1 [Expressions], page 105), while available with any language, is not useful with Modula-2. Its intent is to aid the debugging of *dynamic arrays*, which cannot be created in Modula-2 as they can in C or C++. However, because an address can be specified by an integral constant, the construct '`{type}adrexp`' is still useful.

In GDB scripts, the Modula-2 inequality operator `#` is interpreted as the beginning of a comment. Use `<>` instead.

15.4.9 Ada

The extensions made to GDB for Ada only support output from the GNU Ada (GNAT) compiler. Other Ada compilers are not currently supported, and attempting to debug executables produced by them is most likely to be difficult.

15.4.9.1 Introduction

The Ada mode of GDB supports a fairly large subset of Ada expression syntax, with some extensions. The philosophy behind the design of this subset is

- That GDB should provide basic literals and access to operations for arithmetic, dereferencing, field selection, indexing, and subprogram calls, leaving more sophisticated computations to subprograms written into the program (which therefore may be called from GDB).
- That type safety and strict adherence to Ada language restrictions are not particularly important to the GDB user.
- That brevity is important to the GDB user.

Thus, for brevity, the debugger acts as if all names declared in user-written packages are directly visible, even if they are not visible according to Ada rules, thus making it unnecessary to fully qualify most names with their packages, regardless of context. Where this causes ambiguity, GDB asks the user's intent.

The debugger will start in Ada mode if it detects an Ada main program. As for other languages, it will enter Ada mode when stopped in a program that was translated from an Ada source file.

While in Ada mode, you may use '`--`' for comments. This is useful mostly for documenting command files. The standard GDB comment ('`#`') still works at the beginning of a line in Ada mode, but not in the middle (to allow based literals).

The debugger supports limited overloading. Given a subprogram call in which the function symbol has multiple definitions, it will use the number of actual parameters and some information about their types to attempt to narrow the set of definitions. It also makes very limited use of context, preferring procedures to functions in the context of the `call` command, and functions to procedures elsewhere.

15.4.9.2 Omissions from Ada

Here are the notable omissions from the subset:

- Only a subset of the attributes are supported:
  - `'First`, `'Last`, and `'Length` on array objects (not on types and subtypes).
  - `'Min` and `'Max`.
  - `'Pos` and `'Val`.
  - `'Tag`.
  - `'Range` on array objects (not subtypes), but only as the right operand of the membership (`in`) operator.
  - `'Access`, `'Unchecked_Access`, and `'Unrestricted_Access` (a GNAT extension).
  - `'Address`.
- The names in `Characters.Latin_1` are not available and concatenation is not implemented. Thus, escape characters in strings are not currently available.
- Equality tests ('`=`' and '`/=`') on arrays test for bitwise equality of representations. They will generally work correctly for strings and arrays whose elements have integer or enumeration types. They may not work correctly for arrays whose element types have user-defined equality, for arrays of real values (in particular, IEEE-conformant floating point, because of negative zeroes and NaNs), and for arrays whose elements contain unused bits with indeterminate values.
- The other component-by-component array operations (`and`, `or`, `xor`, `not`, and relational tests other than equality) are not implemented.
- There is limited support for array and record aggregates. They are permitted only on the right sides of assignments, as in these examples:

```
(gdb) set An_Array := (1, 2, 3, 4, 5, 6)
(gdb) set An_Array := (1, others => 0)
(gdb) set An_Array := (0|4 => 1, 1..3 => 2, 5 => 6)
(gdb) set A_2D_Array := ((1, 2, 3), (4, 5, 6), (7, 8, 9))
(gdb) set A_Record := (1, "Peter", True);
(gdb) set A_Record := (Name => "Peter", Id => 1, Alive => True)
```

  Changing a discriminant's value by assigning an aggregate has an undefined effect if that discriminant is used within the record. However, you can first modify discriminants by directly assigning to them (which normally would not be allowed in Ada), and then performing an aggregate assignment. For example, given a variable `A_Rec` declared to have a type such as:

```
type Rec (Len : Small_Integer := 0) is record
    Id : Integer;
```

```
    Vals : IntArray (1 .. Len);
end record;
```

you can assign a value with a different size of `Vals` with two assignments:

```
(gdb) set A_Rec.Len := 4
(gdb) set A_Rec := (Id => 42, Vals => (1, 2, 3, 4))
```

As this example also illustrates, GDB is very loose about the usual rules concerning aggregates. You may leave out some of the components of an array or record aggregate (such as the `Len` component in the assignment to `A_Rec` above); they will retain their original values upon assignment. You may freely use dynamic values as indices in component associations. You may even use overlapping or redundant component associations, although which component values are assigned in such cases is not defined.

- Calls to dispatching subprograms are not implemented.
- The overloading algorithm is much more limited (i.e., less selective) than that of real Ada. It makes only limited use of the context in which a subexpression appears to resolve its meaning, and it is much looser in its rules for allowing type matches. As a result, some function calls will be ambiguous, and the user will be asked to choose the proper resolution.
- The `new` operator is not implemented.
- Entry calls are not implemented.
- Aside from printing, arithmetic operations on the native VAX floating-point formats are not supported.
- It is not possible to slice a packed array.
- The names `True` and `False`, when not part of a qualified name, are interpreted as if implicitly prefixed by `Standard`, regardless of context. Should your program redefine these names in a package or procedure (at best a dubious practice), you will have to use fully qualified names to access their new definitions.

15.4.9.3 Additions to Ada

As it does for other languages, GDB makes certain generic extensions to Ada (see Section 10.1 [Expressions], page 105):

- If the expression *E* is a variable residing in memory (typically a local variable or array element) and *N* is a positive integer, then `E@N` displays the values of *E* and the *N*-1 adjacent variables following it in memory as an array. In Ada, this operator is generally not necessary, since its prime use is in displaying parts of an array, and slicing will usually do this in Ada. However, there are occasional uses when debugging programs in which certain debugging information has been optimized away.
- `B::var` means "the variable named *var* that appears in function or file *B*." When *B* is a file name, you must typically surround it in single quotes.
- The expression `{type} addr` means "the variable of type *type* that appears at address *addr*."
- A name starting with '`$`' is a convenience variable (see Section 10.11 [Convenience Vars], page 126) or a machine register (see Section 10.13 [Registers], page 128).

In addition, GDB provides a few other shortcuts and outright additions specific to Ada:

- The assignment statement is allowed as an expression, returning its right-hand operand as its value. Thus, you may enter

```
(gdb) set x := y + 3
(gdb) print A(tmp := y + 1)
```

- The semicolon is allowed as an "operator," returning as its value the value of its right-hand operand. This allows, for example, complex conditional breaks:

```
(gdb) break f
(gdb) condition 1 (report(i); k += 1; A(k) > 100)
```

- Rather than use catenation and symbolic character names to introduce special characters into strings, one may instead use a special bracket notation, which is also used to print strings. A sequence of characters of the form '`["XX"]`' within a string or character literal denotes the (single) character whose numeric encoding is *XX* in hexadecimal. The sequence of characters '`["""]`' also denotes a single quotation mark in strings. For example,

```
"One line.["0a"]Next line.["0a"]"
```

  contains an ASCII newline character (`Ada.Characters.Latin_1.LF`) after each period.

- The subtype used as a prefix for the attributes `'Pos`, `'Min`, and `'Max` is optional (and is ignored in any case). For example, it is valid to write

```
(gdb) print 'max(x, y)
```

- When printing arrays, GDB uses positional notation when the array has a lower bound of 1, and uses a modified named notation otherwise. For example, a one-dimensional array of three integers with a lower bound of 3 might print as

```
(3 => 10, 17, 1)
```

  That is, in contrast to valid Ada, only the first component has a `=>` clause.

- You may abbreviate attributes in expressions with any unique, multi-character subsequence of their names (an exact match gets preference). For example, you may use `a'len`, `a'gth`, or `a'lh` in place of `a'length`.

- Since Ada is case-insensitive, the debugger normally maps identifiers you type to lower case. The GNAT compiler uses upper-case characters for some of its internal identifiers, which are normally of no interest to users. For the rare occasions when you actually have to look at them, enclose them in angle brackets to avoid the lower-case mapping. For example,

```
(gdb) print <JMPBUF_SAVE>[0]
```

- Printing an object of class-wide type or dereferencing an access-to-class-wide value will display all the components of the object's specific type (as indicated by its run-time tag). Likewise, component selection on such a value will operate on the specific type of the object.

15.4.9.4 Stopping at the Very Beginning

It is sometimes necessary to debug the program during elaboration, and before reaching the main procedure. As defined in the Ada Reference Manual, the elaboration code is invoked from a procedure called `adainit`. To run your program up to the beginning of elaboration, simply use the following two commands: `tbreak adainit` and `run`.

15.4.9.5 Extensions for Ada Tasks

Support for Ada tasks is analogous to that for threads (see Section 4.10 [Threads], page 35). GDB provides the following task-related commands:

`info tasks`

This command shows a list of current Ada tasks, as in the following example:

```
(gdb) info tasks
  ID       TID P-ID Pri State                  Name
   1   8088000   0   15 Child Activation Wait main_task
   2   80a4000   1   15 Accept Statement      b
   3   809a800   1   15 Child Activation Wait a
*  4   80ae800   3   15 Runnable             c
```

In this listing, the asterisk before the last task indicates it to be the task currently being inspected.

ID — Represents GDB's internal task number.

TID — The Ada task ID.

P-ID — The parent's task ID (GDB's internal task number).

Pri — The base priority of the task.

State — Current state of the task.

`Unactivated`
: The task has been created but has not been activated. It cannot be executing.

`Runnable`
: The task is not blocked for any reason known to Ada. (It may be waiting for a mutex, though.) It is conceptually "executing" in normal mode.

`Terminated`
: The task is terminated, in the sense of ARM 9.3 (5). Any dependents that were waiting on terminate alternatives have been awakened and have terminated themselves.

`Child Activation Wait`
: The task is waiting for created tasks to complete activation.

`Accept Statement`
: The task is waiting on an accept or selective wait statement.

`Waiting on entry call`
: The task is waiting on an entry call.

`Async Select Wait`
: The task is waiting to start the abortable part of an asynchronous select statement.

`Delay Sleep`
: The task is waiting on a select statement with only a delay alternative open.

`Child Termination Wait`
: The task is sleeping having completed a master within itself, and is waiting for the tasks dependent on that master to become terminated or waiting on a terminate Phase.

`Wait Child in Term Alt`
: The task is sleeping waiting for tasks on terminate alternatives to finish terminating.

`Accepting RV with` *taskno*
: The task is accepting a rendez-vous with the task *taskno*.

Name
: Name of the task in the program.

`info task` *taskno*
: This command shows detailled informations on the specified task, as in the following example:

```
(gdb) info tasks
  ID       TID P-ID Pri State                  Name
   1   8077880    0  15 Child Activation Wait  main_task
*  2   807c468    1  15 Runnable               task_1
(gdb) info task 2
Ada Task: 0x807c468
Name: task_1
Thread: 0x807f378
Parent: 1 (main_task)
Base Priority: 15
State: Runnable
```

`task`
: This command prints the ID of the current task.

```
(gdb) info tasks
  ID       TID P-ID Pri State                  Name
   1   8077870    0  15 Child Activation Wait  main_task
*  2   807c458    1  15 Runnable               t
(gdb) task
[Current task is 2]
```

`task` *taskno*
: This command is like the `thread` *threadno* command (see Section 4.10 [Threads], page 35). It switches the context of debugging from the current task to the given task.

```
(gdb) info tasks
  ID       TID P-ID Pri State                  Name
```

```
   1   8077870    0  15 Child Activation Wait  main_task
*  2   807c458    1  15 Runnable               t
(gdb) task 1
[Switching to task 1]
#0  0x8067726 in pthread_cond_wait ()
(gdb) bt
#0  0x8067726 in pthread_cond_wait ()
#1  0x8056714 in system.os_interface.pthread_cond_wait ()
#2  0x805cb63 in system.task_primitives.operations.sleep ()
#3  0x806153e in system.tasking.stages.activate_tasks ()
#4  0x804aacc in un () at un.adb:5
```

`break` *linespec* `task` *taskno*

`break` *linespec* `task` *taskno* `if ...`

These commands are like the `break ... thread ...` command (see Section 5.5 [Thread Stops], page 72). *linespec* specifies source lines, as described in Section 9.2 [Specify Location], page 94.

Use the qualifier '`task` *taskno*' with a breakpoint command to specify that you only want GDB to stop the program when a particular Ada task reaches this breakpoint. *taskno* is one of the numeric task identifiers assigned by GDB, shown in the first column of the '`info tasks`' display.

If you do not specify '`task` *taskno*' when you set a breakpoint, the breakpoint applies to *all* tasks of your program.

You can use the `task` qualifier on conditional breakpoints as well; in this case, place '`task` *taskno*' before the breakpoint condition (before the `if`).

For example,

```
(gdb) info tasks
  ID       TID P-ID Pri State                 Name
   1 140022020   0   15 Child Activation Wait main_task
   2 140045060   1   15 Accept/Select Wait    t2
   3 140044840   1   15 Runnable              t1
*  4 140056040   1   15 Runnable              t3
(gdb) b 15 task 2
Breakpoint 5 at 0x120044cb0: file test_task_debug.adb, line 15.
(gdb) cont
Continuing.
task # 1 running
task # 2 running

Breakpoint 5, test_task_debug () at test_task_debug.adb:15
15              flush;
(gdb) info tasks
  ID       TID P-ID Pri State                 Name
   1 140022020   0   15 Child Activation Wait main_task
*  2 140045060   1   15 Runnable              t2
   3 140044840   1   15 Runnable              t1
   4 140056040   1   15 Delay Sleep           t3
```

15.4.9.6 Tasking Support when Debugging Core Files

When inspecting a core file, as opposed to debugging a live program, tasking support may be limited or even unavailable, depending on the platform being used. For instance, on

x86-linux, the list of tasks is available, but task switching is not supported. On Tru64, however, task switching will work as usual.

On certain platforms, including Tru64, the debugger needs to perform some memory writes in order to provide Ada tasking support. When inspecting a core file, this means that the core file must be opened with read-write privileges, using the command '`"set write on"`' (see Section 17.6 [Patching], page 213). Under these circumstances, you should make a backup copy of the core file before inspecting it with GDB.

15.4.9.7 Tasking Support when using the Ravenscar Profile

The *Ravenscar Profile* is a subset of the Ada tasking features, specifically designed for systems with safety-critical real-time requirements.

`set ravenscar task-switching on`
: Allows task switching when debugging a program that uses the Ravenscar Profile. This is the default.

`set ravenscar task-switching off`
: Turn off task switching when debugging a program that uses the Ravenscar Profile. This is mostly intended to disable the code that adds support for the Ravenscar Profile, in case a bug in either GDB or in the Ravenscar runtime is preventing GDB from working properly. To be effective, this command should be run before the program is started.

`show ravenscar task-switching`
: Show whether it is possible to switch from task to task in a program using the Ravenscar Profile.

15.4.9.8 Known Peculiarities of Ada Mode

Besides the omissions listed previously (see Section 15.4.9.2 [Omissions from Ada], page 193), we know of several problems with and limitations of Ada mode in GDB, some of which will be fixed with planned future releases of the debugger and the GNU Ada compiler.

- Static constants that the compiler chooses not to materialize as objects in storage are invisible to the debugger.
- Named parameter associations in function argument lists are ignored (the argument lists are treated as positional).
- Many useful library packages are currently invisible to the debugger.
- Fixed-point arithmetic, conversions, input, and output is carried out using floating-point arithmetic, and may give results that only approximate those on the host machine.
- The GNAT compiler never generates the prefix `Standard` for any of the standard symbols defined by the Ada language. GDB knows about this: it will strip the prefix from names when you use it, and will never look for a name you have so qualified among local symbols, nor match against symbols in other packages or subprograms. If you have defined entities anywhere in your program other than parameters and local variables whose simple names match names in `Standard`, GNAT's lack of qualification here can cause confusion. When this happens, you can usually resolve the confusion by qualifying the problematic names with package `Standard` explicitly.

Older versions of the compiler sometimes generate erroneous debugging information, resulting in the debugger incorrectly printing the value of affected entities. In some cases, the debugger is able to work around an issue automatically. In other cases, the debugger is able to work around the issue, but the work-around has to be specifically enabled.

`set ada trust-PAD-over-XVS on`
: Configure GDB to strictly follow the GNAT encoding when computing the value of Ada entities, particularly when `PAD` and `PAD___XVS` types are involved (see `ada/exp_dbug.ads` in the GCC sources for a complete description of the encoding used by the GNAT compiler). This is the default.

`set ada trust-PAD-over-XVS off`
: This is related to the encoding using by the GNAT compiler. If GDB sometimes prints the wrong value for certain entities, changing `ada trust-PAD-over-XVS` to `off` activates a work-around which may fix the issue. It is always safe to set `ada trust-PAD-over-XVS` to `off`, but this incurs a slight performance penalty, so it is recommended to leave this setting to `on` unless necessary.

15.5 Unsupported Languages

In addition to the other fully-supported programming languages, GDB also provides a pseudo-language, called `minimal`. It does not represent a real programming language, but provides a set of capabilities close to what the C or assembly languages provide. This should allow most simple operations to be performed while debugging an application that uses a language currently not supported by GDB.

If the language is set to `auto`, GDB will automatically select this language if the current frame corresponds to an unsupported language.

16 Examining the Symbol Table

The commands described in this chapter allow you to inquire about the symbols (names of variables, functions and types) defined in your program. This information is inherent in the text of your program and does not change as your program executes. GDB finds it in your program's symbol table, in the file indicated when you started GDB (see Section 2.1.1 [Choosing Files], page 12), or by one of the file-management commands (see Section 18.1 [Commands to Specify Files], page 215).

Occasionally, you may need to refer to symbols that contain unusual characters, which GDB ordinarily treats as word delimiters. The most frequent case is in referring to static variables in other source files (see Section 10.3 [Program Variables], page 107). File names are recorded in object files as debugging symbols, but GDB would ordinarily parse a typical file name, like '`foo.c`', as the three words '`foo`' '`.`' '`c`'. To allow GDB to recognize '`foo.c`' as a single symbol, enclose it in single quotes; for example,

```
p 'foo.c'::x
```

looks up the value of `x` in the scope of the file '`foo.c`'.

`set case-sensitive on`
`set case-sensitive off`
`set case-sensitive auto`

Normally, when GDB looks up symbols, it matches their names with case sensitivity determined by the current source language. Occasionally, you may wish to control that. The command `set case-sensitive` lets you do that by specifying `on` for case-sensitive matches or `off` for case-insensitive ones. If you specify `auto`, case sensitivity is reset to the default suitable for the source language. The default is case-sensitive matches for all languages except for Fortran, for which the default is case-insensitive matches.

`show case-sensitive`

This command shows the current setting of case sensitivity for symbols lookups.

`set print type methods`
`set print type methods on`
`set print type methods off`

Normally, when GDB prints a class, it displays any methods declared in that class. You can control this behavior either by passing the appropriate flag to `ptype`, or using `set print type methods`. Specifying `on` will cause GDB to display the methods; this is the default. Specifying `off` will cause GDB to omit the methods.

`show print type methods`

This command shows the current setting of method display when printing classes.

`set print type typedefs`
`set print type typedefs on`
`set print type typedefs off`

Normally, when GDB prints a class, it displays any typedefs defined in that class. You can control this behavior either by passing the appropriate flag to `ptype`,

or using `set print type typedefs`. Specifying `on` will cause GDB to display the typedef definitions; this is the default. Specifying `off` will cause GDB to omit the typedef definitions. Note that this controls whether the typedef definition itself is printed, not whether typedef names are substituted when printing other types.

`show print type typedefs`
: This command shows the current setting of typedef display when printing classes.

`info address` *symbol*
: Describe where the data for *symbol* is stored. For a register variable, this says which register it is kept in. For a non-register local variable, this prints the stack-frame offset at which the variable is always stored.

  Note the contrast with '`print &`*symbol*', which does not work at all for a register variable, and for a stack local variable prints the exact address of the current instantiation of the variable.

`info symbol` *addr*
: Print the name of a symbol which is stored at the address *addr*. If no symbol is stored exactly at *addr*, GDB prints the nearest symbol and an offset from it:

```
(gdb) info symbol 0x54320
_initialize_vx + 396 in section .text
```

  This is the opposite of the `info address` command. You can use it to find out the name of a variable or a function given its address.

  For dynamically linked executables, the name of executable or shared library containing the symbol is also printed:

```
(gdb) info symbol 0x400225
_start + 5 in section .text of /tmp/a.out
(gdb) info symbol 0x2aaaac2811cf
__read_nocancel + 6 in section .text of /usr/lib64/libc.so.6
```

`whatis[/`*flags*`] [`*arg*`]`
: Print the data type of *arg*, which can be either an expression or a name of a data type. With no argument, print the data type of `$`, the last value in the value history.

  If *arg* is an expression (see Section 10.1 [Expressions], page 105), it is not actually evaluated, and any side-effecting operations (such as assignments or function calls) inside it do not take place.

  If *arg* is a variable or an expression, `whatis` prints its literal type as it is used in the source code. If the type was defined using a `typedef`, `whatis` will *not* print the data type underlying the `typedef`. If the type of the variable or the expression is a compound data type, such as `struct` or `class`, `whatis` never prints their fields or methods. It just prints the `struct`/`class` name (a.k.a. its *tag*). If you want to see the members of such a compound data type, use `ptype`.

  If *arg* is a type name that was defined using `typedef`, `whatis` *unrolls* only one level of that `typedef`. Unrolling means that `whatis` will show the underlying

type used in the `typedef` declaration of *arg*. However, if that underlying type is also a `typedef`, `whatis` will not unroll it.

For C code, the type names may also have the form '`class` *class-name*', '`struct` *struct-tag*', '`union` *union-tag*' or '`enum` *enum-tag*'.

flags can be used to modify how the type is displayed. Available flags are:

`r` Display in "raw" form. Normally, GDB substitutes template parameters and typedefs defined in a class when printing the class' members. The `/r` flag disables this.

`m` Do not print methods defined in the class.

`M` Print methods defined in the class. This is the default, but the flag exists in case you change the default with `set print type methods`.

`t` Do not print typedefs defined in the class. Note that this controls whether the typedef definition itself is printed, not whether typedef names are substituted when printing other types.

`T` Print typedefs defined in the class. This is the default, but the flag exists in case you change the default with `set print type typedefs`.

`ptype[/`*flags*`] [`*arg*`]`

`ptype` accepts the same arguments as `whatis`, but prints a detailed description of the type, instead of just the name of the type. See Section 10.1 [Expressions], page 105.

Contrary to `whatis`, `ptype` always unrolls any `typedef`s in its argument declaration, whether the argument is a variable, expression, or a data type. This means that `ptype` of a variable or an expression will not print literally its type as present in the source code—use `whatis` for that. `typedef`s at the pointer or reference targets are also unrolled. Only `typedef`s of fields, methods and inner `class typedef`s of `struct`s, `class`es and `union`s are not unrolled even with `ptype`.

For example, for this variable declaration:

```
typedef double real_t;
struct complex { real_t real; double imag; };
typedef struct complex complex_t;
complex_t var;
real_t *real_pointer_var;
```

the two commands give this output:

```
(gdb) whatis var
type = complex_t
(gdb) ptype var
type = struct complex {
    real_t real;
    double imag;
}
(gdb) whatis complex_t
type = struct complex
(gdb) whatis struct complex
type = struct complex
(gdb) ptype struct complex
type = struct complex {
    real_t real;
    double imag;
}
(gdb) whatis real_pointer_var
type = real_t *
(gdb) ptype real_pointer_var
type = double *
```

As with `whatis`, using `ptype` without an argument refers to the type of `$`, the last value in the value history.

Sometimes, programs use opaque data types or incomplete specifications of complex data structure. If the debug information included in the program does not allow GDB to display a full declaration of the data type, it will say '`<incomplete type>`'. For example, given these declarations:

```
struct foo;
struct foo *fooptr;
```

but no definition for `struct foo` itself, GDB will say:

```
(gdb) ptype foo
$1 = <incomplete type>
```

"Incomplete type" is C terminology for data types that are not completely specified.

`info types` *regexp*
`info types`

Print a brief description of all types whose names match the regular expression *regexp* (or all types in your program, if you supply no argument). Each complete typename is matched as though it were a complete line; thus, '`i type value`' gives information on all types in your program whose names include the string `value`, but '`i type ^value$`' gives information only on types whose complete name is `value`.

This command differs from `ptype` in two ways: first, like `whatis`, it does not print a detailed description; second, it lists all source files where a type is defined.

`info type-printers`

Versions of GDB that ship with Python scripting enabled may have "type printers" available. When using `ptype` or `whatis`, these printers are consulted when the name of a type is needed. See Section 23.2.2.8 [Type Printing API], page 321, for more information on writing type printers.

`info type-printers` displays all the available type printers.

`enable type-printer` *`name`*`...`
`disable type-printer` *`name`*`...`
These commands can be used to enable or disable type printers.

`info scope` *`location`*
List all the variables local to a particular scope. This command accepts a *location* argument—a function name, a source line, or an address preceded by a '`*`', and prints all the variables local to the scope defined by that location. (See Section 9.2 [Specify Location], page 94, for details about supported forms of *location*.) For example:

```
(gdb) info scope command_line_handler
Scope for command_line_handler:
Symbol rl is an argument at stack/frame offset 8, length 4.
Symbol linebuffer is in static storage at address 0x150a18, length 4.
Symbol linelength is in static storage at address 0x150a1c, length 4.
Symbol p is a local variable in register $esi, length 4.
Symbol p1 is a local variable in register $ebx, length 4.
Symbol nline is a local variable in register $edx, length 4.
Symbol repeat is a local variable at frame offset -8, length 4.
```

This command is especially useful for determining what data to collect during a *trace experiment*, see Section 13.1.6 [Tracepoint Actions], page 154.

`info source`
Show information about the current source file—that is, the source file for the function containing the current point of execution:

- the name of the source file, and the directory containing it,
- the directory it was compiled in,
- its length, in lines,
- which programming language it is written in,
- whether the executable includes debugging information for that file, and if so, what format the information is in (e.g., STABS, Dwarf 2, etc.), and
- whether the debugging information includes information about preprocessor macros.

`info sources`
Print the names of all source files in your program for which there is debugging information, organized into two lists: files whose symbols have already been read, and files whose symbols will be read when needed.

`info functions`
Print the names and data types of all defined functions.

`info functions` *`regexp`*
Print the names and data types of all defined functions whose names contain a match for regular expression *regexp*. Thus, '`info fun step`' finds all functions whose names include `step`; '`info fun ^step`' finds those whose names start with `step`. If a function name contains characters that conflict with the regular expression language (e.g. '`operator*()`'), they may be quoted with a backslash.

`info variables`
: Print the names and data types of all variables that are defined outside of functions (i.e. excluding local variables).

`info variables` *regexp*
: Print the names and data types of all variables (except for local variables) whose names contain a match for regular expression *regexp*.

`info classes`
`info classes` *regexp*
: Display all Objective-C classes in your program, or (with the *regexp* argument) all those matching a particular regular expression.

`info selectors`
`info selectors` *regexp*
: Display all Objective-C selectors in your program, or (with the *regexp* argument) all those matching a particular regular expression.

`set opaque-type-resolution on`
: Tell GDB to resolve opaque types. An opaque type is a type declared as a pointer to a `struct`, `class`, or `union`—for example, `struct MyType *`—that is used in one source file although the full declaration of `struct MyType` is in another source file. The default is on.

  A change in the setting of this subcommand will not take effect until the next time symbols for a file are loaded.

`set opaque-type-resolution off`
: Tell GDB not to resolve opaque types. In this case, the type is printed as follows:

```
{<no data fields>}
```

`show opaque-type-resolution`
: Show whether opaque types are resolved or not.

`maint print symbols` *filename*
`maint print psymbols` *filename*
`maint print msymbols` *filename*
: Write a dump of debugging symbol data into the file *filename*. These commands are used to debug the GDB symbol-reading code. Only symbols with debugging data are included. If you use '`maint print symbols`', GDB includes all the symbols for which it has already collected full details: that is, *filename* reflects symbols for only those files whose symbols GDB has read. You can use the command `info sources` to find out which files these are. If you use '`maint print psymbols`' instead, the dump shows information about symbols that GDB only knows partially—that is, symbols defined in files that GDB has skimmed, but not yet read completely. Finally, '`maint print msymbols`' dumps just the minimal symbol information required for each object file from which GDB has read some symbols. See Section 18.1 [Commands to Specify Files], page 215, for a discussion of how GDB reads symbols (in the description of `symbol-file`).

`maint info symtabs` [*regexp*]
`maint info psymtabs` [*regexp*]

List the `struct symtab` or `struct partial_symtab` structures whose names match *regexp*. If *regexp* is not given, list them all. The output includes expressions which you can copy into a GDB debugging this one to examine a particular structure in more detail. For example:

```
(gdb) maint info psymtabs dwarf2read
{ objfile /home/gnu/build/gdb/gdb
  ((struct objfile *) 0x82e69d0)
  { psymtab /home/gnu/src/gdb/dwarf2read.c
    ((struct partial_symtab *) 0x8474b10)
    readin no
    fullname (null)
    text addresses 0x814d3c8 -- 0x8158074
    globals (* (struct partial_symbol **) 0x8507a08 @ 9)
    statics (* (struct partial_symbol **) 0x40e95b78 @ 2882)
    dependencies (none)
  }
}
(gdb) maint info symtabs
(gdb)
```

We see that there is one partial symbol table whose filename contains the string '`dwarf2read`', belonging to the '`gdb`' executable; and we see that GDB has not read in any symtabs yet at all. If we set a breakpoint on a function, that will cause GDB to read the symtab for the compilation unit containing that function:

```
(gdb) break dwarf2_psymtab_to_symtab
Breakpoint 1 at 0x814e5da: file /home/gnu/src/gdb/dwarf2read.c,
line 1574.
(gdb) maint info symtabs
{ objfile /home/gnu/build/gdb/gdb
  ((struct objfile *) 0x82e69d0)
  { symtab /home/gnu/src/gdb/dwarf2read.c
    ((struct symtab *) 0x86c1f38)
    dirname (null)
    fullname (null)
    blockvector ((struct blockvector *) 0x86c1bd0) (primary)
    linetable ((struct linetable *) 0x8370fa0)
    debugformat DWARF 2
  }
}
(gdb)
```

17 Altering Execution

Once you think you have found an error in your program, you might want to find out for certain whether correcting the apparent error would lead to correct results in the rest of the run. You can find the answer by experiment, using the GDB features for altering execution of the program.

For example, you can store new values into variables or memory locations, give your program a signal, restart it at a different address, or even return prematurely from a function.

17.1 Assignment to Variables

To alter the value of a variable, evaluate an assignment expression. See Section 10.1 [Expressions], page 105. For example,

```
print x=4
```

stores the value 4 into the variable `x`, and then prints the value of the assignment expression (which is 4). See Chapter 15 [Using GDB with Different Languages], page 173, for more information on operators in supported languages.

If you are not interested in seeing the value of the assignment, use the `set` command instead of the `print` command. `set` is really the same as `print` except that the expression's value is not printed and is not put in the value history (see Section 10.10 [Value History], page 125). The expression is evaluated only for its effects.

If the beginning of the argument string of the `set` command appears identical to a `set` subcommand, use the `set variable` command instead of just `set`. This command is identical to `set` except for its lack of subcommands. For example, if your program has a variable `width`, you get an error if you try to set a new value with just '`set width=13`', because GDB has the command `set width`:

```
(gdb) whatis width
type = double
(gdb) p width
$4 = 13
(gdb) set width=47
Invalid syntax in expression.
```

The invalid expression, of course, is '`=47`'. In order to actually set the program's variable `width`, use

```
(gdb) set var width=47
```

Because the `set` command has many subcommands that can conflict with the names of program variables, it is a good idea to use the `set variable` command instead of just `set`. For example, if your program has a variable `g`, you run into problems if you try to set a new value with just '`set g=4`', because GDB has the command `set gnutarget`, abbreviated `set g`:

```
(gdb) whatis g
type = double
(gdb) p g
$1 = 1
(gdb) set g=4
(gdb) p g
$2 = 1
(gdb) r
The program being debugged has been started already.
Start it from the beginning? (y or n) y
Starting program: /home/smith/cc_progs/a.out
"/home/smith/cc_progs/a.out": can't open to read symbols:
                                 Invalid bfd target.
(gdb) show g
The current BFD target is "=4".
```

The program variable `g` did not change, and you silently set the `gnutarget` to an invalid value. In order to set the variable `g`, use

```
(gdb) set var g=4
```

GDB allows more implicit conversions in assignments than C; you can freely store an integer value into a pointer variable or vice versa, and you can convert any structure to any other structure that is the same length or shorter.

To store values into arbitrary places in memory, use the '`{...}`' construct to generate a value of specified type at a specified address (see Section 10.1 [Expressions], page 105). For example, `{int}0x83040` refers to memory location `0x83040` as an integer (which implies a certain size and representation in memory), and

```
set {int}0x83040 = 4
```

stores the value 4 into that memory location.

17.2 Continuing at a Different Address

Ordinarily, when you continue your program, you do so at the place where it stopped, with the `continue` command. You can instead continue at an address of your own choosing, with the following commands:

`jump` *linespec*
`j` *linespec*
`jump` *location*
`j` *location*

Resume execution at line *linespec* or at address given by *location*. Execution stops again immediately if there is a breakpoint there. See Section 9.2 [Specify Location], page 94, for a description of the different forms of *linespec* and *location*. It is common practice to use the `tbreak` command in conjunction with `jump`. See Section 5.1.1 [Setting Breakpoints], page 44.

The `jump` command does not change the current stack frame, or the stack pointer, or the contents of any memory location or any register other than the program counter. If line *linespec* is in a different function from the one currently executing, the results may be bizarre if the two functions expect different patterns of arguments or of local variables. For this reason, the `jump` command requests confirmation if the specified line is not in the function currently exe-

cuting. However, even bizarre results are predictable if you are well acquainted with the machine-language code of your program.

On many systems, you can get much the same effect as the `jump` command by storing a new value into the register `$pc`. The difference is that this does not start your program running; it only changes the address of where it *will* run when you continue. For example,

```
set $pc = 0x485
```

makes the next `continue` command or stepping command execute at address `0x485`, rather than at the address where your program stopped. See Section 5.2 [Continuing and Stepping], page 65.

The most common occasion to use the `jump` command is to back up—perhaps with more breakpoints set—over a portion of a program that has already executed, in order to examine its execution in more detail.

17.3 Giving your Program a Signal

`signal` *`signal`*

Resume execution where your program stopped, but immediately give it the signal *signal*. *signal* can be the name or the number of a signal. For example, on many systems `signal 2` and `signal SIGINT` are both ways of sending an interrupt signal.

Alternatively, if *signal* is zero, continue execution without giving a signal. This is useful when your program stopped on account of a signal and would ordinarily see the signal when resumed with the `continue` command; '`signal 0`' causes it to resume without a signal.

`signal` does not repeat when you press RET a second time after executing the command.

Invoking the `signal` command is not the same as invoking the `kill` utility from the shell. Sending a signal with `kill` causes GDB to decide what to do with the signal depending on the signal handling tables (see Section 5.4 [Signals], page 70). The `signal` command passes the signal directly to your program.

17.4 Returning from a Function

`return`
`return` *`expression`*

You can cancel execution of a function call with the `return` command. If you give an *expression* argument, its value is used as the function's return value.

When you use `return`, GDB discards the selected stack frame (and all frames within it). You can think of this as making the discarded frame return prematurely. If you wish to specify a value to be returned, give that value as the argument to `return`.

This pops the selected stack frame (see Section 8.3 [Selecting a Frame], page 90), and any other frames inside of it, leaving its caller as the innermost remaining frame. That frame becomes selected. The specified value is stored in the registers used for returning values of functions.

The `return` command does not resume execution; it leaves the program stopped in the state that would exist if the function had just returned. In contrast, the `finish` command (see Section 5.2 [Continuing and Stepping], page 65) resumes execution until the selected stack frame returns naturally.

GDB needs to know how the *expression* argument should be set for the inferior. The concrete registers assignment depends on the OS ABI and the type being returned by the selected stack frame. For example it is common for OS ABI to return floating point values in FPU registers while integer values in CPU registers. Still some ABIs return even floating point values in CPU registers. Larger integer widths (such as `long long int`) also have specific placement rules. GDB already knows the OS ABI from its current target so it needs to find out also the type being returned to make the assignment into the right register(s).

Normally, the selected stack frame has debug info. GDB will always use the debug info instead of the implicit type of *expression* when the debug info is available. For example, if you type *`return -1`*, and the function in the current stack frame is declared to return a `long long int`, GDB transparently converts the implicit `int` value of -1 into a `long long int`:

```
Breakpoint 1, func () at gdb.base/return-nodebug.c:29
29        return 31;
(gdb) return -1
Make func return now? (y or n) y
#0  0x004004f6 in main () at gdb.base/return-nodebug.c:43
43        printf ("result=%lld\n", func ());
(gdb)
```

However, if the selected stack frame does not have a debug info, e.g., if the function was compiled without debug info, GDB has to find out the type to return from user. Specifying a different type by mistake may set the value in different inferior registers than the caller code expects. For example, typing *`return -1`* with its implicit type `int` would set only a part of a `long long int` result for a debug info less function (on 32-bit architectures). Therefore the user is required to specify the return type by an appropriate cast explicitly:

```
Breakpoint 2, 0x0040050b in func ()
(gdb) return -1
Return value type not available for selected stack frame.
Please use an explicit cast of the value to return.
(gdb) return (long long int) -1
Make selected stack frame return now? (y or n) y
#0  0x00400526 in main ()
(gdb)
```

17.5 Calling Program Functions

`print` *`expr`*

Evaluate the expression *expr* and display the resulting value. *expr* may include calls to functions in the program being debugged.

`call` *`expr`*

Evaluate the expression *expr* without displaying `void` returned values.

You can use this variant of the `print` command if you want to execute a function from your program that does not return anything (a.k.a. *a void function*), but without cluttering the output with `void` returned values that GDB will otherwise print. If the result is not void, it is printed and saved in the value history.

It is possible for the function you call via the `print` or `call` command to generate a signal (e.g., if there's a bug in the function, or if you passed it incorrect arguments). What happens in that case is controlled by the `set unwindonsignal` command.

Similarly, with a C++ program it is possible for the function you call via the `print` or `call` command to generate an exception that is not handled due to the constraints of the dummy frame. In this case, any exception that is raised in the frame, but has an out-of-frame exception handler will not be found. GDB builds a dummy-frame for the inferior function call, and the unwinder cannot seek for exception handlers outside of this dummy-frame. What happens in that case is controlled by the `set unwind-on-terminating-exception` command.

`set unwindonsignal`
: Set unwinding of the stack if a signal is received while in a function that GDB called in the program being debugged. If set to on, GDB unwinds the stack it created for the call and restores the context to what it was before the call. If set to off (the default), GDB stops in the frame where the signal was received.

`show unwindonsignal`
: Show the current setting of stack unwinding in the functions called by GDB.

`set unwind-on-terminating-exception`
: Set unwinding of the stack if a C++ exception is raised, but left unhandled while in a function that GDB called in the program being debugged. If set to on (the default), GDB unwinds the stack it created for the call and restores the context to what it was before the call. If set to off, GDB the exception is delivered to the default C++ exception handler and the inferior terminated.

`show unwind-on-terminating-exception`
: Show the current setting of stack unwinding in the functions called by GDB.

Sometimes, a function you wish to call is actually a *weak alias* for another function. In such case, GDB might not pick up the type information, including the types of the function arguments, which causes GDB to call the inferior function incorrectly. As a result, the called function will function erroneously and may even crash. A solution to that is to use the name of the aliased function instead.

17.6 Patching Programs

By default, GDB opens the file containing your program's executable code (or the corefile) read-only. This prevents accidental alterations to machine code; but it also prevents you from intentionally patching your program's binary.

If you'd like to be able to patch the binary, you can specify that explicitly with the `set write` command. For example, you might want to turn on internal debugging flags, or even to make emergency repairs.

`set write on`
`set write off`
: If you specify '`set write on`', GDB opens executable and core files for both reading and writing; if you specify *`set write off`* (the default), GDB opens them read-only.

If you have already loaded a file, you must load it again (using the `exec-file` or `core-file` command) after changing `set write`, for your new setting to take effect.

`show write`
: Display whether executable files and core files are opened for writing as well as reading.

18 GDB Files

GDB needs to know the file name of the program to be debugged, both in order to read its symbol table and in order to start your program. To debug a core dump of a previous run, you must also tell GDB the name of the core dump file.

18.1 Commands to Specify Files

You may want to specify executable and core dump file names. The usual way to do this is at start-up time, using the arguments to GDB's start-up commands (see Chapter 2 [Getting In and Out of GDB], page 11).

Occasionally it is necessary to change to a different file during a GDB session. Or you may run GDB and forget to specify a file you want to use. Or you are debugging a remote target via `gdbserver` (see Section 20.3 [Using the `gdbserver` Program], page 237). In these situations the GDB commands to specify new files are useful.

`file` *`filename`*
: Use *filename* as the program to be debugged. It is read for its symbols and for the contents of pure memory. It is also the program executed when you use the `run` command. If you do not specify a directory and the file is not found in the GDB working directory, GDB uses the environment variable `PATH` as a list of directories to search, just as the shell does when looking for a program to run. You can change the value of this variable, for both GDB and your program, using the `path` command.

  You can load unlinked object '`.o`' files into GDB using the `file` command. You will not be able to "run" an object file, but you can disassemble functions and inspect variables. Also, if the underlying BFD functionality supports it, you could use *`gdb -write`* to patch object files using this technique. Note that GDB can neither interpret nor modify relocations in this case, so branches and some initialized variables will appear to go to the wrong place. But this feature is still handy from time to time.

`file`
: `file` with no argument makes GDB discard any information it has on both executable file and the symbol table.

`exec-file` [*`filename`*]
: Specify that the program to be run (but not the symbol table) is found in *filename*. GDB searches the environment variable `PATH` if necessary to locate your program. Omitting *filename* means to discard information on the executable file.

`symbol-file` [*`filename`*]
: Read symbol table information from file *filename*. `PATH` is searched when necessary. Use the `file` command to get both symbol table and program to run from the same file.

  `symbol-file` with no argument clears out GDB information on your program's symbol table.

  The `symbol-file` command causes GDB to forget the contents of some breakpoints and auto-display expressions. This is because they may contain pointers

to the internal data recording symbols and data types, which are part of the old symbol table data being discarded inside GDB.

`symbol-file` does not repeat if you press RET again after executing it once.

When GDB is configured for a particular environment, it understands debugging information in whatever format is the standard generated for that environment; you may use either a GNU compiler, or other compilers that adhere to the local conventions. Best results are usually obtained from GNU compilers; for example, using GCC you can generate debugging information for optimized code.

For most kinds of object files, with the exception of old SVR3 systems using COFF, the `symbol-file` command does not normally read the symbol table in full right away. Instead, it scans the symbol table quickly to find which source files and which symbols are present. The details are read later, one source file at a time, as they are needed.

The purpose of this two-stage reading strategy is to make GDB start up faster. For the most part, it is invisible except for occasional pauses while the symbol table details for a particular source file are being read. (The `set verbose` command can turn these pauses into messages if desired. See Section 22.8 [Optional Warnings and Messages], page 291.)

We have not implemented the two-stage strategy for COFF yet. When the symbol table is stored in COFF format, `symbol-file` reads the symbol table data in full right away. Note that "stabs-in-COFF" still does the two-stage strategy, since the debug info is actually in stabs format.

`symbol-file` [`-readnow`] *`filename`*
`file` [`-readnow`] *`filename`*

You can override the GDB two-stage strategy for reading symbol tables by using the '`-readnow`' option with any of the commands that load symbol table information, if you want to be sure GDB has the entire symbol table available.

`core-file` [*`filename`*]
`core`

Specify the whereabouts of a core dump file to be used as the "contents of memory". Traditionally, core files contain only some parts of the address space of the process that generated them; GDB can access the executable file itself for other parts.

`core-file` with no argument specifies that no core file is to be used.

Note that the core file is ignored when your program is actually running under GDB. So, if you have been running your program and you wish to debug a core file instead, you must kill the subprocess in which the program is running. To do this, use the `kill` command (see Section 4.8 [Killing the Child Process], page 32).

`add-symbol-file` *`filename address`*
`add-symbol-file` *`filename address`* [`-readnow`]
`add-symbol-file` *`filename address`* `-s` *`section address ...`*

The `add-symbol-file` command reads additional symbol table information from the file *filename*. You would use this command when *filename* has been dynamically loaded (by some other means) into the program that is running.

address should be the memory address at which the file has been loaded; GDB cannot figure this out for itself. You can additionally specify an arbitrary number of '`-s` *`section address`*' pairs, to give an explicit section name and base address for that section. You can specify any *address* as an expression.

The symbol table of the file *filename* is added to the symbol table originally read with the `symbol-file` command. You can use the `add-symbol-file` command any number of times; the new symbol data thus read keeps adding to the old. To discard all old symbol data instead, use the `symbol-file` command without any arguments.

Although *filename* is typically a shared library file, an executable file, or some other object file which has been fully relocated for loading into a process, you can also load symbolic information from relocatable '`.o`' files, as long as:

- the file's symbolic information refers only to linker symbols defined in that file, not to symbols defined by other object files,
- every section the file's symbolic information refers to has actually been loaded into the inferior, as it appears in the file, and
- you can determine the address at which every section was loaded, and provide these to the `add-symbol-file` command.

Some embedded operating systems, like Sun Chorus and VxWorks, can load relocatable files into an already running program; such systems typically make the requirements above easy to meet. However, it's important to recognize that many native systems use complex link procedures (`.linkonce` section factoring and C++ constructor table assembly, for example) that make the requirements difficult to meet. In general, one cannot assume that using `add-symbol-file` to read a relocatable object file's symbolic information will have the same effect as linking the relocatable object file into the program in the normal way.

`add-symbol-file` does not repeat if you press RET after using it.

`add-symbol-file-from-memory` *`address`*
: Load symbols from the given *address* in a dynamically loaded object file whose image is mapped directly into the inferior's memory. For example, the Linux kernel maps a `syscall DSO` into each process's address space; this DSO provides kernel-specific code for some system calls. The argument can be any expression whose evaluation yields the address of the file's shared object file header. For this command to work, you must have used `symbol-file` or `exec-file` commands in advance.

`add-shared-symbol-files` *`library-file`*
`assf` *`library-file`*
: The `add-shared-symbol-files` command can currently be used only in the Cygwin build of GDB on MS-Windows OS, where it is an alias for the `dll-symbols` command (see Section 21.1.5 [Cygwin Native], page 255). GDB automatically looks for shared libraries, however if GDB does not find yours, you can invoke `add-shared-symbol-files`. It takes one argument: the shared library's file name. `assf` is a shorthand alias for `add-shared-symbol-files`.

`section` *section addr*
: The `section` command changes the base address of the named *section* of the exec file to *addr*. This can be used if the exec file does not contain section addresses, (such as in the `a.out` format), or when the addresses specified in the file itself are wrong. Each section must be changed separately. The `info files` command, described below, lists all the sections and their addresses.

`info files`
`info target`
: `info files` and `info target` are synonymous; both print the current target (see Chapter 19 [Specifying a Debugging Target], page 231), including the names of the executable and core dump files currently in use by GDB, and the files from which symbols were loaded. The command `help target` lists all possible targets rather than current ones.

`maint info sections`
: Another command that can give you extra information about program sections is `maint info sections`. In addition to the section information displayed by `info files`, this command displays the flags and file offset of each section in the executable and core dump files. In addition, `maint info sections` provides the following command options (which may be arbitrarily combined):

  `ALLOBJ` Display sections for all loaded object files, including shared libraries.

  `sections` Display info only for named *sections*.

  `section-flags`
  : Display info only for sections for which *section-flags* are true. The section flags that GDB currently knows about are:

    `ALLOC` Section will have space allocated in the process when loaded. Set for all sections except those containing debug information.

    `LOAD` Section will be loaded from the file into the child process memory. Set for pre-initialized code and data, clear for `.bss` sections.

    `RELOC` Section needs to be relocated before loading.

    `READONLY` Section cannot be modified by the child process.

    `CODE` Section contains executable code only.

    `DATA` Section contains data only (no executable code).

    `ROM` Section will reside in ROM.

    `CONSTRUCTOR`
    : Section contains data for constructor/destructor lists.

    `HAS_CONTENTS`
    : Section is not empty.

`NEVER_LOAD`
: An instruction to the linker to not output the section.

`COFF_SHARED_LIBRARY`
: A notification to the linker that the section contains COFF shared library information.

`IS_COMMON`
: Section contains common symbols.

`set trust-readonly-sections on`
: Tell GDB that readonly sections in your object file really are read-only (i.e. that their contents will not change). In that case, GDB can fetch values from these sections out of the object file, rather than from the target program. For some targets (notably embedded ones), this can be a significant enhancement to debugging performance.

  The default is off.

`set trust-readonly-sections off`
: Tell GDB not to trust readonly sections. This means that the contents of the section might change while the program is running, and must therefore be fetched from the target when needed.

`show trust-readonly-sections`
: Show the current setting of trusting readonly sections.

All file-specifying commands allow both absolute and relative file names as arguments. GDB always converts the file name to an absolute file name and remembers it that way.

GDB supports GNU/Linux, MS-Windows, HP-UX, SunOS, SVr4, Irix, and IBM RS/6000 AIX shared libraries.

On MS-Windows GDB must be linked with the Expat library to support shared libraries. See [Expat], page 489.

GDB automatically loads symbol definitions from shared libraries when you use the `run` command, or when you examine a core file. (Before you issue the `run` command, GDB does not understand references to a function in a shared library, however—unless you are debugging a core file).

On HP-UX, if the program loads a library explicitly, GDB automatically loads the symbols at the time of the `shl_load` call.

There are times, however, when you may wish to not automatically load symbol definitions from shared libraries, such as when they are particularly large or there are many of them.

To control the automatic loading of shared library symbols, use the commands:

`set auto-solib-add` *mode*
: If *mode* is `on`, symbols from all shared object libraries will be loaded automatically when the inferior begins execution, you attach to an independently started inferior, or when the dynamic linker informs GDB that a new library has been loaded. If *mode* is `off`, symbols must be loaded manually, using the `sharedlibrary` command. The default value is `on`.

If your program uses lots of shared libraries with debug info that takes large amounts of memory, you can decrease the GDB memory footprint by preventing it from automatically loading the symbols from shared libraries. To that end, type *`set auto-solib-add off`* before running the inferior, then load each library whose debug symbols you do need with *`sharedlibrary regexp`*, where *regexp* is a regular expression that matches the libraries whose symbols you want to be loaded.

`show auto-solib-add`
Display the current autoloading mode.

To explicitly load shared library symbols, use the `sharedlibrary` command:

`info share` *`regex`*
`info sharedlibrary` *`regex`*
Print the names of the shared libraries which are currently loaded that match *regex*. If *regex* is omitted then print all shared libraries that are loaded.

`sharedlibrary` *`regex`*
`share` *`regex`*
Load shared object library symbols for files matching a Unix regular expression. As with files loaded automatically, it only loads shared libraries required by your program for a core file or after typing `run`. If *regex* is omitted all shared libraries required by your program are loaded.

`nosharedlibrary`
Unload all shared object library symbols. This discards all symbols that have been loaded from all shared libraries. Symbols from shared libraries that were loaded by explicit user requests are not discarded.

Sometimes you may wish that GDB stops and gives you control when any of shared library events happen. The best way to do this is to use `catch load` and `catch unload` (see Section 5.1.3 [Set Catchpoints], page 53).

GDB also supports the the `set stop-on-solib-events` command for this. This command exists for historical reasons. It is less useful than setting a catchpoint, because it does not allow for conditions or commands as a catchpoint does.

`set stop-on-solib-events`
This command controls whether GDB should give you control when the dynamic linker notifies it about some shared library event. The most common event of interest is loading or unloading of a new shared library.

`show stop-on-solib-events`
Show whether GDB stops and gives you control when shared library events happen.

Shared libraries are also supported in many cross or remote debugging configurations. GDB needs to have access to the target's libraries; this can be accomplished either by providing copies of the libraries on the host system, or by asking GDB to automatically retrieve the libraries from the target. If copies of the target libraries are provided, they need to be the same as the target libraries, although the copies on the target can be stripped as long as the copies on the host are not.

For remote debugging, you need to tell GDB where the target libraries are, so that it can load the correct copies—otherwise, it may try to load the host's libraries. GDB has two variables to specify the search directories for target libraries.

`set sysroot` *path*

Use *path* as the system root for the program being debugged. Any absolute shared library paths will be prefixed with *path*; many runtime loaders store the absolute paths to the shared library in the target program's memory. If you use `set sysroot` to find shared libraries, they need to be laid out in the same way that they are on the target, with e.g. a '`/lib`' and '`/usr/lib`' hierarchy under *path*.

If *path* starts with the sequence '`remote:`', GDB will retrieve the target libraries from the remote system. This is only supported when using a remote target that supports the `remote get` command (see Section 20.2 [Sending files to a remote system], page 237). The part of *path* following the initial '`remote:`' (if present) is used as system root prefix on the remote file system.[1]

For targets with an MS-DOS based filesystem, such as MS-Windows and SymbianOS, GDB tries prefixing a few variants of the target absolute file name with *path*. But first, on Unix hosts, GDB converts all backslash directory separators into forward slashes, because the backslash is not a directory separator on Unix:

```
c:\foo\bar.dll ⇒ c:/foo/bar.dll
```

Then, GDB attempts prefixing the target file name with *path*, and looks for the resulting file name in the host file system:

```
c:/foo/bar.dll ⇒ /path/to/sysroot/c:/foo/bar.dll
```

If that does not find the shared library, GDB tries removing the '`:`' character from the drive spec, both for convenience, and, for the case of the host file system not supporting file names with colons:

```
c:/foo/bar.dll ⇒ /path/to/sysroot/c/foo/bar.dll
```

This makes it possible to have a system root that mirrors a target with more than one drive. E.g., you may want to setup your local copies of the target system shared libraries like so (note '`c`' vs '`z`'):

```
'/path/to/sysroot/c/sys/bin/foo.dll'
'/path/to/sysroot/c/sys/bin/bar.dll'
'/path/to/sysroot/z/sys/bin/bar.dll'
```

and point the system root at '`/path/to/sysroot`', so that GDB can find the correct copies of both '`c:\sys\bin\foo.dll`', and '`z:\sys\bin\bar.dll`'.

If that still does not find the shared library, GDB tries removing the whole drive spec from the target file name:

```
c:/foo/bar.dll ⇒ /path/to/sysroot/foo/bar.dll
```

This last lookup makes it possible to not care about the drive name, if you don't want or need to.

The `set solib-absolute-prefix` command is an alias for `set sysroot`.

You can set the default system root by using the configure-time '`--with-sysroot`' option. If the system root is inside GDB's configured binary

[1] If you want to specify a local system root using a directory that happens to be named '`remote:`', you need to use some equivalent variant of the name like '`./remote:`'.

prefix (set with '`--prefix`' or '`--exec-prefix`'), then the default system root will be updated automatically if the installed GDB is moved to a new location.

`show sysroot`
: Display the current shared library prefix.

`set solib-search-path` *path*
: If this variable is set, *path* is a colon-separated list of directories to search for shared libraries. '`solib-search-path`' is used after '`sysroot`' fails to locate the library, or if the path to the library is relative instead of absolute. If you want to use '`solib-search-path`' instead of '`sysroot`', be sure to set '`sysroot`' to a nonexistent directory to prevent GDB from finding your host's libraries. '`sysroot`' is preferred; setting it to a nonexistent directory may interfere with automatic loading of shared library symbols.

`show solib-search-path`
: Display the current shared library search path.

`set target-file-system-kind` *kind*
: Set assumed file system kind for target reported file names.

  Shared library file names as reported by the target system may not make sense as is on the system GDB is running on. For example, when remote debugging a target that has MS-DOS based file system semantics, from a Unix host, the target may be reporting to GDB a list of loaded shared libraries with file names such as '`c:\Windows\kernel32.dll`'. On Unix hosts, there's no concept of drive letters, so the '`c:\`' prefix is not normally understood as indicating an absolute file name, and neither is the backslash normally considered a directory separator character. In that case, the native file system would interpret this whole absolute file name as a relative file name with no directory components. This would make it impossible to point GDB at a copy of the remote target's shared libraries on the host using `set sysroot`, and impractical with `set solib-search-path`. Setting `target-file-system-kind` to `dos-based` tells GDB to interpret such file names similarly to how the target would, and to map them to file names valid on GDB's native file system semantics. The value of *kind* can be `"auto"`, in addition to one of the supported file system kinds. In that case, GDB tries to determine the appropriate file system variant based on the current target's operating system (see Section 22.6 [Configuring the Current ABI], page 285). The supported file system settings are:

  `unix`
  : Instruct GDB to assume the target file system is of Unix kind. Only file names starting the forward slash ('`/`') character are considered absolute, and the directory separator character is also the forward slash.

  `dos-based`
  : Instruct GDB to assume the target file system is DOS based. File names starting with either a forward slash, or a drive letter followed by a colon (e.g., '`c:`'), are considered absolute, and both the slash ('`/`') and the backslash ('`\\`') characters are considered directory separators.

`auto` Instruct GDB to use the file system kind associated with the target operating system (see Section 22.6 [Configuring the Current ABI], page 285). This is the default.

When processing file names provided by the user, GDB frequently needs to compare them to the file names recorded in the program's debug info. Normally, GDB compares just the *base names* of the files as strings, which is reasonably fast even for very large programs. (The base name of a file is the last portion of its name, after stripping all the leading directories.) This shortcut in comparison is based upon the assumption that files cannot have more than one base name. This is usually true, but references to files that use symlinks or similar filesystem facilities violate that assumption. If your program records files using such facilities, or if you provide file names to GDB using symlinks etc., you can set `basenames-may-differ` to `true` to instruct GDB to completely canonicalize each pair of file names it needs to compare. This will make file-name comparisons accurate, but at a price of a significant slowdown.

`set basenames-may-differ`
Set whether a source file may have multiple base names.

`show basenames-may-differ`
Show whether a source file may have multiple base names.

18.2 Debugging Information in Separate Files

GDB allows you to put a program's debugging information in a file separate from the executable itself, in a way that allows GDB to find and load the debugging information automatically. Since debugging information can be very large—sometimes larger than the executable code itself—some systems distribute debugging information for their executables in separate files, which users can install only when they need to debug a problem.

GDB supports two ways of specifying the separate debug info file:

- The executable contains a *debug link* that specifies the name of the separate debug info file. The separate debug file's name is usually '`executable.debug`', where *executable* is the name of the corresponding executable file without leading directories (e.g., '`ls.debug`' for '`/usr/bin/ls`'). In addition, the debug link specifies a 32-bit *Cyclic Redundancy Check* (CRC) checksum for the debug file, which GDB uses to validate that the executable and the debug file came from the same build.
- The executable contains a *build ID*, a unique bit string that is also present in the corresponding debug info file. (This is supported only on some operating systems, notably those which use the ELF format for binary files and the GNU Binutils.) For more details about this feature, see the description of the '`--build-id`' command-line option in Section "Command Line Options" in *The GNU Linker*. The debug info file's name is not specified explicitly by the build ID, but can be computed from the build ID, see below.

Depending on the way the debug info file is specified, GDB uses two different methods of looking for the debug file:

- For the "debug link" method, GDB looks up the named file in the directory of the executable file, then in a subdirectory of that directory named '`.debug`', and finally

under each one of the global debug directories, in a subdirectory whose name is identical to the leading directories of the executable's absolute file name.

- For the "build ID" method, GDB looks in the '`.build-id`' subdirectory of each one of the global debug directories for a file named '*nn*`/`*nnnnnnnn*`.debug`', where *nn* are the first 2 hex characters of the build ID bit string, and *nnnnnnnn* are the rest of the bit string. (Real build ID strings are 32 or more hex characters, not 10.)

So, for example, suppose you ask GDB to debug '`/usr/bin/ls`', which has a debug link that specifies the file '`ls.debug`', and a build ID whose value in hex is `abcdef1234`. If the list of the global debug directories includes '`/usr/lib/debug`', then GDB will look for the following debug information files, in the indicated order:

- '`/usr/lib/debug/.build-id/ab/cdef1234.debug`'
- '`/usr/bin/ls.debug`'
- '`/usr/bin/.debug/ls.debug`'
- '`/usr/lib/debug/usr/bin/ls.debug`'.

Global debugging info directories default to what is set by GDB configure option '`--with-separate-debug-dir`'. During GDB run you can also set the global debugging info directories, and view the list GDB is currently using.

`set debug-file-directory` *directories*
: Set the directories which GDB searches for separate debugging information files to *directory*. Multiple path components can be set concatenating them by a path separator.

`show debug-file-directory`
: Show the directories GDB searches for separate debugging information files.

A debug link is a special section of the executable file named `.gnu_debuglink`. The section must contain:

- A filename, with any leading directory components removed, followed by a zero byte,
- zero to three bytes of padding, as needed to reach the next four-byte boundary within the section, and
- a four-byte CRC checksum, stored in the same endianness used for the executable file itself. The checksum is computed on the debugging information file's full contents by the function given below, passing zero as the *crc* argument.

Any executable file format can carry a debug link, as long as it can contain a section named `.gnu_debuglink` with the contents described above.

The build ID is a special section in the executable file (and in other ELF binary files that GDB may consider). This section is often named `.note.gnu.build-id`, but that name is not mandatory. It contains unique identification for the built files—the ID remains the same across multiple builds of the same build tree. The default algorithm SHA1 produces 160 bits (40 hexadecimal characters) of the content for the build ID string. The same section with an identical value is present in the original built binary with symbols, in its stripped variant, and in the separate debugging information file.

The debugging information file itself should be an ordinary executable, containing a full set of linker symbols, sections, and debugging information. The sections of the debugging

information file should have the same names, addresses, and sizes as the original file, but they need not contain any data—much like a `.bss` section in an ordinary executable.

The GNU binary utilities (Binutils) package includes the '`objcopy`' utility that can produce the separated executable / debugging information file pairs using the following commands:

```
objcopy --only-keep-debug foo foo.debug
strip -g foo
```

These commands remove the debugging information from the executable file '`foo`' and place it in the file '`foo.debug`'. You can use the first, second or both methods to link the two files:

- The debug link method needs the following additional command to also leave behind a debug link in '`foo`':

  ```
  objcopy --add-gnu-debuglink=foo.debug foo
  ```

  Ulrich Drepper's '`elfutils`' package, starting with version 0.53, contains a version of the `strip` command such that the command *`strip foo -f foo.debug`* has the same functionality as the two `objcopy` commands and the `ln -s` command above, together.
- Build ID gets embedded into the main executable using `ld --build-id` or the GCC counterpart `gcc -Wl,--build-id`. Build ID support plus compatibility fixes for debug files separation are present in GNU binary utilities (Binutils) package since version 2.18.

The CRC used in `.gnu_debuglink` is the CRC-32 defined in IEEE 802.3 using the polynomial:

$$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$$

The function is computed byte at a time, taking the least significant bit of each byte first. The initial pattern `0xffffffff` is used, to ensure leading zeros affect the CRC and the final result is inverted to ensure trailing zeros also affect the CRC.

Note: This is the same CRC polynomial as used in handling the *Remote Serial Protocol* `qCRC` packet (see Appendix E [GDB Remote Serial Protocol], page 503). However in the case of the Remote Serial Protocol, the CRC is computed *most* significant bit first, and the result is not inverted, so trailing zeros have no effect on the CRC value.

To complete the description, we show below the code of the function which produces the CRC used in `.gnu_debuglink`. Inverting the initially supplied `crc` argument means that an initial call to this function passing in zero will start computing the CRC using `0xffffffff`.

```
unsigned long
gnu_debuglink_crc32 (unsigned long crc,
                     unsigned char *buf, size_t len)
{
  static const unsigned long crc32_table[256] =
    {
      0x00000000, 0x77073096, 0xee0e612c, 0x990951ba, 0x076dc419,
      0x706af48f, 0xe963a535, 0x9e6495a3, 0x0edb8832, 0x79dcb8a4,
      0xe0d5e91e, 0x97d2d988, 0x09b64c2b, 0x7eb17cbd, 0xe7b82d07,
      0x90bf1d91, 0x1db71064, 0x6ab020f2, 0xf3b97148, 0x84be41de,
      0x1adad47d, 0x6ddde4eb, 0xf4d4b551, 0x83d385c7, 0x136c9856,
      0x646ba8c0, 0xfd62f97a, 0x8a65c9ec, 0x14015c4f, 0x63066cd9,
      0xfa0f3d63, 0x8d080df5, 0x3b6e20c8, 0x4c69105e, 0xd56041e4,
      0xa2677172, 0x3c03e4d1, 0x4b04d447, 0xd20d85fd, 0xa50ab56b,
```

```
      0x35b5a8fa, 0x42b2986c, 0xdbbbc9d6, 0xacbcf940, 0x32d86ce3,
      0x45df5c75, 0xdcd60dcf, 0xabd13d59, 0x26d930ac, 0x51de003a,
      0xc8d75180, 0xbfd06116, 0x21b4f4b5, 0x56b3c423, 0xcfba9599,
      0xb8bda50f, 0x2802b89e, 0x5f058808, 0xc60cd9b2, 0xb10be924,
      0x2f6f7c87, 0x58684c11, 0xc1611dab, 0xb6662d3d, 0x76dc4190,
      0x01db7106, 0x98d220bc, 0xefd5102a, 0x71b18589, 0x06b6b51f,
      0x9fbfe4a5, 0xe8b8d433, 0x7807c9a2, 0x0f00f934, 0x9609a88e,
      0xe10e9818, 0x7f6a0dbb, 0x086d3d2d, 0x91646c97, 0xe6635c01,
      0x6b6b51f4, 0x1c6c6162, 0x856530d8, 0xf262004e, 0x6c0695ed,
      0x1b01a57b, 0x8208f4c1, 0xf50fc457, 0x65b0d9c6, 0x12b7e950,
      0x8bbeb8ea, 0xfcb9887c, 0x62dd1ddf, 0x15da2d49, 0x8cd37cf3,
      0xfbd44c65, 0x4db26158, 0x3ab551ce, 0xa3bc0074, 0xd4bb30e2,
      0x4adfa541, 0x3dd895d7, 0xa4d1c46d, 0xd3d6f4fb, 0x4369e96a,
      0x346ed9fc, 0xad678846, 0xda60b8d0, 0x44042d73, 0x33031de5,
      0xaa0a4c5f, 0xdd0d7cc9, 0x5005713c, 0x270241aa, 0xbe0b1010,
      0xc90c2086, 0x5768b525, 0x206f85b3, 0xb966d409, 0xce61e49f,
      0x5edef90e, 0x29d9c998, 0xb0d09822, 0xc7d7a8b4, 0x59b33d17,
      0x2eb40d81, 0xb7bd5c3b, 0xc0ba6cad, 0xedb88320, 0x9abfb3b6,
      0x03b6e20c, 0x74b1d29a, 0xead54739, 0x9dd277af, 0x04db2615,
      0x73dc1683, 0xe3630b12, 0x94643b84, 0x0d6d6a3e, 0x7a6a5aa8,
      0xe40ecf0b, 0x9309ff9d, 0x0a00ae27, 0x7d079eb1, 0xf00f9344,
      0x8708a3d2, 0x1e01f268, 0x6906c2fe, 0xf762575d, 0x806567cb,
      0x196c3671, 0x6e6b06e7, 0xfed41b76, 0x89d32be0, 0x10da7a5a,
      0x67dd4acc, 0xf9b9df6f, 0x8ebeeff9, 0x17b7be43, 0x60b08ed5,
      0xd6d6a3e8, 0xa1d1937e, 0x38d8c2c4, 0x4fdff252, 0xd1bb67f1,
      0xa6bc5767, 0x3fb506dd, 0x48b2364b, 0xd80d2bda, 0xaf0a1b4c,
      0x36034af6, 0x41047a60, 0xdf60efc3, 0xa867df55, 0x316e8eef,
      0x4669be79, 0xcb61b38c, 0xbc66831a, 0x256fd2a0, 0x5268e236,
      0xcc0c7795, 0xbb0b4703, 0x220216b9, 0x5505262f, 0xc5ba3bbe,
      0xb2bd0b28, 0x2bb45a92, 0x5cb36a04, 0xc2d7ffa7, 0xb5d0cf31,
      0x2cd99e8b, 0x5bdeae1d, 0x9b64c2b0, 0xec63f226, 0x756aa39c,
      0x026d930a, 0x9c0906a9, 0xeb0e363f, 0x72076785, 0x05005713,
      0x95bf4a82, 0xe2b87a14, 0x7bb12bae, 0x0cb61b38, 0x92d28e9b,
      0xe5d5be0d, 0x7cdcefb7, 0x0bdbdf21, 0x86d3d2d4, 0xf1d4e242,
      0x68ddb3f8, 0x1fda836e, 0x81be16cd, 0xf6b9265b, 0x6fb077e1,
      0x18b74777, 0x88085ae6, 0xff0f6a70, 0x66063bca, 0x11010b5c,
      0x8f659eff, 0xf862ae69, 0x616bffd3, 0x166ccf45, 0xa00ae278,
      0xd70dd2ee, 0x4e048354, 0x3903b3c2, 0xa7672661, 0xd06016f7,
      0x4969474d, 0x3e6e77db, 0xaed16a4a, 0xd9d65adc, 0x40df0b66,
      0x37d83bf0, 0xa9bcae53, 0xdebb9ec5, 0x47b2cf7f, 0x30b5ffe9,
      0xbdbdf21c, 0xcabac28a, 0x53b39330, 0x24b4a3a6, 0xbad03605,
      0xcdd70693, 0x54de5729, 0x23d967bf, 0xb3667a2e, 0xc4614ab8,
      0x5d681b02, 0x2a6f2b94, 0xb40bbe37, 0xc30c8ea1, 0x5a05df1b,
      0x2d02ef8d
    };
  unsigned char *end;

  crc = ~crc & 0xffffffff;
  for (end = buf + len; buf < end; ++buf)
    crc = crc32_table[(crc ^ *buf) & 0xff] ^ (crc >> 8);
  return ~crc & 0xffffffff;
}
```

This computation does not apply to the “build ID” method.

18.3 Debugging information in a special section

Some systems ship pre-built executables and libraries that have a special '`.gnu_debugdata`' section. This feature is called *MiniDebugInfo*. This section holds an LZMA-compressed object and is used to supply extra symbols for backtraces.

The intent of this section is to provide extra minimal debugging information for use in simple backtraces. It is not intended to be a replacement for full separate debugging information (see Section 18.2 [Separate Debug Files], page 223). The example below shows the intended use; however, GDB does not currently put restrictions on what sort of debugging information might be included in the section.

GDB has support for this extension. If the section exists, then it is used provided that no other source of debugging information can be found, and that GDB was configured with LZMA support.

This section can be easily created using `objcopy` and other standard utilities:

```
# Extract the dynamic symbols from the main binary, there is no need
# to also have these in the normal symbol table
nm -D binary --format=posix --defined-only \
  | awk '{ print $1 }' | sort > dynsyms

# Extract all the text (i.e. function) symbols from the debuginfo .
nm binary --format=posix --defined-only \
  | awk '{ if ($2 == "T" || $2 == "t") print $1 }' \
  | sort > funcsyms

# Keep all the function symbols not already in the dynamic symbol
# table.
comm -13 dynsyms funcsyms > keep_symbols

# Copy the full debuginfo, keeping only a minimal set of symbols and
# removing some unnecessary sections.
objcopy -S --remove-section .gdb_index --remove-section .comment \
  --keep-symbols=keep_symbols binary mini_debuginfo

# Inject the compressed data into the .gnu_debugdata section of the
# original binary.
xz mini_debuginfo
objcopy --add-section .gnu_debugdata=mini_debuginfo.xz binary
```

18.4 Index Files Speed Up GDB

When GDB finds a symbol file, it scans the symbols in the file in order to construct an internal symbol table. This lets most GDB operations work quickly—at the cost of a delay early on. For large programs, this delay can be quite lengthy, so GDB provides a way to build an index, which speeds up startup.

The index is stored as a section in the symbol file. GDB can write the index to a file, then you can put it into the symbol file using `objcopy`.

To create an index file, use the `save gdb-index` command:

`save gdb-index` *directory*

> Create an index file for each symbol file currently known by GDB. Each file is named after its corresponding symbol file, with '`.gdb-index`' appended, and is written into the given *directory*.

Once you have created an index file you can merge it into your symbol file, here named '`symfile`', using `objcopy`:

```
$ objcopy --add-section .gdb_index=symfile.gdb-index \
    --set-section-flags .gdb_index=readonly symfile symfile
```

GDB will normally ignore older versions of '`.gdb_index`' sections that have been deprecated. Usually they are deprecated because they are missing a new feature or have performance issues. To tell GDB to use a deprecated index section anyway specify `set use-deprecated-index-sections on`. The default is `off`. This can speed up startup, but may result in some functionality being lost. See Appendix J [Index Section Format], page 589.

Warning: Setting `use-deprecated-index-sections` to `on` must be done before gdb reads the file. The following will not work:

```
$ gdb -ex "set use-deprecated-index-sections on" <program>
```

Instead you must do, for example,

```
$ gdb -iex "set use-deprecated-index-sections on" <program>
```

There are currently some limitation on indices. They only work when for DWARF debugging information, not stabs. And, they do not currently work for programs using Ada.

18.5 Errors Reading Symbol Files

While reading a symbol file, GDB occasionally encounters problems, such as symbol types it does not recognize, or known bugs in compiler output. By default, GDB does not notify you of such problems, since they are relatively common and primarily of interest to people debugging compilers. If you are interested in seeing information about ill-constructed symbol tables, you can either ask GDB to print only one message about each such type of problem, no matter how many times the problem occurs; or you can ask GDB to print more messages, to see how many times the problems occur, with the `set complaints` command (see Section 22.8 [Optional Warnings and Messages], page 291).

The messages currently printed, and their meanings, include:

`inner block not inside outer block in` *`symbol`*

> The symbol information shows where symbol scopes begin and end (such as at the start of a function or a block of statements). This error indicates that an inner scope block is not fully contained in its outer scope blocks.
>
> GDB circumvents the problem by treating the inner block as if it had the same scope as the outer block. In the error message, *symbol* may be shown as "`(don't know)`" if the outer block is not a function.

`block at` *`address`* `out of order`

> The symbol information for symbol scope blocks should occur in order of increasing addresses. This error indicates that it does not do so.
>
> GDB does not circumvent this problem, and has trouble locating symbols in the source file whose symbols it is reading. (You can often determine what source file is affected by specifying `set verbose on`. See Section 22.8 [Optional Warnings and Messages], page 291.)

`bad block start address patched`
: The symbol information for a symbol scope block has a start address smaller than the address of the preceding source line. This is known to occur in the SunOS 4.1.1 (and earlier) C compiler.

  GDB circumvents the problem by treating the symbol scope block as starting on the previous source line.

`bad string table offset in symbol` *n*
: Symbol number *n* contains a pointer into the string table which is larger than the size of the string table.

  GDB circumvents the problem by considering the symbol to have the name `foo`, which may cause other problems if many symbols end up with this name.

`unknown symbol type 0x`*nn*
: The symbol information contains new data types that GDB does not yet know how to read. `0x`*nn* is the symbol type of the uncomprehended information, in hexadecimal.

  GDB circumvents the error by ignoring this symbol information. This usually allows you to debug your program, though certain symbols are not accessible. If you encounter such a problem and feel like debugging it, you can debug `gdb` with itself, breakpoint on `complain`, then go up to the function `read_dbx_symtab` and examine `*bufp` to see the symbol.

`stub type has NULL name`
: GDB could not find the full definition for a struct or class.

`const/volatile indicator missing (ok if using g++ v1.x), got...`
: The symbol information for a C++ member function is missing some information that recent versions of the compiler should have output for it.

`info mismatch between compiler and debugger`
: GDB could not parse a type specification output by the compiler.

18.6 GDB Data Files

GDB will sometimes read an auxiliary data file. These files are kept in a directory known as the *data directory*.

You can set the data directory's name, and view the name GDB is currently using.

`set data-directory` *directory*
: Set the directory which GDB searches for auxiliary data files to *directory*.

`show data-directory`
: Show the directory GDB searches for auxiliary data files.

You can set the default data directory by using the configure-time '`--with-gdb-datadir`' option. If the data directory is inside GDB's configured binary prefix (set with '`--prefix`' or '`--exec-prefix`'), then the default data directory will be updated automatically if the installed GDB is moved to a new location.

The data directory may also be specified with the `--data-directory` command line option. See Section 2.1.2 [Mode Options], page 13.

19 Specifying a Debugging Target

A *target* is the execution environment occupied by your program.

Often, GDB runs in the same host environment as your program; in that case, the debugging target is specified as a side effect when you use the `file` or `core` commands. When you need more flexibility—for example, running GDB on a physically separate host, or controlling a standalone system over a serial port or a realtime system over a TCP/IP connection—you can use the `target` command to specify one of the target types configured for GDB (see Section 19.2 [Commands for Managing Targets], page 231).

It is possible to build GDB for several different *target architectures*. When GDB is built like that, you can choose one of the available architectures with the `set architecture` command.

`set architecture` *arch*
: This command sets the current target architecture to *arch*. The value of *arch* can be `"auto"`, in addition to one of the supported architectures.

`show architecture`
: Show the current target architecture.

`set processor`
`processor`
: These are alias commands for, respectively, `set architecture` and `show architecture`.

19.1 Active Targets

There are multiple classes of targets such as: processes, executable files or recording sessions. Core files belong to the process class, making core file and process mutually exclusive. Otherwise, GDB can work concurrently on multiple active targets, one in each class. This allows you to (for example) start a process and inspect its activity, while still having access to the executable file after the process finishes. Or if you start process recording (see Chapter 6 [Reverse Execution], page 79) and `reverse-step` there, you are presented a virtual layer of the recording target, while the process target remains stopped at the chronologically last point of the process execution.

Use the `core-file` and `exec-file` commands to select a new core file or executable target (see Section 18.1 [Commands to Specify Files], page 215). To specify as a target a process that is already running, use the `attach` command (see Section 4.7 [Debugging an Already-running Process], page 31).

19.2 Commands for Managing Targets

`target` *type parameters*
: Connects the GDB host environment to a target machine or process. A target is typically a protocol for talking to debugging facilities. You use the argument *type* to specify the type or protocol of the target machine.

  Further *parameters* are interpreted by the target protocol, but typically include things like device names or host names to connect with, process numbers, and baud rates.

The `target` command does not repeat if you press RET again after executing the command.

`help target`
: Displays the names of all targets available. To display targets currently selected, use either `info target` or `info files` (see Section 18.1 [Commands to Specify Files], page 215).

`help target` *`name`*
: Describe a particular target, including any parameters necessary to select it.

`set gnutarget` *`args`*
: GDB uses its own library BFD to read your files. GDB knows whether it is reading an *executable*, a *core*, or a *.o* file; however, you can specify the file format with the `set gnutarget` command. Unlike most `target` commands, with `gnutarget` the `target` refers to a program, not a machine.

  > *Warning:* To specify a file format with `set gnutarget`, you must know the actual BFD name.

  See Section 18.1 [Commands to Specify Files], page 215.

`show gnutarget`
: Use the `show gnutarget` command to display what file format `gnutarget` is set to read. If you have not set `gnutarget`, GDB will determine the file format for each file automatically, and `show gnutarget` displays '`The current BFD target is "auto"`'.

Here are some common targets (available, or not, depending on the GDB configuration):

`target exec` *`program`*
: An executable file. '`target exec` *`program`*' is the same as '`exec-file` *`program`*'.

`target core` *`filename`*
: A core dump file. '`target core` *`filename`*' is the same as '`core-file` *`filename`*'.

`target remote` *`medium`*
: A remote system connected to GDB via a serial line or network connection. This command tells GDB to use its own remote protocol over *medium* for debugging. See Chapter 20 [Remote Debugging], page 235.

  For example, if you have a board connected to '`/dev/ttya`' on the machine running GDB, you could say:

  ```
  target remote /dev/ttya
  ```

  `target remote` supports the `load` command. This is only useful if you have some other way of getting the stub to the target system, and you can put it somewhere in memory where it won't get clobbered by the download.

`target sim` [*`simargs`*] `...`
: Builtin CPU simulator. GDB includes simulators for most architectures. In general,

```
target sim
load
run
```

works; however, you cannot assume that a specific memory map, device drivers, or even basic I/O is available, although some simulators do provide these. For info about any processor-specific simulator details, see the appropriate section in Section 21.3 [Embedded Processors], page 263.

Some configurations may include these targets as well:

`target nrom` *dev*
: NetROM ROM emulator. This target only supports downloading.

Different targets are available on different configurations of GDB; your configuration may have more or fewer targets.

Many remote targets require you to download the executable's code once you've successfully established a connection. You may wish to control various aspects of this process.

`set hash` This command controls whether a hash mark '`#`' is displayed while downloading a file to the remote monitor. If on, a hash mark is displayed after each S-record is successfully downloaded to the monitor.

`show hash` Show the current status of displaying the hash mark.

`set debug monitor`
: Enable or disable display of communications messages between GDB and the remote monitor.

`show debug monitor`
: Show the current status of displaying communications between GDB and the remote monitor.

`load` *filename*
: Depending on what remote debugging facilities are configured into GDB, the `load` command may be available. Where it exists, it is meant to make *filename* (an executable) available for debugging on the remote system—by downloading, or dynamic linking, for example. `load` also records the *filename* symbol table in GDB, like the `add-symbol-file` command.

  If your GDB does not have a `load` command, attempting to execute it gets the error message "`You can't do that when your target is ...`"

  The file is loaded at whatever address is specified in the executable. For some object file formats, you can specify the load address when you link the program; for other formats, like a.out, the object file format specifies a fixed address.

  Depending on the remote side capabilities, GDB may be able to load programs into flash memory.

  `load` does not repeat if you press RET again after using it.

19.3 Choosing Target Byte Order

Some types of processors, such as the MIPS, PowerPC, and Renesas SH, offer the ability to run either big-endian or little-endian byte orders. Usually the executable or symbol will include a bit to designate the endian-ness, and you will not need to worry about which to use. However, you may still find it useful to adjust GDB's idea of processor endian-ness manually.

`set endian big`
: Instruct GDB to assume the target is big-endian.

`set endian little`
: Instruct GDB to assume the target is little-endian.

`set endian auto`
: Instruct GDB to use the byte order associated with the executable.

`show endian`
: Display GDB's current idea of the target byte order.

Note that these commands merely adjust interpretation of symbolic data on the host, and that they have absolutely no effect on the target system.

20 Debugging Remote Programs

If you are trying to debug a program running on a machine that cannot run GDB in the usual way, it is often useful to use remote debugging. For example, you might use remote debugging on an operating system kernel, or on a small system which does not have a general purpose operating system powerful enough to run a full-featured debugger.

Some configurations of GDB have special serial or TCP/IP interfaces to make this work with particular debugging targets. In addition, GDB comes with a generic serial protocol (specific to GDB, but not specific to any particular target system) which you can use if you write the remote stubs—the code that runs on the remote system to communicate with GDB.

Other remote targets may be available in your configuration of GDB; use `help target` to list them.

20.1 Connecting to a Remote Target

On the GDB host machine, you will need an unstripped copy of your program, since GDB needs symbol and debugging information. Start up GDB as usual, using the name of the local copy of your program as the first argument.

GDB can communicate with the target over a serial line, or over an IP network using TCP or UDP. In each case, GDB uses the same protocol for debugging your program; only the medium carrying the debugging packets varies. The `target remote` command establishes a connection to the target. Its arguments indicate which medium to use:

`target remote` *`serial-device`*

Use *serial-device* to communicate with the target. For example, to use a serial line connected to the device named '`/dev/ttyb`':

```
target remote /dev/ttyb
```

If you're using a serial line, you may want to give GDB the '`--baud`' option, or use the `set remotebaud` command (see Section 20.4 [Remote Configuration], page 242) before the `target` command.

`target remote` *`host`*`:`*`port`*
`target remote tcp:`*`host`*`:`*`port`*

Debug using a TCP connection to *port* on *host*. The *host* may be either a host name or a numeric IP address; *port* must be a decimal number. The *host* could be the target machine itself, if it is directly connected to the net, or it might be a terminal server which in turn has a serial line to the target.

For example, to connect to port 2828 on a terminal server named `manyfarms`:

```
target remote manyfarms:2828
```

If your remote target is actually running on the same machine as your debugger session (e.g. a simulator for your target running on the same host), you can omit the hostname. For example, to connect to port 1234 on your local machine:

```
target remote :1234
```

Note that the colon is still required here.

`target remote udp:`*`host`*`:`*`port`*

Debug using UDP packets to *port* on *host*. For example, to connect to UDP port 2828 on a terminal server named `manyfarms`:

```
target remote udp:manyfarms:2828
```

When using a UDP connection for remote debugging, you should keep in mind that the 'U' stands for "Unreliable". UDP can silently drop packets on busy or unreliable networks, which will cause havoc with your debugging session.

`target remote | `*`command`*

Run *command* in the background and communicate with it using a pipe. The *command* is a shell command, to be parsed and expanded by the system's command shell, `/bin/sh`; it should expect remote protocol packets on its standard input, and send replies on its standard output. You could use this to run a stand-alone simulator that speaks the remote debugging protocol, to make net connections using programs like `ssh`, or for other similar tricks.

If *command* closes its standard output (perhaps by exiting), GDB will try to send it a `SIGTERM` signal. (If the program has already exited, this will have no effect.)

Once the connection has been established, you can use all the usual commands to examine and change data. The remote program is already running; you can use *`step`* and *`continue`*, and you do not need to use *`run`*.

Whenever GDB is waiting for the remote program, if you type the interrupt character (often *`Ctrl-c`*), GDB attempts to stop the program. This may or may not succeed, depending in part on the hardware and the serial drivers the remote system uses. If you type the interrupt character once again, GDB displays this prompt:

```
Interrupted while waiting for the program.
Give up (and stop debugging it)?  (y or n)
```

If you type *`y`*, GDB abandons the remote debugging session. (If you decide you want to try again later, you can use '`target remote`' again to connect once more.) If you type *`n`*, GDB goes back to waiting.

`detach` When you have finished debugging the remote program, you can use the `detach` command to release it from GDB control. Detaching from the target normally resumes its execution, but the results will depend on your particular remote stub. After the `detach` command, GDB is free to connect to another target.

`disconnect`

The `disconnect` command behaves like `detach`, except that the target is generally not resumed. It will wait for GDB (this instance or another one) to connect and continue debugging. After the `disconnect` command, GDB is again free to connect to another target.

`monitor `*`cmd`*

This command allows you to send arbitrary commands directly to the remote monitor. Since GDB doesn't care about the commands it sends like this, this command is the way to extend GDB—you can add new commands that only the external monitor will understand and implement.

20.2 Sending files to a remote system

Some remote targets offer the ability to transfer files over the same connection used to communicate with GDB. This is convenient for targets accessible through other means, e.g. GNU/Linux systems running `gdbserver` over a network interface. For other targets, e.g. embedded devices with only a single serial port, this may be the only way to upload or download files.

Not all remote targets support these commands.

`remote put` *`hostfile targetfile`*
: Copy file *hostfile* from the host system (the machine running GDB) to *targetfile* on the target system.

`remote get` *`targetfile hostfile`*
: Copy file *targetfile* from the target system to *hostfile* on the host system.

`remote delete` *`targetfile`*
: Delete *targetfile* from the target system.

20.3 Using the `gdbserver` Program

`gdbserver` is a control program for Unix-like systems, which allows you to connect your program with a remote GDB via `target remote`—but without linking in the usual debugging stub.

`gdbserver` is not a complete replacement for the debugging stubs, because it requires essentially the same operating-system facilities that GDB itself does. In fact, a system that can run `gdbserver` to connect to a remote GDB could also run GDB locally! `gdbserver` is sometimes useful nevertheless, because it is a much smaller program than GDB itself. It is also easier to port than all of GDB, so you may be able to get started more quickly on a new system by using `gdbserver`. Finally, if you develop code for real-time systems, you may find that the tradeoffs involved in real-time operation make it more convenient to do as much development work as possible on another system, for example by cross-compiling. You can use `gdbserver` to make a similar choice for debugging.

GDB and `gdbserver` communicate via either a serial line or a TCP connection, using the standard GDB remote serial protocol.

> *Warning:* `gdbserver` does not have any built-in security. Do not run `gdbserver` connected to any public network; a GDB connection to `gdbserver` provides access to the target system with the same privileges as the user running `gdbserver`.

20.3.1 Running `gdbserver`

Run `gdbserver` on the target system. You need a copy of the program you want to debug, including any libraries it requires. `gdbserver` does not need your program's symbol table, so you can strip the program if necessary to save space. GDB on the host system does all the symbol handling.

To use the server, you must tell it how to communicate with GDB; the name of your program; and the arguments for your program. The usual syntax is:

```
target> gdbserver comm program [ args ... ]
```

comm is either a device name (to use a serial line), or a TCP hostname and portnumber, or `-` or `stdio` to use stdin/stdout of `gdbserver`. For example, to debug Emacs with the argument '`foo.txt`' and communicate with GDB over the serial port '`/dev/com1`':

```
target> gdbserver /dev/com1 emacs foo.txt
```

`gdbserver` waits passively for the host GDB to communicate with it.

To use a TCP connection instead of a serial line:

```
target> gdbserver host:2345 emacs foo.txt
```

The only difference from the previous example is the first argument, specifying that you are communicating with the host GDB via TCP. The '`host:2345`' argument means that `gdbserver` is to expect a TCP connection from machine '`host`' to local TCP port 2345. (Currently, the '`host`' part is ignored.) You can choose any number you want for the port number as long as it does not conflict with any TCP ports already in use on the target system (for example, 23 is reserved for `telnet`).[1] You must use the same port number with the host GDB `target remote` command.

The `stdio` connection is useful when starting `gdbserver` with ssh:

```
(gdb) target remote | ssh -T hostname gdbserver - hello
```

The '`-T`' option to ssh is provided because we don't need a remote pty, and we don't want escape-character handling. Ssh does this by default when a command is provided, the flag is provided to make it explicit. You could elide it if you want to.

Programs started with stdio-connected gdbserver have '`/dev/null`' for `stdin`, and `stdout`,`stderr` are sent back to gdb for display through a pipe connected to gdbserver. Both `stdout` and `stderr` use the same pipe.

20.3.1.1 Attaching to a Running Program

On some targets, `gdbserver` can also attach to running programs. This is accomplished via the `--attach` argument. The syntax is:

```
target> gdbserver --attach comm pid
```

pid is the process ID of a currently running process. It isn't necessary to point `gdbserver` at a binary for the running process.

You can debug processes by name instead of process ID if your target has the `pidof` utility:

```
target> gdbserver --attach comm `pidof program`
```

In case more than one copy of *program* is running, or *program* has multiple threads, most versions of `pidof` support the `-s` option to only return the first process ID.

20.3.1.2 Multi-Process Mode for `gdbserver`

When you connect to `gdbserver` using `target remote`, `gdbserver` debugs the specified program only once. When the program exits, or you detach from it, GDB closes the connection and `gdbserver` exits.

If you connect using *`target extended-remote`*, `gdbserver` enters multi-process mode. When the debugged program exits, or you detach from it, GDB stays connected to `gdbserver`

[1] If you choose a port number that conflicts with another service, `gdbserver` prints an error message and exits.

even though no program is running. The `run` and `attach` commands instruct `gdbserver` to run or attach to a new program. The `run` command uses `set remote exec-file` (see [set remote exec-file], page 243) to select the program to run. Command line arguments are supported, except for wildcard expansion and I/O redirection (see Section 4.3 [Arguments], page 28).

To start `gdbserver` without supplying an initial command to run or process ID to attach, use the '`--multi`' command line option. Then you can connect using *`target extended-remote`* and start the program you want to debug.

In multi-process mode `gdbserver` does not automatically exit unless you use the option '`--once`'. You can terminate it by using `monitor exit` (see [Monitor Commands for gdbserver], page 240). Note that the conditions under which `gdbserver` terminates depend on how GDB connects to it (*`target remote`* or *`target extended-remote`*). The '`--multi`' option to `gdbserver` has no influence on that.

20.3.1.3 TCP port allocation lifecycle of `gdbserver`

This section applies only when `gdbserver` is run to listen on a TCP port.

`gdbserver` normally terminates after all of its debugged processes have terminated in *`target remote`* mode. On the other hand, for *`target extended-remote`*, `gdbserver` stays running even with no processes left. GDB normally terminates the spawned debugged process on its exit, which normally also terminates `gdbserver` in the *`target remote`* mode. Therefore, when the connection drops unexpectedly, and GDB cannot ask `gdbserver` to kill its debugged processes, `gdbserver` stays running even in the *`target remote`* mode.

When `gdbserver` stays running, GDB can connect to it again later. Such reconnecting is useful for features like [disconnected tracing], page 158. For completeness, at most one GDB can be connected at a time.

By default, `gdbserver` keeps the listening TCP port open, so that additional connections are possible. However, if you start `gdbserver` with the '`--once`' option, it will stop listening for any further connection attempts after connecting to the first GDB session. This means no further connections to `gdbserver` will be possible after the first one. It also means `gdbserver` will terminate after the first connection with remote GDB has closed, even for unexpectedly closed connections and even in the *`target extended-remote`* mode. The '`--once`' option allows reusing the same port number for connecting to multiple instances of `gdbserver` running on the same host, since each instance closes its port after the first connection.

20.3.1.4 Other Command-Line Arguments for `gdbserver`

The '`--debug`' option tells `gdbserver` to display extra status information about the debugging process. The '`--remote-debug`' option tells `gdbserver` to display remote protocol debug output. These options are intended for `gdbserver` development and for bug reports to the developers.

The '`--wrapper`' option specifies a wrapper to launch programs for debugging. The option should be followed by the name of the wrapper, then any command-line arguments to pass to the wrapper, then `--` indicating the end of the wrapper arguments.

`gdbserver` runs the specified wrapper program with a combined command line including the wrapper arguments, then the name of the program to debug, then any arguments to the program. The wrapper runs until it executes your program, and then GDB gains control.

You can use any program that eventually calls `execve` with its arguments as a wrapper. Several standard Unix utilities do this, e.g. `env` and `nohup`. Any Unix shell script ending with `exec "$@"` will also work.

For example, you can use `env` to pass an environment variable to the debugged program, without setting the variable in `gdbserver`'s environment:

```
$ gdbserver --wrapper env LD_PRELOAD=libtest.so -- :2222 ./testprog
```

20.3.2 Connecting to `gdbserver`

Run GDB on the host system.

First make sure you have the necessary symbol files. Load symbols for your application using the `file` command before you connect. Use `set sysroot` to locate target libraries (unless your GDB was compiled with the correct sysroot using `--with-sysroot`).

The symbol file and target libraries must exactly match the executable and libraries on the target, with one exception: the files on the host system should not be stripped, even if the files on the target system are. Mismatched or missing files will lead to confusing results during debugging. On GNU/Linux targets, mismatched or missing files may also prevent `gdbserver` from debugging multi-threaded programs.

Connect to your target (see Section 20.1 [Connecting to a Remote Target], page 235). For TCP connections, you must start up `gdbserver` prior to using the `target remote` command. Otherwise you may get an error whose text depends on the host system, but which usually looks something like '`Connection refused`'. Don't use the `load` command in GDB when using `gdbserver`, since the program is already on the target.

20.3.3 Monitor Commands for `gdbserver`

During a GDB session using `gdbserver`, you can use the `monitor` command to send special requests to `gdbserver`. Here are the available commands.

`monitor help`
: List the available monitor commands.

`monitor set debug 0`
`monitor set debug 1`
: Disable or enable general debugging messages.

`monitor set remote-debug 0`
`monitor set remote-debug 1`
: Disable or enable specific debugging messages associated with the remote protocol (see Appendix E [Remote Protocol], page 503).

`monitor set libthread-db-search-path [PATH]`
: When this command is issued, *path* is a colon-separated list of directories to search for `libthread_db` (see Section 4.10 [set libthread-db-search-path], page 35). If you omit *path*, '`libthread-db-search-path`' will be reset to its default value.

The special entry '`$pdir`' for '`libthread-db-search-path`' is not supported in `gdbserver`.

`monitor exit`
: Tell gdbserver to exit immediately. This command should be followed by `disconnect` to close the debugging session. `gdbserver` will detach from any attached processes and kill any processes it created. Use `monitor exit` to terminate `gdbserver` at the end of a multi-process mode debug session.

20.3.4 Tracepoints support in `gdbserver`

On some targets, `gdbserver` supports tracepoints, fast tracepoints and static tracepoints.

For fast or static tracepoints to work, a special library called the *in-process agent* (IPA), must be loaded in the inferior process. This library is built and distributed as an integral part of `gdbserver`. In addition, support for static tracepoints requires building the in-process agent library with static tracepoints support. At present, the UST (LTTng Userspace Tracer, http://lttng.org/ust) tracing engine is supported. This support is automatically available if UST development headers are found in the standard include path when `gdbserver` is built, or if `gdbserver` was explicitly configured using '`--with-ust`' to point at such headers. You can explicitly disable the support using '`--with-ust=no`'.

There are several ways to load the in-process agent in your program:

`Specifying it as dependency at link time`
: You can link your program dynamically with the in-process agent library. On most systems, this is accomplished by adding `-linproctrace` to the link command.

`Using the system's preloading mechanisms`
: You can force loading the in-process agent at startup time by using your system's support for preloading shared libraries. Many Unixes support the concept of preloading user defined libraries. In most cases, you do that by specifying `LD_PRELOAD=libinproctrace.so` in the environment. See also the description of `gdbserver`'s '`--wrapper`' command line option.

`Using GDB to force loading the agent at run time`
: On some systems, you can force the inferior to load a shared library, by calling a dynamic loader function in the inferior that takes care of dynamically looking up and loading a shared library. On most Unix systems, the function is `dlopen`. You'll use the `call` command for that. For example:

```
(gdb) call dlopen ("libinproctrace.so", ...)
```

Note that on most Unix systems, for the `dlopen` function to be available, the program needs to be linked with `-ldl`.

On systems that have a userspace dynamic loader, like most Unix systems, when you connect to `gdbserver` using `target remote`, you'll find that the program is stopped at the dynamic loader's entry point, and no shared library has been loaded in the program's address space yet, including the in-process agent. In that case, before being able to use any of the fast or static tracepoints features, you need to let the loader run and load the shared libraries. The simplest way to do that is to run the program to the main procedure. E.g., if debugging a C or C++ program, start `gdbserver` like so:

```
$ gdbserver :9999 myprogram
```

Start GDB and connect to `gdbserver` like so, and run to main:

```
$ gdb myprogram
(gdb) target remote myhost:9999
0x00007f215893ba60 in ?? () from /lib64/ld-linux-x86-64.so.2
(gdb) b main
(gdb) continue
```

The in-process tracing agent library should now be loaded into the process; you can confirm it with the `info sharedlibrary` command, which will list '`libinproctrace.so`' as loaded in the process. You are now ready to install fast tracepoints, list static tracepoint markers, probe static tracepoints markers, and start tracing.

20.4 Remote Configuration

This section documents the configuration options available when debugging remote programs. For the options related to the File I/O extensions of the remote protocol, see [system], page 555.

`set remoteaddresssize` *bits*
: Set the maximum size of address in a memory packet to the specified number of bits. GDB will mask off the address bits above that number, when it passes addresses to the remote target. The default value is the number of bits in the target's address.

`show remoteaddresssize`
: Show the current value of remote address size in bits.

`set remotebaud` *n*
: Set the baud rate for the remote serial I/O to *n* baud. The value is used to set the speed of the serial port used for debugging remote targets.

`show remotebaud`
: Show the current speed of the remote connection.

`set remotebreak`
: If set to on, GDB sends a `BREAK` signal to the remote when you type *`Ctrl-c`* to interrupt the program running on the remote. If set to off, GDB sends the '`Ctrl-C`' character instead. The default is off, since most remote systems expect to see '`Ctrl-C`' as the interrupt signal.

`show remotebreak`
: Show whether GDB sends `BREAK` or '`Ctrl-C`' to interrupt the remote program.

`set remoteflow on`
`set remoteflow off`
: Enable or disable hardware flow control (`RTS`/`CTS`) on the serial port used to communicate to the remote target.

`show remoteflow`
: Show the current setting of hardware flow control.

`set remotelogbase` *base*
: Set the base (a.k.a. radix) of logging serial protocol communications to *base*. Supported values of *base* are: `ascii`, `octal`, and `hex`. The default is `ascii`.

`show remotelogbase`
: Show the current setting of the radix for logging remote serial protocol.

`set remotelogfile` *file*
: Record remote serial communications on the named *file*. The default is not to record at all.

`show remotelogfile.`
: Show the current setting of the file name on which to record the serial communications.

`set remotetimeout` *num*
: Set the timeout limit to wait for the remote target to respond to *num* seconds. The default is 2 seconds.

`show remotetimeout`
: Show the current number of seconds to wait for the remote target responses.

`set remote hardware-watchpoint-limit` *limit*
`set remote hardware-breakpoint-limit` *limit*
: Restrict GDB to using *limit* remote hardware breakpoint or watchpoints. A limit of -1, the default, is treated as unlimited.

`set remote hardware-watchpoint-length-limit` *limit*
: Restrict GDB to using *limit* bytes for the maximum length of a remote hardware watchpoint. A limit of -1, the default, is treated as unlimited.

`show remote hardware-watchpoint-length-limit`
: Show the current limit (in bytes) of the maximum length of a remote hardware watchpoint.

`set remote exec-file` *filename*
`show remote exec-file`
: Select the file used for `run` with `target extended-remote`. This should be set to a filename valid on the target system. If it is not set, the target will use a default filename (e.g. the last program run).

`set remote interrupt-sequence`
: Allow the user to select one of '`Ctrl-C`', a `BREAK` or '`BREAK-g`' as the sequence to the remote target in order to interrupt the execution. '`Ctrl-C`' is a default. Some system prefers `BREAK` which is high level of serial line for some certain time. Linux kernel prefers '`BREAK-g`', a.k.a Magic SysRq g. It is `BREAK` signal followed by character `g`.

`show interrupt-sequence`
: Show which of '`Ctrl-C`', `BREAK` or `BREAK-g` is sent by GDB to interrupt the remote program. `BREAK-g` is BREAK signal followed by `g` and also known as Magic SysRq g.

`set remote interrupt-on-connect`
: Specify whether interrupt-sequence is sent to remote target when GDB connects to it. This is mostly needed when you debug Linux kernel. Linux kernel expects `BREAK` followed by `g` which is known as Magic SysRq g in order to connect GDB.

`show interrupt-on-connect`
: Show whether interrupt-sequence is sent to remote target when GDB connects to it.

`set tcp auto-retry on`
: Enable auto-retry for remote TCP connections. This is useful if the remote debugging agent is launched in parallel with GDB; there is a race condition because the agent may not become ready to accept the connection before GDB attempts to connect. When auto-retry is enabled, if the initial attempt to connect fails, GDB reattempts to establish the connection using the timeout specified by `set tcp connect-timeout`.

`set tcp auto-retry off`
: Do not auto-retry failed TCP connections.

`show tcp auto-retry`
: Show the current auto-retry setting.

`set tcp connect-timeout` *seconds*
: Set the timeout for establishing a TCP connection to the remote target to *seconds*. The timeout affects both polling to retry failed connections (enabled by `set tcp auto-retry on`) and waiting for connections that are merely slow to complete, and represents an approximate cumulative value.

`show tcp connect-timeout`
: Show the current connection timeout setting.

The GDB remote protocol autodetects the packets supported by your debugging stub. If you need to override the autodetection, you can use these commands to enable or disable individual packets. Each packet can be set to '`on`' (the remote target supports this packet), '`off`' (the remote target does not support this packet), or '`auto`' (detect remote target support for this packet). They all default to '`auto`'. For more information about each packet, see Appendix E [Remote Protocol], page 503.

During normal use, you should not have to use any of these commands. If you do, that may be a bug in your remote debugging stub, or a bug in GDB. You may want to report the problem to the GDB developers.

For each packet *name*, the command to enable or disable the packet is `set remote` *name*`-packet`. The available settings are:

Command Name	Remote Packet	Related Features
`fetch-register`	`p`	`info registers`
`set-register`	`P`	`set`
`binary-download`	`X`	`load`, `set`
`read-aux-vector`	`qXfer:auxv:read`	`info auxv`

`symbol-lookup`	`qSymbol`	Detecting multiple threads
`attach`	`vAttach`	`attach`
`verbose-resume`	`vCont`	Stepping or resuming multiple threads
`run`	`vRun`	`run`
`software-breakpoint`	`Z0`	`break`
`hardware-breakpoint`	`Z1`	`hbreak`
`write-watchpoint`	`Z2`	`watch`
`read-watchpoint`	`Z3`	`rwatch`
`access-watchpoint`	`Z4`	`awatch`
`target-features`	`qXfer:features:read`	`set architecture`
`library-info`	`qXfer:libraries:read`	`info sharedlibrary`
`memory-map`	`qXfer:memory-map:read`	`info mem`
`read-sdata-object`	`qXfer:sdata:read`	`print $_sdata`
`read-spu-object`	`qXfer:spu:read`	`info spu`
`write-spu-object`	`qXfer:spu:write`	`info spu`
`read-siginfo-object`	`qXfer:siginfo:read`	`print $_siginfo`
`write-siginfo-object`	`qXfer:siginfo:write`	`set $_siginfo`
`threads`	`qXfer:threads:read`	`info threads`
`get-thread-local-storage-address`	`qGetTLSAddr`	Displaying `__thread` variables
`get-thread-information-block-address`	`qGetTIBAddr`	Display MS-Windows Thread Information Block.

`search-memory`	`qSearch:memory`	`find`
`supported-packets`	`qSupported`	Remote communications parameters
`pass-signals`	`QPassSignals`	`handle` *`signal`*
`program-signals`	`QProgramSignals`	`handle` *`signal`*
`hostio-close-packet`	`vFile:close`	`remote get`, `remote put`
`hostio-open-packet`	`vFile:open`	`remote get`, `remote put`
`hostio-pread-packet`	`vFile:pread`	`remote get`, `remote put`
`hostio-pwrite-packet`	`vFile:pwrite`	`remote get`, `remote put`
`hostio-unlink-packet`	`vFile:unlink`	`remote delete`
`hostio-readlink-packet`	`vFile:readlink`	Host I/O
`noack-packet`	`QStartNoAckMode`	Packet acknowledgment
`osdata`	`qXfer:osdata:read`	`info os`
`query-attached`	`qAttached`	Querying remote process attach state.
`trace-buffer-size`	`QTBuffer:size`	`set trace-buffer-size`
`traceframe-info`	`qXfer:traceframe-info:read`	Traceframe info
`install-in-trace`	`InstallInTrace`	Install tracepoint in tracing
`disable-randomization`	`QDisableRandomization`	`set disable-randomization`

`conditional-breakpoints-packet`	`Z0` and `Z1`	`Support for target-side breakpoint condition evaluation`

20.5 Implementing a Remote Stub

The stub files provided with GDB implement the target side of the communication protocol, and the GDB side is implemented in the GDB source file '`remote.c`'. Normally, you can simply allow these subroutines to communicate, and ignore the details. (If you're implementing your own stub file, you can still ignore the details: start with one of the existing stub files. '`sparc-stub.c`' is the best organized, and therefore the easiest to read.)

To debug a program running on another machine (the debugging *target* machine), you must first arrange for all the usual prerequisites for the program to run by itself. For example, for a C program, you need:

1. A startup routine to set up the C runtime environment; these usually have a name like '`crt0`'. The startup routine may be supplied by your hardware supplier, or you may have to write your own.
2. A C subroutine library to support your program's subroutine calls, notably managing input and output.
3. A way of getting your program to the other machine—for example, a download program. These are often supplied by the hardware manufacturer, but you may have to write your own from hardware documentation.

The next step is to arrange for your program to use a serial port to communicate with the machine where GDB is running (the *host* machine). In general terms, the scheme looks like this:

On the host,
: GDB already understands how to use this protocol; when everything else is set up, you can simply use the '`target remote`' command (see Chapter 19 [Specifying a Debugging Target], page 231).

On the target,
: you must link with your program a few special-purpose subroutines that implement the GDB remote serial protocol. The file containing these subroutines is called a *debugging stub*.

  On certain remote targets, you can use an auxiliary program `gdbserver` instead of linking a stub into your program. See Section 20.3 [Using the `gdbserver` Program], page 237, for details.

The debugging stub is specific to the architecture of the remote machine; for example, use '`sparc-stub.c`' to debug programs on SPARC boards.

These working remote stubs are distributed with GDB:

`i386-stub.c`
: For Intel 386 and compatible architectures.

`m68k-stub.c`
: For Motorola 680x0 architectures.

`sh-stub.c`
: For Renesas SH architectures.

`sparc-stub.c`
: For SPARC architectures.

`sparcl-stub.c`
: For Fujitsu SPARCLITE architectures.

The '`README`' file in the GDB distribution may list other recently added stubs.

20.5.1 What the Stub Can Do for You

The debugging stub for your architecture supplies these three subroutines:

`set_debug_traps`
: This routine arranges for `handle_exception` to run when your program stops. You must call this subroutine explicitly in your program's startup code.

`handle_exception`
: This is the central workhorse, but your program never calls it explicitly—the setup code arranges for `handle_exception` to run when a trap is triggered.

  `handle_exception` takes control when your program stops during execution (for example, on a breakpoint), and mediates communications with GDB on the host machine. This is where the communications protocol is implemented; `handle_exception` acts as the GDB representative on the target machine. It begins by sending summary information on the state of your program, then continues to execute, retrieving and transmitting any information GDB needs, until you execute a GDB command that makes your program resume; at that point, `handle_exception` returns control to your own code on the target machine.

`breakpoint`
: Use this auxiliary subroutine to make your program contain a breakpoint. Depending on the particular situation, this may be the only way for GDB to get control. For instance, if your target machine has some sort of interrupt button, you won't need to call this; pressing the interrupt button transfers control to `handle_exception`—in effect, to GDB. On some machines, simply receiving characters on the serial port may also trigger a trap; again, in that situation, you don't need to call `breakpoint` from your own program—simply running '`target remote`' from the host GDB session gets control.

  Call `breakpoint` if none of these is true, or if you simply want to make certain your program stops at a predetermined point for the start of your debugging session.

20.5.2 What You Must Do for the Stub

The debugging stubs that come with GDB are set up for a particular chip architecture, but they have no information about the rest of your debugging target machine.

First of all you need to tell the stub how to communicate with the serial port.

`int getDebugChar()`
: Write this subroutine to read a single character from the serial port. It may be identical to `getchar` for your target system; a different name is used to allow you to distinguish the two if you wish.

`void putDebugChar(int)`
: Write this subroutine to write a single character to the serial port. It may be identical to `putchar` for your target system; a different name is used to allow you to distinguish the two if you wish.

If you want GDB to be able to stop your program while it is running, you need to use an interrupt-driven serial driver, and arrange for it to stop when it receives a `^C` (‘`\003`’, the control-C character). That is the character which GDB uses to tell the remote system to stop.

Getting the debugging target to return the proper status to GDB probably requires changes to the standard stub; one quick and dirty way is to just execute a breakpoint instruction (the “dirty” part is that GDB reports a `SIGTRAP` instead of a `SIGINT`).

Other routines you need to supply are:

`void exceptionHandler (int` *`exception_number`*`, void *`*`exception_address`*`)`
: Write this function to install *exception_address* in the exception handling tables. You need to do this because the stub does not have any way of knowing what the exception handling tables on your target system are like (for example, the processor’s table might be in ROM, containing entries which point to a table in RAM). *exception_number* is the exception number which should be changed; its meaning is architecture-dependent (for example, different numbers might represent divide by zero, misaligned access, etc). When this exception occurs, control should be transferred directly to *exception_address*, and the processor state (stack, registers, and so on) should be just as it is when a processor exception occurs. So if you want to use a jump instruction to reach *exception_address*, it should be a simple jump, not a jump to subroutine.

  For the 386, *exception_address* should be installed as an interrupt gate so that interrupts are masked while the handler runs. The gate should be at privilege level 0 (the most privileged level). The SPARC and 68k stubs are able to mask interrupts themselves without help from `exceptionHandler`.

`void flush_i_cache()`
: On SPARC and SPARCLITE only, write this subroutine to flush the instruction cache, if any, on your target machine. If there is no instruction cache, this subroutine may be a no-op.

  On target machines that have instruction caches, GDB requires this function to make certain that the state of your program is stable.

You must also make sure this library routine is available:

`void *memset(void *, int, int)`
: This is the standard library function `memset` that sets an area of memory to a known value. If you have one of the free versions of `libc.a`, `memset` can be found there; otherwise, you must either obtain it from your hardware manufacturer, or write your own.

If you do not use the GNU C compiler, you may need other standard library subroutines as well; this varies from one stub to another, but in general the stubs are likely to use any of the common library subroutines which GCC generates as inline code.

20.5.3 Putting it All Together

In summary, when your program is ready to debug, you must follow these steps.

1. Make sure you have defined the supporting low-level routines (see Section 20.5.2 [What You Must Do for the Stub], page 248):

   ```
   getDebugChar, putDebugChar,
   flush_i_cache, memset, exceptionHandler.
   ```

2. Insert these lines in your program's startup code, before the main procedure is called:

   ```
   set_debug_traps();
   breakpoint();
   ```

   On some machines, when a breakpoint trap is raised, the hardware automatically makes the PC point to the instruction after the breakpoint. If your machine doesn't do that, you may need to adjust `handle_exception` to arrange for it to return to the instruction after the breakpoint on this first invocation, so that your program doesn't keep hitting the initial breakpoint instead of making progress.

3. For the 680x0 stub only, you need to provide a variable called `exceptionHook`. Normally you just use:

   ```
   void (*exceptionHook)() = 0;
   ```

   but if before calling `set_debug_traps`, you set it to point to a function in your program, that function is called when GDB continues after stopping on a trap (for example, bus error). The function indicated by `exceptionHook` is called with one parameter: an `int` which is the exception number.

4. Compile and link together: your program, the GDB debugging stub for your target architecture, and the supporting subroutines.

5. Make sure you have a serial connection between your target machine and the GDB host, and identify the serial port on the host.

6. Download your program to your target machine (or get it there by whatever means the manufacturer provides), and start it.

7. Start GDB on the host, and connect to the target (see Section 20.1 [Connecting to a Remote Target], page 235).

21 Configuration-Specific Information

While nearly all GDB commands are available for all native and cross versions of the debugger, there are some exceptions. This chapter describes things that are only available in certain configurations.

There are three major categories of configurations: native configurations, where the host and target are the same, embedded operating system configurations, which are usually the same for several different processor architectures, and bare embedded processors, which are quite different from each other.

21.1 Native

This section describes details specific to particular native configurations.

21.1.1 HP-UX

On HP-UX systems, if you refer to a function or variable name that begins with a dollar sign, GDB searches for a user or system name first, before it searches for a convenience variable.

21.1.2 BSD libkvm Interface

BSD-derived systems (FreeBSD/NetBSD/OpenBSD) have a kernel memory interface that provides a uniform interface for accessing kernel virtual memory images, including live systems and crash dumps. GDB uses this interface to allow you to debug live kernels and kernel crash dumps on many native BSD configurations. This is implemented as a special `kvm` debugging target. For debugging a live system, load the currently running kernel into GDB and connect to the `kvm` target:

```
(gdb) target kvm
```

For debugging crash dumps, provide the file name of the crash dump as an argument:

```
(gdb) target kvm /var/crash/bsd.0
```

Once connected to the `kvm` target, the following commands are available:

`kvm pcb` Set current context from the *Process Control Block* (PCB) address.

`kvm proc` Set current context from proc address. This command isn't available on modern FreeBSD systems.

21.1.3 SVR4 Process Information

Many versions of SVR4 and compatible systems provide a facility called '`/proc`' that can be used to examine the image of a running process using file-system subroutines.

If GDB is configured for an operating system with this facility, the command `info proc` is available to report information about the process running your program, or about any process running on your system. This includes, as of this writing, GNU/Linux, OSF/1 (Digital Unix), Solaris, and Irix, but not HP-UX, for example.

This command may also work on core files that were created on a system that has the '`/proc`' facility.

`info proc`
`info proc` *`process-id`*
: Summarize available information about any running process. If a process ID is specified by *process-id*, display information about that process; otherwise display information about the program being debugged. The summary includes the debugged process ID, the command line used to invoke it, its current working directory, and its executable file's absolute file name.

  On some systems, *process-id* can be of the form '`[pid]/tid`' which specifies a certain thread ID within a process. If the optional *pid* part is missing, it means a thread from the process being debugged (the leading '`/`' still needs to be present, or else GDB will interpret the number as a process ID rather than a thread ID).

`info proc cmdline`
: Show the original command line of the process. This command is specific to GNU/Linux.

`info proc cwd`
: Show the current working directory of the process. This command is specific to GNU/Linux.

`info proc exe`
: Show the name of executable of the process. This command is specific to GNU/Linux.

`info proc mappings`
: Report the memory address space ranges accessible in the program, with information on whether the process has read, write, or execute access rights to each range. On GNU/Linux systems, each memory range includes the object file which is mapped to that range, instead of the memory access rights to that range.

`info proc stat`
`info proc status`
: These subcommands are specific to GNU/Linux systems. They show the process-related information, including the user ID and group ID; how many threads are there in the process; its virtual memory usage; the signals that are pending, blocked, and ignored; its TTY; its consumption of system and user time; its stack size; its '`nice`' value; etc. For more information, see the '`proc`' man page (type *`man 5 proc`* from your shell prompt).

`info proc all`
: Show all the information about the process described under all of the above `info proc` subcommands.

`set procfs-trace`
: This command enables and disables tracing of `procfs` API calls.

`show procfs-trace`
: Show the current state of `procfs` API call tracing.

`set procfs-file` *file*
: Tell GDB to write `procfs` API trace to the named *file*. GDB appends the trace info to the previous contents of the file. The default is to display the trace on the standard output.

`show procfs-file`
: Show the file to which `procfs` API trace is written.

`proc-trace-entry`
`proc-trace-exit`
`proc-untrace-entry`
`proc-untrace-exit`
: These commands enable and disable tracing of entries into and exits from the `syscall` interface.

`info pidlist`
: For QNX Neutrino only, this command displays the list of all the processes and all the threads within each process.

`info meminfo`
: For QNX Neutrino only, this command displays the list of all mapinfos.

21.1.4 Features for Debugging DJGPP Programs

DJGPP is a port of the GNU development tools to MS-DOS and MS-Windows. DJGPP programs are 32-bit protected-mode programs that use the *DPMI* (DOS Protected-Mode Interface) API to run on top of real-mode DOS systems and their emulations.

GDB supports native debugging of DJGPP programs, and defines a few commands specific to the DJGPP port. This subsection describes those commands.

`info dos` This is a prefix of DJGPP-specific commands which print information about the target system and important OS structures.

`info dos sysinfo`
: This command displays assorted information about the underlying platform: the CPU type and features, the OS version and flavor, the DPMI version, and the available conventional and DPMI memory.

`info dos gdt`
`info dos ldt`
`info dos idt`
: These 3 commands display entries from, respectively, Global, Local, and Interrupt Descriptor Tables (GDT, LDT, and IDT). The descriptor tables are data structures which store a descriptor for each segment that is currently in use. The segment's selector is an index into a descriptor table; the table entry for that index holds the descriptor's base address and limit, and its attributes and access rights.

  A typical DJGPP program uses 3 segments: a code segment, a data segment (used for both data and the stack), and a DOS segment (which allows access to DOS/BIOS data structures and absolute addresses in conventional memory). However, the DPMI host will usually define additional segments in order to support the DPMI environment.

These commands allow to display entries from the descriptor tables. Without an argument, all entries from the specified table are displayed. An argument, which should be an integer expression, means display a single entry whose index is given by the argument. For example, here's a convenient way to display information about the debugged program's data segment:

```
(gdb) info dos ldt $ds
0x13f: base=0x11970000 limit=0x0009ffff 32-Bit Data (Read/Write, Exp-up)
```

This comes in handy when you want to see whether a pointer is outside the data segment's limit (i.e. *garbled*).

`info dos pde`
`info dos pte`

These two commands display entries from, respectively, the Page Directory and the Page Tables. Page Directories and Page Tables are data structures which control how virtual memory addresses are mapped into physical addresses. A Page Table includes an entry for every page of memory that is mapped into the program's address space; there may be several Page Tables, each one holding up to 4096 entries. A Page Directory has up to 4096 entries, one each for every Page Table that is currently in use.

Without an argument, *`info dos pde`* displays the entire Page Directory, and *`info dos pte`* displays all the entries in all of the Page Tables. An argument, an integer expression, given to the *`info dos pde`* command means display only that entry from the Page Directory table. An argument given to the *`info dos pte`* command means display entries from a single Page Table, the one pointed to by the specified entry in the Page Directory.

These commands are useful when your program uses *DMA* (Direct Memory Access), which needs physical addresses to program the DMA controller.

These commands are supported only with some DPMI servers.

`info dos address-pte` *`addr`*

This command displays the Page Table entry for a specified linear address. The argument *addr* is a linear address which should already have the appropriate segment's base address added to it, because this command accepts addresses which may belong to *any* segment. For example, here's how to display the Page Table entry for the page where a variable `i` is stored:

```
(gdb) info dos address-pte __djgpp_base_address + (char *)&i
Page Table entry for address 0x11a00d30:
Base=0x02698000 Dirty Acc. Not-Cached Write-Back Usr Read-Write +0xd30
```

This says that `i` is stored at offset `0xd30` from the page whose physical base address is `0x02698000`, and shows all the attributes of that page.

Note that you must cast the addresses of variables to a `char *`, since otherwise the value of `__djgpp_base_address`, the base address of all variables and functions in a DJGPP program, will be added using the rules of C pointer arithmetics: if `i` is declared an `int`, GDB will add 4 times the value of `__djgpp_base_address` to the address of `i`.

Here's another example, it displays the Page Table entry for the transfer buffer:

```
(gdb) info dos address-pte *((unsigned *)&_go32_info_block + 3)
```

```
Page Table entry for address 0x29110:
Base=0x00029000 Dirty Acc. Not-Cached Write-Back Usr Read-Write +0x110
```

(The `+ 3` offset is because the transfer buffer's address is the 3rd member of the `_go32_info_block` structure.) The output clearly shows that this DPMI server maps the addresses in conventional memory 1:1, i.e. the physical (`0x00029000 + 0x110`) and linear (`0x29110`) addresses are identical.

This command is supported only with some DPMI servers.

In addition to native debugging, the DJGPP port supports remote debugging via a serial data link. The following commands are specific to remote serial debugging in the DJGPP port of GDB.

`set com1base` *addr*
: This command sets the base I/O port address of the '`COM1`' serial port.

`set com1irq` *irq*
: This command sets the *Interrupt Request* (`IRQ`) line to use for the '`COM1`' serial port.

  There are similar commands '`set com2base`', '`set com3irq`', etc. for setting the port address and the `IRQ` lines for the other 3 COM ports.

  The related commands '`show com1base`', '`show com1irq`' etc. display the current settings of the base address and the `IRQ` lines used by the COM ports.

`info serial`
: This command prints the status of the 4 DOS serial ports. For each port, it prints whether it's active or not, its I/O base address and IRQ number, whether it uses a 16550-style FIFO, its baudrate, and the counts of various errors encountered so far.

21.1.5 Features for Debugging MS Windows PE Executables

GDB supports native debugging of MS Windows programs, including DLLs with and without symbolic debugging information.

MS-Windows programs that call `SetConsoleMode` to switch off the special meaning of the '`Ctrl-C`' keystroke cannot be interrupted by typing *`C-c`*. For this reason, GDB on MS-Windows supports *`C-BREAK`* as an alternative interrupt key sequence, which can be used to interrupt the debuggee even if it ignores *`C-c`*.

There are various additional Cygwin-specific commands, described in this section. Working with DLLs that have no debugging symbols is described in Section 21.1.5.1 [Non-debug DLL Symbols], page 257.

`info w32` This is a prefix of MS Windows-specific commands which print information about the target system and important OS structures.

`info w32 selector`
: This command displays information returned by the Win32 API `GetThreadSelectorEntry` function. It takes an optional argument that is evaluated to a long value to give the information about this given selector. Without argument, this command displays information about the six segment registers.

`info w32 thread-information-block`
: This command displays thread specific information stored in the Thread Information Block (readable on the X86 CPU family using `$fs` selector for 32-bit programs and `$gs` for 64-bit programs).

`info dll` This is a Cygwin-specific alias of `info shared`.

`dll-symbols`
: This command loads symbols from a dll similarly to add-sym command but without the need to specify a base address.

`set cygwin-exceptions` *mode*
: If *mode* is `on`, GDB will break on exceptions that happen inside the Cygwin DLL. If *mode* is `off`, GDB will delay recognition of exceptions, and may ignore some exceptions which seem to be caused by internal Cygwin DLL "bookkeeping". This option is meant primarily for debugging the Cygwin DLL itself; the default value is `off` to avoid annoying GDB users with false `SIGSEGV` signals.

`show cygwin-exceptions`
: Displays whether GDB will break on exceptions that happen inside the Cygwin DLL itself.

`set new-console` *mode*
: If *mode* is `on` the debuggee will be started in a new console on next start. If *mode* is `off`, the debuggee will be started in the same console as the debugger.

`show new-console`
: Displays whether a new console is used when the debuggee is started.

`set new-group` *mode*
: This boolean value controls whether the debuggee should start a new group or stay in the same group as the debugger. This affects the way the Windows OS handles '`Ctrl-C`'.

`show new-group`
: Displays current value of new-group boolean.

`set debugevents`
: This boolean value adds debug output concerning kernel events related to the debuggee seen by the debugger. This includes events that signal thread and process creation and exit, DLL loading and unloading, console interrupts, and debugging messages produced by the Windows `OutputDebugString` API call.

`set debugexec`
: This boolean value adds debug output concerning execute events (such as resume thread) seen by the debugger.

`set debugexceptions`
: This boolean value adds debug output concerning exceptions in the debuggee seen by the debugger.

`set debugmemory`
: This boolean value adds debug output concerning debuggee memory reads and writes by the debugger.

`set shell` This boolean values specifies whether the debuggee is called via a shell or directly (default value is on).

`show shell`
Displays if the debuggee will be started with a shell.

21.1.5.1 Support for DLLs without Debugging Symbols

Very often on windows, some of the DLLs that your program relies on do not include symbolic debugging information (for example, '`kernel32.dll`'). When GDB doesn't recognize any debugging symbols in a DLL, it relies on the minimal amount of symbolic information contained in the DLL's export table. This section describes working with such symbols, known internally to GDB as "minimal symbols".

Note that before the debugged program has started execution, no DLLs will have been loaded. The easiest way around this problem is simply to start the program — either by setting a breakpoint or letting the program run once to completion. It is also possible to force GDB to load a particular DLL before starting the executable — see the shared library information in Section 18.1 [Files], page 215, or the `dll-symbols` command in Section 21.1.5 [Cygwin Native], page 255. Currently, explicitly loading symbols from a DLL with no debugging information will cause the symbol names to be duplicated in GDB's lookup table, which may adversely affect symbol lookup performance.

21.1.5.2 DLL Name Prefixes

In keeping with the naming conventions used by the Microsoft debugging tools, DLL export symbols are made available with a prefix based on the DLL name, for instance `KERNEL32!CreateFileA`. The plain name is also entered into the symbol table, so `CreateFileA` is often sufficient. In some cases there will be name clashes within a program (particularly if the executable itself includes full debugging symbols) necessitating the use of the fully qualified name when referring to the contents of the DLL. Use single-quotes around the name to avoid the exclamation mark ("!") being interpreted as a language operator.

Note that the internal name of the DLL may be all upper-case, even though the file name of the DLL is lower-case, or vice-versa. Since symbols within GDB are *case-sensitive* this may cause some confusion. If in doubt, try the `info functions` and `info variables` commands or even `maint print msymbols` (see Chapter 16 [Symbols], page 201). Here's an example:

```
(gdb) info function CreateFileA
All functions matching regular expression "CreateFileA":

Non-debugging symbols:
0x77e885f4  CreateFileA
0x77e885f4  KERNEL32!CreateFileA
(gdb) info function !
All functions matching regular expression "!":

Non-debugging symbols:
0x6100114c  cygwin1!__assert
0x61004034  cygwin1!_dll_crt0@0
0x61004240  cygwin1!dll_crt0(per_process *)
[etc...]
```

21.1.5.3 Working with Minimal Symbols

Symbols extracted from a DLL's export table do not contain very much type information. All that GDB can do is guess whether a symbol refers to a function or variable depending on the linker section that contains the symbol. Also note that the actual contents of the memory contained in a DLL are not available unless the program is running. This means that you cannot examine the contents of a variable or disassemble a function within a DLL without a running program.

Variables are generally treated as pointers and dereferenced automatically. For this reason, it is often necessary to prefix a variable name with the address-of operator ("&") and provide explicit type information in the command. Here's an example of the type of problem:

```
(gdb) print 'cygwin1!__argv'
$1 = 268572168
(gdb) x 'cygwin1!__argv'
0x10021610:      "\230y\""
```

And two possible solutions:

```
(gdb) print ((char **)'cygwin1!__argv')[0]
$2 = 0x22fd98 "/cygdrive/c/mydirectory/myprogram"
(gdb) x/2x &'cygwin1!__argv'
0x610c0aa8 <cygwin1!__argv>:    0x10021608      0x00000000
(gdb) x/x 0x10021608
0x10021608:     0x0022fd98
(gdb) x/s 0x0022fd98
0x22fd98:        "/cygdrive/c/mydirectory/myprogram"
```

Setting a break point within a DLL is possible even before the program starts execution. However, under these circumstances, GDB can't examine the initial instructions of the function in order to skip the function's frame set-up code. You can work around this by using "*&" to set the breakpoint at a raw memory address:

```
(gdb) break *&'python22!PyOS_Readline'
Breakpoint 1 at 0x1e04eff0
```

The author of these extensions is not entirely convinced that setting a break point within a shared DLL like '`kernel32.dll`' is completely safe.

21.1.6 Commands Specific to GNU Hurd Systems

This subsection describes GDB commands specific to the GNU Hurd native debugging.

`set signals`
`set sigs` This command toggles the state of inferior signal interception by GDB. Mach exceptions, such as breakpoint traps, are not affected by this command. `sigs` is a shorthand alias for `signals`.

`show signals`
`show sigs` Show the current state of intercepting inferior's signals.

`set signal-thread`
`set sigthread`
This command tells GDB which thread is the `libc` signal thread. That thread is run when a signal is delivered to a running process. `set sigthread` is the shorthand alias of `set signal-thread`.

`show signal-thread`
`show sigthread`
: These two commands show which thread will run when the inferior is delivered a signal.

`set stopped`
: This commands tells GDB that the inferior process is stopped, as with the `SIGSTOP` signal. The stopped process can be continued by delivering a signal to it.

`show stopped`
: This command shows whether GDB thinks the debuggee is stopped.

`set exceptions`
: Use this command to turn off trapping of exceptions in the inferior. When exception trapping is off, neither breakpoints nor single-stepping will work. To restore the default, set exception trapping on.

`show exceptions`
: Show the current state of trapping exceptions in the inferior.

`set task pause`
: This command toggles task suspension when GDB has control. Setting it to on takes effect immediately, and the task is suspended whenever GDB gets control. Setting it to off will take effect the next time the inferior is continued. If this option is set to off, you can use `set thread default pause on` or `set thread pause on` (see below) to pause individual threads.

`show task pause`
: Show the current state of task suspension.

`set task detach-suspend-count`
: This command sets the suspend count the task will be left with when GDB detaches from it.

`show task detach-suspend-count`
: Show the suspend count the task will be left with when detaching.

`set task exception-port`
`set task excp`
: This command sets the task exception port to which GDB will forward exceptions. The argument should be the value of the *send rights* of the task. `set task excp` is a shorthand alias.

`set noninvasive`
: This command switches GDB to a mode that is the least invasive as far as interfering with the inferior is concerned. This is the same as using `set task pause`, `set exceptions`, and `set signals` to values opposite to the defaults.

`info send-rights`
`info receive-rights`
`info port-rights`
`info port-sets`
`info dead-names`
`info ports`
`info psets`
: These commands display information about, respectively, send rights, receive rights, port rights, port sets, and dead names of a task. There are also shorthand aliases: `info ports` for `info port-rights` and `info psets` for `info port-sets`.

`set thread pause`
: This command toggles current thread suspension when GDB has control. Setting it to on takes effect immediately, and the current thread is suspended whenever GDB gets control. Setting it to off will take effect the next time the inferior is continued. Normally, this command has no effect, since when GDB has control, the whole task is suspended. However, if you used `set task pause off` (see above), this command comes in handy to suspend only the current thread.

`show thread pause`
: This command shows the state of current thread suspension.

`set thread run`
: This command sets whether the current thread is allowed to run.

`show thread run`
: Show whether the current thread is allowed to run.

`set thread detach-suspend-count`
: This command sets the suspend count GDB will leave on a thread when detaching. This number is relative to the suspend count found by GDB when it notices the thread; use `set thread takeover-suspend-count` to force it to an absolute value.

`show thread detach-suspend-count`
: Show the suspend count GDB will leave on the thread when detaching.

`set thread exception-port`
`set thread excp`
: Set the thread exception port to which to forward exceptions. This overrides the port set by `set task exception-port` (see above). `set thread excp` is the shorthand alias.

`set thread takeover-suspend-count`
: Normally, GDB's thread suspend counts are relative to the value GDB finds when it notices each thread. This command changes the suspend counts to be absolute instead.

`set thread default`
`show thread default`
: Each of the above `set thread` commands has a `set thread default` counterpart (e.g., `set thread default pause`, `set thread default exception-port`,

etc.). The `thread default` variety of commands sets the default thread properties for all threads; you can then change the properties of individual threads with the non-default commands.

21.1.7 Darwin

GDB provides the following commands specific to the Darwin target:

`set debug darwin` *num*
: When set to a non zero value, enables debugging messages specific to the Darwin support. Higher values produce more verbose output.

`show debug darwin`
: Show the current state of Darwin messages.

`set debug mach-o` *num*
: When set to a non zero value, enables debugging messages while GDB is reading Darwin object files. (*Mach-O* is the file format used on Darwin for object and executable files.) Higher values produce more verbose output. This is a command to diagnose problems internal to GDB and should not be needed in normal usage.

`show debug mach-o`
: Show the current state of Mach-O file messages.

`set mach-exceptions on`
`set mach-exceptions off`
: On Darwin, faults are first reported as a Mach exception and are then mapped to a Posix signal. Use this command to turn on trapping of Mach exceptions in the inferior. This might be sometimes useful to better understand the cause of a fault. The default is off.

`show mach-exceptions`
: Show the current state of exceptions trapping.

21.2 Embedded Operating Systems

This section describes configurations involving the debugging of embedded operating systems that are available for several different architectures.

GDB includes the ability to debug programs running on various real-time operating systems.

21.2.1 Using GDB with VxWorks

`target vxworks` *machinename*
: A VxWorks system, attached via TCP/IP. The argument *machinename* is the target system's machine name or IP address.

On VxWorks, `load` links *filename* dynamically on the current target system as well as adding its symbols in GDB.

GDB enables developers to spawn and debug tasks running on networked VxWorks targets from a Unix host. Already-running tasks spawned from the VxWorks shell can also be

debugged. GDB uses code that runs on both the Unix host and on the VxWorks target. The program `gdb` is installed and executed on the Unix host. (It may be installed with the name `vxgdb`, to distinguish it from a GDB for debugging programs on the host itself.)

`VxWorks-timeout` *args*
: All VxWorks-based targets now support the option `vxworks-timeout`. This option is set by the user, and *args* represents the number of seconds GDB waits for responses to rpc's. You might use this if your VxWorks target is a slow software simulator or is on the far side of a thin network line.

The following information on connecting to VxWorks was current when this manual was produced; newer releases of VxWorks may use revised procedures.

To use GDB with VxWorks, you must rebuild your VxWorks kernel to include the remote debugging interface routines in the VxWorks library '`rdb.a`'. To do this, define `INCLUDE_RDB` in the VxWorks configuration file '`configAll.h`' and rebuild your VxWorks kernel. The resulting kernel contains '`rdb.a`', and spawns the source debugging task `tRdbTask` when VxWorks is booted. For more information on configuring and remaking VxWorks, see the manufacturer's manual.

Once you have included '`rdb.a`' in your VxWorks system image and set your Unix execution search path to find GDB, you are ready to run GDB. From your Unix host, run `gdb` (or `vxgdb`, depending on your installation).

GDB comes up showing the prompt:

```
(vxgdb)
```

21.2.1.1 Connecting to VxWorks

The GDB command `target` lets you connect to a VxWorks target on the network. To connect to a target whose host name is "`tt`", type:

```
(vxgdb) target vxworks tt
```

GDB displays messages like these:

```
Attaching remote machine across net...
Connected to tt.
```

GDB then attempts to read the symbol tables of any object modules loaded into the VxWorks target since it was last booted. GDB locates these files by searching the directories listed in the command search path (see Section 4.4 [Your Program's Environment], page 29); if it fails to find an object file, it displays a message such as:

```
prog.o: No such file or directory.
```

When this happens, add the appropriate directory to the search path with the GDB command `path`, and execute the `target` command again.

21.2.1.2 VxWorks Download

If you have connected to the VxWorks target and you want to debug an object that has not yet been loaded, you can use the GDB `load` command to download a file from Unix to VxWorks incrementally. The object file given as an argument to the `load` command is actually opened twice: first by the VxWorks target in order to download the code, then by GDB in order to read the symbol table. This can lead to problems if the current working directories on the two systems differ. If both systems have NFS mounted the same filesystems, you can avoid these problems by using absolute paths. Otherwise, it is

simplest to set the working directory on both systems to the directory in which the object file resides, and then to reference the file by its name, without any path. For instance, a program '`prog.o`' may reside in '*`vxpath`*`/vw/demo/rdb`' in VxWorks and in '*`hostpath`*`/vw/demo/rdb`' on the host. To load this program, type this on VxWorks:

```
-> cd "vxpath/vw/demo/rdb"
```

Then, in GDB, type:

```
(vxgdb) cd hostpath/vw/demo/rdb
(vxgdb) load prog.o
```

GDB displays a response similar to this:

```
Reading symbol data from wherever/vw/demo/rdb/prog.o... done.
```

You can also use the `load` command to reload an object module after editing and recompiling the corresponding source file. Note that this makes GDB delete all currently-defined breakpoints, auto-displays, and convenience variables, and to clear the value history. (This is necessary in order to preserve the integrity of debugger's data structures that reference the target system's symbol table.)

21.2.1.3 Running Tasks

You can also attach to an existing task using the `attach` command as follows:

```
(vxgdb) attach task
```

where *task* is the VxWorks hexadecimal task ID. The task can be running or suspended when you attach to it. Running tasks are suspended at the time of attachment.

21.3 Embedded Processors

This section goes into details specific to particular embedded configurations.

Whenever a specific embedded processor has a simulator, GDB allows to send an arbitrary command to the simulator.

`sim` *`command`*
: Send an arbitrary *command* string to the simulator. Consult the documentation for the specific simulator in use for information about acceptable commands.

21.3.1 ARM

`target rdi` *`dev`*
: ARM Angel monitor, via RDI library interface to ADP protocol. You may use this target to communicate with both boards running the Angel monitor, or with the EmbeddedICE JTAG debug device.

`target rdp` *`dev`*
: ARM Demon monitor.

GDB provides the following ARM-specific commands:

`set arm disassembler`
: This commands selects from a list of disassembly styles. The `"std"` style is the standard style.

`show arm disassembler`
: Show the current disassembly style.

`set arm apcs32`
: This command toggles ARM operation mode between 32-bit and 26-bit.

`show arm apcs32`
: Display the current usage of the ARM 32-bit mode.

`set arm fpu` *fputype*
: This command sets the ARM floating-point unit (FPU) type. The argument *fputype* can be one of these:

  `auto` Determine the FPU type by querying the OS ABI.

  `softfpa` Software FPU, with mixed-endian doubles on little-endian ARM processors.

  `fpa` GCC-compiled FPA co-processor.

  `softvfp` Software FPU with pure-endian doubles.

  `vfp` VFP co-processor.

`show arm fpu`
: Show the current type of the FPU.

`set arm abi`
: This command forces GDB to use the specified ABI.

`show arm abi`
: Show the currently used ABI.

`set arm fallback-mode (arm|thumb|auto)`
: GDB uses the symbol table, when available, to determine whether instructions are ARM or Thumb. This command controls GDB's default behavior when the symbol table is not available. The default is '`auto`', which causes GDB to use the current execution mode (from the `T` bit in the `CPSR` register).

`show arm fallback-mode`
: Show the current fallback instruction mode.

`set arm force-mode (arm|thumb|auto)`
: This command overrides use of the symbol table to determine whether instructions are ARM or Thumb. The default is '`auto`', which causes GDB to use the symbol table and then the setting of '`set arm fallback-mode`'.

`show arm force-mode`
: Show the current forced instruction mode.

`set debug arm`
: Toggle whether to display ARM-specific debugging messages from the ARM target support subsystem.

`show debug arm`
: Show whether ARM-specific debugging messages are enabled.

The following commands are available when an ARM target is debugged using the RDI interface:

`rdilogfile` [*file*]
: Set the filename for the ADP (Angel Debugger Protocol) packet log. With an argument, sets the log file to the specified *file*. With no argument, show the current log file name. The default log file is '`rdi.log`'.

`rdilogenable` [*arg*]
: Control logging of ADP packets. With an argument of 1 or `"yes"` enables logging, with an argument 0 or `"no"` disables it. With no arguments displays the current setting. When logging is enabled, ADP packets exchanged between GDB and the RDI target device are logged to a file.

`set rdiromatzero`
: Tell GDB whether the target has ROM at address 0. If on, vector catching is disabled, so that zero address can be used. If off (the default), vector catching is enabled. For this command to take effect, it needs to be invoked prior to the `target rdi` command.

`show rdiromatzero`
: Show the current setting of ROM at zero address.

`set rdiheartbeat`
: Enable or disable RDI heartbeat packets. It is not recommended to turn on this option, since it confuses ARM and EPI JTAG interface, as well as the Angel monitor.

`show rdiheartbeat`
: Show the setting of RDI heartbeat packets.

`target sim` [*simargs*] `...`
: The GDB ARM simulator accepts the following optional arguments.

  `--swi-support=`*type*
  : Tell the simulator which SWI interfaces to support. *type* may be a comma separated list of the following values. The default value is `all`.

    `none`

    `demon`

    `angel`

    `redboot`

    `all`

21.3.2 Renesas M32R/D and M32R/SDI

`target m32r` *dev*
: Renesas M32R/D ROM monitor.

`target m32rsdi` *dev*
: Renesas M32R SDI server, connected via parallel port to the board.

The following GDB commands are specific to the M32R monitor:

`set download-path` *path*
: Set the default path for finding downloadable SREC files.

`show download-path`
: Show the default path for downloadable SREC files.

`set board-address` *addr*
: Set the IP address for the M32R-EVA target board.

`show board-address`
: Show the current IP address of the target board.

`set server-address` *addr*
: Set the IP address for the download server, which is the GDB's host machine.

`show server-address`
: Display the IP address of the download server.

`upload` [*file*]
: Upload the specified SREC *file* via the monitor's Ethernet upload capability. If no *file* argument is given, the current executable file is uploaded.

`tload` [*file*]
: Test the `upload` command.

The following commands are available for M32R/SDI:

`sdireset` This command resets the SDI connection.

`sdistatus`
: This command shows the SDI connection status.

`debug_chaos`
: Instructs the remote that M32R/Chaos debugging is to be used.

`use_debug_dma`
: Instructs the remote to use the DEBUG_DMA method of accessing memory.

`use_mon_code`
: Instructs the remote to use the MON_CODE method of accessing memory.

`use_ib_break`
: Instructs the remote to set breakpoints by IB break.

`use_dbt_break`
: Instructs the remote to set breakpoints by DBT.

21.3.3 M68k

The Motorola m68k configuration includes ColdFire support, and a target command for the following ROM monitor.

`target dbug` *dev*
: dBUG ROM monitor for Motorola ColdFire.

21.3.4 MicroBlaze

The MicroBlaze is a soft-core processor supported on various Xilinx FPGAs, such as Spartan or Virtex series. Boards with these processors usually have JTAG ports which connect to a host system running the Xilinx Embedded Development Kit (EDK) or Software Development Kit (SDK). This host system is used to download the configuration bitstream to the target FPGA. The Xilinx Microprocessor Debugger (XMD) program communicates with the target board using the JTAG interface and presents a `gdbserver` interface to the board. By default `xmd` uses port `1234`. (While it is possible to change this default port, it requires the use of undocumented `xmd` commands. Contact Xilinx support if you need to do this.)

Use these GDB commands to connect to the MicroBlaze target processor.

`target remote :1234`
: Use this command to connect to the target if you are running GDB on the same system as `xmd`.

`target remote` *`xmd-host`*`:1234`
: Use this command to connect to the target if it is connected to `xmd` running on a different system named *xmd-host*.

`load`
: Use this command to download a program to the MicroBlaze target.

`set debug microblaze` *`n`*
: Enable MicroBlaze-specific debugging messages if non-zero.

`show debug microblaze` *`n`*
: Show MicroBlaze-specific debugging level.

21.3.5 MIPS Embedded

GDB can use the MIPS remote debugging protocol to talk to a MIPS board attached to a serial line. This is available when you configure GDB with '`--target=mips-elf`'.

Use these GDB commands to specify the connection to your target board:

`target mips` *`port`*
: To run a program on the board, start up `gdb` with the name of your program as the argument. To connect to the board, use the command '`target mips` *`port`*', where *port* is the name of the serial port connected to the board. If the program has not already been downloaded to the board, you may use the `load` command to download it. You can then use all the usual GDB commands.

  For example, this sequence connects to the target board through a serial port, and loads and runs a program called *prog* through the debugger:

```
host$ gdb prog
GDB is free software and ...
(gdb) target mips /dev/ttyb
(gdb) load prog
(gdb) run
```

`target mips` *`hostname`*`:`*`portnumber`*
: On some GDB host configurations, you can specify a TCP connection (for instance, to a serial line managed by a terminal concentrator) instead of a serial port, using the syntax '*`hostname`*`:`*`portnumber`*'.

`target pmon` *port*
: PMON ROM monitor.

`target ddb` *port*
: NEC's DDB variant of PMON for Vr4300.

`target lsi` *port*
: LSI variant of PMON.

`target r3900` *dev*
: Densan DVE-R3900 ROM monitor for Toshiba R3900 Mips.

`target array` *dev*
: Array Tech LSI33K RAID controller board.

GDB also supports these special commands for MIPS targets:

`set mipsfpu double`
`set mipsfpu single`
`set mipsfpu none`
`set mipsfpu auto`
`show mipsfpu`
: If your target board does not support the MIPS floating point coprocessor, you should use the command '`set mipsfpu none`' (if you need this, you may wish to put the command in your GDB init file). This tells GDB how to find the return value of functions which return floating point values. It also allows GDB to avoid saving the floating point registers when calling functions on the board. If you are using a floating point coprocessor with only single precision floating point support, as on the R4650 processor, use the command '`set mipsfpu single`'. The default double precision floating point coprocessor may be selected using '`set mipsfpu double`'.

  In previous versions the only choices were double precision or no floating point, so '`set mipsfpu on`' will select double precision and '`set mipsfpu off`' will select no floating point.

  As usual, you can inquire about the `mipsfpu` variable with '`show mipsfpu`'.

`set timeout` *seconds*
`set retransmit-timeout` *seconds*
`show timeout`
`show retransmit-timeout`
: You can control the timeout used while waiting for a packet, in the MIPS remote protocol, with the `set timeout` *seconds* command. The default is 5 seconds. Similarly, you can control the timeout used while waiting for an acknowledgment of a packet with the `set retransmit-timeout` *seconds* command. The default is 3 seconds. You can inspect both values with `show timeout` and `show retransmit-timeout`. (These commands are *only* available when GDB is configured for '`--target=mips-elf`'.)

  The timeout set by `set timeout` does not apply when GDB is waiting for your program to stop. In that case, GDB waits forever because it has no way of knowing how long the program is going to run before stopping.

`set syn-garbage-limit` *num*
: Limit the maximum number of characters GDB should ignore when it tries to synchronize with the remote target. The default is 10 characters. Setting the limit to -1 means there's no limit.

`show syn-garbage-limit`
: Show the current limit on the number of characters to ignore when trying to synchronize with the remote system.

`set monitor-prompt` *prompt*
: Tell GDB to expect the specified *prompt* string from the remote monitor. The default depends on the target:

  pmon target
  : '`PMON`'

  ddb target '`NEC010`'

  lsi target '`PMON>`'

`show monitor-prompt`
: Show the current strings GDB expects as the prompt from the remote monitor.

`set monitor-warnings`
: Enable or disable monitor warnings about hardware breakpoints. This has effect only for the `lsi` target. When on, GDB will display warning messages whose codes are returned by the `lsi` PMON monitor for breakpoint commands.

`show monitor-warnings`
: Show the current setting of printing monitor warnings.

`pmon` *command*
: This command allows sending an arbitrary *command* string to the monitor. The monitor must be in debug mode for this to work.

21.3.6 OpenRISC 1000

See OR1k Architecture document (`www.opencores.org`) for more information about platform and commands.

`target jtag jtag://`*host*`:`*port*
: Connects to remote JTAG server. JTAG remote server can be either an or1ksim or JTAG server, connected via parallel port to the board.

  Example: `target jtag jtag://localhost:9999`

`or1ksim` *command*
: If connected to `or1ksim` OpenRISC 1000 Architectural Simulator, proprietary commands can be executed.

`info or1k spr`
: Displays spr groups.

`info or1k spr` *group*
`info or1k spr` *groupno*
: Displays register names in selected group.

`info or1k spr` *`group register`*
`info or1k spr` *`register`*
`info or1k spr` *`groupno registerno`*
`info or1k spr` *`registerno`*
: Shows information about specified spr register.

`spr` *`group register value`*
`spr` *`register value`*
`spr` *`groupno registerno value`*
`spr` *`registerno value`*
: Writes *value* to specified spr register.

Some implementations of OpenRISC 1000 Architecture also have hardware trace. It is very similar to GDB trace, except it does not interfere with normal program execution and is thus much faster. Hardware breakpoints/watchpoint triggers can be set using:

`$LEA/$LDATA`
: Load effective address/data

`$SEA/$SDATA`
: Store effective address/data

`$AEA/$ADATA`
: Access effective address ($SEA or $LEA) or data ($SDATA/$LDATA)

`$FETCH` Fetch data

When triggered, it can capture low level data, like: `PC`, `LSEA`, `LDATA`, `SDATA`, `READSPR`, `WRITESPR`, `INSTR`.

`htrace` commands:

`hwatch` *`conditional`*
: Set hardware watchpoint on combination of Load/Store Effective Address(es) or Data. For example:

```
hwatch ($LEA == my_var) && ($LDATA < 50) || ($SEA == my_var) &&
($SDATA >= 50)
```

```
hwatch ($LEA == my_var) && ($LDATA < 50) || ($SEA == my_var) &&
($SDATA >= 50)
```

`htrace info`
: Display information about current HW trace configuration.

`htrace trigger` *`conditional`*
: Set starting criteria for HW trace.

`htrace qualifier` *`conditional`*
: Set acquisition qualifier for HW trace.

`htrace stop` *`conditional`*
: Set HW trace stopping criteria.

`htrace record [`*`data`*`]*`
: Selects the data to be recorded, when qualifier is met and HW trace was triggered.

`htrace enable`
`htrace disable`
: Enables/disables the HW trace.

`htrace rewind [`*`filename`*`]`
: Clears currently recorded trace data.

  If filename is specified, new trace file is made and any newly collected data will be written there.

`htrace print [`*`start`* `[`*`len`*`]]`
: Prints trace buffer, using current record configuration.

`htrace mode continuous`
: Set continuous trace mode.

`htrace mode suspend`
: Set suspend trace mode.

21.3.7 PowerPC Embedded

GDB supports using the DVC (Data Value Compare) register to implement in hardware simple hardware watchpoint conditions of the form:

```
(gdb) watch ADDRESS|VARIABLE \
  if  ADDRESS|VARIABLE == CONSTANT EXPRESSION
```

The DVC register will be automatically used when GDB detects such pattern in a condition expression, and the created watchpoint uses one debug register (either the `exact-watchpoints` option is on and the variable is scalar, or the variable has a length of one byte). This feature is available in native GDB running on a Linux kernel version 2.6.34 or newer.

When running on PowerPC embedded processors, GDB automatically uses ranged hardware watchpoints, unless the `exact-watchpoints` option is on, in which case watchpoints using only one debug register are created when watching variables of scalar types.

You can create an artificial array to watch an arbitrary memory region using one of the following commands (see Section 10.1 [Expressions], page 105):

```
(gdb) watch *((char *) address)@length
(gdb) watch {char[length]} address
```

PowerPC embedded processors support masked watchpoints. See the discussion about the `mask` argument in Section 5.1.2 [Set Watchpoints], page 50.

PowerPC embedded processors support hardware accelerated *ranged breakpoints*. A ranged breakpoint stops execution of the inferior whenever it executes an instruction at any address within the range it specifies. To set a ranged breakpoint in GDB, use the `break-range` command.

GDB provides the following PowerPC-specific commands:

`break-range` *`start-location`*`,` *`end-location`*
: Set a breakpoint for an address range. *start-location* and *end-location* can specify a function name, a line number, an offset of lines from the current line or from the start location, or an address of an instruction (see Section 9.2 [Specify Location], page 94, for a list of all the possible ways to specify a *location*.) The

breakpoint will stop execution of the inferior whenever it executes an instruction at any address within the specified range, (including *start-location* and *end-location*.)

`set powerpc soft-float`
`show powerpc soft-float`
: Force GDB to use (or not use) a software floating point calling convention. By default, GDB selects the calling convention based on the selected architecture and the provided executable file.

`set powerpc vector-abi`
`show powerpc vector-abi`
: Force GDB to use the specified calling convention for vector arguments and return values. The valid options are '`auto`'; '`generic`', to avoid vector registers even if they are present; '`altivec`', to use AltiVec registers; and '`spe`' to use SPE registers. By default, GDB selects the calling convention based on the selected architecture and the provided executable file.

`set powerpc exact-watchpoints`
`show powerpc exact-watchpoints`
: Allow GDB to use only one debug register when watching a variable of scalar type, thus assuming that the variable is accessed through the address of its first byte.

`target dink32` *dev*
: DINK32 ROM monitor.

`target ppcbug` *dev*
`target ppcbug1` *dev*
: PPCBUG ROM monitor for PowerPC.

`target sds` *dev*
: SDS monitor, running on a PowerPC board (such as Motorola's ADS).

The following commands specific to the SDS protocol are supported by GDB:

`set sdstimeout` *nsec*
: Set the timeout for SDS protocol reads to be *nsec* seconds. The default is 2 seconds.

`show sdstimeout`
: Show the current value of the SDS timeout.

`sds` *command*
: Send the specified *command* string to the SDS monitor.

21.3.8 HP PA Embedded

`target op50n` *dev*
: OP50N monitor, running on an OKI HPPA board.

`target w89k` *dev*
: W89K monitor, running on a Winbond HPPA board.

21.3.9 Tsqware Sparclet

GDB enables developers to debug tasks running on Sparclet targets from a Unix host. GDB uses code that runs on both the Unix host and on the Sparclet target. The program `gdb` is installed and executed on the Unix host.

`remotetimeout` *args*

GDB supports the option `remotetimeout`. This option is set by the user, and *args* represents the number of seconds GDB waits for responses.

When compiling for debugging, include the options '`-g`' to get debug information and '`-Ttext`' to relocate the program to where you wish to load it on the target. You may also want to add the options '`-n`' or '`-N`' in order to reduce the size of the sections. Example:

```
sparclet-aout-gcc prog.c -Ttext 0x12010000 -g -o prog -N
```

You can use `objdump` to verify that the addresses are what you intended:

```
sparclet-aout-objdump --headers --syms prog
```

Once you have set your Unix execution search path to find GDB, you are ready to run GDB. From your Unix host, run `gdb` (or `sparclet-aout-gdb`, depending on your installation).

GDB comes up showing the prompt:

```
(gdbslet)
```

21.3.9.1 Setting File to Debug

The GDB command `file` lets you choose with program to debug.

```
(gdbslet) file prog
```

GDB then attempts to read the symbol table of '`prog`'. GDB locates the file by searching the directories listed in the command search path. If the file was compiled with debug information (option '`-g`'), source files will be searched as well. GDB locates the source files by searching the directories listed in the directory search path (see Section 4.4 [Your Program's Environment], page 29). If it fails to find a file, it displays a message such as:

```
prog: No such file or directory.
```

When this happens, add the appropriate directories to the search paths with the GDB commands `path` and `dir`, and execute the `target` command again.

21.3.9.2 Connecting to Sparclet

The GDB command `target` lets you connect to a Sparclet target. To connect to a target on serial port "`ttya`", type:

```
(gdbslet) target sparclet /dev/ttya
Remote target sparclet connected to /dev/ttya
main () at ../prog.c:3
```

GDB displays messages like these:

```
Connected to ttya.
```

21.3.9.3 Sparclet Download

Once connected to the Sparclet target, you can use the GDB `load` command to download the file from the host to the target. The file name and load offset should be given as arguments to the `load` command. Since the file format is aout, the program must be loaded to the starting address. You can use `objdump` to find out what this value is. The load offset is an

offset which is added to the VMA (virtual memory address) of each of the file's sections. For instance, if the program '`prog`' was linked to text address 0x1201000, with data at 0x12010160 and bss at 0x12010170, in GDB, type:

```
(gdbslet) load prog 0x12010000
Loading section .text, size 0xdb0 vma 0x12010000
```

If the code is loaded at a different address then what the program was linked to, you may need to use the `section` and `add-symbol-file` commands to tell GDB where to map the symbol table.

21.3.9.4 Running and Debugging

You can now begin debugging the task using GDB's execution control commands, `b`, `step`, `run`, etc. See the GDB manual for the list of commands.

```
(gdbslet) b main
Breakpoint 1 at 0x12010000: file prog.c, line 3.
(gdbslet) run
Starting program: prog
Breakpoint 1, main (argc=1, argv=0xeffff21c) at prog.c:3
3        char *symarg = 0;
(gdbslet) step
4        char *execarg = "hello!";
(gdbslet)
```

21.3.10 Fujitsu Sparclite

`target sparclite` *dev*

Fujitsu sparclite boards, used only for the purpose of loading. You must use an additional command to debug the program. For example: target remote *dev* using GDB standard remote protocol.

21.3.11 Zilog Z8000

When configured for debugging Zilog Z8000 targets, GDB includes a Z8000 simulator.

For the Z8000 family, '`target sim`' simulates either the Z8002 (the unsegmented variant of the Z8000 architecture) or the Z8001 (the segmented variant). The simulator recognizes which architecture is appropriate by inspecting the object code.

`target sim` *args*

Debug programs on a simulated CPU. If the simulator supports setup options, specify them via *args*.

After specifying this target, you can debug programs for the simulated CPU in the same style as programs for your host computer; use the `file` command to load a new program image, the `run` command to run your program, and so on.

As well as making available all the usual machine registers (see Section 10.13 [Registers], page 128), the Z8000 simulator provides three additional items of information as specially named registers:

`cycles` Counts clock-ticks in the simulator.

`insts` Counts instructions run in the simulator.

`time` Execution time in 60ths of a second.

You can refer to these values in GDB expressions with the usual conventions; for example, '`b fputc if $cycles>5000`' sets a conditional breakpoint that suspends only after at least 5000 simulated clock ticks.

21.3.12 Atmel AVR

When configured for debugging the Atmel AVR, GDB supports the following AVR-specific commands:

`info io_registers`
: This command displays information about the AVR I/O registers. For each register, GDB prints its number and value.

21.3.13 CRIS

When configured for debugging CRIS, GDB provides the following CRIS-specific commands:

`set cris-version` *ver*
: Set the current CRIS version to *ver*, either '`10`' or '`32`'. The CRIS version affects register names and sizes. This command is useful in case autodetection of the CRIS version fails.

`show cris-version`
: Show the current CRIS version.

`set cris-dwarf2-cfi`
: Set the usage of DWARF-2 CFI for CRIS debugging. The default is '`on`'. Change to '`off`' when using `gcc-cris` whose version is below `R59`.

`show cris-dwarf2-cfi`
: Show the current state of using DWARF-2 CFI.

`set cris-mode` *mode*
: Set the current CRIS mode to *mode*. It should only be changed when debugging in guru mode, in which case it should be set to '`guru`' (the default is '`normal`').

`show cris-mode`
: Show the current CRIS mode.

21.3.14 Renesas Super-H

For the Renesas Super-H processor, GDB provides these commands:

`set sh calling-convention` *convention*
: Set the calling-convention used when calling functions from GDB. Allowed values are '`gcc`', which is the default setting, and '`renesas`'. With the '`gcc`' setting, functions are called using the GCC calling convention. If the DWARF-2 information of the called function specifies that the function follows the Renesas calling convention, the function is called using the Renesas calling convention. If the calling convention is set to '`renesas`', the Renesas calling convention is always used, regardless of the DWARF-2 information. This can be used to override the default of '`gcc`' if debug information is missing, or the compiler does not emit the DWARF-2 calling convention entry for a function.

`show sh calling-convention`
: Show the current calling convention setting.

21.4 Architectures

This section describes characteristics of architectures that affect all uses of GDB with the architecture, both native and cross.

21.4.1 AArch64

When GDB is debugging the AArch64 architecture, it provides the following special commands:

`set debug aarch64`
: This command determines whether AArch64 architecture-specific debugging messages are to be displayed.

`show debug aarch64`
: Show whether AArch64 debugging messages are displayed.

21.4.2 x86 Architecture-specific Issues

`set struct-convention` *mode*
: Set the convention used by the inferior to return `struct`s and `union`s from functions to *mode*. Possible values of *mode* are `"pcc"`, `"reg"`, and `"default"` (the default). `"default"` or `"pcc"` means that `struct`s are returned on the stack, while `"reg"` means that a `struct` or a `union` whose size is 1, 2, 4, or 8 bytes will be returned in a register.

`show struct-convention`
: Show the current setting of the convention to return `struct`s from functions.

21.4.3 Alpha

See the following section.

21.4.4 MIPS

Alpha- and MIPS-based computers use an unusual stack frame, which sometimes requires GDB to search backward in the object code to find the beginning of a function.

To improve response time (especially for embedded applications, where GDB may be restricted to a slow serial line for this search) you may want to limit the size of this search, using one of these commands:

`set heuristic-fence-post` *limit*
: Restrict GDB to examining at most *limit* bytes in its search for the beginning of a function. A value of *0* (the default) means there is no limit. However, except for *0*, the larger the limit the more bytes `heuristic-fence-post` must search and therefore the longer it takes to run. You should only need to use this command when debugging a stripped executable.

`show heuristic-fence-post`
: Display the current limit.

These commands are available *only* when GDB is configured for debugging programs on Alpha or MIPS processors.

Several MIPS-specific commands are available when debugging MIPS programs:

`set mips abi` *arg*
: Tell GDB which MIPS ABI is used by the inferior. Possible values of *arg* are:

  ‘`auto`’ The default ABI associated with the current binary (this is the default).

  ‘`o32`’

  ‘`o64`’

  ‘`n32`’

  ‘`n64`’

  ‘`eabi32`’

  ‘`eabi64`’

`show mips abi`
: Show the MIPS ABI used by GDB to debug the inferior.

`set mips compression` *arg*
: Tell GDB which MIPS compressed ISA (Instruction Set Architecture) encoding is used by the inferior. GDB uses this for code disassembly and other internal interpretation purposes. This setting is only referred to when no executable has been associated with the debugging session or the executable does not provide information about the encoding it uses. Otherwise this setting is automatically updated from information provided by the executable.

  Possible values of *arg* are ‘`mips16`’ and ‘`micromips`’. The default compressed ISA encoding is ‘`mips16`’, as executables containing MIPS16 code frequently are not identified as such.

  This setting is “sticky”; that is, it retains its value across debugging sessions until reset either explicitly with this command or implicitly from an executable.

  The compiler and/or assembler typically add symbol table annotations to identify functions compiled for the MIPS16 or microMIPS ISAs. If these function-scope annotations are present, GDB uses them in preference to the global compressed ISA encoding setting.

`show mips compression`
: Show the MIPS compressed ISA encoding used by GDB to debug the inferior.

`set mipsfpu`
`show mipsfpu`
: See Section 21.3.5 [MIPS Embedded], page 267.

`set mips mask-address` *arg*
: This command determines whether the most-significant 32 bits of 64-bit MIPS addresses are masked off. The argument *arg* can be ‘`on`’, ‘`off`’, or ‘`auto`’. The latter is the default setting, which lets GDB determine the correct value.

`show mips mask-address`
: Show whether the upper 32 bits of MIPS addresses are masked off or not.

`set remote-mips64-transfers-32bit-regs`
: This command controls compatibility with 64-bit MIPS targets that transfer data in 32-bit quantities. If you have an old MIPS 64 target that transfers 32 bits for some registers, like SR and FSR, and 64 bits for other registers, set this option to '`on`'.

`show remote-mips64-transfers-32bit-regs`
: Show the current setting of compatibility with older MIPS 64 targets.

`set debug mips`
: This command turns on and off debugging messages for the MIPS-specific target code in GDB.

`show debug mips`
: Show the current setting of MIPS debugging messages.

21.4.5 HPPA

When GDB is debugging the HP PA architecture, it provides the following special commands:

`set debug hppa`
: This command determines whether HPPA architecture-specific debugging messages are to be displayed.

`show debug hppa`
: Show whether HPPA debugging messages are displayed.

`maint print unwind` *address*
: This command displays the contents of the unwind table entry at the given *address*.

21.4.6 Cell Broadband Engine SPU architecture

When GDB is debugging the Cell Broadband Engine SPU architecture, it provides the following special commands:

`info spu event`
: Display SPU event facility status. Shows current event mask and pending event status.

`info spu signal`
: Display SPU signal notification facility status. Shows pending signal-control word and signal notification mode of both signal notification channels.

`info spu mailbox`
: Display SPU mailbox facility status. Shows all pending entries, in order of processing, in each of the SPU Write Outbound, SPU Write Outbound Interrupt, and SPU Read Inbound mailboxes.

`info spu dma`
: Display MFC DMA status. Shows all pending commands in the MFC DMA queue. For each entry, opcode, tag, class IDs, effective and local store addresses and transfer size are shown.

`info spu proxydma`
: Display MFC Proxy-DMA status. Shows all pending commands in the MFC Proxy-DMA queue. For each entry, opcode, tag, class IDs, effective and local store addresses and transfer size are shown.

When GDB is debugging a combined PowerPC/SPU application on the Cell Broadband Engine, it provides in addition the following special commands:

`set spu stop-on-load` *arg*
: Set whether to stop for new SPE threads. When set to `on`, GDB will give control to the user when a new SPE thread enters its `main` function. The default is `off`.

`show spu stop-on-load`
: Show whether to stop for new SPE threads.

`set spu auto-flush-cache` *arg*
: Set whether to automatically flush the software-managed cache. When set to `on`, GDB will automatically cause the SPE software-managed cache to be flushed whenever SPE execution stops. This provides a consistent view of PowerPC memory that is accessed via the cache. If an application does not use the software-managed cache, this option has no effect.

`show spu auto-flush-cache`
: Show whether to automatically flush the software-managed cache.

21.4.7 PowerPC

When GDB is debugging the PowerPC architecture, it provides a set of pseudo-registers to enable inspection of 128-bit wide Decimal Floating Point numbers stored in the floating point registers. These values must be stored in two consecutive registers, always starting at an even register like `f0` or `f2`.

The pseudo-registers go from `$dl0` through `$dl15`, and are formed by joining the even/odd register pairs `f0` and `f1` for `$dl0`, `f2` and `f3` for `$dl1` and so on.

For POWER7 processors, GDB provides a set of pseudo-registers, the 64-bit wide Extended Floating Point Registers (‘`f32`’ through ‘`f63`’).

22 Controlling GDB

You can alter the way GDB interacts with you by using the `set` command. For commands controlling how GDB displays data, see Section 10.8 [Print Settings], page 115. Other settings are described here.

22.1 Prompt

GDB indicates its readiness to read a command by printing a string called the *prompt*. This string is normally '`(gdb)`'. You can change the prompt string with the `set prompt` command. For instance, when debugging GDB with GDB, it is useful to change the prompt in one of the GDB sessions so that you can always tell which one you are talking to.

Note: `set prompt` does not add a space for you after the prompt you set. This allows you to set a prompt which ends in a space or a prompt that does not.

`set prompt` *newprompt*
: Directs GDB to use *newprompt* as its prompt string henceforth.

`show prompt`
: Prints a line of the form: '`Gdb's prompt is:` *your-prompt*'

Versions of GDB that ship with Python scripting enabled have prompt extensions. The commands for interacting with these extensions are:

`set extended-prompt` *prompt*
: Set an extended prompt that allows for substitutions. See Section 23.2.4.3 [gdb.prompt], page 351, for a list of escape sequences that can be used for substitution. Any escape sequences specified as part of the prompt string are replaced with the corresponding strings each time the prompt is displayed.

  For example:

  ```
  set extended-prompt Current working directory: \w (gdb)
  ```

  Note that when an extended-prompt is set, it takes control of the *prompt_hook* hook. See [prompt_hook], page 307, for further information.

`show extended-prompt`
: Prints the extended prompt. Any escape sequences specified as part of the prompt string with `set extended-prompt`, are replaced with the corresponding strings each time the prompt is displayed.

22.2 Command Editing

GDB reads its input commands via the *Readline* interface. This GNU library provides consistent behavior for programs which provide a command line interface to the user. Advantages are GNU Emacs-style or *vi*-style inline editing of commands, `csh`-like history substitution, and a storage and recall of command history across debugging sessions.

You may control the behavior of command line editing in GDB with the command `set`.

`set editing`
`set editing on`
: Enable command line editing (enabled by default).

`set editing off`
: Disable command line editing.

`show editing`
: Show whether command line editing is enabled.

See Chapter 32 [Command Line Editing], page 459, for more details about the Readline interface. Users unfamiliar with GNU Emacs or `vi` are encouraged to read that chapter.

22.3 Command History

GDB can keep track of the commands you type during your debugging sessions, so that you can be certain of precisely what happened. Use these commands to manage the GDB command history facility.

GDB uses the GNU History library, a part of the Readline package, to provide the history facility. See Chapter 33 [Using History Interactively], page 481, for the detailed description of the History library.

To issue a command to GDB without affecting certain aspects of the state which is seen by users, prefix it with '`server` ' (see Section 28.2 [Server Prefix], page 444). This means that this command will not affect the command history, nor will it affect GDB's notion of which command to repeat if RET is pressed on a line by itself.

The server prefix does not affect the recording of values into the value history; to print a value without recording it into the value history, use the `output` command instead of the `print` command.

Here is the description of GDB commands related to command history.

`set history filename` *fname*
: Set the name of the GDB command history file to *fname*. This is the file where GDB reads an initial command history list, and where it writes the command history from this session when it exits. You can access this list through history expansion or through the history command editing characters listed below. This file defaults to the value of the environment variable `GDBHISTFILE`, or to '`./.gdb_history`' ('`./_gdb_history`' on MS-DOS) if this variable is not set.

`set history save`
`set history save on`
: Record command history in a file, whose name may be specified with the `set history filename` command. By default, this option is disabled.

`set history save off`
: Stop recording command history in a file.

`set history size` *size*
: Set the number of commands which GDB keeps in its history list. This defaults to the value of the environment variable `HISTSIZE`, or to 256 if this variable is not set.

History expansion assigns special meaning to the character *!*. See Section 33.1.1 [Event Designators], page 481, for more details.

Since *!* is also the logical not operator in C, history expansion is off by default. If you decide to enable history expansion with the `set history expansion on` command, you may

sometimes need to follow `!` (when it is used as logical not, in an expression) with a space or a tab to prevent it from being expanded. The readline history facilities do not attempt substitution on the strings `!=` and `!(`, even when history expansion is enabled.

The commands to control history expansion are:

`set history expansion on`
`set history expansion`
: Enable history expansion. History expansion is off by default.

`set history expansion off`
: Disable history expansion.

`show history`
`show history filename`
`show history save`
`show history size`
`show history expansion`
: These commands display the state of the GDB history parameters. `show history` by itself displays all four states.

`show commands`
: Display the last ten commands in the command history.

`show commands` *n*
: Print ten commands centered on command number *n*.

`show commands +`
: Print ten commands just after the commands last printed.

22.4 Screen Size

Certain commands to GDB may produce large amounts of information output to the screen. To help you read all of it, GDB pauses and asks you for input at the end of each page of output. Type RET when you want to continue the output, or `q` to discard the remaining output. Also, the screen width setting determines when to wrap lines of output. Depending on what is being printed, GDB tries to break the line at a readable place, rather than simply letting it overflow onto the following line.

Normally GDB knows the size of the screen from the terminal driver software. For example, on Unix GDB uses the termcap data base together with the value of the `TERM` environment variable and the `stty rows` and `stty cols` settings. If this is not correct, you can override it with the `set height` and `set width` commands:

`set height` *lpp*
`show height`
`set width` *cpl*
`show width`
: These `set` commands specify a screen height of *lpp* lines and a screen width of *cpl* characters. The associated `show` commands display the current settings.

  If you specify a height of zero lines, GDB does not pause during output no matter how long the output is. This is useful if output is to a file or to an editor buffer.

Likewise, you can specify '`set width 0`' to prevent GDB from wrapping its output.

`set pagination on`
`set pagination off`
: Turn the output pagination on or off; the default is on. Turning pagination off is the alternative to `set height 0`. Note that running GDB with the '`--batch`' option (see Section 2.1.2 [Mode Options], page 13) also automatically disables pagination.

`show pagination`
: Show the current pagination mode.

22.5 Numbers

You can always enter numbers in octal, decimal, or hexadecimal in GDB by the usual conventions: octal numbers begin with '`0`', decimal numbers end with '`.`', and hexadecimal numbers begin with '`0x`'. Numbers that neither begin with '`0`' or '`0x`', nor end with a '`.`' are, by default, entered in base 10; likewise, the default display for numbers—when no particular format is specified—is base 10. You can change the default base for both input and output with the commands described below.

`set input-radix` *base*
: Set the default base for numeric input. Supported choices for *base* are decimal 8, 10, or 16. *base* must itself be specified either unambiguously or using the current input radix; for example, any of

```
set input-radix 012
set input-radix 10.
set input-radix 0xa
```

sets the input base to decimal. On the other hand, '`set input-radix 10`' leaves the input radix unchanged, no matter what it was, since '`10`', being without any leading or trailing signs of its base, is interpreted in the current radix. Thus, if the current radix is 16, '`10`' is interpreted in hex, i.e. as 16 decimal, which doesn't change the radix.

`set output-radix` *base*
: Set the default base for numeric display. Supported choices for *base* are decimal 8, 10, or 16. *base* must itself be specified either unambiguously or using the current input radix.

`show input-radix`
: Display the current default base for numeric input.

`show output-radix`
: Display the current default base for numeric display.

`set radix` [*base*]
`show radix`
: These commands set and show the default base for both input and output of numbers. `set radix` sets the radix of input and output to the same base; without an argument, it resets the radix back to its default value of 10.

22.6 Configuring the Current ABI

GDB can determine the *ABI* (Application Binary Interface) of your application automatically. However, sometimes you need to override its conclusions. Use these commands to manage GDB's view of the current ABI.

One GDB configuration can debug binaries for multiple operating system targets, either via remote debugging or native emulation. GDB will autodetect the *OS ABI* (Operating System ABI) in use, but you can override its conclusion using the `set osabi` command. One example where this is useful is in debugging of binaries which use an alternate C library (e.g. uClibc for GNU/Linux) which does not have the same identifying marks that the standard C library for your platform provides.

When GDB is debugging the AArch64 architecture, it provides a "Newlib" OS ABI. This is useful for handling `setjmp` and `longjmp` when debugging binaries that use the NEWLIB C library. The "Newlib" OS ABI can be selected by `set osabi Newlib`.

`show osabi`
: Show the OS ABI currently in use.

`set osabi` With no argument, show the list of registered available OS ABI's.

`set osabi` *`abi`*
: Set the current OS ABI to *abi*.

Generally, the way that an argument of type `float` is passed to a function depends on whether the function is prototyped. For a prototyped (i.e. ANSI/ISO style) function, `float` arguments are passed unchanged, according to the architecture's convention for `float`. For unprototyped (i.e. K&R style) functions, `float` arguments are first promoted to type `double` and then passed.

Unfortunately, some forms of debug information do not reliably indicate whether a function is prototyped. If GDB calls a function that is not marked as prototyped, it consults *`set coerce-float-to-double`*.

`set coerce-float-to-double`
`set coerce-float-to-double on`
: Arguments of type `float` will be promoted to `double` when passed to an unprototyped function. This is the default setting.

`set coerce-float-to-double off`
: Arguments of type `float` will be passed directly to unprototyped functions.

`show coerce-float-to-double`
: Show the current setting of promoting `float` to `double`.

GDB needs to know the ABI used for your program's C++ objects. The correct C++ ABI depends on which C++ compiler was used to build your application. GDB only fully supports programs with a single C++ ABI; if your program contains code using multiple C++ ABI's or if GDB can not identify your program's ABI correctly, you can tell GDB which ABI to use. Currently supported ABI's include "gnu-v2", for `g++` versions before 3.0, "gnu-v3", for `g++` versions 3.0 and later, and "hpaCC" for the HP ANSI C++ compiler. Other C++ compilers may use the "gnu-v2" or "gnu-v3" ABI's as well. The default setting is "auto".

`show cp-abi`
: Show the C++ ABI currently in use.

`set cp-abi`
: With no argument, show the list of supported C++ ABI's.

`set cp-abi` *abi*
`set cp-abi auto`
: Set the current C++ ABI to *abi*, or return to automatic detection.

22.7 Automatically loading associated files

GDB sometimes reads files with commands and settings automatically, without being explicitly told so by the user. We call this feature *auto-loading*. While auto-loading is useful for automatically adapting GDB to the needs of your project, it can sometimes produce unexpected results or introduce security risks (e.g., if the file comes from untrusted sources).

Note that loading of these associated files (including the local '`.gdbinit`' file) requires accordingly configured `auto-load safe-path` (see Section 22.7.4 [Auto-loading safe path], page 289).

For these reasons, GDB includes commands and options to let you control when to auto-load files and which files should be auto-loaded.

`set auto-load off`
: Globally disable loading of all auto-loaded files. You may want to use this command with the '`-iex`' option (see [Option -init-eval-command], page 16) such as:

```
$ gdb -iex "set auto-load off" untrusted-executable corefile
```

Be aware that system init file (see Section C.6 [System-wide configuration], page 494) and init files from your home directory (see [Home Directory Init File], page 16) still get read (as they come from generally trusted directories). To prevent GDB from auto-loading even those init files, use the '`-nx`' option (see Section 2.1.2 [Mode Options], page 13), in addition to `set auto-load no`.

`show auto-load`
: Show whether auto-loading of each specific '`auto-load`' file(s) is enabled or disabled.

```
(gdb) show auto-load
gdb-scripts:  Auto-loading of canned sequences of commands scripts is on.
libthread-db:  Auto-loading of inferior specific libthread_db is on.
local-gdbinit:  Auto-loading of .gdbinit script from current directory
                is on.
python-scripts:  Auto-loading of Python scripts is on.
safe-path:  List of directories from which it is safe to auto-load files
            is $debugdir:$datadir/auto-load.
scripts-directory:  List of directories from which to load auto-loaded scripts
                    is $debugdir:$datadir/auto-load.
```

`info auto-load`
: Print whether each specific '`auto-load`' file(s) have been auto-loaded or not.

```
(gdb) info auto-load
gdb-scripts:
Loaded  Script
```

```
Yes     /home/user/gdb/gdb-gdb.gdb
libthread-db:  No auto-loaded libthread-db.
local-gdbinit:  Local .gdbinit file "/home/user/gdb/.gdbinit" has been
                loaded.
python-scripts:
Loaded  Script
Yes     /home/user/gdb/gdb-gdb.py
```

These are various kinds of files GDB can automatically load:

- See Section 23.2.3.1 [objfile-gdb.py file], page 347, controlled by [set auto-load python-scripts], page 347.
- See Section 22.7.3 [objfile-gdb.gdb file], page 288, controlled by [set auto-load gdb-scripts], page 289.
- See Section 23.2.3.2 [dotdebug_gdb_scripts section], page 348, controlled by [set auto-load python-scripts], page 347.
- See Section 22.7.1 [Init File in the Current Directory], page 288, controlled by [set auto-load local-gdbinit], page 288.
- See Section 22.7.2 [libthread_db.so.1 file], page 288, controlled by [set auto-load libthread-db], page 288.

These are GDB control commands for the auto-loading:

See [set auto-load off], page 286.	Disable auto-loading globally.
See [show auto-load], page 286.	Show setting of all kinds of files.
See [info auto-load], page 286.	Show state of all kinds of files.
See [set auto-load gdb-scripts], page 289.	Control for GDB command scripts.
See [show auto-load gdb-scripts], page 289.	Show setting of GDB command scripts.
See [info auto-load gdb-scripts], page 289.	Show state of GDB command scripts.
See [set auto-load python-scripts], page 347.	Control for GDB Python scripts.
See [show auto-load python-scripts], page 347.	Show setting of GDB Python scripts.
See [info auto-load python-scripts], page 347.	Show state of GDB Python scripts.
See [set auto-load scripts-directory], page 347.	Control for GDB auto-loaded scripts location.
See [show auto-load scripts-directory], page 348.	Show GDB auto-loaded scripts location.
See [set auto-load local-gdbinit], page 288.	Control for init file in the current directory.
See [show auto-load local-gdbinit], page 288.	Show setting of init file in the current directory.
See [info auto-load local-gdbinit], page 288.	Show state of init file in the current directory.
See [set auto-load libthread-db], page 288.	Control for thread debugging library.
See [show auto-load libthread-db], page 288.	Show setting of thread debugging library.
See [info auto-load libthread-db], page 288.	Show state of thread debugging library.
See [set auto-load safe-path], page 289.	Control directories trusted for automatic loading.
See [show auto-load safe-path], page 289.	Show directories trusted for automatic loading.
See [add-auto-load-safe-path], page 289.	Add directory trusted for automatic loading.

22.7.1 Automatically loading init file in the current directory

By default, GDB reads and executes the canned sequences of commands from init file (if any) in the current working directory, see [Init File in the Current Directory during Startup], page 16.

Note that loading of this local '`.gdbinit`' file also requires accordingly configured `auto-load safe-path` (see Section 22.7.4 [Auto-loading safe path], page 289).

`set auto-load local-gdbinit [on|off]`
: Enable or disable the auto-loading of canned sequences of commands (see Section 23.1 [Sequences], page 297) found in init file in the current directory.

`show auto-load local-gdbinit`
: Show whether auto-loading of canned sequences of commands from init file in the current directory is enabled or disabled.

`info auto-load local-gdbinit`
: Print whether canned sequences of commands from init file in the current directory have been auto-loaded.

22.7.2 Automatically loading thread debugging library

This feature is currently present only on GNU/Linux native hosts.

GDB reads in some cases thread debugging library from places specific to the inferior (see [set libthread-db-search-path], page 37).

The special '`libthread-db-search-path`' entry '`$sdir`' is processed without checking this '`set auto-load libthread-db`' switch as system libraries have to be trusted in general. In all other cases of '`libthread-db-search-path`' entries GDB checks first if '`set auto-load libthread-db`' is enabled before trying to open such thread debugging library.

Note that loading of this debugging library also requires accordingly configured `auto-load safe-path` (see Section 22.7.4 [Auto-loading safe path], page 289).

`set auto-load libthread-db [on|off]`
: Enable or disable the auto-loading of inferior specific thread debugging library.

`show auto-load libthread-db`
: Show whether auto-loading of inferior specific thread debugging library is enabled or disabled.

`info auto-load libthread-db`
: Print the list of all loaded inferior specific thread debugging libraries and for each such library print list of inferior *pid*s using it.

22.7.3 The '*objfile*-gdb.gdb' file

GDB tries to load an '*objfile*-gdb.gdb' file containing canned sequences of commands (see Section 23.1 [Sequences], page 297), as long as '`set auto-load gdb-scripts`' is set to '`on`'.

Note that loading of this script file also requires accordingly configured `auto-load safe-path` (see Section 22.7.4 [Auto-loading safe path], page 289).

For more background refer to the similar Python scripts auto-loading description (see Section 23.2.3.1 [objfile-gdb.py file], page 347).

`set auto-load gdb-scripts [on|off]`
: Enable or disable the auto-loading of canned sequences of commands scripts.

`show auto-load gdb-scripts`
: Show whether auto-loading of canned sequences of commands scripts is enabled or disabled.

`info auto-load gdb-scripts [`*regexp*`]`
: Print the list of all canned sequences of commands scripts that GDB auto-loaded.

If *regexp* is supplied only canned sequences of commands scripts with matching names are printed.

22.7.4 Security restriction for auto-loading

As the files of inferior can come from untrusted source (such as submitted by an application user) GDB does not always load any files automatically. GDB provides the '`set auto-load safe-path`' setting to list directories trusted for loading files not explicitly requested by user. Each directory can also be a shell wildcard pattern.

If the path is not set properly you will see a warning and the file will not get loaded:

```
$ ./gdb -q ./gdb
Reading symbols from /home/user/gdb/gdb...done.
warning: File "/home/user/gdb/gdb-gdb.gdb" auto-loading has been
         declined by your 'auto-load safe-path' set
         to "$debugdir:$datadir/auto-load".
warning: File "/home/user/gdb/gdb-gdb.py" auto-loading has been
         declined by your 'auto-load safe-path' set
         to "$debugdir:$datadir/auto-load".
```

To instruct GDB to go ahead and use the init files anyway, invoke GDB like this:

```
$ gdb -q -iex "set auto-load safe-path /home/user/gdb" ./gdb
```

The list of trusted directories is controlled by the following commands:

`set auto-load safe-path [`*directories*`]`
: Set the list of directories (and their subdirectories) trusted for automatic loading and execution of scripts. You can also enter a specific trusted file. Each directory can also be a shell wildcard pattern; wildcards do not match directory separator - see `FNM_PATHNAME` for system function `fnmatch` (see Section "Wildcard Matching" in *GNU C Library Reference Manual*). If you omit *directories*, '`auto-load safe-path`' will be reset to its default value as specified during GDB compilation.

  The list of directories uses path separator ('`:`' on GNU and Unix systems, '`;`' on MS-Windows and MS-DOS) to separate directories, similarly to the `PATH` environment variable.

`show auto-load safe-path`
: Show the list of directories trusted for automatic loading and execution of scripts.

`add-auto-load-safe-path`
: Add an entry (or list of entries) the list of directories trusted for automatic loading and execution of scripts. Multiple entries may be delimited by the host platform path separator in use.

This variable defaults to what `--with-auto-load-dir` has been configured to (see [with-auto-load-dir], page 347). '`$debugdir`' and '`$datadir`' substitution applies the same as for [set auto-load scripts-directory], page 347. The default `set auto-load safe-path` value can be also overriden by GDB configuration option '`--with-auto-load-safe-path`'.

Setting this variable to '`/`' disables this security protection, corresponding GDB configuration option is '`--without-auto-load-safe-path`'. This variable is supposed to be set to the system directories writable by the system superuser only. Users can add their source directories in init files in their home directories (see [Home Directory Init File], page 16). See also deprecated init file in the current directory (see [Init File in the Current Directory during Startup], page 16).

To force GDB to load the files it declined to load in the previous example, you could use one of the following ways:

'`~/.gdbinit`': '`add-auto-load-safe-path ~/src/gdb`'
: Specify this trusted directory (or a file) as additional component of the list. You have to specify also any existing directories displayed by by '`show auto-load safe-path`' (such as '`/usr:/bin`' in this example).

`gdb -iex "set auto-load safe-path /usr:/bin:~/src/gdb" ...`
: Specify this directory as in the previous case but just for a single GDB session.

`gdb -iex "set auto-load safe-path /" ...`
: Disable auto-loading safety for a single GDB session. This assumes all the files you debug during this GDB session will come from trusted sources.

`./configure --without-auto-load-safe-path`
: During compilation of GDB you may disable any auto-loading safety. This assumes all the files you will ever debug with this GDB come from trusted sources.

On the other hand you can also explicitly forbid automatic files loading which also suppresses any such warning messages:

`gdb -iex "set auto-load no" ...`
: You can use GDB command-line option for a single GDB session.

'`~/.gdbinit`': '`set auto-load no`'
: Disable auto-loading globally for the user (see [Home Directory Init File], page 16). While it is improbable, you could also use system init file instead (see Section C.6 [System-wide configuration], page 494).

This setting applies to the file names as entered by user. If no entry matches GDB tries as a last resort to also resolve all the file names into their canonical form (typically resolving symbolic links) and compare the entries again. GDB already canonicalizes most of the filenames on its own before starting the comparison so a canonical form of directories is recommended to be entered.

22.7.5 Displaying files tried for auto-load

For better visibility of all the file locations where you can place scripts to be auto-loaded with inferior — or to protect yourself against accidental execution of untrusted scripts —

GDB provides a feature for printing all the files attempted to be loaded. Both existing and non-existing files may be printed.

For example the list of directories from which it is safe to auto-load files (see Section 22.7.4 [Auto-loading safe path], page 289) applies also to canonicalized filenames which may not be too obvious while setting it up.

```
(gdb) set debug auto-load on
(gdb) file ~/src/t/true
auto-load: Loading canned sequences of commands script "/tmp/true-gdb.gdb"
           for objfile "/tmp/true".
auto-load: Updating directories of "/usr:/opt".
auto-load: Using directory "/usr".
auto-load: Using directory "/opt".
warning: File "/tmp/true-gdb.gdb" auto-loading has been declined
         by your ‘auto-load safe-path’ set to "/usr:/opt".
```

`set debug auto-load [on|off]`
: Set whether to print the filenames attempted to be auto-loaded.

`show debug auto-load`
: Show whether printing of the filenames attempted to be auto-loaded is turned on or off.

22.8 Optional Warnings and Messages

By default, GDB is silent about its inner workings. If you are running on a slow machine, you may want to use the `set verbose` command. This makes GDB tell you when it does a lengthy internal operation, so you will not think it has crashed.

Currently, the messages controlled by `set verbose` are those which announce that the symbol table for a source file is being read; see `symbol-file` in Section 18.1 [Commands to Specify Files], page 215.

`set verbose on`
: Enables GDB output of certain informational messages.

`set verbose off`
: Disables GDB output of certain informational messages.

`show verbose`
: Displays whether `set verbose` is on or off.

By default, if GDB encounters bugs in the symbol table of an object file, it is silent; but if you are debugging a compiler, you may find this information useful (see Section 18.5 [Errors Reading Symbol Files], page 228).

`set complaints` *limit*
: Permits GDB to output *limit* complaints about each type of unusual symbols before becoming silent about the problem. Set *limit* to zero to suppress all complaints; set it to a large number to prevent complaints from being suppressed.

`show complaints`
: Displays how many symbol complaints GDB is permitted to produce.

By default, GDB is cautious, and asks what sometimes seems to be a lot of stupid questions to confirm certain commands. For example, if you try to run a program which is already running:

```
(gdb) run
The program being debugged has been started already.
Start it from the beginning? (y or n)
```

If you are willing to unflinchingly face the consequences of your own commands, you can disable this "feature":

`set confirm off`
: Disables confirmation requests. Note that running GDB with the '`--batch`' option (see Section 2.1.2 [Mode Options], page 13) also automatically disables confirmation requests.

`set confirm on`
: Enables confirmation requests (the default).

`show confirm`
: Displays state of confirmation requests.

If you need to debug user-defined commands or sourced files you may find it useful to enable *command tracing*. In this mode each command will be printed as it is executed, prefixed with one or more '`+`' symbols, the quantity denoting the call depth of each command.

`set trace-commands on`
: Enable command tracing.

`set trace-commands off`
: Disable command tracing.

`show trace-commands`
: Display the current state of command tracing.

22.9 Optional Messages about Internal Happenings

GDB has commands that enable optional debugging messages from various GDB subsystems; normally these commands are of interest to GDB maintainers, or when reporting a bug. This section documents those commands.

`set exec-done-display`
: Turns on or off the notification of asynchronous commands' completion. When on, GDB will print a message when an asynchronous command finishes its execution. The default is off.

`show exec-done-display`
: Displays the current setting of asynchronous command completion notification.

`set debug aarch64`
: Turns on or off display of debugging messages related to ARM AArch64. The default is off.

`show debug aarch64`
: Displays the current state of displaying debugging messages related to ARM AArch64.

`set debug arch`
: Turns on or off display of gdbarch debugging info. The default is off

`show debug arch`
: Displays the current state of displaying gdbarch debugging info.

`set debug aix-thread`
: Display debugging messages about inner workings of the AIX thread module.

`show debug aix-thread`
: Show the current state of AIX thread debugging info display.

`set debug check-physname`
: Check the results of the "physname" computation. When reading DWARF debugging information for C++, GDB attempts to compute each entity's name. GDB can do this computation in two different ways, depending on exactly what information is present. When enabled, this setting causes GDB to compute the names both ways and display any discrepancies.

`show debug check-physname`
: Show the current state of "physname" checking.

`set debug coff-pe-read`
: Control display of debugging messages related to reading of COFF/PE exported symbols. The default is off.

`show debug coff-pe-read`
: Displays the current state of displaying debugging messages related to reading of COFF/PE exported symbols.

`set debug dwarf2-die`
: Dump DWARF2 DIEs after they are read in. The value is the number of nesting levels to print. A value of zero turns off the display.

`show debug dwarf2-die`
: Show the current state of DWARF2 DIE debugging.

`set debug dwarf2-read`
: Turns on or off display of debugging messages related to reading DWARF debug info. The default is off.

`show debug dwarf2-read`
: Show the current state of DWARF2 reader debugging.

`set debug displaced`
: Turns on or off display of GDB debugging info for the displaced stepping support. The default is off.

`show debug displaced`
: Displays the current state of displaying GDB debugging info related to displaced stepping.

`set debug event`
: Turns on or off display of GDB event debugging info. The default is off.

`show debug event`
: Displays the current state of displaying GDB event debugging info.

`set debug expression`
: Turns on or off display of debugging info about GDB expression parsing. The default is off.

`show debug expression`
: Displays the current state of displaying debugging info about GDB expression parsing.

`set debug frame`
: Turns on or off display of GDB frame debugging info. The default is off.

`show debug frame`
: Displays the current state of displaying GDB frame debugging info.

`set debug gnu-nat`
: Turns on or off debugging messages from the GNU/Hurd debug support.

`show debug gnu-nat`
: Show the current state of GNU/Hurd debugging messages.

`set debug infrun`
: Turns on or off display of GDB debugging info for running the inferior. The default is off. '`infrun.c`' contains GDB's runtime state machine used for implementing operations such as single-stepping the inferior.

`show debug infrun`
: Displays the current state of GDB inferior debugging.

`set debug jit`
: Turns on or off debugging messages from JIT debug support.

`show debug jit`
: Displays the current state of GDB JIT debugging.

`set debug lin-lwp`
: Turns on or off debugging messages from the Linux LWP debug support.

`show debug lin-lwp`
: Show the current state of Linux LWP debugging messages.

`set debug mach-o`
: Control display of debugging messages related to Mach-O symbols processing. The default is off.

`show debug mach-o`
: Displays the current state of displaying debugging messages related to reading of COFF/PE exported symbols.

`set debug notification`
: Turns on or off debugging messages about remote async notification. The default is off.

`show debug notification`
: Displays the current state of remote async notification debugging messages.

`set debug observer`
: Turns on or off display of GDB observer debugging. This includes info such as the notification of observable events.

`show debug observer`
: Displays the current state of observer debugging.

`set debug overload`
: Turns on or off display of GDB C++ overload debugging info. This includes info such as ranking of functions, etc. The default is off.

`show debug overload`
: Displays the current state of displaying GDB C++ overload debugging info.

`set debug parser`
: Turns on or off the display of expression parser debugging output. Internally, this sets the `yydebug` variable in the expression parser. See Section "Tracing Your Parser" in *Bison*, for details. The default is off.

`show debug parser`
: Show the current state of expression parser debugging.

`set debug remote`
: Turns on or off display of reports on all packets sent back and forth across the serial line to the remote machine. The info is printed on the GDB standard output stream. The default is off.

`show debug remote`
: Displays the state of display of remote packets.

`set debug serial`
: Turns on or off display of GDB serial debugging info. The default is off.

`show debug serial`
: Displays the current state of displaying GDB serial debugging info.

`set debug solib-frv`
: Turns on or off debugging messages for FR-V shared-library code.

`show debug solib-frv`
: Display the current state of FR-V shared-library code debugging messages.

`set debug symtab-create`
: Turns on or off display of debugging messages related to symbol table creation. The default is off.

`show debug symtab-create`
: Show the current state of symbol table creation debugging.

`set debug target`
: Turns on or off display of GDB target debugging info. This info includes what is going on at the target level of GDB, as it happens. The default is 0. Set it to 1 to track events, and to 2 to also track the value of large memory transfers. Changes to this flag do not take effect until the next time you connect to a target or use the `run` command.

`show debug target`
: Displays the current state of displaying GDB target debugging info.

`set debug timestamp`
: Turns on or off display of timestamps with GDB debugging info. When enabled, seconds and microseconds are displayed before each debugging message.

`show debug timestamp`
: Displays the current state of displaying timestamps with GDB debugging info.

`set debugvarobj`
: Turns on or off display of GDB variable object debugging info. The default is off.

`show debugvarobj`
: Displays the current state of displaying GDB variable object debugging info.

`set debug xml`
: Turns on or off debugging messages for built-in XML parsers.

`show debug xml`
: Displays the current state of XML debugging messages.

22.10 Other Miscellaneous Settings

`set interactive-mode`
: If `on`, forces GDB to assume that GDB was started in a terminal. In practice, this means that GDB should wait for the user to answer queries generated by commands entered at the command prompt. If `off`, forces GDB to operate in the opposite mode, and it uses the default answers to all queries. If `auto` (the default), GDB tries to determine whether its standard input is a terminal, and works in interactive-mode if it is, non-interactively otherwise.

  In the vast majority of cases, the debugger should be able to guess correctly which mode should be used. But this setting can be useful in certain specific cases, such as running a MinGW GDB inside a cygwin window.

`show interactive-mode`
: Displays whether the debugger is operating in interactive mode or not.

23 Extending GDB

GDB provides three mechanisms for extension. The first is based on composition of GDB commands, the second is based on the Python scripting language, and the third is for defining new aliases of existing commands.

To facilitate the use of the first two extensions, GDB is capable of evaluating the contents of a file. When doing so, GDB can recognize which scripting language is being used by looking at the filename extension. Files with an unrecognized filename extension are always treated as a GDB Command Files. See Section 23.1.3 [Command files], page 300.

You can control how GDB evaluates these files with the following setting:

`set script-extension off`
: All scripts are always evaluated as GDB Command Files.

`set script-extension soft`
: The debugger determines the scripting language based on filename extension. If this scripting language is supported, GDB evaluates the script using that language. Otherwise, it evaluates the file as a GDB Command File.

`set script-extension strict`
: The debugger determines the scripting language based on filename extension, and evaluates the script using that language. If the language is not supported, then the evaluation fails.

`show script-extension`
: Display the current value of the `script-extension` option.

23.1 Canned Sequences of Commands

Aside from breakpoint commands (see Section 5.1.7 [Breakpoint Command Lists], page 60), GDB provides two ways to store sequences of commands for execution as a unit: user-defined commands and command files.

23.1.1 User-defined Commands

A *user-defined command* is a sequence of GDB commands to which you assign a new name as a command. This is done with the `define` command. User commands may accept up to 10 arguments separated by whitespace. Arguments are accessed within the user command via `$arg0...$arg9`. A trivial example:

```
define adder
  print $arg0 + $arg1 + $arg2
end
```

To execute the command use:

```
adder 1 2 3
```

This defines the command `adder`, which prints the sum of its three arguments. Note the arguments are text substitutions, so they may reference variables, use complex expressions, or even perform inferior functions calls.

In addition, `$argc` may be used to find out how many arguments have been passed. This expands to a number in the range 0...10.

```
define adder
  if $argc == 2
    print $arg0 + $arg1
  end
  if $argc == 3
    print $arg0 + $arg1 + $arg2
  end
end
```

`define` *commandname*
: Define a command named *commandname*. If there is already a command by that name, you are asked to confirm that you want to redefine it. *commandname* may be a bare command name consisting of letters, numbers, dashes, and underscores. It may also start with any predefined prefix command. For example, '`define target my-target`' creates a user-defined '`target my-target`' command.

  The definition of the command is made up of other GDB command lines, which are given following the `define` command. The end of these commands is marked by a line containing `end`.

`document` *commandname*
: Document the user-defined command *commandname*, so that it can be accessed by `help`. The command *commandname* must already be defined. This command reads lines of documentation just as `define` reads the lines of the command definition, ending with `end`. After the `document` command is finished, `help` on command *commandname* displays the documentation you have written.

  You may use the `document` command again to change the documentation of a command. Redefining the command with `define` does not change the documentation.

`dont-repeat`
: Used inside a user-defined command, this tells GDB that this command should not be repeated when the user hits RET (see Section 3.1 [Command Syntax], page 19).

`help user-defined`
: List all user-defined commands and all python commands defined in class COMAND_USER. The first line of the documentation or docstring is included (if any).

`show user`
`show user` *commandname*
: Display the GDB commands used to define *commandname* (but not its documentation). If no *commandname* is given, display the definitions for all user-defined commands. This does not work for user-defined python commands.

`show max-user-call-depth`
`set max-user-call-depth`
: The value of `max-user-call-depth` controls how many recursion levels are allowed in user-defined commands before GDB suspects an infinite recursion and aborts the command. This does not apply to user-defined python commands.

In addition to the above commands, user-defined commands frequently use control flow commands, described in Section 23.1.3 [Command Files], page 300.

When user-defined commands are executed, the commands of the definition are not printed. An error in any command stops execution of the user-defined command.

If used interactively, commands that would ask for confirmation proceed without asking when used inside a user-defined command. Many GDB commands that normally print messages to say what they are doing omit the messages when used in a user-defined command.

23.1.2 User-defined Command Hooks

You may define *hooks*, which are a special kind of user-defined command. Whenever you run the command '`foo`', if the user-defined command '`hook-foo`' exists, it is executed (with no arguments) before that command.

A hook may also be defined which is run after the command you executed. Whenever you run the command '`foo`', if the user-defined command '`hookpost-foo`' exists, it is executed (with no arguments) after that command. Post-execution hooks may exist simultaneously with pre-execution hooks, for the same command.

It is valid for a hook to call the command which it hooks. If this occurs, the hook is not re-executed, thereby avoiding infinite recursion.

In addition, a pseudo-command, '`stop`' exists. Defining ('`hook-stop`') makes the associated commands execute every time execution stops in your program: before breakpoint commands are run, displays are printed, or the stack frame is printed.

For example, to ignore `SIGALRM` signals while single-stepping, but treat them normally during normal execution, you could define:

```
define hook-stop
handle SIGALRM nopass
end

define hook-run
handle SIGALRM pass
end

define hook-continue
handle SIGALRM pass
end
```

As a further example, to hook at the beginning and end of the `echo` command, and to add extra text to the beginning and end of the message, you could define:

```
define hook-echo
echo <<<---
end

define hookpost-echo
echo --->>>\n
end

(gdb) echo Hello World
<<<---Hello World--->>>
(gdb)
```

You can define a hook for any single-word command in GDB, but not for command aliases; you should define a hook for the basic command name, e.g. `backtrace` rather than

`bt`. You can hook a multi-word command by adding `hook-` or `hookpost-` to the last word of the command, e.g. '`define target hook-remote`' to add a hook to '`target remote`'.

If an error occurs during the execution of your hook, execution of GDB commands stops and GDB issues a prompt (before the command that you actually typed had a chance to run).

If you try to define a hook which does not match any known command, you get a warning from the `define` command.

23.1.3 Command Files

A command file for GDB is a text file made of lines that are GDB commands. Comments (lines starting with `#`) may also be included. An empty line in a command file does nothing; it does not mean to repeat the last command, as it would from the terminal.

You can request the execution of a command file with the `source` command. Note that the `source` command is also used to evaluate scripts that are not Command Files. The exact behavior can be configured using the `script-extension` setting. See Chapter 23 [Extending GDB], page 297.

`source [-s] [-v] filename`
: Execute the command file *filename*.

The lines in a command file are generally executed sequentially, unless the order of execution is changed by one of the *flow-control commands* described below. The commands are not printed as they are executed. An error in any command terminates execution of the command file and control is returned to the console.

GDB first searches for *filename* in the current directory. If the file is not found there, and *filename* does not specify a directory, then GDB also looks for the file on the source search path (specified with the '`directory`' command); except that '`$cdir`' is not searched because the compilation directory is not relevant to scripts.

If `-s` is specified, then GDB searches for *filename* on the search path even if *filename* specifies a directory. The search is done by appending *filename* to each element of the search path. So, for example, if *filename* is '`mylib/myscript`' and the search path contains '`/home/user`' then GDB will look for the script '`/home/user/mylib/myscript`'. The search is also done if *filename* is an absolute path. For example, if *filename* is '`/tmp/myscript`' and the search path contains '`/home/user`' then GDB will look for the script '`/home/user/tmp/myscript`'. For DOS-like systems, if *filename* contains a drive specification, it is stripped before concatenation. For example, if *filename* is '`d:myscript`' and the search path contains '`c:/tmp`' then GDB will look for the script '`c:/tmp/myscript`'.

If `-v`, for verbose mode, is given then GDB displays each command as it is executed. The option must be given before *filename*, and is interpreted as part of the filename anywhere else.

Commands that would ask for confirmation if used interactively proceed without asking when used in a command file. Many GDB commands that normally print messages to say what they are doing omit the messages when called from command files.

GDB also accepts command input from standard input. In this mode, normal output goes to standard output and error output goes to standard error. Errors in a command file supplied on standard input do not terminate execution of the command file—execution continues with the next command.

```
gdb < cmds > log 2>&1
```

(The syntax above will vary depending on the shell used.) This example will execute commands from the file '`cmds`'. All output and errors would be directed to '`log`'.

Since commands stored on command files tend to be more general than commands typed interactively, they frequently need to deal with complicated situations, such as different or unexpected values of variables and symbols, changes in how the program being debugged is built, etc. GDB provides a set of flow-control commands to deal with these complexities. Using these commands, you can write complex scripts that loop over data structures, execute commands conditionally, etc.

`if`
`else` This command allows to include in your script conditionally executed commands. The `if` command takes a single argument, which is an expression to evaluate. It is followed by a series of commands that are executed only if the expression is true (its value is nonzero). There can then optionally be an `else` line, followed by a series of commands that are only executed if the expression was false. The end of the list is marked by a line containing `end`.

`while` This command allows to write loops. Its syntax is similar to `if`: the command takes a single argument, which is an expression to evaluate, and must be followed by the commands to execute, one per line, terminated by an `end`. These commands are called the *body* of the loop. The commands in the body of `while` are executed repeatedly as long as the expression evaluates to true.

`loop_break`
This command exits the `while` loop in whose body it is included. Execution of the script continues after that `while`s `end` line.

`loop_continue`
This command skips the execution of the rest of the body of commands in the `while` loop in whose body it is included. Execution branches to the beginning of the `while` loop, where it evaluates the controlling expression.

`end` Terminate the block of commands that are the body of `if`, `else`, or `while` flow-control commands.

23.1.4 Commands for Controlled Output

During the execution of a command file or a user-defined command, normal GDB output is suppressed; the only output that appears is what is explicitly printed by the commands in the definition. This section describes three commands useful for generating exactly the output you want.

`echo` *text*
Print *text*. Nonprinting characters can be included in *text* using C escape sequences, such as '`\n`' to print a newline. **No newline is printed unless you specify one.** In addition to the standard C escape sequences, a backslash followed by a space stands for a space. This is useful for displaying a string with spaces at the beginning or the end, since leading and trailing spaces are otherwise trimmed from all arguments. To print ' `and foo =` ', use the command '`echo \ and foo = \ `'.

A backslash at the end of *text* can be used, as in C, to continue the command onto subsequent lines. For example,

```
echo This is some text\n\
which is continued\n\
onto several lines.\n
```

produces the same output as

```
echo This is some text\n
echo which is continued\n
echo onto several lines.\n
```

`output` *`expression`*

Print the value of *expression* and nothing but that value: no newlines, no '`$`*`nn`*` = `'. The value is not entered in the value history either. See Section 10.1 [Expressions], page 105, for more information on expressions.

`output/`*`fmt expression`*

Print the value of *expression* in format *fmt*. You can use the same formats as for `print`. See Section 10.5 [Output Formats], page 110, for more information.

`printf` *`template, expressions...`*

Print the values of one or more *expressions* under the control of the string *template*. To print several values, make *expressions* be a comma-separated list of individual expressions, which may be either numbers or pointers. Their values are printed as specified by *template*, exactly as a C program would do by executing the code below:

```
printf (template, expressions...);
```

As in `C printf`, ordinary characters in *template* are printed verbatim, while *conversion specification* introduced by the '`%`' character cause subsequent *expressions* to be evaluated, their values converted and formatted according to type and style information encoded in the conversion specifications, and then printed.

For example, you can print two values in hex like this:

```
printf "foo, bar-foo = 0x%x, 0x%x\n", foo, bar-foo
```

`printf` supports all the standard `C` conversion specifications, including the flags and modifiers between the '`%`' character and the conversion letter, with the following exceptions:

- The argument-ordering modifiers, such as '`2$`', are not supported.
- The modifier '`*`' is not supported for specifying precision or width.
- The '`'`' flag (for separation of digits into groups according to `LC_NUMERIC`') is not supported.
- The type modifiers '`hh`', '`j`', '`t`', and '`z`' are not supported.
- The conversion letter '`n`' (as in '`%n`') is not supported.
- The conversion letters '`a`' and '`A`' are not supported.

Note that the '`ll`' type modifier is supported only if the underlying `C` implementation used to build GDB supports the `long long int` type, and the '`L`' type modifier is supported only if `long double` type is available.

As in C, printf supports simple backslash-escape sequences, such as \n, '\t', '\\', '\"', '\a', and '\f', that consist of backslash followed by a single character. Octal and hexadecimal escape sequences are not supported.

Additionally, printf supports conversion specifications for DFP (*Decimal Floating Point*) types using the following length modifiers together with a floating point specifier. letters:

- 'H' for printing Decimal32 types.
- 'D' for printing Decimal64 types.
- 'DD' for printing Decimal128 types.

If the underlying C implementation used to build GDB has support for the three length modifiers for DFP types, other modifiers such as width and precision will also be available for GDB to use.

In case there is no such C support, no additional modifiers will be available and the value will be printed in the standard way.

Here's an example of printing DFP types using the above conversion letters:

```
printf "D32: %Hf - D64: %Df - D128: %DDf\n",1.2345df,1.2E10dd,1.2E1dl
```

eval *template, expressions...*

Convert the values of one or more *expressions* under the control of the string *template* to a command line, and call it.

23.2 Scripting GDB using Python

You can script GDB using the Python programming language. This feature is available only if GDB was configured using '--with-python'.

Python scripts used by GDB should be installed in '*data-directory*/python', where *data-directory* is the data directory as determined at GDB startup (see Section 18.6 [Data Files], page 229). This directory, known as the *python directory*, is automatically added to the Python Search Path in order to allow the Python interpreter to locate all scripts installed at this location.

Additionally, GDB commands and convenience functions which are written in Python and are located in the '*data-directory*/python/gdb/command' or '*data-directory*/python/gdb/function' directories are automatically imported when GDB starts.

23.2.1 Python Commands

GDB provides two commands for accessing the Python interpreter, and one related setting:

python-interactive [*command*]
pi [*command*]

Without an argument, the python-interactive command can be used to start an interactive Python prompt. To return to GDB, type the EOF character (e.g., *Ctrl-D* on an empty prompt).

Alternatively, a single-line Python command can be given as an argument and evaluated. If the command is an expression, the result will be printed; otherwise, nothing will be printed. For example:

```
(gdb) python-interactive 2 + 3
5
```

`python` [*command*]
`py` [*command*]
: The `python` command can be used to evaluate Python code.

  If given an argument, the `python` command will evaluate the argument as a Python command. For example:

  ```
  (gdb) python print 23
  23
  ```

  If you do not provide an argument to `python`, it will act as a multi-line command, like `define`. In this case, the Python script is made up of subsequent command lines, given after the `python` command. This command list is terminated using a line containing `end`. For example:

  ```
  (gdb) python
  Type python script
  End with a line saying just "end".
  >print 23
  >end
  23
  ```

`set python print-stack`
: By default, GDB will print only the message component of a Python exception when an error occurs in a Python script. This can be controlled using `set python print-stack`: if `full`, then full Python stack printing is enabled; if `none`, then Python stack and message printing is disabled; if `message`, the default, only the message component of the error is printed.

It is also possible to execute a Python script from the GDB interpreter:

`source 'script-name'`
: The script name must end with '`.py`' and GDB must be configured to recognize the script language based on filename extension using the `script-extension` setting. See Chapter 23 [Extending GDB], page 297.

`python execfile ("script-name")`
: This method is based on the `execfile` Python built-in function, and thus is always available.

23.2.2 Python API

At startup, GDB overrides Python's `sys.stdout` and `sys.stderr` to print using GDB's output-paging streams. A Python program which outputs to one of these streams may have its output interrupted by the user (see Section 22.4 [Screen Size], page 283). In this situation, a Python `KeyboardInterrupt` exception is thrown.

23.2.2.1 Basic Python

GDB introduces a new Python module, named `gdb`. All methods and classes added by GDB are placed in this module. GDB automatically `import`s the `gdb` module for use in all scripts evaluated by the `python` command.

`gdb.PYTHONDIR` [Variable]
: A string containing the python directory (see Section 23.2 [Python], page 303).

`gdb.execute` (*command* [, *from_tty* [, *to_string*]]) [Function]
Evaluate *command*, a string, as a GDB CLI command. If a GDB exception happens while *command* runs, it is translated as described in Section 23.2.2.2 [Exception Handling], page 308.

from_tty specifies whether GDB ought to consider this command as having originated from the user invoking it interactively. It must be a boolean value. If omitted, it defaults to `False`.

By default, any output produced by *command* is sent to GDB's standard output. If the *to_string* parameter is `True`, then output will be collected by `gdb.execute` and returned as a string. The default is `False`, in which case the return value is `None`. If *to_string* is `True`, the GDB virtual terminal will be temporarily set to unlimited width and height, and its pagination will be disabled; see Section 22.4 [Screen Size], page 283.

`gdb.breakpoints` () [Function]
Return a sequence holding all of GDB's breakpoints. See Section 23.2.2.21 [Breakpoints In Python], page 342, for more information.

`gdb.parameter` (*parameter*) [Function]
Return the value of a GDB parameter. *parameter* is a string naming the parameter to look up; *parameter* may contain spaces if the parameter has a multi-part name. For example, '`print object`' is a valid parameter name.

If the named parameter does not exist, this function throws a `gdb.error` (see Section 23.2.2.2 [Exception Handling], page 308). Otherwise, the parameter's value is converted to a Python value of the appropriate type, and returned.

`gdb.history` (*number*) [Function]
Return a value from GDB's value history (see Section 10.10 [Value History], page 125). *number* indicates which history element to return. If *number* is negative, then GDB will take its absolute value and count backward from the last element (i.e., the most recent element) to find the value to return. If *number* is zero, then GDB will return the most recent element. If the element specified by *number* doesn't exist in the value history, a `gdb.error` exception will be raised.

If no exception is raised, the return value is always an instance of `gdb.Value` (see Section 23.2.2.3 [Values From Inferior], page 309).

`gdb.parse_and_eval` (*expression*) [Function]
Parse *expression* as an expression in the current language, evaluate it, and return the result as a `gdb.Value`. *expression* must be a string.

This function can be useful when implementing a new command (see Section 23.2.2.12 [Commands In Python], page 326), as it provides a way to parse the command's argument as an expression. It is also useful simply to compute values, for example, it is the only way to get the value of a convenience variable (see Section 10.11 [Convenience Vars], page 126) as a `gdb.Value`.

`gdb.find_pc_line` (*pc*) [Function]
Return the `gdb.Symtab_and_line` object corresponding to the *pc* value. See Section 23.2.2.20 [Symbol Tables In Python], page 340. If an invalid value of *pc*

is passed as an argument, then the `symtab` and `line` attributes of the returned `gdb.Symtab_and_line` object will be `None` and 0 respectively.

`gdb.post_event` (*event*) [Function]

Put *event*, a callable object taking no arguments, into GDB's internal event queue. This callable will be invoked at some later point, during GDB's event processing. Events posted using `post_event` will be run in the order in which they were posted; however, there is no way to know when they will be processed relative to other events inside GDB.

GDB is not thread-safe. If your Python program uses multiple threads, you must be careful to only call GDB-specific functions in the main GDB thread. `post_event` ensures this. For example:

```
(gdb) python
>import threading
>
>class Writer():
> def __init__(self, message):
>        self.message = message;
> def __call__(self):
>        gdb.write(self.message)
>
>class MyThread1 (threading.Thread):
> def run (self):
>        gdb.post_event(Writer("Hello "))
>
>class MyThread2 (threading.Thread):
> def run (self):
>        gdb.post_event(Writer("World\n"))
>
>MyThread1().start()
>MyThread2().start()
>end
(gdb) Hello World
```

`gdb.write` (*string* [, *stream*]) [Function]

Print a string to GDB's paginated output stream. The optional *stream* determines the stream to print to. The default stream is GDB's standard output stream. Possible stream values are:

`gdb.STDOUT`
: GDB's standard output stream.

`gdb.STDERR`
: GDB's standard error stream.

`gdb.STDLOG`
: GDB's log stream (see Section 2.4 [Logging Output], page 18).

Writing to `sys.stdout` or `sys.stderr` will automatically call this function and will automatically direct the output to the relevant stream.

`gdb.flush` () [Function]

Flush the buffer of a GDB paginated stream so that the contents are displayed immediately. GDB will flush the contents of a stream automatically when it encounters

a newline in the buffer. The optional *stream* determines the stream to flush. The default stream is GDB's standard output stream. Possible stream values are:

`gdb.STDOUT`
: GDB's standard output stream.

`gdb.STDERR`
: GDB's standard error stream.

`gdb.STDLOG`
: GDB's log stream (see Section 2.4 [Logging Output], page 18).

Flushing `sys.stdout` or `sys.stderr` will automatically call this function for the relevant stream.

`gdb.target_charset ()` [Function]
Return the name of the current target character set (see Section 10.20 [Character Sets], page 135). This differs from `gdb.parameter('target-charset')` in that '`auto`' is never returned.

`gdb.target_wide_charset ()` [Function]
Return the name of the current target wide character set (see Section 10.20 [Character Sets], page 135). This differs from `gdb.parameter('target-wide-charset')` in that '`auto`' is never returned.

`gdb.solib_name` (*address*) [Function]
Return the name of the shared library holding the given *address* as a string, or `None`.

`gdb.decode_line` [*expression*] [Function]
Return locations of the line specified by *expression*, or of the current line if no argument was given. This function returns a Python tuple containing two elements. The first element contains a string holding any unparsed section of *expression* (or `None` if the expression has been fully parsed). The second element contains either `None` or another tuple that contains all the locations that match the expression represented as `gdb.Symtab_and_line` objects (see Section 23.2.2.20 [Symbol Tables In Python], page 340). If *expression* is provided, it is decoded the way that GDB's inbuilt `break` or `edit` commands do (see Section 9.2 [Specify Location], page 94).

`gdb.prompt_hook` (*current_prompt*) [Function]
If *prompt_hook* is callable, GDB will call the method assigned to this operation before a prompt is displayed by GDB.

The parameter `current_prompt` contains the current GDB prompt. This method must return a Python string, or `None`. If a string is returned, the GDB prompt will be set to that string. If `None` is returned, GDB will continue to use the current prompt.

Some prompts cannot be substituted in GDB. Secondary prompts such as those used by readline for command input, and annotation related prompts are prohibited from being changed.

23.2.2.2 Exception Handling

When executing the `python` command, Python exceptions uncaught within the Python code are translated to calls to GDB error-reporting mechanism. If the command that called `python` does not handle the error, GDB will terminate it and print an error message containing the Python exception name, the associated value, and the Python call stack backtrace at the point where the exception was raised. Example:

```
(gdb) python print foo
Traceback (most recent call last):
  File "<string>", line 1, in <module>
NameError: name 'foo' is not defined
```

GDB errors that happen in GDB commands invoked by Python code are converted to Python exceptions. The type of the Python exception depends on the error.

`gdb.error`
: This is the base class for most exceptions generated by GDB. It is derived from `RuntimeError`, for compatibility with earlier versions of GDB.

  If an error occurring in GDB does not fit into some more specific category, then the generated exception will have this type.

`gdb.MemoryError`
: This is a subclass of `gdb.error` which is thrown when an operation tried to access invalid memory in the inferior.

`KeyboardInterrupt`
: User interrupt (via `C-c` or by typing `q` at a pagination prompt) is translated to a Python `KeyboardInterrupt` exception.

In all cases, your exception handler will see the GDB error message as its value and the Python call stack backtrace at the Python statement closest to where the GDB error occured as the traceback.

When implementing GDB commands in Python via `gdb.Command`, it is useful to be able to throw an exception that doesn't cause a traceback to be printed. For example, the user may have invoked the command incorrectly. Use the `gdb.GdbError` exception to handle this case. Example:

```
(gdb) python
>class HelloWorld (gdb.Command):
>  """Greet the whole world."""
>  def __init__ (self):
>    super (HelloWorld, self).__init__ ("hello-world", gdb.COMMAND_USER)
>  def invoke (self, args, from_tty):
>    argv = gdb.string_to_argv (args)
>    if len (argv) != 0:
>      raise gdb.GdbError ("hello-world takes no arguments")
>    print "Hello, World!"
>HelloWorld ()
>end
(gdb) hello-world 42
hello-world takes no arguments
```

23.2.2.3 Values From Inferior

GDB provides values it obtains from the inferior program in an object of type `gdb.Value`. GDB uses this object for its internal bookkeeping of the inferior's values, and for fetching values when necessary.

Inferior values that are simple scalars can be used directly in Python expressions that are valid for the value's data type. Here's an example for an integer or floating-point value `some_val`:

```
bar = some_val + 2
```

As result of this, `bar` will also be a `gdb.Value` object whose values are of the same type as those of `some_val`.

Inferior values that are structures or instances of some class can be accessed using the Python *dictionary syntax*. For example, if `some_val` is a `gdb.Value` instance holding a structure, you can access its `foo` element with:

```
bar = some_val['foo']
```

Again, `bar` will also be a `gdb.Value` object.

A `gdb.Value` that represents a function can be executed via inferior function call. Any arguments provided to the call must match the function's prototype, and must be provided in the order specified by that prototype.

For example, `some_val` is a `gdb.Value` instance representing a function that takes two integers as arguments. To execute this function, call it like so:

```
result = some_val (10,20)
```

Any values returned from a function call will be stored as a `gdb.Value`.

The following attributes are provided:

`Value.address` [Variable]
: If this object is addressable, this read-only attribute holds a `gdb.Value` object representing the address. Otherwise, this attribute holds `None`.

`Value.is_optimized_out` [Variable]
: This read-only boolean attribute is true if the compiler optimized out this value, thus it is not available for fetching from the inferior.

`Value.type` [Variable]
: The type of this `gdb.Value`. The value of this attribute is a `gdb.Type` object (see Section 23.2.2.4 [Types In Python], page 313).

`Value.dynamic_type` [Variable]
: The dynamic type of this `gdb.Value`. This uses C++ run-time type information (RTTI) to determine the dynamic type of the value. If this value is of class type, it will return the class in which the value is embedded, if any. If this value is of pointer or reference to a class type, it will compute the dynamic type of the referenced object, and return a pointer or reference to that type, respectively. In all other cases, it will return the value's static type.

  Note that this feature will only work when debugging a C++ program that includes RTTI for the object in question. Otherwise, it will just return the static type of the value as in *`ptype foo`* (see Chapter 16 [Symbols], page 201).

`Value.is_lazy` [Variable]

The value of this read-only boolean attribute is `True` if this `gdb.Value` has not yet been fetched from the inferior. GDB does not fetch values until necessary, for efficiency. For example:

```
myval = gdb.parse_and_eval ('somevar')
```

The value of `somevar` is not fetched at this time. It will be fetched when the value is needed, or when the `fetch_lazy` method is invoked.

The following methods are provided:

`Value.__init__ (val)` [Function]

Many Python values can be converted directly to a `gdb.Value` via this object initializer. Specifically:

Python boolean
: A Python boolean is converted to the boolean type from the current language.

Python integer
: A Python integer is converted to the C `long` type for the current architecture.

Python long
: A Python long is converted to the C `long long` type for the current architecture.

Python float
: A Python float is converted to the C `double` type for the current architecture.

Python string
: A Python string is converted to a target string, using the current target encoding.

`gdb.Value`
: If `val` is a `gdb.Value`, then a copy of the value is made.

`gdb.LazyString`
: If `val` is a `gdb.LazyString` (see Section 23.2.2.23 [Lazy Strings In Python], page 345), then the lazy string's `value` method is called, and its result is used.

`Value.cast (type)` [Function]

Return a new instance of `gdb.Value` that is the result of casting this instance to the type described by *type*, which must be a `gdb.Type` object. If the cast cannot be performed for some reason, this method throws an exception.

`Value.dereference ()` [Function]

For pointer data types, this method returns a new `gdb.Value` object whose contents is the object pointed to by the pointer. For example, if `foo` is a C pointer to an `int`, declared in your C program as

```
int *foo;
```

then you can use the corresponding `gdb.Value` to access what `foo` points to like this:

```
bar = foo.dereference ()
```

The result `bar` will be a `gdb.Value` object holding the value pointed to by `foo`.

A similar function `Value.referenced_value` exists which also returns `gdb.Value` objects corresonding to the values pointed to by pointer values (and additionally, values referenced by reference values). However, the behavior of `Value.dereference` differs from `Value.referenced_value` by the fact that the behavior of `Value.dereference` is identical to applying the C unary operator `*` on a given value. For example, consider a reference to a pointer `ptrref`, declared in your C++ program as

```
typedef int *intptr;
...
int val = 10;
intptr ptr = &val;
intptr &ptrref = ptr;
```

Though `ptrref` is a reference value, one can apply the method `Value.dereference` to the `gdb.Value` object corresponding to it and obtain a `gdb.Value` which is identical to that corresponding to `val`. However, if you apply the method `Value.referenced_value`, the result would be a `gdb.Value` object identical to that corresponding to `ptr`.

```
py_ptrref = gdb.parse_and_eval ("ptrref")
py_val = py_ptrref.dereference ()
py_ptr = py_ptrref.referenced_value ()
```

The `gdb.Value` object `py_val` is identical to that corresponding to `val`, and `py_ptr` is identical to that corresponding to `ptr`. In general, `Value.dereference` can be applied whenever the C unary operator `*` can be applied to the corresponding C value. For those cases where applying both `Value.dereference` and `Value.referenced_value` is allowed, the results obtained need not be identical (as we have seen in the above example). The results are however identical when applied on `gdb.Value` objects corresponding to pointers (`gdb.Value` objects with type code `TYPE_CODE_PTR`) in a C/C++ program.

`Value.referenced_value ()` [Function]

For pointer or reference data types, this method returns a new `gdb.Value` object corresponding to the value referenced by the pointer/reference value. For pointer data types, `Value.dereference` and `Value.referenced_value` produce identical results. The difference between these methods is that `Value.dereference` cannot get the values referenced by reference values. For example, consider a reference to an `int`, declared in your C++ program as

```
int val = 10;
int &ref = val;
```

then applying `Value.dereference` to the `gdb.Value` object corresponding to `ref` will result in an error, while applying `Value.referenced_value` will result in a `gdb.Value` object identical to that corresponding to `val`.

```
py_ref = gdb.parse_and_eval ("ref")
er_ref = py_ref.dereference ()       # Results in error
py_val = py_ref.referenced_value ()  # Returns the referenced value
```

The `gdb.Value` object `py_val` is identical to that corresponding to `val`.

`Value.dynamic_cast` (*type*) [Function]
Like `Value.cast`, but works as if the C++ `dynamic_cast` operator were used. Consult a C++ reference for details.

`Value.reinterpret_cast` (*type*) [Function]
Like `Value.cast`, but works as if the C++ `reinterpret_cast` operator were used. Consult a C++ reference for details.

`Value.string` ([*encoding*[, *errors*[, *length*]]]) [Function]
If this `gdb.Value` represents a string, then this method converts the contents to a Python string. Otherwise, this method will throw an exception.

Strings are recognized in a language-specific way; whether a given `gdb.Value` represents a string is determined by the current language.

For C-like languages, a value is a string if it is a pointer to or an array of characters or ints. The string is assumed to be terminated by a zero of the appropriate width. However if the optional length argument is given, the string will be converted to that given length, ignoring any embedded zeros that the string may contain.

If the optional *encoding* argument is given, it must be a string naming the encoding of the string in the `gdb.Value`, such as `"ascii"`, `"iso-8859-6"` or `"utf-8"`. It accepts the same encodings as the corresponding argument to Python's `string.decode` method, and the Python codec machinery will be used to convert the string. If *encoding* is not given, or if *encoding* is the empty string, then either the `target-charset` (see Section 10.20 [Character Sets], page 135) will be used, or a language-specific encoding will be used, if the current language is able to supply one.

The optional *errors* argument is the same as the corresponding argument to Python's `string.decode` method.

If the optional *length* argument is given, the string will be fetched and converted to the given length.

`Value.lazy_string` ([*encoding* [, *length*]]) [Function]
If this `gdb.Value` represents a string, then this method converts the contents to a `gdb.LazyString` (see Section 23.2.2.23 [Lazy Strings In Python], page 345). Otherwise, this method will throw an exception.

If the optional *encoding* argument is given, it must be a string naming the encoding of the `gdb.LazyString`. Some examples are: '`ascii`', '`iso-8859-6`' or '`utf-8`'. If the *encoding* argument is an encoding that GDB does recognize, GDB will raise an error.

When a lazy string is printed, the GDB encoding machinery is used to convert the string during printing. If the optional *encoding* argument is not provided, or is an empty string, GDB will automatically select the encoding most suitable for the string type. For further information on encoding in GDB please see Section 10.20 [Character Sets], page 135.

If the optional *length* argument is given, the string will be fetched and encoded to the length of characters specified. If the *length* argument is not provided, the string will be fetched and encoded until a null of appropriate width is found.

`Value.fetch_lazy ()` [Function]

If the `gdb.Value` object is currently a lazy value (`gdb.Value.is_lazy` is `True`), then the value is fetched from the inferior. Any errors that occur in the process will produce a Python exception.

If the `gdb.Value` object is not a lazy value, this method has no effect.

This method does not return a value.

23.2.2.4 Types In Python

GDB represents types from the inferior using the class `gdb.Type`.

The following type-related functions are available in the `gdb` module:

`gdb.lookup_type (`*name* [, *block*]`)` [Function]

This function looks up a type by name. *name* is the name of the type to look up. It must be a string.

If *block* is given, then *name* is looked up in that scope. Otherwise, it is searched for globally.

Ordinarily, this function will return an instance of `gdb.Type`. If the named type cannot be found, it will throw an exception.

If the type is a structure or class type, or an enum type, the fields of that type can be accessed using the Python *dictionary syntax*. For example, if `some_type` is a `gdb.Type` instance holding a structure type, you can access its `foo` field with:

```
bar = some_type['foo']
```

`bar` will be a `gdb.Field` object; see below under the description of the `Type.fields` method for a description of the `gdb.Field` class.

An instance of `Type` has the following attributes:

`Type.code` [Variable]

The type code for this type. The type code will be one of the `TYPE_CODE_` constants defined below.

`Type.sizeof` [Variable]

The size of this type, in target `char` units. Usually, a target's `char` type will be an 8-bit byte. However, on some unusual platforms, this type may have a different size.

`Type.tag` [Variable]

The tag name for this type. The tag name is the name after `struct`, `union`, or `enum` in C and C++; not all languages have this concept. If this type has no tag name, then `None` is returned.

The following methods are provided:

`Type.fields ()` [Function]

For structure and union types, this method returns the fields. Range types have two fields, the minimum and maximum values. Enum types have one field per enum constant. Function and method types have one field per parameter. The base types of C++ classes are also represented as fields. If the type has no fields, or does not fit into one of these categories, an empty sequence will be returned.

Each field is a `gdb.Field` object, with some pre-defined attributes:

`bitpos` This attribute is not available for `static` fields (as in C++ or Java). For non-`static` fields, the value is the bit position of the field. For `enum` fields, the value is the enumeration member's integer representation.

`name` The name of the field, or `None` for anonymous fields.

`artificial`
This is `True` if the field is artificial, usually meaning that it was provided by the compiler and not the user. This attribute is always provided, and is `False` if the field is not artificial.

`is_base_class`
This is `True` if the field represents a base class of a C++ structure. This attribute is always provided, and is `False` if the field is not a base class of the type that is the argument of `fields`, or if that type was not a C++ class.

`bitsize` If the field is packed, or is a bitfield, then this will have a non-zero value, which is the size of the field in bits. Otherwise, this will be zero; in this case the field's size is given by its type.

`type` The type of the field. This is usually an instance of `Type`, but it can be `None` in some situations.

`Type.array` (*n1* [, *n2*]) [Function]
Return a new `gdb.Type` object which represents an array of this type. If one argument is given, it is the inclusive upper bound of the array; in this case the lower bound is zero. If two arguments are given, the first argument is the lower bound of the array, and the second argument is the upper bound of the array. An array's length must not be negative, but the bounds can be.

`Type.vector` (*n1* [, *n2*]) [Function]
Return a new `gdb.Type` object which represents a vector of this type. If one argument is given, it is the inclusive upper bound of the vector; in this case the lower bound is zero. If two arguments are given, the first argument is the lower bound of the vector, and the second argument is the upper bound of the vector. A vector's length must not be negative, but the bounds can be.

The difference between an `array` and a `vector` is that arrays behave like in C: when used in expressions they decay to a pointer to the first element whereas vectors are treated as first class values.

`Type.const` () [Function]
Return a new `gdb.Type` object which represents a `const`-qualified variant of this type.

`Type.volatile` () [Function]
Return a new `gdb.Type` object which represents a `volatile`-qualified variant of this type.

`Type.unqualified` () [Function]
Return a new `gdb.Type` object which represents an unqualified variant of this type. That is, the result is neither `const` nor `volatile`.

`Type.range` () [Function]
Return a Python `Tuple` object that contains two elements: the low bound of the argument type and the high bound of that type. If the type does not have a range, GDB will raise a `gdb.error` exception (see Section 23.2.2.2 [Exception Handling], page 308).

`Type.reference` () [Function]
Return a new `gdb.Type` object which represents a reference to this type.

`Type.pointer` () [Function]
Return a new `gdb.Type` object which represents a pointer to this type.

`Type.strip_typedefs` () [Function]
Return a new `gdb.Type` that represents the real type, after removing all layers of typedefs.

`Type.target` () [Function]
Return a new `gdb.Type` object which represents the target type of this type.

For a pointer type, the target type is the type of the pointed-to object. For an array type (meaning C-like arrays), the target type is the type of the elements of the array. For a function or method type, the target type is the type of the return value. For a complex type, the target type is the type of the elements. For a typedef, the target type is the aliased type.

If the type does not have a target, this method will throw an exception.

`Type.template_argument` (*n* [, *block*]) [Function]
If this `gdb.Type` is an instantiation of a template, this will return a new `gdb.Type` which represents the type of the *n*th template argument.

If this `gdb.Type` is not a template type, this will throw an exception. Ordinarily, only C++ code will have template types.

If *block* is given, then *name* is looked up in that scope. Otherwise, it is searched for globally.

Each type has a code, which indicates what category this type falls into. The available type categories are represented by constants defined in the `gdb` module:

`gdb.TYPE_CODE_PTR`
The type is a pointer.

`gdb.TYPE_CODE_ARRAY`
The type is an array.

`gdb.TYPE_CODE_STRUCT`
The type is a structure.

`gdb.TYPE_CODE_UNION`
The type is a union.

`gdb.TYPE_CODE_ENUM`
The type is an enum.

`gdb.TYPE_CODE_FLAGS`
: A bit flags type, used for things such as status registers.

`gdb.TYPE_CODE_FUNC`
: The type is a function.

`gdb.TYPE_CODE_INT`
: The type is an integer type.

`gdb.TYPE_CODE_FLT`
: A floating point type.

`gdb.TYPE_CODE_VOID`
: The special type `void`.

`gdb.TYPE_CODE_SET`
: A Pascal set type.

`gdb.TYPE_CODE_RANGE`
: A range type, that is, an integer type with bounds.

`gdb.TYPE_CODE_STRING`
: A string type. Note that this is only used for certain languages with language-defined string types; C strings are not represented this way.

`gdb.TYPE_CODE_BITSTRING`
: A string of bits. It is deprecated.

`gdb.TYPE_CODE_ERROR`
: An unknown or erroneous type.

`gdb.TYPE_CODE_METHOD`
: A method type, as found in C++ or Java.

`gdb.TYPE_CODE_METHODPTR`
: A pointer-to-member-function.

`gdb.TYPE_CODE_MEMBERPTR`
: A pointer-to-member.

`gdb.TYPE_CODE_REF`
: A reference type.

`gdb.TYPE_CODE_CHAR`
: A character type.

`gdb.TYPE_CODE_BOOL`
: A boolean type.

`gdb.TYPE_CODE_COMPLEX`
: A complex float type.

`gdb.TYPE_CODE_TYPEDEF`
: A typedef to some other type.

`gdb.TYPE_CODE_NAMESPACE`
: A C++ namespace.

`gdb.TYPE_CODE_DECFLOAT`
: A decimal floating point type.

`gdb.TYPE_CODE_INTERNAL_FUNCTION`
: A function internal to GDB. This is the type used to represent convenience functions.

Further support for types is provided in the `gdb.types` Python module (see Section 23.2.4.2 [gdb.types], page 350).

23.2.2.5 Pretty Printing API

An example output is provided (see Section 10.9 [Pretty Printing], page 123).

A pretty-printer is just an object that holds a value and implements a specific interface, defined here.

`pretty_printer.children` (*self*) [Function]
: GDB will call this method on a pretty-printer to compute the children of the pretty-printer's value.

  This method must return an object conforming to the Python iterator protocol. Each item returned by the iterator must be a tuple holding two elements. The first element is the "name" of the child; the second element is the child's value. The value can be any Python object which is convertible to a GDB value.

  This method is optional. If it does not exist, GDB will act as though the value has no children.

`pretty_printer.display_hint` (*self*) [Function]
: The CLI may call this method and use its result to change the formatting of a value. The result will also be supplied to an MI consumer as a '`displayhint`' attribute of the variable being printed.

  This method is optional. If it does exist, this method must return a string.

  Some display hints are predefined by GDB:

  '`array`' Indicate that the object being printed is "array-like". The CLI uses this to respect parameters such as `set print elements` and `set print array`.

  '`map`' Indicate that the object being printed is "map-like", and that the children of this value can be assumed to alternate between keys and values.

  '`string`' Indicate that the object being printed is "string-like". If the printer's `to_string` method returns a Python string of some kind, then GDB will call its internal language-specific string-printing function to format the string. For the CLI this means adding quotation marks, possibly escaping some characters, respecting `set print elements`, and the like.

`pretty_printer.to_string` (*self*) [Function]
: GDB will call this method to display the string representation of the value passed to the object's constructor.

  When printing from the CLI, if the `to_string` method exists, then GDB will prepend its result to the values returned by `children`. Exactly how this formatting is done

is dependent on the display hint, and may change as more hints are added. Also, depending on the print settings (see Section 10.8 [Print Settings], page 115), the CLI may print just the result of `to_string` in a stack trace, omitting the result of `children`.

If this method returns a string, it is printed verbatim.

Otherwise, if this method returns an instance of `gdb.Value`, then GDB prints this value. This may result in a call to another pretty-printer.

If instead the method returns a Python value which is convertible to a `gdb.Value`, then GDB performs the conversion and prints the resulting value. Again, this may result in a call to another pretty-printer. Python scalars (integers, floats, and booleans) and strings are convertible to `gdb.Value`; other types are not.

Finally, if this method returns `None` then no further operations are peformed in this method and nothing is printed.

If the result is not one of these types, an exception is raised.

GDB provides a function which can be used to look up the default pretty-printer for a `gdb.Value`:

`gdb.default_visualizer` (*value*) [Function]

This function takes a `gdb.Value` object as an argument. If a pretty-printer for this value exists, then it is returned. If no such printer exists, then this returns `None`.

23.2.2.6 Selecting Pretty-Printers

The Python list `gdb.pretty_printers` contains an array of functions or callable objects that have been registered via addition as a pretty-printer. Printers in this list are called `global` printers, they're available when debugging all inferiors. Each `gdb.Progspace` contains a `pretty_printers` attribute. Each `gdb.Objfile` also contains a `pretty_printers` attribute.

Each function on these lists is passed a single `gdb.Value` argument and should return a pretty-printer object conforming to the interface definition above (see Section 23.2.2.5 [Pretty Printing API], page 317). If a function cannot create a pretty-printer for the value, it should return `None`.

GDB first checks the `pretty_printers` attribute of each `gdb.Objfile` in the current program space and iteratively calls each enabled lookup routine in the list for that `gdb.Objfile` until it receives a pretty-printer object. If no pretty-printer is found in the objfile lists, GDB then searches the pretty-printer list of the current program space, calling each enabled function until an object is returned. After these lists have been exhausted, it tries the global `gdb.pretty_printers` list, again calling each enabled function until an object is returned.

The order in which the objfiles are searched is not specified. For a given list, functions are always invoked from the head of the list, and iterated over sequentially until the end of the list, or a printer object is returned.

For various reasons a pretty-printer may not work. For example, the underlying data structure may have changed and the pretty-printer is out of date.

The consequences of a broken pretty-printer are severe enough that GDB provides support for enabling and disabling individual printers. For example, if `print frame-arguments` is on, a backtrace can become highly illegible if any argument is printed with a broken printer.

Pretty-printers are enabled and disabled by attaching an `enabled` attribute to the registered function or callable object. If this attribute is present and its value is `False`, the printer is disabled, otherwise the printer is enabled.

23.2.2.7 Writing a Pretty-Printer

A pretty-printer consists of two parts: a lookup function to detect if the type is supported, and the printer itself.

Here is an example showing how a `std::string` printer might be written. See Section 23.2.2.5 [Pretty Printing API], page 317, for details on the API this class must provide.

```
class StdStringPrinter(object):
    "Print a std::string"

    def __init__(self, val):
        self.val = val

    def to_string(self):
        return self.val['_M_dataplus']['_M_p']

    def display_hint(self):
        return 'string'
```

And here is an example showing how a lookup function for the printer example above might be written.

```
def str_lookup_function(val):
    lookup_tag = val.type.tag
    if lookup_tag == None:
        return None
    regex = re.compile("^std::basic_string<char,.*>$")
    if regex.match(lookup_tag):
        return StdStringPrinter(val)
    return None
```

The example lookup function extracts the value's type, and attempts to match it to a type that it can pretty-print. If it is a type the printer can pretty-print, it will return a printer object. If not, it returns `None`.

We recommend that you put your core pretty-printers into a Python package. If your pretty-printers are for use with a library, we further recommend embedding a version number into the package name. This practice will enable GDB to load multiple versions of your pretty-printers at the same time, because they will have different names.

You should write auto-loaded code (see Section 23.2.3 [Python Auto-loading], page 346) such that it can be evaluated multiple times without changing its meaning. An ideal auto-load file will consist solely of `import`s of your printer modules, followed by a call to a register pretty-printers with the current objfile.

Taken as a whole, this approach will scale nicely to multiple inferiors, each potentially using a different library version. Embedding a version number in the Python package name will ensure that GDB is able to load both sets of printers simultaneously. Then, because the search for pretty-printers is done by objfile, and because your auto-loaded code took care to register your library's printers with a specific objfile, GDB will find the correct printers for the specific version of the library used by each inferior.

To continue the `std::string` example (see Section 23.2.2.5 [Pretty Printing API], page 317), this code might appear in `gdb.libstdcxx.v6`:

```
def register_printers(objfile):
    objfile.pretty_printers.append(str_lookup_function)
```

And then the corresponding contents of the auto-load file would be:

```
import gdb.libstdcxx.v6
gdb.libstdcxx.v6.register_printers(gdb.current_objfile())
```

The previous example illustrates a basic pretty-printer. There are a few things that can be improved on. The printer doesn't have a name, making it hard to identify in a list of installed printers. The lookup function has a name, but lookup functions can have arbitrary, even identical, names.

Second, the printer only handles one type, whereas a library typically has several types. One could install a lookup function for each desired type in the library, but one could also have a single lookup function recognize several types. The latter is the conventional way this is handled. If a pretty-printer can handle multiple data types, then its *subprinters* are the printers for the individual data types.

The `gdb.printing` module provides a formal way of solving these problems (see Section 23.2.4.1 [gdb.printing], page 349). Here is another example that handles multiple types.

These are the types we are going to pretty-print:

```
struct foo { int a, b; };
struct bar { struct foo x, y; };
```

Here are the printers:

```
class fooPrinter:
    """Print a foo object."""

    def __init__(self, val):
        self.val = val

    def to_string(self):
        return ("a=<" + str(self.val["a"]) +
                "> b=<" + str(self.val["b"]) + ">")

class barPrinter:
    """Print a bar object."""

    def __init__(self, val):
        self.val = val

    def to_string(self):
        return ("x=<" + str(self.val["x"]) +
                "> y=<" + str(self.val["y"]) + ">")
```

This example doesn't need a lookup function, that is handled by the `gdb.printing` module. Instead a function is provided to build up the object that handles the lookup.

```
import gdb.printing

def build_pretty_printer():
    pp = gdb.printing.RegexpCollectionPrettyPrinter(
        "my_library")
    pp.add_printer('foo', '^foo$', fooPrinter)
    pp.add_printer('bar', '^bar$', barPrinter)
```

```
        return pp
```

And here is the autoload support:

```
import gdb.printing
import my_library
gdb.printing.register_pretty_printer(
    gdb.current_objfile(),
    my_library.build_pretty_printer())
```

Finally, when this printer is loaded into GDB, here is the corresponding output of '`info pretty-printer`':

```
(gdb) info pretty-printer
my_library.so:
  my_library
    foo
    bar
```

23.2.2.8 Type Printing API

GDB provides a way for Python code to customize type display. This is mainly useful for substituting canonical typedef names for types.

A *type printer* is just a Python object conforming to a certain protocol. A simple base class implementing the protocol is provided; see Section 23.2.4.2 [gdb.types], page 350. A type printer must supply at least:

`enabled` [Instance Variable of `type_printer`]
: A boolean which is True if the printer is enabled, and False otherwise. This is manipulated by the `enable type-printer` and `disable type-printer` commands.

`name` [Instance Variable of `type_printer`]
: The name of the type printer. This must be a string. This is used by the `enable type-printer` and `disable type-printer` commands.

`instantiate` (*self*) [Method on `type_printer`]
: This is called by GDB at the start of type-printing. It is only called if the type printer is enabled. This method must return a new object that supplies a `recognize` method, as described below.

When displaying a type, say via the `ptype` command, GDB will compute a list of type recognizers. This is done by iterating first over the per-objfile type printers (see Section 23.2.2.16 [Objfiles In Python], page 333), followed by the per-progspace type printers (see Section 23.2.2.15 [Progspaces In Python], page 332), and finally the global type printers.

GDB will call the `instantiate` method of each enabled type printer. If this method returns `None`, then the result is ignored; otherwise, it is appended to the list of recognizers.

Then, when GDB is going to display a type name, it iterates over the list of recognizers. For each one, it calls the recognition function, stopping if the function returns a non-`None` value. The recognition function is defined as:

`recognize` (*self*, *type*) [Method on `type_recognizer`]
: If *type* is not recognized, return `None`. Otherwise, return a string which is to be printed as the name of *type*. *type* will be an instance of `gdb.Type` (see Section 23.2.2.4 [Types In Python], page 313).

GDB uses this two-pass approach so that type printers can efficiently cache information without holding on to it too long. For example, it can be convenient to look up type information in a type printer and hold it for a recognizer's lifetime; if a single pass were done then type printers would have to make use of the event system in order to avoid holding information that could become stale as the inferior changed.

23.2.2.9 Inferiors In Python

Programs which are being run under GDB are called inferiors (see Section 4.9 [Inferiors and Programs], page 32). Python scripts can access information about and manipulate inferiors controlled by GDB via objects of the `gdb.Inferior` class.

The following inferior-related functions are available in the `gdb` module:

`gdb.inferiors ()` [Function]
Return a tuple containing all inferior objects.

`gdb.selected_inferior ()` [Function]
Return an object representing the current inferior.

A `gdb.Inferior` object has the following attributes:

`Inferior.num` [Variable]
ID of inferior, as assigned by GDB.

`Inferior.pid` [Variable]
Process ID of the inferior, as assigned by the underlying operating system.

`Inferior.was_attached` [Variable]
Boolean signaling whether the inferior was created using 'attach', or started by GDB itself.

A `gdb.Inferior` object has the following methods:

`Inferior.is_valid ()` [Function]
Returns `True` if the `gdb.Inferior` object is valid, `False` if not. A `gdb.Inferior` object will become invalid if the inferior no longer exists within GDB. All other `gdb.Inferior` methods will throw an exception if it is invalid at the time the method is called.

`Inferior.threads ()` [Function]
This method returns a tuple holding all the threads which are valid when it is called. If there are no valid threads, the method will return an empty tuple.

`Inferior.read_memory` (*address*, *length*) [Function]
Read *length* bytes of memory from the inferior, starting at *address*. Returns a buffer object, which behaves much like an array or a string. It can be modified and given to the `Inferior.write_memory` function. In `Python` 3, the return value is a `memoryview` object.

`Inferior.write_memory` (*address, buffer* [, *length*]) [Function]
Write the contents of *buffer* to the inferior, starting at *address*. The *buffer* parameter must be a Python object which supports the buffer protocol, i.e., a string, an array or the object returned from `Inferior.read_memory`. If given, *length* determines the number of bytes from *buffer* to be written.

`Inferior.search_memory` (*address, length, pattern*) [Function]
Search a region of the inferior memory starting at *address* with the given *length* using the search pattern supplied in *pattern*. The *pattern* parameter must be a Python object which supports the buffer protocol, i.e., a string, an array or the object returned from `gdb.read_memory`. Returns a Python `Long` containing the address where the pattern was found, or `None` if the pattern could not be found.

23.2.2.10 Events In Python

GDB provides a general event facility so that Python code can be notified of various state changes, particularly changes that occur in the inferior.

An *event* is just an object that describes some state change. The type of the object and its attributes will vary depending on the details of the change. All the existing events are described below.

In order to be notified of an event, you must register an event handler with an *event registry*. An event registry is an object in the `gdb.events` module which dispatches particular events. A registry provides methods to register and unregister event handlers:

`EventRegistry.connect` (*object*) [Function]
Add the given callable *object* to the registry. This object will be called when an event corresponding to this registry occurs.

`EventRegistry.disconnect` (*object*) [Function]
Remove the given *object* from the registry. Once removed, the object will no longer receive notifications of events.

Here is an example:

```
def exit_handler (event):
    print "event type: exit"
    print "exit code: %d" % (event.exit_code)

gdb.events.exited.connect (exit_handler)
```

In the above example we connect our handler `exit_handler` to the registry `events.exited`. Once connected, `exit_handler` gets called when the inferior exits. The argument *event* in this example is of type `gdb.ExitedEvent`. As you can see in the example the `ExitedEvent` object has an attribute which indicates the exit code of the inferior.

The following is a listing of the event registries that are available and details of the events they emit:

`events.cont`
Emits `gdb.ThreadEvent`.

Some events can be thread specific when GDB is running in non-stop mode. When represented in Python, these events all extend `gdb.ThreadEvent`. Note,

this event is not emitted directly; instead, events which are emitted by this or other modules might extend this event. Examples of these events are `gdb.BreakpointEvent` and `gdb.ContinueEvent`.

`ThreadEvent.inferior_thread` [Variable]
: In non-stop mode this attribute will be set to the specific thread which was involved in the emitted event. Otherwise, it will be set to `None`.

Emits `gdb.ContinueEvent` which extends `gdb.ThreadEvent`.

This event indicates that the inferior has been continued after a stop. For inherited attribute refer to `gdb.ThreadEvent` above.

`events.exited`
: Emits `events.ExitedEvent` which indicates that the inferior has exited. `events.ExitedEvent` has two attributes:

`ExitedEvent.exit_code` [Variable]
: An integer representing the exit code, if available, which the inferior has returned. (The exit code could be unavailable if, for example, GDB detaches from the inferior.) If the exit code is unavailable, the attribute does not exist.

`ExitedEvent` *inferior* [Variable]
: A reference to the inferior which triggered the `exited` event.

`events.stop`
: Emits `gdb.StopEvent` which extends `gdb.ThreadEvent`.

Indicates that the inferior has stopped. All events emitted by this registry extend StopEvent. As a child of `gdb.ThreadEvent`, `gdb.StopEvent` will indicate the stopped thread when GDB is running in non-stop mode. Refer to `gdb.ThreadEvent` above for more details.

Emits `gdb.SignalEvent` which extends `gdb.StopEvent`.

This event indicates that the inferior or one of its threads has received as signal. `gdb.SignalEvent` has the following attributes:

`SignalEvent.stop_signal` [Variable]
: A string representing the signal received by the inferior. A list of possible signal values can be obtained by running the command `info signals` in the GDB command prompt.

Also emits `gdb.BreakpointEvent` which extends `gdb.StopEvent`.

`gdb.BreakpointEvent` event indicates that one or more breakpoints have been hit, and has the following attributes:

`BreakpointEvent.breakpoints` [Variable]
: A sequence containing references to all the breakpoints (type `gdb.Breakpoint`) that were hit. See Section 23.2.2.21 [Breakpoints In Python], page 342, for details of the `gdb.Breakpoint` object.

`BreakpointEvent.breakpoint` [Variable]
: A reference to the first breakpoint that was hit. This function is maintained for backward compatibility and is now deprecated in favor of the `gdb.BreakpointEvent.breakpoints` attribute.

`events.new_objfile`
: Emits `gdb.NewObjFileEvent` which indicates that a new object file has been loaded by GDB. `gdb.NewObjFileEvent` has one attribute:

`NewObjFileEvent.new_objfile` [Variable]
: A reference to the object file (`gdb.Objfile`) which has been loaded. See Section 23.2.2.16 [Objfiles In Python], page 333, for details of the `gdb.Objfile` object.

23.2.2.11 Threads In Python

Python scripts can access information about, and manipulate inferior threads controlled by GDB, via objects of the `gdb.InferiorThread` class.

The following thread-related functions are available in the `gdb` module:

`gdb.selected_thread ()` [Function]
: This function returns the thread object for the selected thread. If there is no selected thread, this will return `None`.

A `gdb.InferiorThread` object has the following attributes:

`InferiorThread.name` [Variable]
: The name of the thread. If the user specified a name using `thread name`, then this returns that name. Otherwise, if an OS-supplied name is available, then it is returned. Otherwise, this returns `None`.

  This attribute can be assigned to. The new value must be a string object, which sets the new name, or `None`, which removes any user-specified thread name.

`InferiorThread.num` [Variable]
: ID of the thread, as assigned by GDB.

`InferiorThread.ptid` [Variable]
: ID of the thread, as assigned by the operating system. This attribute is a tuple containing three integers. The first is the Process ID (PID); the second is the Lightweight Process ID (LWPID), and the third is the Thread ID (TID). Either the LWPID or TID may be 0, which indicates that the operating system does not use that identifier.

A `gdb.InferiorThread` object has the following methods:

`InferiorThread.is_valid ()` [Function]
: Returns `True` if the `gdb.InferiorThread` object is valid, `False` if not. A `gdb.InferiorThread` object will become invalid if the thread exits, or the inferior that the thread belongs is deleted. All other `gdb.InferiorThread` methods will throw an exception if it is invalid at the time the method is called.

`InferiorThread.switch` () [Function]
This changes GDB's currently selected thread to the one represented by this object.

`InferiorThread.is_stopped` () [Function]
Return a Boolean indicating whether the thread is stopped.

`InferiorThread.is_running` () [Function]
Return a Boolean indicating whether the thread is running.

`InferiorThread.is_exited` () [Function]
Return a Boolean indicating whether the thread is exited.

23.2.2.12 Commands In Python

You can implement new GDB CLI commands in Python. A CLI command is implemented using an instance of the `gdb.Command` class, most commonly using a subclass.

`Command.__init__` (*name*, *`command_class`* [, *`completer_class`* [, *`prefix`*]]) [Function]
The object initializer for `Command` registers the new command with GDB. This initializer is normally invoked from the subclass' own `__init__` method.

name is the name of the command. If *name* consists of multiple words, then the initial words are looked for as prefix commands. In this case, if one of the prefix commands does not exist, an exception is raised.

There is no support for multi-line commands.

command_class should be one of the '`COMMAND_`' constants defined below. This argument tells GDB how to categorize the new command in the help system.

completer_class is an optional argument. If given, it should be one of the '`COMPLETE_`' constants defined below. This argument tells GDB how to perform completion for this command. If not given, GDB will attempt to complete using the object's `complete` method (see below); if no such method is found, an error will occur when completion is attempted.

prefix is an optional argument. If `True`, then the new command is a prefix command; sub-commands of this command may be registered.

The help text for the new command is taken from the Python documentation string for the command's class, if there is one. If no documentation string is provided, the default value "This command is not documented." is used.

`Command.dont_repeat` () [Function]
By default, a GDB command is repeated when the user enters a blank line at the command prompt. A command can suppress this behavior by invoking the `dont_repeat` method. This is similar to the user command `dont-repeat`, see Section 23.1.1 [Define], page 297.

`Command.invoke` (*argument*, *from_tty*) [Function]
This method is called by GDB when this command is invoked.

argument is a string. It is the argument to the command, after leading and trailing whitespace has been stripped.

from_tty is a boolean argument. When true, this means that the command was entered by the user at the terminal; when false it means that the command came from elsewhere.

If this method throws an exception, it is turned into a GDB `error` call. Otherwise, the return value is ignored.

To break *argument* up into an argv-like string use `gdb.string_to_argv`. This function behaves identically to GDB's internal argument lexer `buildargv`. It is recommended to use this for consistency. Arguments are separated by spaces and may be quoted. Example:

```
print gdb.string_to_argv ("1 2\ \\\"3 '4 \"5' \"6 '7\"")
['1', '2 "3', '4 "5', "6 '7"]
```

`Command.complete` (*text*, *word*) [Function]

This method is called by GDB when the user attempts completion on this command. All forms of completion are handled by this method, that is, the TAB and M-? key bindings (see Section 3.2 [Completion], page 19), and the `complete` command (see Section 3.3 [Help], page 21).

The arguments *text* and *word* are both strings. *text* holds the complete command line up to the cursor's location. *word* holds the last word of the command line; this is computed using a word-breaking heuristic.

The `complete` method can return several values:

- If the return value is a sequence, the contents of the sequence are used as the completions. It is up to `complete` to ensure that the contents actually do complete the word. A zero-length sequence is allowed, it means that there were no completions available. Only string elements of the sequence are used; other elements in the sequence are ignored.
- If the return value is one of the '`COMPLETE_`' constants defined below, then the corresponding GDB-internal completion function is invoked, and its result is used.
- All other results are treated as though there were no available completions.

When a new command is registered, it must be declared as a member of some general class of commands. This is used to classify top-level commands in the on-line help system; note that prefix commands are not listed under their own category but rather that of their top-level command. The available classifications are represented by constants defined in the `gdb` module:

`gdb.COMMAND_NONE`

The command does not belong to any particular class. A command in this category will not be displayed in any of the help categories.

`gdb.COMMAND_RUNNING`

The command is related to running the inferior. For example, `start`, `step`, and `continue` are in this category. Type *`help running`* at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_DATA`

The command is related to data or variables. For example, `call`, `find`, and `print` are in this category. Type *`help data`* at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_STACK`
: The command has to do with manipulation of the stack. For example, `backtrace`, `frame`, and `return` are in this category. Type *`help stack`* at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_FILES`
: This class is used for file-related commands. For example, `file`, `list` and `section` are in this category. Type *`help files`* at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_SUPPORT`
: This should be used for "support facilities", generally meaning things that are useful to the user when interacting with GDB, but not related to the state of the inferior. For example, `help`, `make`, and `shell` are in this category. Type *`help support`* at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_STATUS`
: The command is an '`info`'-related command, that is, related to the state of GDB itself. For example, `info`, `macro`, and `show` are in this category. Type *`help status`* at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_BREAKPOINTS`
: The command has to do with breakpoints. For example, `break`, `clear`, and `delete` are in this category. Type *`help breakpoints`* at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_TRACEPOINTS`
: The command has to do with tracepoints. For example, `trace`, `actions`, and `tfind` are in this category. Type *`help tracepoints`* at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_USER`
: The command is a general purpose command for the user, and typically does not fit in one of the other categories. Type *`help user-defined`* at the GDB prompt to see a list of commands in this category, as well as the list of gdb macros (see Section 23.1 [Sequences], page 297).

`gdb.COMMAND_OBSCURE`
: The command is only used in unusual circumstances, or is not of general interest to users. For example, `checkpoint`, `fork`, and `stop` are in this category. Type *`help obscure`* at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_MAINTENANCE`
: The command is only useful to GDB maintainers. The `maintenance` and `flushregs` commands are in this category. Type *`help internals`* at the GDB prompt to see a list of commands in this category.

A new command can use a predefined completion function, either by specifying it via an argument at initialization, or by returning it from the `complete` method. These predefined completion constants are all defined in the `gdb` module:

`gdb.COMPLETE_NONE`
: This constant means that no completion should be done.

`gdb.COMPLETE_FILENAME`
: This constant means that filename completion should be performed.

`gdb.COMPLETE_LOCATION`
: This constant means that location completion should be done. See Section 9.2 [Specify Location], page 94.

`gdb.COMPLETE_COMMAND`
: This constant means that completion should examine GDB command names.

`gdb.COMPLETE_SYMBOL`
: This constant means that completion should be done using symbol names as the source.

The following code snippet shows how a trivial CLI command can be implemented in Python:

```
class HelloWorld (gdb.Command):
  """Greet the whole world."""

  def __init__ (self):
    super (HelloWorld, self).__init__ ("hello-world", gdb.COMMAND_USER)

  def invoke (self, arg, from_tty):
    print "Hello, World!"

HelloWorld ()
```

The last line instantiates the class, and is necessary to trigger the registration of the command with GDB. Depending on how the Python code is read into GDB, you may need to import the `gdb` module explicitly.

23.2.2.13 Parameters In Python

You can implement new GDB parameters using Python. A new parameter is implemented as an instance of the `gdb.Parameter` class.

Parameters are exposed to the user via the `set` and `show` commands. See Section 3.3 [Help], page 21.

There are many parameters that already exist and can be set in GDB. Two examples are: `set follow fork` and `set charset`. Setting these parameters influences certain behavior in GDB. Similarly, you can define parameters that can be used to influence behavior in custom Python scripts and commands.

`Parameter.__init__` (*name*, *command-class*, *parameter-class* [, *enum-sequence*]) [Function]
: The object initializer for `Parameter` registers the new parameter with GDB. This initializer is normally invoked from the subclass' own `__init__` method.

  name is the name of the new parameter. If *name* consists of multiple words, then the initial words are looked for as prefix parameters. An example of this can be illustrated with the `set print` set of parameters. If *name* is `print foo`, then `print` will be searched as the prefix parameter. In this case the parameter can subsequently be accessed in GDB as `set print foo`.

If *name* consists of multiple words, and no prefix parameter group can be found, an exception is raised.

command-class should be one of the '`COMMAND_`' constants (see Section 23.2.2.12 [Commands In Python], page 326). This argument tells GDB how to categorize the new parameter in the help system.

parameter-class should be one of the '`PARAM_`' constants defined below. This argument tells GDB the type of the new parameter; this information is used for input validation and completion.

If *parameter-class* is `PARAM_ENUM`, then *enum-sequence* must be a sequence of strings. These strings represent the possible values for the parameter.

If *parameter-class* is not `PARAM_ENUM`, then the presence of a fourth argument will cause an exception to be thrown.

The help text for the new parameter is taken from the Python documentation string for the parameter's class, if there is one. If there is no documentation string, a default value is used.

`Parameter.set_doc` [Variable]
: If this attribute exists, and is a string, then its value is used as the help text for this parameter's `set` command. The value is examined when `Parameter.__init__` is invoked; subsequent changes have no effect.

`Parameter.show_doc` [Variable]
: If this attribute exists, and is a string, then its value is used as the help text for this parameter's `show` command. The value is examined when `Parameter.__init__` is invoked; subsequent changes have no effect.

`Parameter.value` [Variable]
: The `value` attribute holds the underlying value of the parameter. It can be read and assigned to just as any other attribute. GDB does validation when assignments are made.

There are two methods that should be implemented in any `Parameter` class. These are:

`Parameter.get_set_string` (*self*) [Function]
: GDB will call this method when a *parameter*'s value has been changed via the `set` API (for example, *`set foo off`*). The `value` attribute has already been populated with the new value and may be used in output. This method must return a string.

`Parameter.get_show_string` (*self*, *svalue*) [Function]
: GDB will call this method when a *parameter*'s `show` API has been invoked (for example, *`show foo`*). The argument `svalue` receives the string representation of the current value. This method must return a string.

When a new parameter is defined, its type must be specified. The available types are represented by constants defined in the `gdb` module:

`gdb.PARAM_BOOLEAN`
: The value is a plain boolean. The Python boolean values, `True` and `False` are the only valid values.

`gdb.PARAM_AUTO_BOOLEAN`
: The value has three possible states: true, false, and '`auto`'. In Python, true and false are represented using boolean constants, and '`auto`' is represented using `None`.

`gdb.PARAM_UINTEGER`
: The value is an unsigned integer. The value of 0 should be interpreted to mean "unlimited".

`gdb.PARAM_INTEGER`
: The value is a signed integer. The value of 0 should be interpreted to mean "unlimited".

`gdb.PARAM_STRING`
: The value is a string. When the user modifies the string, any escape sequences, such as '`\t`', '`\f`', and octal escapes, are translated into corresponding characters and encoded into the current host charset.

`gdb.PARAM_STRING_NOESCAPE`
: The value is a string. When the user modifies the string, escapes are passed through untranslated.

`gdb.PARAM_OPTIONAL_FILENAME`
: The value is a either a filename (a string), or `None`.

`gdb.PARAM_FILENAME`
: The value is a filename. This is just like `PARAM_STRING_NOESCAPE`, but uses file names for completion.

`gdb.PARAM_ZINTEGER`
: The value is an integer. This is like `PARAM_INTEGER`, except 0 is interpreted as itself.

`gdb.PARAM_ENUM`
: The value is a string, which must be one of a collection string constants provided when the parameter is created.

23.2.2.14 Writing new convenience functions

You can implement new convenience functions (see Section 10.11 [Convenience Vars], page 126) in Python. A convenience function is an instance of a subclass of the class `gdb.Function`.

`Function.__init__` (*name*) [Function]
: The initializer for `Function` registers the new function with GDB. The argument *name* is the name of the function, a string. The function will be visible to the user as a convenience variable of type `internal function`, whose name is the same as the given *name*.

  The documentation for the new function is taken from the documentation string for the new class.

`Function.invoke` (*`*args`*) [Function]
: When a convenience function is evaluated, its arguments are converted to instances of `gdb.Value`, and then the function's `invoke` method is called. Note that GDB does not

predetermine the arity of convenience functions. Instead, all available arguments are passed to `invoke`, following the standard Python calling convention. In particular, a convenience function can have default values for parameters without ill effect.

The return value of this method is used as its value in the enclosing expression. If an ordinary Python value is returned, it is converted to a `gdb.Value` following the usual rules.

The following code snippet shows how a trivial convenience function can be implemented in Python:

```
class Greet (gdb.Function):
  """Return string to greet someone.
Takes a name as argument."""

  def __init__ (self):
    super (Greet, self).__init__ ("greet")

  def invoke (self, name):
    return "Hello, %s!" % name.string ()

Greet ()
```

The last line instantiates the class, and is necessary to trigger the registration of the function with GDB. Depending on how the Python code is read into GDB, you may need to import the `gdb` module explicitly.

Now you can use the function in an expression:

```
(gdb) print $greet("Bob")
$1 = "Hello, Bob!"
```

23.2.2.15 Program Spaces In Python

A program space, or *progspace*, represents a symbolic view of an address space. It consists of all of the objfiles of the program. See Section 23.2.2.16 [Objfiles In Python], page 333. See Section 4.9 [Inferiors and Programs], page 32, for more details about program spaces.

The following progspace-related functions are available in the `gdb` module:

`gdb.current_progspace ()` [Function]
This function returns the program space of the currently selected inferior. See Section 4.9 [Inferiors and Programs], page 32.

`gdb.progspaces ()` [Function]
Return a sequence of all the progspaces currently known to GDB.

Each progspace is represented by an instance of the `gdb.Progspace` class.

`Progspace.filename` [Variable]
The file name of the progspace as a string.

`Progspace.pretty_printers` [Variable]
The `pretty_printers` attribute is a list of functions. It is used to look up pretty-printers. A `Value` is passed to each function in order; if the function returns `None`, then the search continues. Otherwise, the return value should be an object which is used to format the value. See Section 23.2.2.5 [Pretty Printing API], page 317, for more information.

`Progspace.type_printers` [Variable]
The `type_printers` attribute is a list of type printer objects. See Section 23.2.2.8 [Type Printing API], page 321, for more information.

23.2.2.16 Objfiles In Python

GDB loads symbols for an inferior from various symbol-containing files (see Section 18.1 [Files], page 215). These include the primary executable file, any shared libraries used by the inferior, and any separate debug info files (see Section 18.2 [Separate Debug Files], page 223). GDB calls these symbol-containing files *objfiles*.

The following objfile-related functions are available in the `gdb` module:

`gdb.current_objfile ()` [Function]
When auto-loading a Python script (see Section 23.2.3 [Python Auto-loading], page 346), GDB sets the "current objfile" to the corresponding objfile. This function returns the current objfile. If there is no current objfile, this function returns `None`.

`gdb.objfiles ()` [Function]
Return a sequence of all the objfiles current known to GDB. See Section 23.2.2.16 [Objfiles In Python], page 333.

Each objfile is represented by an instance of the `gdb.Objfile` class.

`Objfile.filename` [Variable]
The file name of the objfile as a string.

`Objfile.pretty_printers` [Variable]
The `pretty_printers` attribute is a list of functions. It is used to look up pretty-printers. A `Value` is passed to each function in order; if the function returns `None`, then the search continues. Otherwise, the return value should be an object which is used to format the value. See Section 23.2.2.5 [Pretty Printing API], page 317, for more information.

`Objfile.type_printers` [Variable]
The `type_printers` attribute is a list of type printer objects. See Section 23.2.2.8 [Type Printing API], page 321, for more information.

A `gdb.Objfile` object has the following methods:

`Objfile.is_valid ()` [Function]
Returns `True` if the `gdb.Objfile` object is valid, `False` if not. A `gdb.Objfile` object can become invalid if the object file it refers to is not loaded in GDB any longer. All other `gdb.Objfile` methods will throw an exception if it is invalid at the time the method is called.

23.2.2.17 Accessing inferior stack frames from Python.

When the debugged program stops, GDB is able to analyze its call stack (see Section 8.1 [Stack frames], page 87). The `gdb.Frame` class represents a frame in the stack. A `gdb.Frame` object is only valid while its corresponding frame exists in the inferior's stack. If you try

to use an invalid frame object, GDB will throw a `gdb.error` exception (see Section 23.2.2.2 [Exception Handling], page 308).

Two `gdb.Frame` objects can be compared for equality with the `==` operator, like:

```
(gdb) python print gdb.newest_frame() == gdb.selected_frame ()
True
```

The following frame-related functions are available in the `gdb` module:

`gdb.selected_frame` () [Function]
Return the selected frame object. (see Section 8.3 [Selecting a Frame], page 90).

`gdb.newest_frame` () [Function]
Return the newest frame object for the selected thread.

`gdb.frame_stop_reason_string` (*reason*) [Function]
Return a string explaining the reason why GDB stopped unwinding frames, as expressed by the given *reason* code (an integer, see the `unwind_stop_reason` method further down in this section).

A `gdb.Frame` object has the following methods:

`Frame.is_valid` () [Function]
Returns true if the `gdb.Frame` object is valid, false if not. A frame object can become invalid if the frame it refers to doesn't exist anymore in the inferior. All `gdb.Frame` methods will throw an exception if it is invalid at the time the method is called.

`Frame.name` () [Function]
Returns the function name of the frame, or `None` if it can't be obtained.

`Frame.architecture` () [Function]
Returns the `gdb.Architecture` object corresponding to the frame's architecture. See Section 23.2.2.24 [Architectures In Python], page 346.

`Frame.type` () [Function]
Returns the type of the frame. The value can be one of:

`gdb.NORMAL_FRAME`
An ordinary stack frame.

`gdb.DUMMY_FRAME`
A fake stack frame that was created by GDB when performing an inferior function call.

`gdb.INLINE_FRAME`
A frame representing an inlined function. The function was inlined into a `gdb.NORMAL_FRAME` that is older than this one.

`gdb.TAILCALL_FRAME`
A frame representing a tail call. See Section 11.2 [Tail Call Frames], page 142.

`gdb.SIGTRAMP_FRAME`
A signal trampoline frame. This is the frame created by the OS when it calls into a signal handler.

`gdb.ARCH_FRAME`
: A fake stack frame representing a cross-architecture call.

`gdb.SENTINEL_FRAME`
: This is like `gdb.NORMAL_FRAME`, but it is only used for the newest frame.

`Frame.unwind_stop_reason ()` [Function]
: Return an integer representing the reason why it's not possible to find more frames toward the outermost frame. Use `gdb.frame_stop_reason_string` to convert the value returned by this function to a string. The value can be one of:

`gdb.FRAME_UNWIND_NO_REASON`
: No particular reason (older frames should be available).

`gdb.FRAME_UNWIND_NULL_ID`
: The previous frame's analyzer returns an invalid result.

`gdb.FRAME_UNWIND_OUTERMOST`
: This frame is the outermost.

`gdb.FRAME_UNWIND_UNAVAILABLE`
: Cannot unwind further, because that would require knowing the values of registers or memory that have not been collected.

`gdb.FRAME_UNWIND_INNER_ID`
: This frame ID looks like it ought to belong to a NEXT frame, but we got it for a PREV frame. Normally, this is a sign of unwinder failure. It could also indicate stack corruption.

`gdb.FRAME_UNWIND_SAME_ID`
: This frame has the same ID as the previous one. That means that unwinding further would almost certainly give us another frame with exactly the same ID, so break the chain. Normally, this is a sign of unwinder failure. It could also indicate stack corruption.

`gdb.FRAME_UNWIND_NO_SAVED_PC`
: The frame unwinder did not find any saved PC, but we needed one to unwind further.

`gdb.FRAME_UNWIND_FIRST_ERROR`
: Any stop reason greater or equal to this value indicates some kind of error. This special value facilitates writing code that tests for errors in unwinding in a way that will work correctly even if the list of the other values is modified in future GDB versions. Using it, you could write:

```
reason = gdb.selected_frame().unwind_stop_reason ()
reason_str =  gdb.frame_stop_reason_string (reason)
if reason >=  gdb.FRAME_UNWIND_FIRST_ERROR:
    print "An error occured: %s" % reason_str
```

`Frame.pc ()` [Function]
: Returns the frame's resume address.

`Frame.block ()` [Function]
: Return the frame's code block. See Section 23.2.2.18 [Blocks In Python], page 336.

`Frame.function ()` [Function]
Return the symbol for the function corresponding to this frame. See Section 23.2.2.19 [Symbols In Python], page 337.

`Frame.older ()` [Function]
Return the frame that called this frame.

`Frame.newer ()` [Function]
Return the frame called by this frame.

`Frame.find_sal ()` [Function]
Return the frame's symtab and line object. See Section 23.2.2.20 [Symbol Tables In Python], page 340.

`Frame.read_var` (*variable* [, *block*]) [Function]
Return the value of *variable* in this frame. If the optional argument *block* is provided, search for the variable from that block; otherwise start at the frame's current block (which is determined by the frame's current program counter). *variable* must be a string or a `gdb.Symbol` object. *block* must be a `gdb.Block` object.

`Frame.select ()` [Function]
Set this frame to be the selected frame. See Chapter 8 [Examining the Stack], page 87.

23.2.2.18 Accessing frame blocks from Python.

Within each frame, GDB maintains information on each block stored in that frame. These blocks are organized hierarchically, and are represented individually in Python as a `gdb.Block`. Please see Section 23.2.2.17 [Frames In Python], page 333, for a more in-depth discussion on frames. Furthermore, see Chapter 8 [Examining the Stack], page 87, for more detailed technical information on GDB's book-keeping of the stack.

A `gdb.Block` is iterable. The iterator returns the symbols (see Section 23.2.2.19 [Symbols In Python], page 337) local to the block. Python programs should not assume that a specific block object will always contain a given symbol, since changes in GDB features and infrastructure may cause symbols move across blocks in a symbol table.

The following block-related functions are available in the `gdb` module:

`gdb.block_for_pc` (*pc*) [Function]
Return the `gdb.Block` containing the given *pc* value. If the block cannot be found for the *pc* value specified, the function will return `None`.

A `gdb.Block` object has the following methods:

`Block.is_valid ()` [Function]
Returns `True` if the `gdb.Block` object is valid, `False` if not. A block object can become invalid if the block it refers to doesn't exist anymore in the inferior. All other `gdb.Block` methods will throw an exception if it is invalid at the time the method is called. The block's validity is also checked during iteration over symbols of the block.

A `gdb.Block` object has the following attributes:

`Block.start` [Variable]
The start address of the block. This attribute is not writable.

`Block.end` [Variable]
The end address of the block. This attribute is not writable.

`Block.function` [Variable]
The name of the block represented as a `gdb.Symbol`. If the block is not named, then this attribute holds `None`. This attribute is not writable.

`Block.superblock` [Variable]
The block containing this block. If this parent block does not exist, this attribute holds `None`. This attribute is not writable.

`Block.global_block` [Variable]
The global block associated with this block. This attribute is not writable.

`Block.static_block` [Variable]
The static block associated with this block. This attribute is not writable.

`Block.is_global` [Variable]
`True` if the `gdb.Block` object is a global block, `False` if not. This attribute is not writable.

`Block.is_static` [Variable]
`True` if the `gdb.Block` object is a static block, `False` if not. This attribute is not writable.

23.2.2.19 Python representation of Symbols.

GDB represents every variable, function and type as an entry in a symbol table. See Chapter 16 [Examining the Symbol Table], page 201. Similarly, Python represents these symbols in GDB with the `gdb.Symbol` object.

The following symbol-related functions are available in the `gdb` module:

`gdb.lookup_symbol` (*name* [, *block* [, *domain*]]) [Function]
This function searches for a symbol by name. The search scope can be restricted to the parameters defined in the optional domain and block arguments.

name is the name of the symbol. It must be a string. The optional *block* argument restricts the search to symbols visible in that *block*. The *block* argument must be a `gdb.Block` object. If omitted, the block for the current frame is used. The optional *domain* argument restricts the search to the domain type. The *domain* argument must be a domain constant defined in the `gdb` module and described later in this chapter.

The result is a tuple of two elements. The first element is a `gdb.Symbol` object or `None` if the symbol is not found. If the symbol is found, the second element is `True` if the symbol is a field of a method's object (e.g., `this` in C++), otherwise it is `False`. If the symbol is not found, the second element is `False`.

`gdb.lookup_global_symbol` (*name* [, *domain*]) [Function]
This function searches for a global symbol by name. The search scope can be restricted to by the domain argument.

name is the name of the symbol. It must be a string. The optional *domain* argument restricts the search to the domain type. The *domain* argument must be a domain constant defined in the `gdb` module and described later in this chapter.

The result is a `gdb.Symbol` object or `None` if the symbol is not found.

A `gdb.Symbol` object has the following attributes:

`Symbol.type` [Variable]
The type of the symbol or `None` if no type is recorded. This attribute is represented as a `gdb.Type` object. See Section 23.2.2.4 [Types In Python], page 313. This attribute is not writable.

`Symbol.symtab` [Variable]
The symbol table in which the symbol appears. This attribute is represented as a `gdb.Symtab` object. See Section 23.2.2.20 [Symbol Tables In Python], page 340. This attribute is not writable.

`Symbol.line` [Variable]
The line number in the source code at which the symbol was defined. This is an integer.

`Symbol.name` [Variable]
The name of the symbol as a string. This attribute is not writable.

`Symbol.linkage_name` [Variable]
The name of the symbol, as used by the linker (i.e., may be mangled). This attribute is not writable.

`Symbol.print_name` [Variable]
The name of the symbol in a form suitable for output. This is either `name` or `linkage_name`, depending on whether the user asked GDB to display demangled or mangled names.

`Symbol.addr_class` [Variable]
The address class of the symbol. This classifies how to find the value of a symbol. Each address class is a constant defined in the `gdb` module and described later in this chapter.

`Symbol.needs_frame` [Variable]
This is `True` if evaluating this symbol's value requires a frame (see Section 23.2.2.17 [Frames In Python], page 333) and `False` otherwise. Typically, local variables will require a frame, but other symbols will not.

`Symbol.is_argument` [Variable]
`True` if the symbol is an argument of a function.

`Symbol.is_constant` [Variable]
`True` if the symbol is a constant.

`Symbol.is_function` [Variable]
: `True` if the symbol is a function or a method.

`Symbol.is_variable` [Variable]
: `True` if the symbol is a variable.

A `gdb.Symbol` object has the following methods:

`Symbol.is_valid ()` [Function]
: Returns `True` if the `gdb.Symbol` object is valid, `False` if not. A `gdb.Symbol` object can become invalid if the symbol it refers to does not exist in GDB any longer. All other `gdb.Symbol` methods will throw an exception if it is invalid at the time the method is called.

`Symbol.value ([`*frame*`])` [Function]
: Compute the value of the symbol, as a `gdb.Value`. For functions, this computes the address of the function, cast to the appropriate type. If the symbol requires a frame in order to compute its value, then *frame* must be given. If *frame* is not given, or if *frame* is invalid, then this method will throw an exception.

The available domain categories in `gdb.Symbol` are represented as constants in the `gdb` module:

`gdb.SYMBOL_UNDEF_DOMAIN`
: This is used when a domain has not been discovered or none of the following domains apply. This usually indicates an error either in the symbol information or in GDB's handling of symbols.

`gdb.SYMBOL_VAR_DOMAIN`
: This domain contains variables, function names, typedef names and enum type values.

`gdb.SYMBOL_STRUCT_DOMAIN`
: This domain holds struct, union and enum type names.

`gdb.SYMBOL_LABEL_DOMAIN`
: This domain contains names of labels (for gotos).

`gdb.SYMBOL_VARIABLES_DOMAIN`
: This domain holds a subset of the `SYMBOLS_VAR_DOMAIN`; it contains everything minus functions and types.

`gdb.SYMBOL_FUNCTION_DOMAIN`
: This domain contains all functions.

`gdb.SYMBOL_TYPES_DOMAIN`
: This domain contains all types.

The available address class categories in `gdb.Symbol` are represented as constants in the `gdb` module:

`gdb.SYMBOL_LOC_UNDEF`
: If this is returned by address class, it indicates an error either in the symbol information or in GDB's handling of symbols.

`gdb.SYMBOL_LOC_CONST`
: Value is constant int.

`gdb.SYMBOL_LOC_STATIC`
: Value is at a fixed address.

`gdb.SYMBOL_LOC_REGISTER`
: Value is in a register.

`gdb.SYMBOL_LOC_ARG`
: Value is an argument. This value is at the offset stored within the symbol inside the frame's argument list.

`gdb.SYMBOL_LOC_REF_ARG`
: Value address is stored in the frame's argument list. Just like `LOC_ARG` except that the value's address is stored at the offset, not the value itself.

`gdb.SYMBOL_LOC_REGPARM_ADDR`
: Value is a specified register. Just like `LOC_REGISTER` except the register holds the address of the argument instead of the argument itself.

`gdb.SYMBOL_LOC_LOCAL`
: Value is a local variable.

`gdb.SYMBOL_LOC_TYPEDEF`
: Value not used. Symbols in the domain `SYMBOL_STRUCT_DOMAIN` all have this class.

`gdb.SYMBOL_LOC_BLOCK`
: Value is a block.

`gdb.SYMBOL_LOC_CONST_BYTES`
: Value is a byte-sequence.

`gdb.SYMBOL_LOC_UNRESOLVED`
: Value is at a fixed address, but the address of the variable has to be determined from the minimal symbol table whenever the variable is referenced.

`gdb.SYMBOL_LOC_OPTIMIZED_OUT`
: The value does not actually exist in the program.

`gdb.SYMBOL_LOC_COMPUTED`
: The value's address is a computed location.

23.2.2.20 Symbol table representation in Python.

Access to symbol table data maintained by GDB on the inferior is exposed to Python via two objects: `gdb.Symtab_and_line` and `gdb.Symtab`. Symbol table and line data for a frame is returned from the `find_sal` method in `gdb.Frame` object. See Section 23.2.2.17 [Frames In Python], page 333.

For more information on GDB's symbol table management, see Chapter 16 [Examining the Symbol Table], page 201, for more information.

A `gdb.Symtab_and_line` object has the following attributes:

`Symtab_and_line.symtab` [Variable]
The symbol table object (`gdb.Symtab`) for this frame. This attribute is not writable.

`Symtab_and_line.pc` [Variable]
Indicates the start of the address range occupied by code for the current source line. This attribute is not writable.

`Symtab_and_line.last` [Variable]
Indicates the end of the address range occupied by code for the current source line. This attribute is not writable.

`Symtab_and_line.line` [Variable]
Indicates the current line number for this object. This attribute is not writable.

A `gdb.Symtab_and_line` object has the following methods:

`Symtab_and_line.is_valid ()` [Function]
Returns `True` if the `gdb.Symtab_and_line` object is valid, `False` if not. A `gdb.Symtab_and_line` object can become invalid if the Symbol table and line object it refers to does not exist in GDB any longer. All other `gdb.Symtab_and_line` methods will throw an exception if it is invalid at the time the method is called.

A `gdb.Symtab` object has the following attributes:

`Symtab.filename` [Variable]
The symbol table's source filename. This attribute is not writable.

`Symtab.objfile` [Variable]
The symbol table's backing object file. See Section 23.2.2.16 [Objfiles In Python], page 333. This attribute is not writable.

A `gdb.Symtab` object has the following methods:

`Symtab.is_valid ()` [Function]
Returns `True` if the `gdb.Symtab` object is valid, `False` if not. A `gdb.Symtab` object can become invalid if the symbol table it refers to does not exist in GDB any longer. All other `gdb.Symtab` methods will throw an exception if it is invalid at the time the method is called.

`Symtab.fullname ()` [Function]
Return the symbol table's source absolute file name.

`Symtab.global_block ()` [Function]
Return the global block of the underlying symbol table. See Section 23.2.2.18 [Blocks In Python], page 336.

`Symtab.static_block ()` [Function]
Return the static block of the underlying symbol table. See Section 23.2.2.18 [Blocks In Python], page 336.

23.2.2.21 Manipulating breakpoints using Python

Python code can manipulate breakpoints via the `gdb.Breakpoint` class.

`Breakpoint.__init__` (*spec* [, *type* [, *wp_class* [,*internal*]]]) [Function]

Create a new breakpoint. *spec* is a string naming the location of the breakpoint, or an expression that defines a watchpoint. The contents can be any location recognized by the `break` command, or in the case of a watchpoint, by the `watch` command. The optional *type* denotes the breakpoint to create from the types defined later in this chapter. This argument can be either: `gdb.BP_BREAKPOINT` or `gdb.BP_WATCHPOINT`. *type* defaults to `gdb.BP_BREAKPOINT`. The optional *internal* argument allows the breakpoint to become invisible to the user. The breakpoint will neither be reported when created, nor will it be listed in the output from `info breakpoints` (but will be listed with the `maint info breakpoints` command). The optional *wp_class* argument defines the class of watchpoint to create, if *type* is `gdb.BP_WATCHPOINT`. If a watchpoint class is not provided, it is assumed to be a `gdb.WP_WRITE` class.

`Breakpoint.stop` (*self*) [Function]

The `gdb.Breakpoint` class can be sub-classed and, in particular, you may choose to implement the `stop` method. If this method is defined as a sub-class of `gdb.Breakpoint`, it will be called when the inferior reaches any location of a breakpoint which instantiates that sub-class. If the method returns `True`, the inferior will be stopped at the location of the breakpoint, otherwise the inferior will continue.

If there are multiple breakpoints at the same location with a `stop` method, each one will be called regardless of the return status of the previous. This ensures that all `stop` methods have a chance to execute at that location. In this scenario if one of the methods returns `True` but the others return `False`, the inferior will still be stopped.

You should not alter the execution state of the inferior (i.e., step, next, etc.), alter the current frame context (i.e., change the current active frame), or alter, add or delete any breakpoint. As a general rule, you should not alter any data within GDB or the inferior at this time.

Example `stop` implementation:

```
class MyBreakpoint (gdb.Breakpoint):
      def stop (self):
        inf_val = gdb.parse_and_eval("foo")
        if inf_val == 3:
          return True
        return False
```

The available watchpoint types represented by constants are defined in the `gdb` module:

`gdb.WP_READ`

Read only watchpoint.

`gdb.WP_WRITE`

Write only watchpoint.

`gdb.WP_ACCESS`

Read/Write watchpoint.

`Breakpoint.is_valid ()` [Function]
: Return `True` if this `Breakpoint` object is valid, `False` otherwise. A `Breakpoint` object can become invalid if the user deletes the breakpoint. In this case, the object still exists, but the underlying breakpoint does not. In the cases of watchpoint scope, the watchpoint remains valid even if execution of the inferior leaves the scope of that watchpoint.

`Breakpoint.delete` [Function]
: Permanently deletes the GDB breakpoint. This also invalidates the Python `Breakpoint` object. Any further access to this object's attributes or methods will raise an error.

`Breakpoint.enabled` [Variable]
: This attribute is `True` if the breakpoint is enabled, and `False` otherwise. This attribute is writable.

`Breakpoint.silent` [Variable]
: This attribute is `True` if the breakpoint is silent, and `False` otherwise. This attribute is writable.

  Note that a breakpoint can also be silent if it has commands and the first command is `silent`. This is not reported by the `silent` attribute.

`Breakpoint.thread` [Variable]
: If the breakpoint is thread-specific, this attribute holds the thread id. If the breakpoint is not thread-specific, this attribute is `None`. This attribute is writable.

`Breakpoint.task` [Variable]
: If the breakpoint is Ada task-specific, this attribute holds the Ada task id. If the breakpoint is not task-specific (or the underlying language is not Ada), this attribute is `None`. This attribute is writable.

`Breakpoint.ignore_count` [Variable]
: This attribute holds the ignore count for the breakpoint, an integer. This attribute is writable.

`Breakpoint.number` [Variable]
: This attribute holds the breakpoint's number — the identifier used by the user to manipulate the breakpoint. This attribute is not writable.

`Breakpoint.type` [Variable]
: This attribute holds the breakpoint's type — the identifier used to determine the actual breakpoint type or use-case. This attribute is not writable.

`Breakpoint.visible` [Variable]
: This attribute tells whether the breakpoint is visible to the user when set, or when the '`info breakpoints`' command is run. This attribute is not writable.

The available types are represented by constants defined in the `gdb` module:

`gdb.BP_BREAKPOINT`
: Normal code breakpoint.

`gdb.BP_WATCHPOINT`
: Watchpoint breakpoint.

`gdb.BP_HARDWARE_WATCHPOINT`
: Hardware assisted watchpoint.

`gdb.BP_READ_WATCHPOINT`
: Hardware assisted read watchpoint.

`gdb.BP_ACCESS_WATCHPOINT`
: Hardware assisted access watchpoint.

`Breakpoint.hit_count` [Variable]
: This attribute holds the hit count for the breakpoint, an integer. This attribute is writable, but currently it can only be set to zero.

`Breakpoint.location` [Variable]
: This attribute holds the location of the breakpoint, as specified by the user. It is a string. If the breakpoint does not have a location (that is, it is a watchpoint) the attribute's value is `None`. This attribute is not writable.

`Breakpoint.expression` [Variable]
: This attribute holds a breakpoint expression, as specified by the user. It is a string. If the breakpoint does not have an expression (the breakpoint is not a watchpoint) the attribute's value is `None`. This attribute is not writable.

`Breakpoint.condition` [Variable]
: This attribute holds the condition of the breakpoint, as specified by the user. It is a string. If there is no condition, this attribute's value is `None`. This attribute is writable.

`Breakpoint.commands` [Variable]
: This attribute holds the commands attached to the breakpoint. If there are commands, this attribute's value is a string holding all the commands, separated by newlines. If there are no commands, this attribute is `None`. This attribute is not writable.

23.2.2.22 Finish Breakpoints

A finish breakpoint is a temporary breakpoint set at the return address of a frame, based on the `finish` command. `gdb.FinishBreakpoint` extends `gdb.Breakpoint`. The underlying breakpoint will be disabled and deleted when the execution will run out of the breakpoint scope (i.e. `Breakpoint.stop` or `FinishBreakpoint.out_of_scope` triggered). Finish breakpoints are thread specific and must be create with the right thread selected.

`FinishBreakpoint.__init__` ([*frame*] [, *internal*]) [Function]
: Create a finish breakpoint at the return address of the `gdb.Frame` object *frame*. If *frame* is not provided, this defaults to the newest frame. The optional *internal* argument allows the breakpoint to become invisible to the user. See Section 23.2.2.21 [Breakpoints In Python], page 342, for further details about this argument.

`FinishBreakpoint.out_of_scope` (*self*) [Function]
In some circumstances (e.g. `longjmp`, C++ exceptions, GDB `return` command, ...), a function may not properly terminate, and thus never hit the finish breakpoint. When GDB notices such a situation, the `out_of_scope` callback will be triggered.

You may want to sub-class `gdb.FinishBreakpoint` and override this method:

```
class MyFinishBreakpoint (gdb.FinishBreakpoint)
    def stop (self):
        print "normal finish"
        return True

    def out_of_scope ():
        print "abnormal finish"
```

`FinishBreakpoint.return_value` [Variable]
When GDB is stopped at a finish breakpoint and the frame used to build the `gdb.FinishBreakpoint` object had debug symbols, this attribute will contain a `gdb.Value` object corresponding to the return value of the function. The value will be `None` if the function return type is `void` or if the return value was not computable. This attribute is not writable.

23.2.2.23 Python representation of lazy strings.

A *lazy string* is a string whose contents is not retrieved or encoded until it is needed.

A `gdb.LazyString` is represented in GDB as an `address` that points to a region of memory, an `encoding` that will be used to encode that region of memory, and a `length` to delimit the region of memory that represents the string. The difference between a `gdb.LazyString` and a string wrapped within a `gdb.Value` is that a `gdb.LazyString` will be treated differently by GDB when printing. A `gdb.LazyString` is retrieved and encoded during printing, while a `gdb.Value` wrapping a string is immediately retrieved and encoded on creation.

A `gdb.LazyString` object has the following functions:

`LazyString.value` () [Function]
Convert the `gdb.LazyString` to a `gdb.Value`. This value will point to the string in memory, but will lose all the delayed retrieval, encoding and handling that GDB applies to a `gdb.LazyString`.

`LazyString.address` [Variable]
This attribute holds the address of the string. This attribute is not writable.

`LazyString.length` [Variable]
This attribute holds the length of the string in characters. If the length is -1, then the string will be fetched and encoded up to the first null of appropriate width. This attribute is not writable.

`LazyString.encoding` [Variable]
This attribute holds the encoding that will be applied to the string when the string is printed by GDB. If the encoding is not set, or contains an empty string, then GDB will select the most appropriate encoding when the string is printed. This attribute is not writable.

`LazyString.type` [Variable]
: This attribute holds the type that is represented by the lazy string's type. For a lazy string this will always be a pointer type. To resolve this to the lazy string's character type, use the type's `target` method. See Section 23.2.2.4 [Types In Python], page 313. This attribute is not writable.

23.2.2.24 Python representation of architectures

GDB uses architecture specific parameters and artifacts in a number of its various computations. An architecture is represented by an instance of the `gdb.Architecture` class.

A `gdb.Architecture` class has the following methods:

`Architecture.name ()` [Function]
: Return the name (string value) of the architecture.

`Architecture.disassemble (`*`start_pc`* [, *`end_pc`* [, *`count`*]]) [Function]
: Return a list of disassembled instructions starting from the memory address *start_pc*. The optional arguments *end_pc* and *count* determine the number of instructions in the returned list. If both the optional arguments *end_pc* and *count* are specified, then a list of at most *count* disassembled instructions whose start address falls in the closed memory address interval from *start_pc* to *end_pc* are returned. If *end_pc* is not specified, but *count* is specified, then *count* number of instructions starting from the address *start_pc* are returned. If *count* is not specified but *end_pc* is specified, then all instructions whose start address falls in the closed memory address interval from *start_pc* to *end_pc* are returned. If neither *end_pc* nor *count* are specified, then a single instruction at *start_pc* is returned. For all of these cases, each element of the returned list is a Python `dict` with the following string keys:

  `addr` The value corresponding to this key is a Python long integer capturing the memory address of the instruction.

  `asm` The value corresponding to this key is a string value which represents the instruction with assembly language mnemonics. The assembly language flavor used is the same as that specified by the current CLI variable `disassembly-flavor`. See Section 9.6 [Machine Code], page 99.

  `length` The value corresponding to this key is the length (integer value) of the instruction in bytes.

23.2.3 Python Auto-loading

When a new object file is read (for example, due to the `file` command, or because the inferior has loaded a shared library), GDB will look for Python support scripts in several ways: '*`objfile`*`-gdb.py`' (see Section 23.2.3.1 [objfile-gdb.py file], page 347) and `.debug_gdb_scripts` section (see Section 23.2.3.2 [dotdebug_gdb_scripts section], page 348).

The auto-loading feature is useful for supplying application-specific debugging commands and scripts.

Auto-loading can be enabled or disabled, and the list of auto-loaded scripts can be printed.

`set auto-load python-scripts [on|off]`
: Enable or disable the auto-loading of Python scripts.

`show auto-load python-scripts`
: Show whether auto-loading of Python scripts is enabled or disabled.

`info auto-load python-scripts [`*`regexp`*`]`
: Print the list of all Python scripts that GDB auto-loaded.

  Also printed is the list of Python scripts that were mentioned in the `.debug_gdb_scripts` section and were not found (see Section 23.2.3.2 [dotdebug_gdb_scripts section], page 348). This is useful because their names are not printed when GDB tries to load them and fails. There may be many of them, and printing an error message for each one is problematic.

  If *regexp* is supplied only Python scripts with matching names are printed.

  Example:

```
(gdb) info auto-load python-scripts
Loaded Script
Yes    py-section-script.py
       full name: /tmp/py-section-script.py
No     my-foo-pretty-printers.py
```

When reading an auto-loaded file, GDB sets the *current objfile*. This is available via the `gdb.current_objfile` function (see Section 23.2.2.16 [Objfiles In Python], page 333). This can be useful for registering objfile-specific pretty-printers.

23.2.3.1 The '*objfile*-gdb.py' file

When a new object file is read, GDB looks for a file named '*objfile*`-gdb.py`' (we call it *script-name* below), where *objfile* is the object file's real name, formed by ensuring that the file name is absolute, following all symlinks, and resolving `.` and `..` components. If this file exists and is readable, GDB will evaluate it as a Python script.

If this file does not exist, then GDB will look for *script-name* file in all of the directories as specified below.

Note that loading of this script file also requires accordingly configured `auto-load safe-path` (see Section 22.7.4 [Auto-loading safe path], page 289).

For object files using '`.exe`' suffix GDB tries to load first the scripts normally according to its '`.exe`' filename. But if no scripts are found GDB also tries script filenames matching the object file without its '`.exe`' suffix. This '`.exe`' stripping is case insensitive and it is attempted on any platform. This makes the script filenames compatible between Unix and MS-Windows hosts.

`set auto-load scripts-directory` [*`directories`*]
: Control GDB auto-loaded scripts location. Multiple directory entries may be delimited by the host platform path separator in use ('`:`' on Unix, '`;`' on MS-Windows and MS-DOS).

  Each entry here needs to be covered also by the security setting `set auto-load safe-path` (see [set auto-load safe-path], page 289).

  This variable defaults to '`$debugdir:$datadir/auto-load`'. The default `set auto-load safe-path` value can be also overriden by GDB configuration option '`--with-auto-load-dir`'.

Any reference to '`$debugdir`' will get replaced by *debug-file-directory* value (see Section 18.2 [Separate Debug Files], page 223) and any reference to '`$datadir`' will get replaced by *data-directory* which is determined at GDB startup (see Section 18.6 [Data Files], page 229). '`$debugdir`' and '`$datadir`' must be placed as a directory component — either alone or delimited by '`/`' or '`\`' directory separators, depending on the host platform.

The list of directories uses path separator ('`:`' on GNU and Unix systems, '`;`' on MS-Windows and MS-DOS) to separate directories, similarly to the `PATH` environment variable.

`show auto-load scripts-directory`
Show GDB auto-loaded scripts location.

GDB does not track which files it has already auto-loaded this way. GDB will load the associated script every time the corresponding *objfile* is opened. So your '`-gdb.py`' file should be careful to avoid errors if it is evaluated more than once.

23.2.3.2 The `.debug_gdb_scripts` section

For systems using file formats like ELF and COFF, when GDB loads a new object file it will look for a special section named '`.debug_gdb_scripts`'. If this section exists, its contents is a list of names of scripts to load.

GDB will look for each specified script file first in the current directory and then along the source search path (see Section 9.5 [Specifying Source Directories], page 96), except that '`$cdir`' is not searched, since the compilation directory is not relevant to scripts.

Entries can be placed in section `.debug_gdb_scripts` with, for example, this GCC macro:

```
/* Note: The "MS" section flags are to remove duplicates.  */
#define DEFINE_GDB_SCRIPT(script_name) \
  asm("\
.pushsection \".debug_gdb_scripts\", \"MS\",@progbits,1\n\
.byte 1\n\
.asciz \"" script_name "\"\n\
.popsection \n\
");
```

Then one can reference the macro in a header or source file like this:

```
DEFINE_GDB_SCRIPT ("my-app-scripts.py")
```

The script name may include directories if desired.

Note that loading of this script file also requires accordingly configured `auto-load safe-path` (see Section 22.7.4 [Auto-loading safe path], page 289).

If the macro is put in a header, any application or library using this header will get a reference to the specified script.

23.2.3.3 Which flavor to choose?

Given the multiple ways of auto-loading Python scripts, it might not always be clear which one to choose. This section provides some guidance.

Benefits of the '`-gdb.py`' way:

- Can be used with file formats that don't support multiple sections.
- Ease of finding scripts for public libraries.

  Scripts specified in the `.debug_gdb_scripts` section are searched for in the source search path. For publicly installed libraries, e.g., '`libstdc++`', there typically isn't a source directory in which to find the script.
- Doesn't require source code additions.

Benefits of the `.debug_gdb_scripts` way:

- Works with static linking.

  Scripts for libraries done the '`-gdb.py`' way require an objfile to trigger their loading. When an application is statically linked the only objfile available is the executable, and it is cumbersome to attach all the scripts from all the input libraries to the executable's '`-gdb.py`' script.
- Works with classes that are entirely inlined.

  Some classes can be entirely inlined, and thus there may not be an associated shared library to attach a '`-gdb.py`' script to.
- Scripts needn't be copied out of the source tree.

  In some circumstances, apps can be built out of large collections of internal libraries, and the build infrastructure necessary to install the '`-gdb.py`' scripts in a place where GDB can find them is cumbersome. It may be easier to specify the scripts in the `.debug_gdb_scripts` section as relative paths, and add a path to the top of the source tree to the source search path.

23.2.4 Python modules

GDB comes with several modules to assist writing Python code.

23.2.4.1 gdb.printing

This module provides a collection of utilities for working with pretty-printers.

`PrettyPrinter (`*`name`*`, `*`subprinters`*`=None)`
: This class specifies the API that makes '`info pretty-printer`', '`enable pretty-printer`' and '`disable pretty-printer`' work. Pretty-printers should generally inherit from this class.

`SubPrettyPrinter (`*`name`*`)`
: For printers that handle multiple types, this class specifies the corresponding API for the subprinters.

`RegexpCollectionPrettyPrinter (`*`name`*`)`
: Utility class for handling multiple printers, all recognized via regular expressions. See Section 23.2.2.7 [Writing a Pretty-Printer], page 319, for an example.

`FlagEnumerationPrinter (`*`name`*`)`
: A pretty-printer which handles printing of `enum` values. Unlike GDB's built-in `enum` printing, this printer attempts to work properly when there is some overlap between the enumeration constants. *name* is the name of the printer and also the name of the `enum` type to look up.

`register_pretty_printer (obj, printer, replace=False)`
: Register *printer* with the pretty-printer list of *obj*. If *replace* is `True` then any existing copy of the printer is replaced. Otherwise a `RuntimeError` exception is raised if a printer with the same name already exists.

23.2.4.2 gdb.types

This module provides a collection of utilities for working with `gdb.Type` objects.

`get_basic_type (type)`
: Return *type* with const and volatile qualifiers stripped, and with typedefs and C++ references converted to the underlying type.

  C++ example:

```
typedef const int const_int;
const_int foo (3);
const_int& foo_ref (foo);
int main () { return 0; }
```

  Then in gdb:

```
(gdb) start
(gdb) python import gdb.types
(gdb) python foo_ref = gdb.parse_and_eval("foo_ref")
(gdb) python print gdb.types.get_basic_type(foo_ref.type)
int
```

`has_field (type, field)`
: Return `True` if *type*, assumed to be a type with fields (e.g., a structure or union), has field *field*.

`make_enum_dict (enum_type)`
: Return a Python `dictionary` type produced from *enum_type*.

`deep_items (type)`
: Returns a Python iterator similar to the standard `gdb.Type.iteritems` method, except that the iterator returned by `deep_items` will recursively traverse anonymous struct or union fields. For example:

```
struct A
{
    int a;
    union {
        int b0;
        int b1;
    };
};
```

  Then in GDB:

```
(gdb) python import gdb.types
(gdb) python struct_a = gdb.lookup_type("struct A")
(gdb) python print struct_a.keys ()
{['a', '']}
(gdb) python print [k for k,v in gdb.types.deep_items(struct_a)]
{['a', 'b0', 'b1']}
```

`get_type_recognizers ()`
: Return a list of the enabled type recognizers for the current context. This is called by GDB during the type-printing process (see Section 23.2.2.8 [Type Printing API], page 321).

`apply_type_recognizers (recognizers, type_obj)`
: Apply the type recognizers, *recognizers*, to the type object *type_obj*. If any recognizer returns a string, return that string. Otherwise, return `None`. This is called by GDB during the type-printing process (see Section 23.2.2.8 [Type Printing API], page 321).

`register_type_printer (locus, printer)`
: This is a convenience function to register a type printer. *printer* is the type printer to register. It must implement the type printer protocol. *locus* is either a `gdb.Objfile`, in which case the printer is registered with that objfile; a `gdb.Progspace`, in which case the printer is registered with that progspace; or `None`, in which case the printer is registered globally.

`TypePrinter`
: This is a base class that implements the type printer protocol. Type printers are encouraged, but not required, to derive from this class. It defines a constructor:

  `__init__` (*self, name*) [Method on `TypePrinter`]
  : Initialize the type printer with the given name. The new printer starts in the enabled state.

23.2.4.3 gdb.prompt

This module provides a method for prompt value-substitution.

`substitute_prompt (string)`
: Return *string* with escape sequences substituted by values. Some escape sequences take arguments. You can specify arguments inside "`{}`" immediately following the escape sequence.

  The escape sequences you can pass to this function are:

  `\\` Substitute a backslash.

  `\e` Substitute an ESC character.

  `\f` Substitute the selected frame; an argument names a frame parameter.

  `\n` Substitute a newline.

  `\p` Substitute a parameter's value; the argument names the parameter.

  `\r` Substitute a carriage return.

  `\t` Substitute the selected thread; an argument names a thread parameter.

  `\v` Substitute the version of GDB.

  `\w` Substitute the current working directory.

  `\[` Begin a sequence of non-printing characters. These sequences are typically used with the ESC character, and are not counted in the string length. Example: "\[\e[0;34m\](gdb)\[\e[0m\]" will return a blue-colored "(gdb)" prompt where the length is five.

`\]` End a sequence of non-printing characters.

For example:

```
substitute_prompt (``frame: \f,
                   print arguments: \p{print frame-arguments}'')
```

will return the string:

```
"frame: main, print arguments: scalars"
```

23.3 Creating new spellings of existing commands

It is often useful to define alternate spellings of existing commands. For example, if a new GDB command defined in Python has a long name to type, it is handy to have an abbreviated version of it that involves less typing.

GDB itself uses aliases. For example '`s`' is an alias of the '`step`' command even though it is otherwise an ambiguous abbreviation of other commands like '`set`' and '`show`'.

Aliases are also used to provide shortened or more common versions of multi-word commands. For example, GDB provides the '`tty`' alias of the '`set inferior-tty`' command.

You can define a new alias with the '`alias`' command.

`alias [-a] [--] ALIAS = COMMAND`

ALIAS specifies the name of the new alias. Each word of *ALIAS* must consist of letters, numbers, dashes and underscores.

COMMAND specifies the name of an existing command that is being aliased.

The '`-a`' option specifies that the new alias is an abbreviation of the command. Abbreviations are not shown in command lists displayed by the '`help`' command.

The '`--`' option specifies the end of options, and is useful when *ALIAS* begins with a dash.

Here is a simple example showing how to make an abbreviation of a command so that there is less to type. Suppose you were tired of typing '`disas`', the current shortest unambiguous abbreviation of the '`disassemble`' command and you wanted an even shorter version named '`di`'. The following will accomplish this.

```
(gdb) alias -a di = disas
```

Note that aliases are different from user-defined commands. With a user-defined command, you also need to write documentation for it with the '`document`' command. An alias automatically picks up the documentation of the existing command.

Here is an example where we make '`elms`' an abbreviation of '`elements`' in the '`set print elements`' command. This is to show that you can make an abbreviation of any part of a command.

```
(gdb) alias -a set print elms = set print elements
(gdb) alias -a show print elms = show print elements
(gdb) set p elms 20
(gdb) show p elms
Limit on string chars or array elements to print is 200.
```

Note that if you are defining an alias of a '`set`' command, and you want to have an alias for the corresponding '`show`' command, then you need to define the latter separately.

Unambiguously abbreviated commands are allowed in *COMMAND* and *ALIAS*, just as they are normally.

```
(gdb) alias -a set pr elms = set p ele
```

Finally, here is an example showing the creation of a one word alias for a more complex command. This creates alias '`spe`' of the command '`set print elements`'.

```
(gdb) alias spe = set print elements
(gdb) spe 20
```

24 Command Interpreters

GDB supports multiple command interpreters, and some command infrastructure to allow users or user interface writers to switch between interpreters or run commands in other interpreters.

GDB currently supports two command interpreters, the console interpreter (sometimes called the command-line interpreter or CLI) and the machine interface interpreter (or GDB/MI). This manual describes both of these interfaces in great detail.

By default, GDB will start with the console interpreter. However, the user may choose to start GDB with another interpreter by specifying the '`-i`' or '`--interpreter`' startup options. Defined interpreters include:

`console` The traditional console or command-line interpreter. This is the most often used interpreter with GDB. With no interpreter specified at runtime, GDB will use this interpreter.

`mi` The newest GDB/MI interface (currently `mi2`). Used primarily by programs wishing to use GDB as a backend for a debugger GUI or an IDE. For more information, see Chapter 27 [The GDB/MI Interface], page 365.

`mi2` The current GDB/MI interface.

`mi1` The GDB/MI interface included in GDB 5.1, 5.2, and 5.3.

The interpreter being used by GDB may not be dynamically switched at runtime. Although possible, this could lead to a very precarious situation. Consider an IDE using GDB/MI. If a user enters the command "interpreter-set console" in a console view, GDB would switch to using the console interpreter, rendering the IDE inoperable!

Although you may only choose a single interpreter at startup, you may execute commands in any interpreter from the current interpreter using the appropriate command. If you are running the console interpreter, simply use the `interpreter-exec` command:

```
interpreter-exec mi "-data-list-register-names"
```

GDB/MI has a similar command, although it is only available in versions of GDB which support GDB/MI version 2 (or greater).

25 GDB Text User Interface

The GDB Text User Interface (TUI) is a terminal interface which uses the `curses` library to show the source file, the assembly output, the program registers and GDB commands in separate text windows. The TUI mode is supported only on platforms where a suitable version of the `curses` library is available.

The TUI mode is enabled by default when you invoke GDB as '`gdb -tui`'. You can also switch in and out of TUI mode while GDB runs by using various TUI commands and key bindings, such as *C-x C-a*. See Section 25.2 [TUI Key Bindings], page 358.

25.1 TUI Overview

In TUI mode, GDB can display several text windows:

command This window is the GDB command window with the GDB prompt and the GDB output. The GDB input is still managed using readline.

source The source window shows the source file of the program. The current line and active breakpoints are displayed in this window.

assembly The assembly window shows the disassembly output of the program.

register This window shows the processor registers. Registers are highlighted when their values change.

The source and assembly windows show the current program position by highlighting the current line and marking it with a '`>`' marker. Breakpoints are indicated with two markers. The first marker indicates the breakpoint type:

`B` Breakpoint which was hit at least once.

`b` Breakpoint which was never hit.

`H` Hardware breakpoint which was hit at least once.

`h` Hardware breakpoint which was never hit.

The second marker indicates whether the breakpoint is enabled or not:

`+` Breakpoint is enabled.

`-` Breakpoint is disabled.

The source, assembly and register windows are updated when the current thread changes, when the frame changes, or when the program counter changes.

These windows are not all visible at the same time. The command window is always visible. The others can be arranged in several layouts:

- source only,
- assembly only,
- source and assembly,
- source and registers, or
- assembly and registers.

A status line above the command window shows the following information:

target Indicates the current GDB target. (see Chapter 19 [Specifying a Debugging Target], page 231).

process Gives the current process or thread number. When no process is being debugged, this field is set to `No process`.

function Gives the current function name for the selected frame. The name is demangled if demangling is turned on (see Section 10.8 [Print Settings], page 115). When there is no symbol corresponding to the current program counter, the string `??` is displayed.

line Indicates the current line number for the selected frame. When the current line number is not known, the string `??` is displayed.

pc Indicates the current program counter address.

25.2 TUI Key Bindings

The TUI installs several key bindings in the readline keymaps (see Chapter 32 [Command Line Editing], page 459). The following key bindings are installed for both TUI mode and the GDB standard mode.

`C-x C-a`
`C-x a`
`C-x A` Enter or leave the TUI mode. When leaving the TUI mode, the curses window management stops and GDB operates using its standard mode, writing on the terminal directly. When reentering the TUI mode, control is given back to the curses windows. The screen is then refreshed.

`C-x 1` Use a TUI layout with only one window. The layout will either be '`source`' or '`assembly`'. When the TUI mode is not active, it will switch to the TUI mode.

Think of this key binding as the Emacs `C-x 1` binding.

`C-x 2` Use a TUI layout with at least two windows. When the current layout already has two windows, the next layout with two windows is used. When a new layout is chosen, one window will always be common to the previous layout and the new one.

Think of it as the Emacs `C-x 2` binding.

`C-x o` Change the active window. The TUI associates several key bindings (like scrolling and arrow keys) with the active window. This command gives the focus to the next TUI window.

Think of it as the Emacs `C-x o` binding.

`C-x s` Switch in and out of the TUI SingleKey mode that binds single keys to GDB commands (see Section 25.3 [TUI Single Key Mode], page 359).

The following key bindings only work in the TUI mode:

PGUP Scroll the active window one page up.

PGDN Scroll the active window one page down.

UP Scroll the active window one line up.

DOWN Scroll the active window one line down.

LEFT Scroll the active window one column left.

RIGHT Scroll the active window one column right.

`C-L` Refresh the screen.

Because the arrow keys scroll the active window in the TUI mode, they are not available for their normal use by readline unless the command window has the focus. When another window is active, you must use other readline key bindings such as `C-p`, `C-n`, `C-b` and `C-f` to control the command window.

25.3 TUI Single Key Mode

The TUI also provides a *SingleKey* mode, which binds several frequently used GDB commands to single keys. Type `C-x s` to switch into this mode, where the following key bindings are used:

`c` continue

`d` down

`f` finish

`n` next

`q` exit the SingleKey mode.

`r` run

`s` step

`u` up

`v` info locals

`w` where

Other keys temporarily switch to the GDB command prompt. The key that was pressed is inserted in the editing buffer so that it is possible to type most GDB commands without interaction with the TUI SingleKey mode. Once the command is entered the TUI SingleKey mode is restored. The only way to permanently leave this mode is by typing `q` or `C-x s`.

25.4 TUI-specific Commands

The TUI has specific commands to control the text windows. These commands are always available, even when GDB is not in the TUI mode. When GDB is in the standard mode, most of these commands will automatically switch to the TUI mode.

Note that if GDB's `stdout` is not connected to a terminal, or GDB has been started with the machine interface interpreter (see Chapter 27 [The GDB/MI Interface], page 365), most of these commands will fail with an error, because it would not be possible or desirable to enable curses window management.

`info win` List and give the size of all displayed windows.

`layout next`
Display the next layout.

`layout prev`
: Display the previous layout.

`layout src`
: Display the source window only.

`layout asm`
: Display the assembly window only.

`layout split`
: Display the source and assembly window.

`layout regs`
: Display the register window together with the source or assembly window.

`focus next`
: Make the next window active for scrolling.

`focus prev`
: Make the previous window active for scrolling.

`focus src` Make the source window active for scrolling.

`focus asm` Make the assembly window active for scrolling.

`focus regs`
: Make the register window active for scrolling.

`focus cmd` Make the command window active for scrolling.

`refresh` Refresh the screen. This is similar to typing *C-L*.

`tui reg float`
: Show the floating point registers in the register window.

`tui reg general`
: Show the general registers in the register window.

`tui reg next`
: Show the next register group. The list of register groups as well as their order is target specific. The predefined register groups are the following: `general`, `float`, `system`, `vector`, `all`, `save`, `restore`.

`tui reg system`
: Show the system registers in the register window.

`update` Update the source window and the current execution point.

`winheight` *name* `+`*count*
`winheight` *name* `-`*count*
: Change the height of the window *name* by *count* lines. Positive counts increase the height, while negative counts decrease it.

`tabset` *nchars*
: Set the width of tab stops to be *nchars* characters.

25.5 TUI Configuration Variables

Several configuration variables control the appearance of TUI windows.

`set tui border-kind` *kind*
: Select the border appearance for the source, assembly and register windows. The possible values are the following:

  `space` Use a space character to draw the border.

  `ascii` Use ASCII characters '`+`', '`-`' and '`|`' to draw the border.

  `acs` Use the Alternate Character Set to draw the border. The border is drawn using character line graphics if the terminal supports them.

`set tui border-mode` *mode*
`set tui active-border-mode` *mode*
: Select the display attributes for the borders of the inactive windows or the active window. The *mode* can be one of the following:

  `normal` Use normal attributes to display the border.

  `standout` Use standout mode.

  `reverse` Use reverse video mode.

  `half` Use half bright mode.

  `half-standout` Use half bright and standout mode.

  `bold` Use extra bright or bold mode.

  `bold-standout` Use extra bright or bold and standout mode.

26 Using GDB under GNU Emacs

A special interface allows you to use GNU Emacs to view (and edit) the source files for the program you are debugging with GDB.

To use this interface, use the command *M-x gdb* in Emacs. Give the executable file you want to debug as an argument. This command starts GDB as a subprocess of Emacs, with input and output through a newly created Emacs buffer.

Running GDB under Emacs can be just like running GDB normally except for two things:

- All "terminal" input and output goes through an Emacs buffer, called the GUD buffer.

  This applies both to GDB commands and their output, and to the input and output done by the program you are debugging.

  This is useful because it means that you can copy the text of previous commands and input them again; you can even use parts of the output in this way.

  All the facilities of Emacs' Shell mode are available for interacting with your program. In particular, you can send signals the usual way—for example, *C-c C-c* for an interrupt, *C-c C-z* for a stop.

- GDB displays source code through Emacs.

  Each time GDB displays a stack frame, Emacs automatically finds the source file for that frame and puts an arrow ('=>') at the left margin of the current line. Emacs uses a separate buffer for source display, and splits the screen to show both your GDB session and the source.

  Explicit GDB `list` or search commands still produce output as usual, but you probably have no reason to use them from Emacs.

We call this *text command mode*. Emacs 22.1, and later, also uses a graphical mode, enabled by default, which provides further buffers that can control the execution and describe the state of your program. See Section "GDB Graphical Interface" in *The GNU Emacs Manual*.

If you specify an absolute file name when prompted for the *M-x gdb* argument, then Emacs sets your current working directory to where your program resides. If you only specify the file name, then Emacs sets your current working directory to the directory associated with the previous buffer. In this case, GDB may find your program by searching your environment's `PATH` variable, but on some operating systems it might not find the source. So, although the GDB input and output session proceeds normally, the auxiliary buffer does not display the current source and line of execution.

The initial working directory of GDB is printed on the top line of the GUD buffer and this serves as a default for the commands that specify files for GDB to operate on. See Section 18.1 [Commands to Specify Files], page 215.

By default, *M-x gdb* calls the program called 'gdb'. If you need to call GDB by a different name (for example, if you keep several configurations around, with different names) you can customize the Emacs variable `gud-gdb-command-name` to run the one you want.

In the GUD buffer, you can use these special Emacs commands in addition to the standard Shell mode commands:

C-h m Describe the features of Emacs' GUD Mode.

C-c C-s Execute to another source line, like the GDB `step` command; also update the display window to show the current file and location.

C-c C-n Execute to next source line in this function, skipping all function calls, like the GDB `next` command. Then update the display window to show the current file and location.

C-c C-i Execute one instruction, like the GDB `stepi` command; update display window accordingly.

C-c C-f Execute until exit from the selected stack frame, like the GDB `finish` command.

C-c C-r Continue execution of your program, like the GDB `continue` command.

C-c < Go up the number of frames indicated by the numeric argument (see Section "Numeric Arguments" in *The GNU Emacs Manual*), like the GDB `up` command.

C-c > Go down the number of frames indicated by the numeric argument, like the GDB `down` command.

In any source file, the Emacs command *C-x SPC* (`gud-break`) tells GDB to set a breakpoint on the source line point is on.

In text command mode, if you type *M-x speedbar*, Emacs displays a separate frame which shows a backtrace when the GUD buffer is current. Move point to any frame in the stack and type RET to make it become the current frame and display the associated source in the source buffer. Alternatively, click *Mouse-2* to make the selected frame become the current one. In graphical mode, the speedbar displays watch expressions.

If you accidentally delete the source-display buffer, an easy way to get it back is to type the command `f` in the GDB buffer, to request a frame display; when you run under Emacs, this recreates the source buffer if necessary to show you the context of the current frame.

The source files displayed in Emacs are in ordinary Emacs buffers which are visiting the source files in the usual way. You can edit the files with these buffers if you wish; but keep in mind that GDB communicates with Emacs in terms of line numbers. If you add or delete lines from the text, the line numbers that GDB knows cease to correspond properly with the code.

A more detailed description of Emacs' interaction with GDB is given in the Emacs manual (see Section "Debuggers" in *The GNU Emacs Manual*).

27 The GDB/MI Interface

Function and Purpose

GDB/MI is a line based machine oriented text interface to GDB and is activated by specifying using the '`--interpreter`' command line option (see Section 2.1.2 [Mode Options], page 13). It is specifically intended to support the development of systems which use the debugger as just one small component of a larger system.

This chapter is a specification of the GDB/MI interface. It is written in the form of a reference manual.

Note that GDB/MI is still under construction, so some of the features described below are incomplete and subject to change (see Section 27.6 [GDB/MI Development and Front Ends], page 371).

Notation and Terminology

This chapter uses the following notation:

- `|` separates two alternatives.
- `[` *`something`* `]` indicates that *something* is optional: it may or may not be given.
- `(` *`group`* `)*` means that *group* inside the parentheses may repeat zero or more times.
- `(` *`group`* `)+` means that *group* inside the parentheses may repeat one or more times.
- `"`*`string`*`"` means a literal *string*.

27.3 GDB/MI General Design

Interaction of a GDB/MI frontend with GDB involves three parts—commands sent to GDB, responses to those commands and notifications. Each command results in exactly one response, indicating either successful completion of the command, or an error. For the commands that do not resume the target, the response contains the requested information. For the commands that resume the target, the response only indicates whether the target was successfully resumed. Notifications is the mechanism for reporting changes in the state of the target, or in GDB state, that cannot conveniently be associated with a command and reported as part of that command response.

The important examples of notifications are:

- Exec notifications. These are used to report changes in target state—when a target is resumed, or stopped. It would not be feasible to include this information in response of resuming commands, because one resume commands can result in multiple events in different threads. Also, quite some time may pass before any event happens in the target, while a frontend needs to know whether the resuming command itself was successfully executed.
- Console output, and status notifications. Console output notifications are used to report output of CLI commands, as well as diagnostics for other commands. Status notifications are used to report the progress of a long-running operation. Naturally, including this information in command response would mean no output is produced until the command is finished, which is undesirable.

- General notifications. Commands may have various side effects on the GDB or target state beyond their official purpose. For example, a command may change the selected thread. Although such changes can be included in command response, using notification allows for more orthogonal frontend design.

There's no guarantee that whenever an MI command reports an error, GDB or the target are in any specific state, and especially, the state is not reverted to the state before the MI command was processed. Therefore, whenever an MI command results in an error, we recommend that the frontend refreshes all the information shown in the user interface.

27.3.1 Context management

In most cases when GDB accesses the target, this access is done in context of a specific thread and frame (see Section 8.1 [Frames], page 87). Often, even when accessing global data, the target requires that a thread be specified. The CLI interface maintains the selected thread and frame, and supplies them to target on each command. This is convenient, because a command line user would not want to specify that information explicitly on each command, and because user interacts with GDB via a single terminal, so no confusion is possible as to what thread and frame are the current ones.

In the case of MI, the concept of selected thread and frame is less useful. First, a frontend can easily remember this information itself. Second, a graphical frontend can have more than one window, each one used for debugging a different thread, and the frontend might want to access additional threads for internal purposes. This increases the risk that by relying on implicitly selected thread, the frontend may be operating on a wrong one. Therefore, each MI command should explicitly specify which thread and frame to operate on. To make it possible, each MI command accepts the '`--thread`' and '`--frame`' options, the value to each is GDB identifier for thread and frame to operate on.

Usually, each top-level window in a frontend allows the user to select a thread and a frame, and remembers the user selection for further operations. However, in some cases GDB may suggest that the current thread be changed. For example, when stopping on a breakpoint it is reasonable to switch to the thread where breakpoint is hit. For another example, if the user issues the CLI '`thread`' command via the frontend, it is desirable to change the frontend's selected thread to the one specified by user. GDB communicates the suggestion to change current thread using the '`=thread-selected`' notification. No such notification is available for the selected frame at the moment.

Note that historically, MI shares the selected thread with CLI, so frontends used the `-thread-select` to execute commands in the right context. However, getting this to work right is cumbersome. The simplest way is for frontend to emit `-thread-select` command before every command. This doubles the number of commands that need to be sent. The alternative approach is to suppress `-thread-select` if the selected thread in GDB is supposed to be identical to the thread the frontend wants to operate on. However, getting this optimization right can be tricky. In particular, if the frontend sends several commands to GDB, and one of the commands changes the selected thread, then the behaviour of subsequent commands will change. So, a frontend should either wait for response from such problematic commands, or explicitly add `-thread-select` for all subsequent commands. No frontend is known to do this exactly right, so it is suggested to just always pass the '`--thread`' and '`--frame`' options.

27.3.2 Asynchronous command execution and non-stop mode

On some targets, GDB is capable of processing MI commands even while the target is running. This is called *asynchronous command execution* (see Section 5.5.3 [Background Execution], page 75). The frontend may specify a preferrence for asynchronous execution using the `-gdb-set target-async 1` command, which should be emitted before either running the executable or attaching to the target. After the frontend has started the executable or attached to the target, it can find if asynchronous execution is enabled using the `-list-target-features` command.

Even if GDB can accept a command while target is running, many commands that access the target do not work when the target is running. Therefore, asynchronous command execution is most useful when combined with non-stop mode (see Section 5.5.2 [Non-Stop Mode], page 74). Then, it is possible to examine the state of one thread, while other threads are running.

When a given thread is running, MI commands that try to access the target in the context of that thread may not work, or may work only on some targets. In particular, commands that try to operate on thread's stack will not work, on any target. Commands that read memory, or modify breakpoints, may work or not work, depending on the target. Note that even commands that operate on global state, such as `print`, `set`, and breakpoint commands, still access the target in the context of a specific thread, so frontend should try to find a stopped thread and perform the operation on that thread (using the '`--thread`' option).

Which commands will work in the context of a running thread is highly target dependent. However, the two commands `-exec-interrupt`, to stop a thread, and `-thread-info`, to find the state of a thread, will always work.

27.3.3 Thread groups

GDB may be used to debug several processes at the same time. On some platfroms, GDB may support debugging of several hardware systems, each one having several cores with several different processes running on each core. This section describes the MI mechanism to support such debugging scenarios.

The key observation is that regardless of the structure of the target, MI can have a global list of threads, because most commands that accept the '`--thread`' option do not need to know what process that thread belongs to. Therefore, it is not necessary to introduce neither additional '`--process`' option, nor an notion of the current process in the MI interface. The only strictly new feature that is required is the ability to find how the threads are grouped into processes.

To allow the user to discover such grouping, and to support arbitrary hierarchy of machines/cores/processes, MI introduces the concept of a *thread group*. Thread group is a collection of threads and other thread groups. A thread group always has a string identifier, a type, and may have additional attributes specific to the type. A new command, `-list-thread-groups`, returns the list of top-level thread groups, which correspond to processes that GDB is debugging at the moment. By passing an identifier of a thread group to the `-list-thread-groups` command, it is possible to obtain the members of specific thread group.

To allow the user to easily discover processes, and other objects, he wishes to debug, a concept of *available thread group* is introduced. Available thread group is an thread group that GDB is not debugging, but that can be attached to, using the `-target-attach` command. The list of available top-level thread groups can be obtained using '`-list-thread-groups --available`'. In general, the content of a thread group may be only retrieved only after attaching to that thread group.

Thread groups are related to inferiors (see Section 4.9 [Inferiors and Programs], page 32). Each inferior corresponds to a thread group of a special type '`process`', and some additional operations are permitted on such thread groups.

27.4 GDB/MI Command Syntax

27.4.1 GDB/MI Input Syntax

command ↦
: *cli-command* | *mi-command*

cli-command ↦
: [*token*] *cli-command nl*, where *cli-command* is any existing GDB CLI command.

mi-command ↦
: [*token*] "-" *operation* (" " *option*)* [" --"] (" " *parameter*)* *nl*

token ↦
: "any sequence of digits"

option ↦
: "-" *parameter* [" " *parameter*]

parameter ↦
: *non-blank-sequence* | *c-string*

operation ↦
: *any of the operations described in this chapter*

non-blank-sequence ↦
: *anything, provided it doesn't contain special characters such as* "-", *nl,* """ *and of course* " "

c-string ↦
: """ *seven-bit-iso-c-string-content* """

nl ↦
: CR | CR-LF

Notes:

- The CLI commands are still handled by the MI interpreter; their output is described below.
- The *token*, when present, is passed back when the command finishes.
- Some MI commands accept optional arguments as part of the parameter list. Each option is identified by a leading '`-`' (dash) and may be followed by an optional argument parameter. Options occur first in the parameter list and can be delimited from normal parameters using '`--`' (this is useful when some parameters begin with a dash).

Pragmatics:

- We want easy access to the existing CLI syntax (for debugging).
- We want it to be easy to spot a MI operation.

27.4.2 GDB/MI Output Syntax

The output from GDB/MI consists of zero or more out-of-band records followed, optionally, by a single result record. This result record is for the most recent command. The sequence of output records is terminated by '`(gdb)`'.

If an input command was prefixed with a *`token`* then the corresponding output for that command will also be prefixed by that same *token*.

output ↦
`( out-of-band-record )* [ result-record ] "(gdb)" nl`

result-record ↦
`[ token ] "^" result-class ( "," result )* nl`

out-of-band-record ↦
`async-record | stream-record`

async-record ↦
`exec-async-output | status-async-output | notify-async-output`

exec-async-output ↦
`[ token ] "*" async-output`

status-async-output ↦
`[ token ] "+" async-output`

notify-async-output ↦
`[ token ] "=" async-output`

async-output ↦
`async-class ( "," result )* nl`

result-class ↦
`"done" | "running" | "connected" | "error" | "exit"`

async-class ↦
`"stopped" | others` (where *others* will be added depending on the needs—this is still in development).

result ↦
`variable "=" value`

variable ↦
`string`

value ↦ `const | tuple | list`

const ↦ `c-string`

tuple ↦ `"{}" | "{" result ( "," result )* "}"`

list ↦ `"[]" | "[" value ( "," value )* "]" | "[" result ( "," result )* "]"`

```
stream-record ↦
          console-stream-output | target-stream-output | log-stream-output

console-stream-output ↦
          "~" c-string

target-stream-output ↦
          "@" c-string

log-stream-output ↦
          "&" c-string

nl ↦      CR | CR-LF

token ↦   any sequence of digits.
```

Notes:

- All output sequences end in a single line containing a period.
- The *token* is from the corresponding request. Note that for all async output, while the token is allowed by the grammar and may be output by future versions of GDB for select async output messages, it is generally omitted. Frontends should treat all async output as reporting general changes in the state of the target and there should be no need to associate async output to any prior command.
- *status-async-output* contains on-going status information about the progress of a slow operation. It can be discarded. All status output is prefixed by '`+`'.
- *exec-async-output* contains asynchronous state change on the target (stopped, started, disappeared). All async output is prefixed by '`*`'.
- *notify-async-output* contains supplementary information that the client should handle (e.g., a new breakpoint information). All notify output is prefixed by '`=`'.
- *console-stream-output* is output that should be displayed as is in the console. It is the textual response to a CLI command. All the console output is prefixed by '`~`'.
- *target-stream-output* is the output produced by the target program. All the target output is prefixed by '`@`'.
- *log-stream-output* is output text coming from GDB's internals, for instance messages that should be displayed as part of an error log. All the log output is prefixed by '`&`'.
- New GDB/MI commands should only output *lists* containing *values*.

See Section 27.7.2 [GDB/MI Stream Records], page 372, for more details about the various output records.

27.5 GDB/MI Compatibility with CLI

For the developers convenience CLI commands can be entered directly, but there may be some unexpected behaviour. For example, commands that query the user will behave as if the user replied yes, breakpoint command lists are not executed and some CLI commands, such as `if`, `when` and `define`, prompt for further input with '`>`', which is not valid MI output.

This feature may be removed at some stage in the future and it is recommended that front ends use the `-interpreter-exec` command (see [-interpreter-exec], page 441).

27.6 GDB/MI Development and Front Ends

The application which takes the MI output and presents the state of the program being debugged to the user is called a *front end*.

Although GDB/MI is still incomplete, it is currently being used by a variety of front ends to GDB. This makes it difficult to introduce new functionality without breaking existing usage. This section tries to minimize the problems by describing how the protocol might change.

Some changes in MI need not break a carefully designed front end, and for these the MI version will remain unchanged. The following is a list of changes that may occur within one level, so front ends should parse MI output in a way that can handle them:

- New MI commands may be added.
- New fields may be added to the output of any MI command.
- The range of values for fields with specified values, e.g., `in_scope` (see [-var-update], page 414) may be extended.

If the changes are likely to break front ends, the MI version level will be increased by one. This will allow the front end to parse the output according to the MI version. Apart from mi0, new versions of GDB will not support old versions of MI and it will be the responsibility of the front end to work with the new one.

The best way to avoid unexpected changes in MI that might break your front end is to make your project known to GDB developers and follow development on `gdb@sourceware.org` and `gdb-patches@sourceware.org`.

27.7 GDB/MI Output Records

27.7.1 GDB/MI Result Records

In addition to a number of out-of-band notifications, the response to a GDB/MI command includes one of the following result indications:

`"^done" [ "," results ]`
: The synchronous operation was successful, *`results`* are the return values.

`"^running"`
: This result record is equivalent to '`^done`'. Historically, it was output instead of '`^done`' if the command has resumed the target. This behaviour is maintained for backward compatibility, but all frontends should treat '`^done`' and '`^running`' identically and rely on the '`*running`' output record to determine which threads are resumed.

`"^connected"`
: GDB has connected to a remote target.

`"^error" "," c-string`
: The operation failed. The *`c-string`* contains the corresponding error message.

`"^exit"`
: GDB has terminated.

27.7.2 GDB/MI Stream Records

GDB internally maintains a number of output streams: the console, the target, and the log. The output intended for each of these streams is funneled through the GDB/MI interface using *stream records*.

Each stream record begins with a unique *prefix character* which identifies its stream (see Section 27.4.2 [GDB/MI Output Syntax], page 369). In addition to the prefix, each stream record contains a *string-output*. This is either raw text (with an implicit new line) or a quoted C string (which does not contain an implicit newline).

"~" *string-output*
: The console output stream contains text that should be displayed in the CLI console window. It contains the textual responses to CLI commands.

"@" *string-output*
: The target output stream contains any textual output from the running target. This is only present when GDB's event loop is truly asynchronous, which is currently only the case for remote targets.

"&" *string-output*
: The log stream contains debugging messages being produced by GDB's internals.

27.7.3 GDB/MI Async Records

Async records are used to notify the GDB/MI client of additional changes that have occurred. Those changes can either be a consequence of GDB/MI commands (e.g., a breakpoint modified) or a result of target activity (e.g., target stopped).

The following is the list of possible async records:

*running,thread-id="*thread*"
: The target is now running. The *thread* field tells which specific thread is now running, and can be 'all' if all threads are running. The frontend should assume that no interaction with a running thread is possible after this notification is produced. The frontend should not assume that this notification is output only once for any command. GDB may emit this notification several times, either for different threads, because it cannot resume all threads together, or even for a single thread, if the thread must be stepped though some code before letting it run freely.

*stopped,reason="*reason*",thread-id="*id*",stopped-threads="*stopped*",core="*core*"
: The target has stopped. The *reason* field can have one of the following values:

  breakpoint-hit
  : A breakpoint was reached.

  watchpoint-trigger
  : A watchpoint was triggered.

  read-watchpoint-trigger
  : A read watchpoint was triggered.

  access-watchpoint-trigger
  : An access watchpoint was triggered.

`function-finished`
: An -exec-finish or similar CLI command was accomplished.

`location-reached`
: An -exec-until or similar CLI command was accomplished.

`watchpoint-scope`
: A watchpoint has gone out of scope.

`end-stepping-range`
: An -exec-next, -exec-next-instruction, -exec-step, -exec-step-instruction or similar CLI command was accomplished.

`exited-signalled`
: The inferior exited because of a signal.

`exited`
: The inferior exited.

`exited-normally`
: The inferior exited normally.

`signal-received`
: A signal was received by the inferior.

`solib-event`
: The inferior has stopped due to a library being loaded or unloaded. This can happen when `stop-on-solib-events` (see Section 18.1 [Files], page 215) is set or when a `catch load` or `catch unload` catchpoint is in use (see Section 5.1.3 [Set Catchpoints], page 53).

`fork`
: The inferior has forked. This is reported when `catch fork` (see Section 5.1.3 [Set Catchpoints], page 53) has been used.

`vfork`
: The inferior has vforked. This is reported in when `catch vfork` (see Section 5.1.3 [Set Catchpoints], page 53) has been used.

`syscall-entry`
: The inferior entered a system call. This is reported when `catch syscall` (see Section 5.1.3 [Set Catchpoints], page 53) has been used.

`syscall-entry`
: The inferior returned from a system call. This is reported when `catch syscall` (see Section 5.1.3 [Set Catchpoints], page 53) has been used.

`exec`
: The inferior called `exec`. This is reported when `catch exec` (see Section 5.1.3 [Set Catchpoints], page 53) has been used.

The *id* field identifies the thread that directly caused the stop – for example by hitting a breakpoint. Depending on whether all-stop mode is in effect (see Section 5.5.1 [All-Stop Mode], page 72), GDB may either stop all threads, or only the thread that directly triggered the stop. If all threads are stopped, the *stopped* field will have the value of `"all"`. Otherwise, the value of the *stopped* field will be a list of thread identifiers. Presently, this list will always include a

single thread, but frontend should be prepared to see several threads in the list. The *core* field reports the processor core on which the stop event has happened. This field may be absent if such information is not available.

`=thread-group-added,id="`*id*`"`
`=thread-group-removed,id="`*id*`"`
A thread group was either added or removed. The *id* field contains the GDB identifier of the thread group. When a thread group is added, it generally might not be associated with a running process. When a thread group is removed, its id becomes invalid and cannot be used in any way.

`=thread-group-started,id="`*id*`",pid="`*pid*`"`
A thread group became associated with a running program, either because the program was just started or the thread group was attached to a program. The *id* field contains the GDB identifier of the thread group. The *pid* field contains process identifier, specific to the operating system.

`=thread-group-exited,id="`*id*`"[,exit-code="`*code*`"]`
A thread group is no longer associated with a running program, either because the program has exited, or because it was detached from. The *id* field contains the GDB identifier of the thread group. *code* is the exit code of the inferior; it exists only when the inferior exited with some code.

`=thread-created,id="`*id*`",group-id="`*gid*`"`
`=thread-exited,id="`*id*`",group-id="`*gid*`"`
A thread either was created, or has exited. The *id* field contains the GDB identifier of the thread. The *gid* field identifies the thread group this thread belongs to.

`=thread-selected,id="`*id*`"`
Informs that the selected thread was changed as result of the last command. This notification is not emitted as result of `-thread-select` command but is emitted whenever an MI command that is not documented to change the selected thread actually changes it. In particular, invoking, directly or indirectly (via user-defined command), the CLI `thread` command, will generate this notification.

We suggest that in response to this notification, front ends highlight the selected thread and cause subsequent commands to apply to that thread.

`=library-loaded,...`
Reports that a new library file was loaded by the program. This notification has 4 fields—*id*, *target-name*, *host-name*, and *symbols-loaded*. The *id* field is an opaque identifier of the library. For remote debugging case, *target-name* and *host-name* fields give the name of the library file on the target, and on the host respectively. For native debugging, both those fields have the same value. The *symbols-loaded* field is emitted only for backward compatibility and should not be relied on to convey any useful information. The *thread-group* field, if present, specifies the id of the thread group in whose context the library was loaded. If the field is absent, it means the library was loaded in the context of all present thread groups.

`=library-unloaded,...`
: Reports that a library was unloaded by the program. This notification has 3 fields—*id*, *target-name* and *host-name* with the same meaning as for the `=library-loaded` notification. The *thread-group* field, if present, specifies the id of the thread group in whose context the library was unloaded. If the field is absent, it means the library was unloaded in the context of all present thread groups.

`=traceframe-changed,num=`*tfnum*`,tracepoint=`*tpnum*
`=traceframe-changed,end`
: Reports that the trace frame was changed and its new number is *tfnum*. The number of the tracepoint associated with this trace frame is *tpnum*.

`=tsv-created,name=`*name*`,initial=`*initial*
: Reports that the new trace state variable *name* is created with initial value *initial*.

`=tsv-deleted,name=`*name*
`=tsv-deleted`
: Reports that the trace state variable *name* is deleted or all trace state variables are deleted.

`=tsv-modified,name=`*name*`,initial=`*initial*`[,current=`*current*`]`
: Reports that the trace state variable *name* is modified with the initial value *initial*. The current value *current* of trace state variable is optional and is reported if the current value of trace state variable is known.

`=breakpoint-created,bkpt={...}`
`=breakpoint-modified,bkpt={...}`
`=breakpoint-deleted,id=`*number*
: Reports that a breakpoint was created, modified, or deleted, respectively. Only user-visible breakpoints are reported to the MI user.

  The *bkpt* argument is of the same form as returned by the various breakpoint commands; See Section 27.10 [GDB/MI Breakpoint Commands], page 380. The *number* is the ordinal number of the breakpoint.

  Note that if a breakpoint is emitted in the result record of a command, then it will not also be emitted in an async record.

`=record-started,thread-group="`*id*`"`
`=record-stopped,thread-group="`*id*`"`
: Execution log recording was either started or stopped on an inferior. The *id* is the GDB identifier of the thread group corresponding to the affected inferior.

`=cmd-param-changed,param=`*param*`,value=`*value*
: Reports that a parameter of the command `set` *param* is changed to *value*. In the multi-word `set` command, the *param* is the whole parameter list to `set` command. For example, In command `set check type on`, *param* is `check type` and *value* is `on`.

`=memory-changed,thread-group=`*id*`,addr=`*addr*`,len=`*len*`[,type="code"]`
: Reports that bytes from *addr* to *data* + *len* were written in an inferior. The *id* is the identifier of the thread group corresponding to the affected inferior.

The optional `type="code"` part is reported if the memory written to holds executable code.

27.7.4 GDB/MI Breakpoint Information

When GDB reports information about a breakpoint, a tracepoint, a watchpoint, or a catchpoint, it uses a tuple with the following fields:

`number` The breakpoint number. For a breakpoint that represents one location of a multi-location breakpoint, this will be a dotted pair, like '`1.2`'.

`type` The type of the breakpoint. For ordinary breakpoints this will be '`breakpoint`', but many values are possible.

`catch-type`
If the type of the breakpoint is '`catchpoint`', then this indicates the exact type of catchpoint.

`disp` This is the breakpoint disposition—either '`del`', meaning that the breakpoint will be deleted at the next stop, or '`keep`', meaning that the breakpoint will not be deleted.

`enabled` This indicates whether the breakpoint is enabled, in which case the value is '`y`', or disabled, in which case the value is '`n`'. Note that this is not the same as the field `enable`.

`addr` The address of the breakpoint. This may be a hexidecimal number, giving the address; or the string '`<PENDING>`', for a pending breakpoint; or the string '`<MULTIPLE>`', for a breakpoint with multiple locations. This field will not be present if no address can be determined. For example, a watchpoint does not have an address.

`func` If known, the function in which the breakpoint appears. If not known, this field is not present.

`filename` The name of the source file which contains this function, if known. If not known, this field is not present.

`fullname` The full file name of the source file which contains this function, if known. If not known, this field is not present.

`line` The line number at which this breakpoint appears, if known. If not known, this field is not present.

`at` If the source file is not known, this field may be provided. If provided, this holds the address of the breakpoint, possibly followed by a symbol name.

`pending` If this breakpoint is pending, this field is present and holds the text used to set the breakpoint, as entered by the user.

`evaluated-by`
Where this breakpoint's condition is evaluated, either '`host`' or '`target`'.

`thread` If this is a thread-specific breakpoint, then this identifies the thread in which the breakpoint can trigger.

`task` If this breakpoint is restricted to a particular Ada task, then this field will hold the task identifier.

`cond` If the breakpoint is conditional, this is the condition expression.

`ignore` The ignore count of the breakpoint.

`enable` The enable count of the breakpoint.

`traceframe-usage`
FIXME.

`static-tracepoint-marker-string-id`
For a static tracepoint, the name of the static tracepoint marker.

`mask` For a masked watchpoint, this is the mask.

`pass` A tracepoint's pass count.

`original-location`
The location of the breakpoint as originally specified by the user. This field is optional.

`times` The number of times the breakpoint has been hit.

`installed`
This field is only given for tracepoints. This is either '`y`', meaning that the tracepoint is installed, or '`n`', meaning that it is not.

`what` Some extra data, the exact contents of which are type-dependent.

For example, here is what the output of `-break-insert` (see Section 27.10 [GDB/MI Breakpoint Commands], page 380) might be:

```
-> -break-insert main
<- ^done,bkpt={number="1",type="breakpoint",disp="keep",
    enabled="y",addr="0x08048564",func="main",file="myprog.c",
    fullname="/home/nickrob/myprog.c",line="68",thread-groups=["i1"],
    times="0"}
<- (gdb)
```

27.7.5 GDB/MI Frame Information

Response from many MI commands includes an information about stack frame. This information is a tuple that may have the following fields:

`level` The level of the stack frame. The innermost frame has the level of zero. This field is always present.

`func` The name of the function corresponding to the frame. This field may be absent if GDB is unable to determine the function name.

`addr` The code address for the frame. This field is always present.

`file` The name of the source files that correspond to the frame's code address. This field may be absent.

`line` The source line corresponding to the frames' code address. This field may be absent.

`from` The name of the binary file (either executable or shared library) the corresponds to the frame's code address. This field may be absent.

27.7.6 GDB/MI Thread Information

Whenever GDB has to report an information about a thread, it uses a tuple with the following fields:

`id` The numeric id assigned to the thread by GDB. This field is always present.

`target-id`
Target-specific string identifying the thread. This field is always present.

`details` Additional information about the thread provided by the target. It is supposed to be human-readable and not interpreted by the frontend. This field is optional.

`state` Either '`stopped`' or '`running`', depending on whether the thread is presently running. This field is always present.

`core` The value of this field is an integer number of the processor core the thread was last seen on. This field is optional.

27.7.7 GDB/MI Ada Exception Information

Whenever a `*stopped` record is emitted because the program stopped after hitting an exception catchpoint (see Section 5.1.3 [Set Catchpoints], page 53), GDB provides the name of the exception that was raised via the `exception-name` field.

27.8 Simple Examples of GDB/MI Interaction

This subsection presents several simple examples of interaction using the GDB/MI interface. In these examples, '`->`' means that the following line is passed to GDB/MI as input, while '`<-`' means the output received from GDB/MI.

Note the line breaks shown in the examples are here only for readability, they don't appear in the real output.

Setting a Breakpoint

Setting a breakpoint generates synchronous output which contains detailed information of the breakpoint.

```
-> -break-insert main
<- ^done,bkpt={number="1",type="breakpoint",disp="keep",
    enabled="y",addr="0x08048564",func="main",file="myprog.c",
    fullname="/home/nickrob/myprog.c",line="68",thread-groups=["i1"],
    times="0"}
<- (gdb)
```

Program Execution

Program execution generates asynchronous records and MI gives the reason that execution stopped.

```
-> -exec-run
<- ^running
<- (gdb)
<- *stopped,reason="breakpoint-hit",disp="keep",bkptno="1",thread-id="0",
   frame={addr="0x08048564",func="main",
   args=[{name="argc",value="1"},{name="argv",value="0xbfc4d4d4"}],
   file="myprog.c",fullname="/home/nickrob/myprog.c",line="68"}
```

```
<- (gdb)
-> -exec-continue
<- ^running
<- (gdb)
<- *stopped,reason="exited-normally"
<- (gdb)
```

Quitting GDB

Quitting GDB just prints the result class '`^exit`'.

```
-> (gdb)
<- -gdb-exit
<- ^exit
```

Please note that '`^exit`' is printed immediately, but it might take some time for GDB to actually exit. During that time, GDB performs necessary cleanups, including killing programs being debugged or disconnecting from debug hardware, so the frontend should wait till GDB exits and should only forcibly kill GDB if it fails to exit in reasonable time.

A Bad Command

Here's what happens if you pass a non-existent command:

```
-> -rubbish
<- ^error,msg="Undefined MI command: rubbish"
<- (gdb)
```

27.9 GDB/MI Command Description Format

The remaining sections describe blocks of commands. Each block of commands is laid out in a fashion similar to this section.

Motivation

The motivation for this collection of commands.

Introduction

A brief introduction to this collection of commands as a whole.

Commands

For each command in the block, the following is described:

Synopsis

```
-command args...
```

Result

GDB Command

The corresponding GDB CLI command(s), if any.

Example

Example(s) formatted for readability. Some of the described commands have not been implemented yet and these are labeled N.A. (not available).

27.10 GDB/MI Breakpoint Commands

This section documents GDB/MI commands for manipulating breakpoints.

The -break-after Command

Synopsis

```
-break-after number count
```

The breakpoint number *number* is not in effect until it has been hit *count* times. To see how this is reflected in the output of the '`-break-list`' command, see the description of the '`-break-list`' command below.

GDB Command

The corresponding GDB command is '`ignore`'.

Example

```
(gdb)
-break-insert main
^done,bkpt={number="1",type="breakpoint",disp="keep",
enabled="y",addr="0x000100d0",func="main",file="hello.c",
fullname="/home/foo/hello.c",line="5",thread-groups=["i1"],
times="0"}
(gdb)
-break-after 1 3
~
^done
(gdb)
-break-list
^done,BreakpointTable={nr_rows="1",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x000100d0",func="main",file="hello.c",fullname="/home/foo/hello.c",
line="5",thread-groups=["i1"],times="0",ignore="3"}]}
(gdb)
```

The -break-commands Command

Synopsis

```
-break-commands number [ command1 ... commandN ]
```

Specifies the CLI commands that should be executed when breakpoint *number* is hit. The parameters *command1* to *commandN* are the commands. If no command is specified, any previously-set commands are cleared. See Section 5.1.7 [Break Commands], page 60. Typical use of this functionality is tracing a program, that is, printing of values of some variables whenever breakpoint is hit and then continuing.

GDB Command

The corresponding GDB command is '`commands`'.

Example

```
(gdb)
-break-insert main
^done,bkpt={number="1",type="breakpoint",disp="keep",
enabled="y",addr="0x000100d0",func="main",file="hello.c",
fullname="/home/foo/hello.c",line="5",thread-groups=["i1"],
times="0"}
(gdb)
-break-commands 1 "print v" "continue"
^done
(gdb)
```

The `-break-condition` Command

Synopsis

```
-break-condition number expr
```

Breakpoint *number* will stop the program only if the condition in *expr* is true. The condition becomes part of the '`-break-list`' output (see the description of the '`-break-list`' command below).

GDB Command

The corresponding GDB command is '`condition`'.

Example

```
(gdb)
-break-condition 1 1
^done
(gdb)
-break-list
^done,BreakpointTable={nr_rows="1",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x000100d0",func="main",file="hello.c",fullname="/home/foo/hello.c",
line="5",cond="1",thread-groups=["i1"],times="0",ignore="3"}]}
(gdb)
```

The `-break-delete` Command

Synopsis

```
-break-delete ( breakpoint )+
```

Delete the breakpoint(s) whose number(s) are specified in the argument list. This is obviously reflected in the breakpoint list.

GDB Command

The corresponding GDB command is '`delete`'.

Example

```
(gdb)
-break-delete 1
^done
(gdb)
-break-list
^done,BreakpointTable={nr_rows="0",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[]}
(gdb)
```

The `-break-disable` Command

Synopsis

```
-break-disable ( breakpoint )+
```

Disable the named *breakpoint*(s). The field '`enabled`' in the break list is now set to '`n`' for the named *breakpoint*(s).

GDB Command

The corresponding GDB command is '`disable`'.

Example

```
(gdb)
-break-disable 2
^done
(gdb)
-break-list
^done,BreakpointTable={nr_rows="1",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="2",type="breakpoint",disp="keep",enabled="n",
addr="0x000100d0",func="main",file="hello.c",fullname="/home/foo/hello.c",
line="5",thread-groups=["i1"],times="0"}]}
(gdb)
```

The `-break-enable` Command

Synopsis

```
-break-enable ( breakpoint )+
```

Enable (previously disabled) *breakpoint*(s).

GDB Command

The corresponding GDB command is '`enable`'.

Example

```
(gdb)
-break-enable 2
^done
(gdb)
-break-list
^done,BreakpointTable={nr_rows="1",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="2",type="breakpoint",disp="keep",enabled="y",
addr="0x000100d0",func="main",file="hello.c",fullname="/home/foo/hello.c",
line="5",thread-groups=["i1"],times="0"}]}
(gdb)
```

The `-break-info` Command

Synopsis

```
-break-info breakpoint
```

Get information about a single breakpoint.

The result is a table of breakpoints. See Section 27.7.4 [GDB/MI Breakpoint Information], page 376, for details on the format of each breakpoint in the table.

GDB Command

The corresponding GDB command is '`info break` *`breakpoint`*'.

Example

N.A.

The `-break-insert` Command

Synopsis

```
-break-insert [ -t ] [ -h ] [ -f ] [ -d ] [ -a ]
   [ -c condition ] [ -i ignore-count ]
   [ -p thread-id ] [ location ]
```

If specified, *location*, can be one of:

- function
- filename:linenum
- filename:function
- *address

The possible optional parameters of this command are:

'`-t`' Insert a temporary breakpoint.

'`-h`' Insert a hardware breakpoint.

‘`-f`’ If *location* cannot be parsed (for example if it refers to unknown files or functions), create a pending breakpoint. Without this flag, GDB will report an error, and won't create a breakpoint, if *location* cannot be parsed.

‘`-d`’ Create a disabled breakpoint.

‘`-a`’ Create a tracepoint. See Chapter 13 [Tracepoints], page 149. When this parameter is used together with ‘`-h`’, a fast tracepoint is created.

‘`-c condition`’
Make the breakpoint conditional on *condition*.

‘`-i ignore-count`’
Initialize the *ignore-count*.

‘`-p thread-id`’
Restrict the breakpoint to the specified *thread-id*.

Result

See Section 27.7.4 [GDB/MI Breakpoint Information], page 376, for details on the format of the resulting breakpoint.

Note: this format is open to change.

GDB Command

The corresponding GDB commands are ‘`break`’, ‘`tbreak`’, ‘`hbreak`’, and ‘`thbreak`’.

Example

```
(gdb)
-break-insert main
^done,bkpt={number="1",addr="0x0001072c",file="recursive2.c",
fullname="/home/foo/recursive2.c,line="4",thread-groups=["i1"],
times="0"}
(gdb)
-break-insert -t foo
^done,bkpt={number="2",addr="0x00010774",file="recursive2.c",
fullname="/home/foo/recursive2.c,line="11",thread-groups=["i1"],
times="0"}
(gdb)
-break-list
^done,BreakpointTable={nr_rows="2",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x0001072c", func="main",file="recursive2.c",
fullname="/home/foo/recursive2.c,"line="4",thread-groups=["i1"],
times="0"},
bkpt={number="2",type="breakpoint",disp="del",enabled="y",
addr="0x00010774",func="foo",file="recursive2.c",
fullname="/home/foo/recursive2.c",line="11",thread-groups=["i1"],
times="0"}]}
(gdb)
```

The -break-list Command

Synopsis

```
-break-list
```

Displays the list of inserted breakpoints, showing the following fields:

'Number' number of the breakpoint

'Type' type of the breakpoint: 'breakpoint' or 'watchpoint'

'Disposition'
should the breakpoint be deleted or disabled when it is hit: 'keep' or 'nokeep'

'Enabled' is the breakpoint enabled or no: 'y' or 'n'

'Address' memory location at which the breakpoint is set

'What' logical location of the breakpoint, expressed by function name, file name, line number

'Thread-groups'
list of thread groups to which this breakpoint applies

'Times' number of times the breakpoint has been hit

If there are no breakpoints or watchpoints, the BreakpointTable body field is an empty list.

GDB Command

The corresponding GDB command is 'info break'.

Example

```
(gdb)
-break-list
^done,BreakpointTable={nr_rows="2",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x000100d0",func="main",file="hello.c",line="5",thread-groups=["i1"],
times="0"},
bkpt={number="2",type="breakpoint",disp="keep",enabled="y",
addr="0x00010114",func="foo",file="hello.c",fullname="/home/foo/hello.c",
line="13",thread-groups=["i1"],times="0"}]}
(gdb)
```

Here's an example of the result when there are no breakpoints:

```
(gdb)
-break-list
^done,BreakpointTable={nr_rows="0",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
```

```
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[]}
(gdb)
```

The -break-passcount Command

Synopsis

```
-break-passcount tracepoint-number passcount
```

Set the passcount for tracepoint *tracepoint-number* to *passcount*. If the breakpoint referred to by *tracepoint-number* is not a tracepoint, error is emitted. This corresponds to CLI command '`passcount`'.

The -break-watch Command

Synopsis

```
-break-watch [ -a | -r ]
```

Create a watchpoint. With the '`-a`' option it will create an *access* watchpoint, i.e., a watchpoint that triggers either on a read from or on a write to the memory location. With the '`-r`' option, the watchpoint created is a *read* watchpoint, i.e., it will trigger only when the memory location is accessed for reading. Without either of the options, the watchpoint created is a regular watchpoint, i.e., it will trigger when the memory location is accessed for writing. See Section 5.1.2 [Setting Watchpoints], page 50.

Note that '`-break-list`' will report a single list of watchpoints and breakpoints inserted.

GDB Command

The corresponding GDB commands are '`watch`', '`awatch`', and '`rwatch`'.

Example

Setting a watchpoint on a variable in the `main` function:

```
(gdb)
-break-watch x
^done,wpt={number="2",exp="x"}
(gdb)
-exec-continue
^running
(gdb)
*stopped,reason="watchpoint-trigger",wpt={number="2",exp="x"},
value={old="-268439212",new="55"},
frame={func="main",args=[],file="recursive2.c",
fullname="/home/foo/bar/recursive2.c",line="5"}
(gdb)
```

Setting a watchpoint on a variable local to a function. GDB will stop the program execution twice: first for the variable changing value, then for the watchpoint going out of scope.

```
(gdb)
-break-watch C
^done,wpt={number="5",exp="C"}
```

```
(gdb)
-exec-continue
^running
(gdb)
*stopped,reason="watchpoint-trigger",
wpt={number="5",exp="C"},value={old="-276895068",new="3"},
frame={func="callee4",args=[],
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="13"}
(gdb)
-exec-continue
^running
(gdb)
*stopped,reason="watchpoint-scope",wpnum="5",
frame={func="callee3",args=[{name="strarg",
value="0x11940 \"A string argument.\""}],
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="18"}
(gdb)
```

Listing breakpoints and watchpoints, at different points in the program execution. Note that once the watchpoint goes out of scope, it is deleted.

```
(gdb)
-break-watch C
^done,wpt={number="2",exp="C"}
(gdb)
-break-list
^done,BreakpointTable={nr_rows="2",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x00010734",func="callee4",
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/devo/gdb/testsuite/gdb.mi/basics.c"line="8",thread-groups=["i1"],
times="1"},
bkpt={number="2",type="watchpoint",disp="keep",
enabled="y",addr="",what="C",thread-groups=["i1"],times="0"}]}
(gdb)
-exec-continue
^running
(gdb)
*stopped,reason="watchpoint-trigger",wpt={number="2",exp="C"},
value={old="-276895068",new="3"},
frame={func="callee4",args=[],
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="13"}
(gdb)
-break-list
^done,BreakpointTable={nr_rows="2",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
```

```
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x00010734",func="callee4",
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/devo/gdb/testsuite/gdb.mi/basics.c",line="8",thread-groups=["i1"],
times="1"},
bkpt={number="2",type="watchpoint",disp="keep",
enabled="y",addr="",what="C",thread-groups=["i1"],times="-5"}]}
(gdb)
-exec-continue
^running
^done,reason="watchpoint-scope",wpnum="2",
frame={func="callee3",args=[{name="strarg",
value="0x11940 \"A string argument.\""}],
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="18"}
(gdb)
-break-list
^done,BreakpointTable={nr_rows="1",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x00010734",func="callee4",
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/devo/gdb/testsuite/gdb.mi/basics.c",line="8",
thread-groups=["i1"],times="1"}]}
(gdb)
```

27.11 GDB/MI Catchpoint Commands

This section documents GDB/MI commands for manipulating catchpoints.

The `-catch-load` Command

Synopsis

```
-catch-load [ -t ] [ -d ] regexp
```

Add a catchpoint for library load events. If the '`-t`' option is used, the catchpoint is a temporary one (see Section 5.1.1 [Setting Breakpoints], page 44). If the '`-d`' option is used, the catchpoint is created in a disabled state. The '`regexp`' argument is a regular expression used to match the name of the loaded library.

GDB Command

The corresponding GDB command is '`catch load`'.

Example

```
-catch-load -t foo.so
^done,bkpt={number="1",type="catchpoint",disp="del",enabled="y",
what="load of library matching foo.so",catch-type="load",times="0"}
(gdb)
```

The `-catch-unload` Command

Synopsis

```
-catch-unload [ -t ] [ -d ] regexp
```

Add a catchpoint for library unload events. If the '`-t`' option is used, the catchpoint is a temporary one (see Section 5.1.1 [Setting Breakpoints], page 44). If the '`-d`' option is used, the catchpoint is created in a disabled state. The '`regexp`' argument is a regular expression used to match the name of the unloaded library.

GDB Command

The corresponding GDB command is '`catch unload`'.

Example

```
-catch-unload -d bar.so
^done,bkpt={number="2",type="catchpoint",disp="keep",enabled="n",
what="load of library matching bar.so",catch-type="unload",times="0"}
(gdb)
```

27.12 GDB/MI Program Context

The `-exec-arguments` Command

Synopsis

```
-exec-arguments args
```

Set the inferior program arguments, to be used in the next '`-exec-run`'.

GDB Command

The corresponding GDB command is '`set args`'.

Example

```
(gdb)
-exec-arguments -v word
^done
(gdb)
```

The `-environment-cd` Command

Synopsis

```
-environment-cd pathdir
```

Set GDB's working directory.

GDB Command

The corresponding GDB command is '`cd`'.

Example

```
(gdb)
-environment-cd /kwikemart/marge/ezannoni/flathead-dev/devo/gdb
^done
(gdb)
```

The -environment-directory Command

Synopsis

```
-environment-directory [ -r ] [ pathdir ]+
```

Add directories *pathdir* to beginning of search path for source files. If the '`-r`' option is used, the search path is reset to the default search path. If directories *pathdir* are supplied in addition to the '`-r`' option, the search path is first reset and then addition occurs as normal. Multiple directories may be specified, separated by blanks. Specifying multiple directories in a single command results in the directories added to the beginning of the search path in the same order they were presented in the command. If blanks are needed as part of a directory name, double-quotes should be used around the name. In the command output, the path will show up separated by the system directory-separator character. The directory-separator character must not be used in any directory name. If no directories are specified, the current search path is displayed.

GDB Command

The corresponding GDB command is '`dir`'.

Example

```
(gdb)
-environment-directory /kwikemart/marge/ezannoni/flathead-dev/devo/gdb
^done,source-path="/kwikemart/marge/ezannoni/flathead-dev/devo/gdb:$cdir:$cwd"
(gdb)
-environment-directory ""
^done,source-path="/kwikemart/marge/ezannoni/flathead-dev/devo/gdb:$cdir:$cwd"
(gdb)
-environment-directory -r /home/jjohnstn/src/gdb /usr/src
^done,source-path="/home/jjohnstn/src/gdb:/usr/src:$cdir:$cwd"
(gdb)
-environment-directory -r
^done,source-path="$cdir:$cwd"
(gdb)
```

The -environment-path Command

Synopsis

```
-environment-path [ -r ] [ pathdir ]+
```

Add directories *pathdir* to beginning of search path for object files. If the '`-r`' option is used, the search path is reset to the original search path that existed at gdb start-up. If directories *pathdir* are supplied in addition to the '`-r`' option, the search path is first reset and then addition occurs as normal. Multiple directories may be specified, separated by blanks. Specifying multiple directories in a single command results in the directories added to the beginning of the search path in the same order they were presented in the command. If blanks are needed as part of a directory name, double-quotes should be used around the name. In the command output, the path will show up separated by the system directory-separator character. The directory-separator character must not be used in any directory name. If no directories are specified, the current path is displayed.

GDB Command

The corresponding GDB command is '`path`'.

Example

```
(gdb)
-environment-path
^done,path="/usr/bin"
(gdb)
-environment-path /kwikemart/marge/ezannoni/flathead-dev/ppc-eabi/gdb /bin
^done,path="/kwikemart/marge/ezannoni/flathead-dev/ppc-eabi/gdb:/bin:/usr/bin"
(gdb)
-environment-path -r /usr/local/bin
^done,path="/usr/local/bin:/usr/bin"
(gdb)
```

The `-environment-pwd` Command

Synopsis

```
-environment-pwd
```

Show the current working directory.

GDB Command

The corresponding GDB command is '`pwd`'.

Example

```
(gdb)
-environment-pwd
^done,cwd="/kwikemart/marge/ezannoni/flathead-dev/devo/gdb"
(gdb)
```

27.13 GDB/MI Thread Commands

The `-thread-info` Command

Synopsis

```
-thread-info [ thread-id ]
```

Reports information about either a specific thread, if the *thread-id* parameter is present, or about all threads. When printing information about all threads, also reports the current thread.

GDB Command

The '`info thread`' command prints the same information about all threads.

Result

The result is a list of threads. The following attributes are defined for a given thread:

'`current`' This field exists only for the current thread. It has the value '`*`'.

'`id`' The identifier that GDB uses to refer to the thread.

‘target-id’
: The identifier that the target uses to refer to the thread.

‘details’
: Extra information about the thread, in a target-specific format. This field is optional.

‘name’
: The name of the thread. If the user specified a name using the `thread name` command, then this name is given. Otherwise, if GDB can extract the thread name from the target, then that name is given. If GDB cannot find the thread name, then this field is omitted.

‘frame’
: The stack frame currently executing in the thread.

‘state’
: The thread's state. The ‘state’ field may have the following values:

  `stopped`
  : The thread is stopped. Frame information is available for stopped threads.

  `running`
  : The thread is running. There's no frame information for running threads.

‘core’
: If GDB can find the CPU core on which this thread is running, then this field is the core identifier. This field is optional.

Example

```
-thread-info
^done,threads=[
{id="2",target-id="Thread 0xb7e14b90 (LWP 21257)",
   frame={level="0",addr="0xffffe410",func="__kernel_vsyscall",
          args=[]},state="running"},
{id="1",target-id="Thread 0xb7e156b0 (LWP 21254)",
   frame={level="0",addr="0x0804891f",func="foo",
          args=[{name="i",value="10"}],
          file="/tmp/a.c",fullname="/tmp/a.c",line="158"},
          state="running"}],
current-thread-id="1"
(gdb)
```

The `-thread-list-ids` Command

Synopsis

```
-thread-list-ids
```

Produces a list of the currently known GDB thread ids. At the end of the list it also prints the total number of such threads.

This command is retained for historical reasons, the `-thread-info` command should be used instead.

GDB Command

Part of ‘`info threads`’ supplies the same information.

Example

```
(gdb)
-thread-list-ids
```

```
^done,thread-ids={thread-id="3",thread-id="2",thread-id="1"},
current-thread-id="1",number-of-threads="3"
(gdb)
```

The `-thread-select` Command

Synopsis

```
-thread-select threadnum
```

Make *threadnum* the current thread. It prints the number of the new current thread, and the topmost frame for that thread.

This command is deprecated in favor of explicitly using the '`--thread`' option to each command.

GDB Command

The corresponding GDB command is '`thread`'.

Example

```
(gdb)
-exec-next
^running
(gdb)
*stopped,reason="end-stepping-range",thread-id="2",line="187",
file="../../../devo/gdb/testsuite/gdb.threads/linux-dp.c"
(gdb)
-thread-list-ids
^done,
thread-ids={thread-id="3",thread-id="2",thread-id="1"},
number-of-threads="3"
(gdb)
-thread-select 3
^done,new-thread-id="3",
frame={level="0",func="vprintf",
args=[{name="format",value="0x8048e9c \"%*s%c %d %c\\n\""},
{name="arg",value="0x2"}],file="vprintf.c",line="31"}
(gdb)
```

27.14 GDB/MI Ada Tasking Commands

The `-ada-task-info` Command

Synopsis

```
-ada-task-info [ task-id ]
```

Reports information about either a specific Ada task, if the *task-id* parameter is present, or about all Ada tasks.

GDB Command

The '`info tasks`' command prints the same information about all Ada tasks (see Section 15.4.9.5 [Ada Tasks], page 196).

Result

The result is a table of Ada tasks. The following columns are defined for each Ada task:

'`current`' This field exists only for the current thread. It has the value '`*`'.

'`id`' The identifier that GDB uses to refer to the Ada task.

'`task-id`' The identifier that the target uses to refer to the Ada task.

'`thread-id`'
The identifier of the thread corresponding to the Ada task.

This field should always exist, as Ada tasks are always implemented on top of a thread. But if GDB cannot find this corresponding thread for any reason, the field is omitted.

'`parent-id`'
This field exists only when the task was created by another task. In this case, it provides the ID of the parent task.

'`priority`'
The base priority of the task.

'`state`' The current state of the task. For a detailed description of the possible states, see Section 15.4.9.5 [Ada Tasks], page 196.

'`name`' The name of the task.

Example

```
-ada-task-info
^done,tasks={nr_rows="3",nr_cols="8",
hdr=[{width="1",alignment="-1",col_name="current",colhdr=""},
{width="3",alignment="1",col_name="id",colhdr="ID"},
{width="9",alignment="1",col_name="task-id",colhdr="TID"},
{width="4",alignment="1",col_name="thread-id",colhdr=""},
{width="4",alignment="1",col_name="parent-id",colhdr="P-ID"},
{width="3",alignment="1",col_name="priority",colhdr="Pri"},
{width="22",alignment="-1",col_name="state",colhdr="State"},
{width="1",alignment="2",col_name="name",colhdr="Name"}],
body=[{current="*",id="1",task-id="   644010",thread-id="1",priority="48",
state="Child Termination Wait",name="main_task"}]}
(gdb)
```

27.15 GDB/MI Program Execution

These are the asynchronous commands which generate the out-of-band record '`*stopped`'. Currently GDB only really executes asynchronously with remote targets and this interaction is mimicked in other cases.

The `-exec-continue` Command

Synopsis

```
-exec-continue [--reverse] [--all|--thread-group N]
```

Resumes the execution of the inferior program, which will continue to execute until it reaches a debugger stop event. If the '`--reverse`' option is specified, execution resumes in reverse until it reaches a stop event. Stop events may include

- breakpoints or watchpoints
- signals or exceptions
- the end of the process (or its beginning under '`--reverse`')
- the end or beginning of a replay log if one is being used.

In all-stop mode (see Section 5.5.1 [All-Stop Mode], page 72), may resume only one thread, or all threads, depending on the value of the '`scheduler-locking`' variable. If '`--all`' is specified, all threads (in all inferiors) will be resumed. The '`--all`' option is ignored in all-stop mode. If the '`--thread-group`' options is specified, then all threads in that thread group are resumed.

GDB Command

The corresponding GDB corresponding is '`continue`'.

Example

```
-exec-continue
^running
(gdb)
@Hello world
*stopped,reason="breakpoint-hit",disp="keep",bkptno="2",frame={
func="foo",args=[],file="hello.c",fullname="/home/foo/bar/hello.c",
line="13"}
(gdb)
```

The `-exec-finish` Command

Synopsis

```
-exec-finish [--reverse]
```

Resumes the execution of the inferior program until the current function is exited. Displays the results returned by the function. If the '`--reverse`' option is specified, resumes the reverse execution of the inferior program until the point where current function was called.

GDB Command

The corresponding GDB command is '`finish`'.

Example

Function returning `void`.

```
-exec-finish
^running
(gdb)
@hello from foo
*stopped,reason="function-finished",frame={func="main",args=[],
file="hello.c",fullname="/home/foo/bar/hello.c",line="7"}
(gdb)
```

Function returning other than `void`. The name of the internal GDB variable storing the result is printed, together with the value itself.

```
-exec-finish
^running
```

```
(gdb)
*stopped,reason="function-finished",frame={addr="0x000107b0",func="foo",
args=[{name="a",value="1"],{name="b",value="9"}},
file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
gdb-result-var="$1",return-value="0"
(gdb)
```

The -exec-interrupt Command

Synopsis

```
-exec-interrupt [--all|--thread-group N]
```

Interrupts the background execution of the target. Note how the token associated with the stop message is the one for the execution command that has been interrupted. The token for the interrupt itself only appears in the '`^done`' output. If the user is trying to interrupt a non-running program, an error message will be printed.

Note that when asynchronous execution is enabled, this command is asynchronous just like other execution commands. That is, first the '`^done`' response will be printed, and the target stop will be reported after that using the '`*stopped`' notification.

In non-stop mode, only the context thread is interrupted by default. All threads (in all inferiors) will be interrupted if the '`--all`' option is specified. If the '`--thread-group`' option is specified, all threads in that group will be interrupted.

GDB Command

The corresponding GDB command is '`interrupt`'.

Example

```
(gdb)
111-exec-continue
111^running

(gdb)
222-exec-interrupt
222^done
(gdb)
111*stopped,signal-name="SIGINT",signal-meaning="Interrupt",
frame={addr="0x00010140",func="foo",args=[],file="try.c",
fullname="/home/foo/bar/try.c",line="13"}
(gdb)

(gdb)
-exec-interrupt
^error,msg="mi_cmd_exec_interrupt: Inferior not executing."
(gdb)
```

The -exec-jump Command

Synopsis

```
-exec-jump location
```

Resumes execution of the inferior program at the location specified by parameter. See Section 9.2 [Specify Location], page 94, for a description of the different forms of *location*.

GDB Command

The corresponding GDB command is '`jump`'.

Example

```
-exec-jump foo.c:10
*running,thread-id="all"
^running
```

The `-exec-next` Command

Synopsis

```
-exec-next [--reverse]
```

Resumes execution of the inferior program, stopping when the beginning of the next source line is reached.

If the '`--reverse`' option is specified, resumes reverse execution of the inferior program, stopping at the beginning of the previous source line. If you issue this command on the first line of a function, it will take you back to the caller of that function, to the source line where the function was called.

GDB Command

The corresponding GDB command is '`next`'.

Example

```
-exec-next
^running
(gdb)
*stopped,reason="end-stepping-range",line="8",file="hello.c"
(gdb)
```

The `-exec-next-instruction` Command

Synopsis

```
-exec-next-instruction [--reverse]
```

Executes one machine instruction. If the instruction is a function call, continues until the function returns. If the program stops at an instruction in the middle of a source line, the address will be printed as well.

If the '`--reverse`' option is specified, resumes reverse execution of the inferior program, stopping at the previous instruction. If the previously executed instruction was a return from another function, it will continue to execute in reverse until the call to that function (from the current stack frame) is reached.

GDB Command

The corresponding GDB command is '`nexti`'.

Example

```
(gdb)
-exec-next-instruction
```

```
^running

(gdb)
*stopped,reason="end-stepping-range",
addr="0x000100d4",line="5",file="hello.c"
(gdb)
```

The -exec-return Command

Synopsis

```
-exec-return
```

Makes current function return immediately. Doesn't execute the inferior. Displays the new current frame.

GDB Command

The corresponding GDB command is '`return`'.

Example

```
(gdb)
200-break-insert callee4
200^done,bkpt={number="1",addr="0x00010734",
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",line="8"}
(gdb)
000-exec-run
000^running
(gdb)
000*stopped,reason="breakpoint-hit",disp="keep",bkptno="1",
frame={func="callee4",args=[],
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="8"}
(gdb)
205-break-delete
205^done
(gdb)
111-exec-return
111^done,frame={level="0",func="callee3",
args=[{name="strarg",
value="0x11940 \"A string argument.\""}],
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="18"}
(gdb)
```

The -exec-run Command

Synopsis

```
-exec-run [--all | --thread-group N]
```

Starts execution of the inferior from the beginning. The inferior executes until either a breakpoint is encountered or the program exits. In the latter case the output will include an exit code, if the program has exited exceptionally.

When no option is specified, the current inferior is started. If the '`--thread-group`' option is specified, it should refer to a thread group of type '`process`', and that thread group will be started. If the '`--all`' option is specified, then all inferiors will be started.

GDB Command

The corresponding GDB command is '`run`'.

Examples

```
(gdb)
-break-insert main
^done,bkpt={number="1",addr="0x0001072c",file="recursive2.c",line="4"}
(gdb)
-exec-run
^running
(gdb)
*stopped,reason="breakpoint-hit",disp="keep",bkptno="1",
frame={func="main",args=[],file="recursive2.c",
fullname="/home/foo/bar/recursive2.c",line="4"}
(gdb)
```

Program exited normally:

```
(gdb)
-exec-run
^running
(gdb)
x = 55
*stopped,reason="exited-normally"
(gdb)
```

Program exited exceptionally:

```
(gdb)
-exec-run
^running
(gdb)
x = 55
*stopped,reason="exited",exit-code="01"
(gdb)
```

Another way the program can terminate is if it receives a signal such as `SIGINT`. In this case, GDB/MI displays this:

```
(gdb)
*stopped,reason="exited-signalled",signal-name="SIGINT",
signal-meaning="Interrupt"
```

The `-exec-step` Command

Synopsis

```
-exec-step [--reverse]
```

Resumes execution of the inferior program, stopping when the beginning of the next source line is reached, if the next source line is not a function call. If it is, stop at the first instruction of the called function. If the '`--reverse`' option is specified, resumes reverse execution of the inferior program, stopping at the beginning of the previously executed source line.

GDB Command

The corresponding GDB command is '`step`'.

Example

Stepping into a function:

```
-exec-step
^running
(gdb)
*stopped,reason="end-stepping-range",
frame={func="foo",args=[{name="a",value="10"},
{name="b",value="0"}],file="recursive2.c",
fullname="/home/foo/bar/recursive2.c",line="11"}
(gdb)
```

Regular stepping:

```
-exec-step
^running
(gdb)
*stopped,reason="end-stepping-range",line="14",file="recursive2.c"
(gdb)
```

The `-exec-step-instruction` Command

Synopsis

```
-exec-step-instruction [--reverse]
```

Resumes the inferior which executes one machine instruction. If the '`--reverse`' option is specified, resumes reverse execution of the inferior program, stopping at the previously executed instruction. The output, once GDB has stopped, will vary depending on whether we have stopped in the middle of a source line or not. In the former case, the address at which the program stopped will be printed as well.

GDB Command

The corresponding GDB command is '`stepi`'.

Example

```
(gdb)
-exec-step-instruction
^running

(gdb)
*stopped,reason="end-stepping-range",
frame={func="foo",args=[],file="try.c",
fullname="/home/foo/bar/try.c",line="10"}
(gdb)
-exec-step-instruction
^running

(gdb)
*stopped,reason="end-stepping-range",
frame={addr="0x000100f4",func="foo",args=[],file="try.c",
fullname="/home/foo/bar/try.c",line="10"}
(gdb)
```

The `-exec-until` Command

Synopsis

```
-exec-until [ location ]
```

Executes the inferior until the *location* specified in the argument is reached. If there is no argument, the inferior executes until a source line greater than the current one is reached. The reason for stopping in this case will be '`location-reached`'.

GDB Command

The corresponding GDB command is '`until`'.

Example

```
(gdb)
-exec-until recursive2.c:6
^running
(gdb)
x = 55
*stopped,reason="location-reached",frame={func="main",args=[],
file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="6"}
(gdb)
```

27.16 GDB/MI Stack Manipulation Commands

The `-stack-info-frame` Command

Synopsis

```
-stack-info-frame
```

Get info on the selected frame.

GDB Command

The corresponding GDB command is '`info frame`' or '`frame`' (without arguments).

Example

```
(gdb)
-stack-info-frame
^done,frame={level="1",addr="0x0001076c",func="callee3",
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="17"}
(gdb)
```

The `-stack-info-depth` Command

Synopsis

```
-stack-info-depth [ max-depth ]
```

Return the depth of the stack. If the integer argument *max-depth* is specified, do not count beyond *max-depth* frames.

GDB Command

There's no equivalent GDB command.

Example

For a stack with frame levels 0 through 11:

```
(gdb)
-stack-info-depth
^done,depth="12"
(gdb)
-stack-info-depth 4
^done,depth="4"
(gdb)
-stack-info-depth 12
^done,depth="12"
(gdb)
-stack-info-depth 11
^done,depth="11"
(gdb)
-stack-info-depth 13
^done,depth="12"
(gdb)
```

The `-stack-list-arguments` Command

Synopsis

```
-stack-list-arguments print-values
   [ low-frame high-frame ]
```

Display a list of the arguments for the frames between *low-frame* and *high-frame* (inclusive). If *low-frame* and *high-frame* are not provided, list the arguments for the whole call stack. If the two arguments are equal, show the single frame at the corresponding level. It is an error if *low-frame* is larger than the actual number of frames. On the other hand, *high-frame* may be larger than the actual number of frames, in which case only existing frames will be returned.

If *print-values* is 0 or `--no-values`, print only the names of the variables; if it is 1 or `--all-values`, print also their values; and if it is 2 or `--simple-values`, print the name, type and value for simple data types, and the name and type for arrays, structures and unions.

Use of this command to obtain arguments in a single frame is deprecated in favor of the '`-stack-list-variables`' command.

GDB Command

GDB does not have an equivalent command. `gdbtk` has a '`gdb_get_args`' command which partially overlaps with the functionality of '`-stack-list-arguments`'.

Example

```
(gdb)
-stack-list-frames
^done,
stack=[
frame={level="0",addr="0x00010734",func="callee4",
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="8"},
frame={level="1",addr="0x0001076c",func="callee3",
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
```

```
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="17"},
frame={level="2",addr="0x0001078c",func="callee2",
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="22"},
frame={level="3",addr="0x000107b4",func="callee1",
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="27"},
frame={level="4",addr="0x000107e0",func="main",
file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="32"}]
(gdb)
-stack-list-arguments 0
^done,
stack-args=[
frame={level="0",args=[]},
frame={level="1",args=[name="strarg"]},
frame={level="2",args=[name="intarg",name="strarg"]},
frame={level="3",args=[name="intarg",name="strarg",name="fltarg"]},
frame={level="4",args=[]}]
(gdb)
-stack-list-arguments 1
^done,
stack-args=[
frame={level="0",args=[]},
frame={level="1",
 args=[{name="strarg",value="0x11940 \"A string argument.\""}]},
frame={level="2",args=[
{name="intarg",value="2"},
{name="strarg",value="0x11940 \"A string argument.\""}]},
{frame={level="3",args=[
{name="intarg",value="2"},
{name="strarg",value="0x11940 \"A string argument.\""},
{name="fltarg",value="3.5"}]},
frame={level="4",args=[]}]
(gdb)
-stack-list-arguments 0 2 2
^done,stack-args=[frame={level="2",args=[name="intarg",name="strarg"]}]
(gdb)
-stack-list-arguments 1 2 2
^done,stack-args=[frame={level="2",
args=[{name="intarg",value="2"},
{name="strarg",value="0x11940 \"A string argument.\""}]}]
(gdb)
```

The `-stack-list-frames` Command

Synopsis

```
-stack-list-frames [ low-frame high-frame ]
```

List the frames currently on the stack. For each frame it displays the following info:

‘*level*’ The frame number, 0 being the topmost frame, i.e., the innermost function.

‘*addr*’ The `$pc` value for that frame.

‘*func*’ Function name.

‘*file*’ File name of the source file where the function lives.

‘*fullname*’
: The full file name of the source file where the function lives.

‘*line*’
: Line number corresponding to the `$pc`.

‘*from*’
: The shared library where this function is defined. This is only given if the frame's function is not known.

If invoked without arguments, this command prints a backtrace for the whole stack. If given two integer arguments, it shows the frames whose levels are between the two arguments (inclusive). If the two arguments are equal, it shows the single frame at the corresponding level. It is an error if *low-frame* is larger than the actual number of frames. On the other hand, *high-frame* may be larger than the actual number of frames, in which case only existing frames will be returned.

GDB Command

The corresponding GDB commands are ‘`backtrace`’ and ‘`where`’.

Example

Full stack backtrace:

```
(gdb)
-stack-list-frames
^done,stack=
[frame={level="0",addr="0x0001076c",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="11"},
frame={level="1",addr="0x000107a4",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="2",addr="0x000107a4",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="3",addr="0x000107a4",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="4",addr="0x000107a4",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="5",addr="0x000107a4",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="6",addr="0x000107a4",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="7",addr="0x000107a4",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="8",addr="0x000107a4",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="9",addr="0x000107a4",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="10",addr="0x000107a4",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="11",addr="0x00010738",func="main",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="4"}]
(gdb)
```

Show frames between *low_frame* and *high_frame*:

```
(gdb)
-stack-list-frames 3 5
^done,stack=
[frame={level="3",addr="0x000107a4",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
```

```
frame={level="4",addr="0x000107a4",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="5",addr="0x000107a4",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"}]
(gdb)
```

Show a single frame:

```
(gdb)
-stack-list-frames 3 3
^done,stack=
[frame={level="3",addr="0x000107a4",func="foo",
  file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"}]
(gdb)
```

The `-stack-list-locals` Command

Synopsis

```
-stack-list-locals print-values
```

Display the local variable names for the selected frame. If *print-values* is 0 or `--no-values`, print only the names of the variables; if it is 1 or `--all-values`, print also their values; and if it is 2 or `--simple-values`, print the name, type and value for simple data types, and the name and type for arrays, structures and unions. In this last case, a frontend can immediately display the value of simple data types and create variable objects for other data types when the user wishes to explore their values in more detail.

This command is deprecated in favor of the '`-stack-list-variables`' command.

GDB Command

'`info locals`' in GDB, '`gdb_get_locals`' in `gdbtk`.

Example

```
(gdb)
-stack-list-locals 0
^done,locals=[name="A",name="B",name="C"]
(gdb)
-stack-list-locals --all-values
^done,locals=[{name="A",value="1"},{name="B",value="2"},
  {name="C",value="{1, 2, 3}"}]
-stack-list-locals --simple-values
^done,locals=[{name="A",type="int",value="1"},
  {name="B",type="int",value="2"},{name="C",type="int [3]"}]
(gdb)
```

The `-stack-list-variables` Command

Synopsis

```
-stack-list-variables print-values
```

Display the names of local variables and function arguments for the selected frame. If *print-values* is 0 or `--no-values`, print only the names of the variables; if it is 1 or `--all-values`, print also their values; and if it is 2 or `--simple-values`, print the name, type and value for simple data types, and the name and type for arrays, structures and unions.

Example

```
(gdb)
-stack-list-variables --thread 1 --frame 0 --all-values
^done,variables=[{name="x",value="11"},{name="s",value="{a = 1, b = 2}"}]
(gdb)
```

The `-stack-select-frame` Command

Synopsis

```
-stack-select-frame framenum
```

Change the selected frame. Select a different frame *framenum* on the stack.

This command in deprecated in favor of passing the '`--frame`' option to every command.

GDB Command

The corresponding GDB commands are '`frame`', '`up`', '`down`', '`select-frame`', '`up-silent`', and '`down-silent`'.

Example

```
(gdb)
-stack-select-frame 2
^done
(gdb)
```

27.17 GDB/MI Variable Objects

Introduction to Variable Objects

Variable objects are "object-oriented" MI interface for examining and changing values of expressions. Unlike some other MI interfaces that work with expressions, variable objects are specifically designed for simple and efficient presentation in the frontend. A variable object is identified by string name. When a variable object is created, the frontend specifies the expression for that variable object. The expression can be a simple variable, or it can be an arbitrary complex expression, and can even involve CPU registers. After creating a variable object, the frontend can invoke other variable object operations—for example to obtain or change the value of a variable object, or to change display format.

Variable objects have hierarchical tree structure. Any variable object that corresponds to a composite type, such as structure in C, has a number of child variable objects, for example corresponding to each element of a structure. A child variable object can itself have children, recursively. Recursion ends when we reach leaf variable objects, which always have built-in types. Child variable objects are created only by explicit request, so if a frontend is not interested in the children of a particular variable object, no child will be created.

For a leaf variable object it is possible to obtain its value as a string, or set the value from a string. String value can be also obtained for a non-leaf variable object, but it's generally a string that only indicates the type of the object, and does not list its contents. Assignment to a non-leaf variable object is not allowed.

A frontend does not need to read the values of all variable objects each time the program stops. Instead, MI provides an update command that lists all variable objects whose values

has changed since the last update operation. This considerably reduces the amount of data that must be transferred to the frontend. As noted above, children variable objects are created on demand, and only leaf variable objects have a real value. As result, gdb will read target memory only for leaf variables that frontend has created.

The automatic update is not always desirable. For example, a frontend might want to keep a value of some expression for future reference, and never update it. For another example, fetching memory is relatively slow for embedded targets, so a frontend might want to disable automatic update for the variables that are either not visible on the screen, or "closed". This is possible using so called "frozen variable objects". Such variable objects are never implicitly updated.

Variable objects can be either *fixed* or *floating*. For the fixed variable object, the expression is parsed when the variable object is created, including associating identifiers to specific variables. The meaning of expression never changes. For a floating variable object the values of variables whose names appear in the expressions are re-evaluated every time in the context of the current frame. Consider this example:

```
void do_work(...)
{
        struct work_state state;

        if (...)
           do_work(...);
}
```

If a fixed variable object for the `state` variable is created in this function, and we enter the recursive call, the variable object will report the value of `state` in the top-level `do_work` invocation. On the other hand, a floating variable object will report the value of `state` in the current frame.

If an expression specified when creating a fixed variable object refers to a local variable, the variable object becomes bound to the thread and frame in which the variable object is created. When such variable object is updated, GDB makes sure that the thread/frame combination the variable object is bound to still exists, and re-evaluates the variable object in context of that thread/frame.

The following is the complete set of GDB/MI operations defined to access this functionality:

Operation	**Description**
`-enable-pretty-printing`	enable Python-based pretty-printing
`-var-create`	create a variable object
`-var-delete`	delete the variable object and/or its children
`-var-set-format`	set the display format of this variable
`-var-show-format`	show the display format of this variable
`-var-info-num-children`	tells how many children this object has
`-var-list-children`	return a list of the object's children
`-var-info-type`	show the type of this variable object
`-var-info-expression`	print parent-relative expression that this variable object represents
`-var-info-path-expression`	print full expression that this variable object represents

`-var-show-attributes`	is this variable editable? does it exist here?
`-var-evaluate-expression`	get the value of this variable
`-var-assign`	set the value of this variable
`-var-update`	update the variable and its children
`-var-set-frozen`	set frozeness attribute
`-var-set-update-range`	set range of children to display on update

In the next subsection we describe each operation in detail and suggest how it can be used.

Description And Use of Operations on Variable Objects

The `-enable-pretty-printing` Command

```
-enable-pretty-printing
```

GDB allows Python-based visualizers to affect the output of the MI variable object commands. However, because there was no way to implement this in a fully backward-compatible way, a front end must request that this functionality be enabled.

Once enabled, this feature cannot be disabled.

Note that if Python support has not been compiled into GDB, this command will still succeed (and do nothing).

This feature is currently (as of GDB 7.0) experimental, and may work differently in future versions of GDB.

The `-var-create` Command

Synopsis

```
-var-create {name | "-"}
   {frame-addr | "*" | "@"} expression
```

This operation creates a variable object, which allows the monitoring of a variable, the result of an expression, a memory cell or a CPU register.

The *name* parameter is the string by which the object can be referenced. It must be unique. If '`-`' is specified, the varobj system will generate a string "varNNNNNN" automatically. It will be unique provided that one does not specify *name* of that format. The command fails if a duplicate name is found.

The frame under which the expression should be evaluated can be specified by *frame-addr*. A '`*`' indicates that the current frame should be used. A '`@`' indicates that a floating variable object must be created.

expression is any expression valid on the current language set (must not begin with a '`*`'), or one of the following:

- '`*addr`', where *addr* is the address of a memory cell
- '`*addr-addr`' — a memory address range (TBD)
- '`$regname`' — a CPU register name

A varobj's contents may be provided by a Python-based pretty-printer. In this case the varobj is known as a *dynamic varobj*. Dynamic varobjs have slightly different semantics in some cases. If the `-enable-pretty-printing` command is not sent, then GDB will never create a dynamic varobj. This ensures backward compatibility for existing clients.

Result

This operation returns attributes of the newly-created varobj. These are:

'`name`' The name of the varobj.

'`numchild`'
The number of children of the varobj. This number is not necessarily reliable for a dynamic varobj. Instead, you must examine the '`has_more`' attribute.

'`value`' The varobj's scalar value. For a varobj whose type is some sort of aggregate (e.g., a `struct`), or for a dynamic varobj, this value will not be interesting.

'`type`' The varobj's type. This is a string representation of the type, as would be printed by the GDB CLI. If '`print object`' (see Section 10.8 [Print Settings], page 115) is set to `on`, the *actual* (derived) type of the object is shown rather than the *declared* one.

'`thread-id`'
If a variable object is bound to a specific thread, then this is the thread's identifier.

'`has_more`'
For a dynamic varobj, this indicates whether there appear to be any children available. For a non-dynamic varobj, this will be 0.

'`dynamic`' This attribute will be present and have the value '`1`' if the varobj is a dynamic varobj. If the varobj is not a dynamic varobj, then this attribute will not be present.

'`displayhint`'
A dynamic varobj can supply a display hint to the front end. The value comes directly from the Python pretty-printer object's `display_hint` method. See Section 23.2.2.5 [Pretty Printing API], page 317.

Typical output will look like this:

```
name="name",numchild="N",type="type",thread-id="M",
 has_more="has_more"
```

The `-var-delete` Command

Synopsis

```
-var-delete [ -c ] name
```

Deletes a previously created variable object and all of its children. With the '`-c`' option, just deletes the children.

Returns an error if the object *name* is not found.

The `-var-set-format` Command

Synopsis

```
-var-set-format name format-spec
```

Sets the output format for the value of the object *name* to be *format-spec*.

The syntax for the *format-spec* is as follows:

format-spec ↦
{binary | decimal | hexadecimal | octal | natural}

The natural format is the default format choosen automatically based on the variable type (like decimal for an `int`, hex for pointers, etc.).

For a variable with children, the format is set only on the variable itself, and the children are not affected.

The `-var-show-format` Command

Synopsis

`-var-show-format` *name*

Returns the format used to display the value of the object *name*.

format ↦
format-spec

The `-var-info-num-children` Command

Synopsis

`-var-info-num-children` *name*

Returns the number of children of a variable object *name*:

`numchild=`*n*

Note that this number is not completely reliable for a dynamic varobj. It will return the current number of children, but more children may be available.

The `-var-list-children` Command

Synopsis

`-var-list-children` [*print-values*] *name* [*from to*]

Return a list of the children of the specified variable object and create variable objects for them, if they do not already exist. With a single argument or if *print-values* has a value of 0 or `--no-values`, print only the names of the variables; if *print-values* is 1 or `--all-values`, also print their values; and if it is 2 or `--simple-values` print the name and value for simple data types and just the name for arrays, structures and unions.

from and *to*, if specified, indicate the range of children to report. If *from* or *to* is less than zero, the range is reset and all children will be reported. Otherwise, children starting at *from* (zero-based) and up to and excluding *to* will be reported.

If a child range is requested, it will only affect the current call to `-var-list-children`, but not future calls to `-var-update`. For this, you must instead use `-var-set-update-range`. The intent of this approach is to enable a front end to implement any update approach it likes; for example, scrolling a view may cause the front end to request more children with `-var-list-children`, and then the front end could call `-var-set-update-range` with a different range to ensure that future updates are restricted to just the visible items.

For each child the following results are returned:

name Name of the variable object created for this child.

exp The expression to be shown to the user by the front end to designate this child. For example this may be the name of a structure member.

For a dynamic varobj, this value cannot be used to form an expression. There is no way to do this at all with a dynamic varobj.

For C/C++ structures there are several pseudo children returned to designate access qualifiers. For these pseudo children *exp* is '`public`', '`private`', or '`protected`'. In this case the type and value are not present.

A dynamic varobj will not report the access qualifying pseudo-children, regardless of the language. This information is not available at all with a dynamic varobj.

numchild Number of children this child has. For a dynamic varobj, this will be 0.

type The type of the child. If '`print object`' (see Section 10.8 [Print Settings], page 115) is set to `on`, the *actual* (derived) type of the object is shown rather than the *declared* one.

value If values were requested, this is the value.

thread-id If this variable object is associated with a thread, this is the thread id. Otherwise this result is not present.

frozen If the variable object is frozen, this variable will be present with a value of 1.

The result may have its own attributes:

'`displayhint`'
A dynamic varobj can supply a display hint to the front end. The value comes directly from the Python pretty-printer object's `display_hint` method. See Section 23.2.2.5 [Pretty Printing API], page 317.

'`has_more`'
This is an integer attribute which is nonzero if there are children remaining after the end of the selected range.

Example

```
(gdb)
 -var-list-children n
 ^done,numchild=n,children=[child={name=name,exp=exp,
 numchild=n,type=type},(repeats N times)]
(gdb)
 -var-list-children --all-values n
 ^done,numchild=n,children=[child={name=name,exp=exp,
 numchild=n,value=value,type=type},(repeats N times)]
```

The `-var-info-type` Command

Synopsis

```
-var-info-type name
```

Returns the type of the specified variable *name*. The type is returned as a string in the same format as it is output by the GDB CLI:

```
type=typename
```

The -var-info-expression Command

Synopsis

```
-var-info-expression name
```

Returns a string that is suitable for presenting this variable object in user interface. The string is generally not valid expression in the current language, and cannot be evaluated.

For example, if `a` is an array, and variable object `A` was created for `a`, then we'll get this output:

```
(gdb) -var-info-expression A.1
^done,lang="C",exp="1"
```

Here, the values of `lang` can be `{"C" | "C++" | "Java"}`.

Note that the output of the `-var-list-children` command also includes those expressions, so the `-var-info-expression` command is of limited use.

The -var-info-path-expression Command

Synopsis

```
-var-info-path-expression name
```

Returns an expression that can be evaluated in the current context and will yield the same value that a variable object has. Compare this with the `-var-info-expression` command, which result can be used only for UI presentation. Typical use of the `-var-info-path-expression` command is creating a watchpoint from a variable object.

This command is currently not valid for children of a dynamic varobj, and will give an error when invoked on one.

For example, suppose `C` is a C++ class, derived from class `Base`, and that the `Base` class has a member called `m_size`. Assume a variable `c` is has the type of `C` and a variable object `C` was created for variable `c`. Then, we'll get this output:

```
(gdb) -var-info-path-expression C.Base.public.m_size
^done,path_expr=((Base)c).m_size)
```

The -var-show-attributes Command

Synopsis

```
-var-show-attributes name
```

List attributes of the specified variable object *name*:

```
status=attr [ ( ,attr )* ]
```

where *attr* is `{ { editable | noneditable } | TBD }`.

The -var-evaluate-expression Command

Synopsis

```
-var-evaluate-expression [-f format-spec] name
```

Evaluates the expression that is represented by the specified variable object and returns its value as a string. The format of the string can be specified with the '`-f`' option. The possible values of this option are the same as for `-var-set-format` (see [-var-set-format],

page 409). If the '`-f`' option is not specified, the current display format will be used. The current display format can be changed using the `-var-set-format` command.

`value=`*value*

Note that one must invoke `-var-list-children` for a variable before the value of a child variable can be evaluated.

The `-var-assign` Command

Synopsis

`-var-assign` *name expression*

Assigns the value of *expression* to the variable object specified by *name*. The object must be '`editable`'. If the variable's value is altered by the assign, the variable will show up in any subsequent `-var-update` list.

Example

```
(gdb)
-var-assign var1 3
^done,value="3"
(gdb)
-var-update *
^done,changelist=[{name="var1",in_scope="true",type_changed="false"}]
(gdb)
```

The `-var-update` Command

Synopsis

`-var-update [`*print-values*`] {`*name* `| "*"}`

Reevaluate the expressions corresponding to the variable object *name* and all its direct and indirect children, and return the list of variable objects whose values have changed; *name* must be a root variable object. Here, "changed" means that the result of `-var-evaluate-expression` before and after the `-var-update` is different. If '`*`' is used as the variable object names, all existing variable objects are updated, except for frozen ones (see [-var-set-frozen], page 415). The option *print-values* determines whether both names and values, or just names are printed. The possible values of this option are the same as for `-var-list-children` (see [-var-list-children], page 410). It is recommended to use the '`--all-values`' option, to reduce the number of MI commands needed on each program stop.

With the '`*`' parameter, if a variable object is bound to a currently running thread, it will not be updated, without any diagnostic.

If `-var-set-update-range` was previously used on a varobj, then only the selected range of children will be reported.

`-var-update` reports all the changed varobjs in a tuple named '`changelist`'.

Each item in the change list is itself a tuple holding:

'`name`' The name of the varobj.

'`value`' If values were requested for this update, then this field will be present and will hold the value of the varobj.

‘in_scope’
This field is a string which may take one of three values:

"true" The variable object's current value is valid.

"false" The variable object does not currently hold a valid value but it may hold one in the future if its associated expression comes back into scope.

"invalid"
The variable object no longer holds a valid value. This can occur when the executable file being debugged has changed, either through recompilation or by using the GDB file command. The front end should normally choose to delete these variable objects.

In the future new values may be added to this list so the front should be prepared for this possibility. See Section 27.6 [GDB/MI Development and Front Ends], page 371.

‘type_changed’
This is only present if the varobj is still valid. If the type changed, then this will be the string ‘true’; otherwise it will be ‘false’.

When a varobj's type changes, its children are also likely to have become incorrect. Therefore, the varobj's children are automatically deleted when this attribute is ‘true’. Also, the varobj's update range, when set using the -var-set-update-range command, is unset.

‘new_type’
If the varobj's type changed, then this field will be present and will hold the new type.

‘new_num_children’
For a dynamic varobj, if the number of children changed, or if the type changed, this will be the new number of children.

The ‘numchild’ field in other varobj responses is generally not valid for a dynamic varobj – it will show the number of children that GDB knows about, but because dynamic varobjs lazily instantiate their children, this will not reflect the number of children which may be available.

The ‘new_num_children’ attribute only reports changes to the number of children known by GDB. This is the only way to detect whether an update has removed children (which necessarily can only happen at the end of the update range).

‘displayhint’
The display hint, if any.

‘has_more’
This is an integer value, which will be 1 if there are more children available outside the varobj's update range.

‘dynamic’ This attribute will be present and have the value ‘1’ if the varobj is a dynamic varobj. If the varobj is not a dynamic varobj, then this attribute will not be present.

‘new_children’
: If new children were added to a dynamic varobj within the selected update range (as set by -var-set-update-range), then they will be listed in this attribute.

Example

```
(gdb)
-var-assign var1 3
^done,value="3"
(gdb)
-var-update --all-values var1
^done,changelist=[{name="var1",value="3",in_scope="true",
type_changed="false"}]
(gdb)
```

The -var-set-frozen Command

Synopsis

```
-var-set-frozen name flag
```

Set the frozenness flag on the variable object *name*. The *flag* parameter should be either ‘1’ to make the variable frozen or ‘0’ to make it unfrozen. If a variable object is frozen, then neither itself, nor any of its children, are implicitly updated by -var-update of a parent variable or by -var-update *. Only -var-update of the variable itself will update its value and values of its children. After a variable object is unfrozen, it is implicitly updated by all subsequent -var-update operations. Unfreezing a variable does not update it, only subsequent -var-update does.

Example

```
(gdb)
-var-set-frozen V 1
^done
(gdb)
```

The -var-set-update-range command

Synopsis

```
-var-set-update-range name from to
```

Set the range of children to be returned by future invocations of -var-update.

from and *to* indicate the range of children to report. If *from* or *to* is less than zero, the range is reset and all children will be reported. Otherwise, children starting at *from* (zero-based) and up to and excluding *to* will be reported.

Example

```
(gdb)
-var-set-update-range V 1 2
^done
```

The -var-set-visualizer command

Synopsis

```
-var-set-visualizer name visualizer
```

Set a visualizer for the variable object *name*.

visualizer is the visualizer to use. The special value '`None`' means to disable any visualizer in use.

If not '`None`', *visualizer* must be a Python expression. This expression must evaluate to a callable object which accepts a single argument. GDB will call this object with the value of the varobj *name* as an argument (this is done so that the same Python pretty-printing code can be used for both the CLI and MI). When called, this object must return an object which conforms to the pretty-printing interface (see Section 23.2.2.5 [Pretty Printing API], page 317).

The pre-defined function `gdb.default_visualizer` may be used to select a visualizer by following the built-in process (see Section 23.2.2.6 [Selecting Pretty-Printers], page 318). This is done automatically when a varobj is created, and so ordinarily is not needed.

This feature is only available if Python support is enabled. The MI command `-list-features` (see Section 27.24 [GDB/MI Miscellaneous Commands], page 435) can be used to check this.

Example

Resetting the visualizer:

```
(gdb)
-var-set-visualizer V None
^done
```

Reselecting the default (type-based) visualizer:

```
(gdb)
-var-set-visualizer V gdb.default_visualizer
^done
```

Suppose `SomeClass` is a visualizer class. A lambda expression can be used to instantiate this class for a varobj:

```
(gdb)
-var-set-visualizer V "lambda val: SomeClass()"
^done
```

27.18 GDB/MI Data Manipulation

This section describes the GDB/MI commands that manipulate data: examine memory and registers, evaluate expressions, etc.

The `-data-disassemble` Command

Synopsis

```
-data-disassemble
   [ -s start-addr -e end-addr ]
 | [ -f filename -l linenum [ -n lines ] ]
 -- mode
```

Where:

'*start-addr*'
: is the beginning address (or `$pc`)

‘*end-addr*’
: is the end address

‘*filename*’
: is the name of the file to disassemble

‘*linenum*’
: is the line number to disassemble around

‘*lines*’
: is the number of disassembly lines to be produced. If it is -1, the whole function will be disassembled, in case no *end-addr* is specified. If *end-addr* is specified as a non-zero value, and *lines* is lower than the number of disassembly lines between *start-addr* and *end-addr*, only *lines* lines are displayed; if *lines* is higher than the number of lines between *start-addr* and *end-addr*, only the lines up to *end-addr* are displayed.

‘*mode*’
: is either 0 (meaning only disassembly), 1 (meaning mixed source and disassembly), 2 (meaning disassembly with raw opcodes), or 3 (meaning mixed source and disassembly with raw opcodes).

Result

The result of the `-data-disassemble` command will be a list named ‘`asm_insns`’, the contents of this list depend on the *mode* used with the `-data-disassemble` command.

For modes 0 and 2 the ‘`asm_insns`’ list contains tuples with the following fields:

`address`
: The address at which this instruction was disassembled.

`func-name`
: The name of the function this instruction is within.

`offset`
: The decimal offset in bytes from the start of ‘`func-name`’.

`inst`
: The text disassembly for this ‘`address`’.

`opcodes`
: This field is only present for mode 2. This contains the raw opcode bytes for the ‘`inst`’ field.

For modes 1 and 3 the ‘`asm_insns`’ list contains tuples named ‘`src_and_asm_line`’, each of which has the following fields:

`line`
: The line number within ‘`file`’.

`file`
: The file name from the compilation unit. This might be an absolute file name or a relative file name depending on the compile command used.

`fullname`
: Absolute file name of ‘`file`’. It is converted to a canonical form using the source file search path (see Section 9.5 [Specifying Source Directories], page 96) and after resolving all the symbolic links.

  If the source file is not found this field will contain the path as present in the debug information.

`line_asm_insn`
: This is a list of tuples containing the disassembly for ‘`line`’ in ‘`file`’. The fields of each tuple are the same as for `-data-disassemble` in *mode* 0 and 2, so ‘`address`’, ‘`func-name`’, ‘`offset`’, ‘`inst`’, and optionally ‘`opcodes`’.

Note that whatever included in the ‘`inst`’ field, is not manipulated directly by GDB/MI, i.e., it is not possible to adjust its format.

GDB Command

The corresponding GDB command is '`disassemble`'.

Example

Disassemble from the current value of `$pc` to `$pc + 20`:

```
(gdb)
-data-disassemble -s $pc -e "$pc + 20" -- 0
^done,
asm_insns=[
{address="0x000107c0",func-name="main",offset="4",
inst="mov  2, %o0"},
{address="0x000107c4",func-name="main",offset="8",
inst="sethi  %hi(0x11800), %o2"},
{address="0x000107c8",func-name="main",offset="12",
inst="or  %o2, 0x140, %o1\t! 0x11940 <_lib_version+8>"},
{address="0x000107cc",func-name="main",offset="16",
inst="sethi  %hi(0x11800), %o2"},
{address="0x000107d0",func-name="main",offset="20",
inst="or  %o2, 0x168, %o4\t! 0x11968 <_lib_version+48>"}]
(gdb)
```

Disassemble the whole `main` function. Line 32 is part of `main`.

```
-data-disassemble -f basics.c -l 32 -- 0
^done,asm_insns=[
{address="0x000107bc",func-name="main",offset="0",
inst="save  %sp, -112, %sp"},
{address="0x000107c0",func-name="main",offset="4",
inst="mov   2, %o0"},
{address="0x000107c4",func-name="main",offset="8",
inst="sethi %hi(0x11800), %o2"},
[...]
{address="0x0001081c",func-name="main",offset="96",inst="ret "},
{address="0x00010820",func-name="main",offset="100",inst="restore "}]
(gdb)
```

Disassemble 3 instructions from the start of `main`:

```
(gdb)
-data-disassemble -f basics.c -l 32 -n 3 -- 0
^done,asm_insns=[
{address="0x000107bc",func-name="main",offset="0",
inst="save  %sp, -112, %sp"},
{address="0x000107c0",func-name="main",offset="4",
inst="mov  2, %o0"},
{address="0x000107c4",func-name="main",offset="8",
inst="sethi  %hi(0x11800), %o2"}]
(gdb)
```

Disassemble 3 instructions from the start of `main` in mixed mode:

```
(gdb)
-data-disassemble -f basics.c -l 32 -n 3 -- 1
^done,asm_insns=[
src_and_asm_line={line="31",
file="../../../src/gdb/testsuite/gdb.mi/basics.c",
fullname="/absolute/path/to/src/gdb/testsuite/gdb.mi/basics.c",
line_asm_insn=[{address="0x000107bc",
func-name="main",offset="0",inst="save  %sp, -112, %sp"}]},
src_and_asm_line={line="32",
```

```
file="../../../src/gdb/testsuite/gdb.mi/basics.c",
fullname="/absolute/path/to/src/gdb/testsuite/gdb.mi/basics.c",
line_asm_insn=[{address="0x000107c0",
func-name="main",offset="4",inst="mov  2, %o0"},
{address="0x000107c4",func-name="main",offset="8",
inst="sethi  %hi(0x11800), %o2"}]}]
(gdb)
```

The `-data-evaluate-expression` Command

Synopsis

```
-data-evaluate-expression expr
```

Evaluate *expr* as an expression. The expression could contain an inferior function call. The function call will execute synchronously. If the expression contains spaces, it must be enclosed in double quotes.

GDB Command

The corresponding GDB commands are '`print`', '`output`', and '`call`'. In `gdbtk` only, there's a corresponding '`gdb_eval`' command.

Example

In the following example, the numbers that precede the commands are the *tokens* described in Section 27.4 [GDB/MI Command Syntax], page 368. Notice how GDB/MI returns the same tokens in its output.

```
211-data-evaluate-expression A
211^done,value="1"
(gdb)
311-data-evaluate-expression &A
311^done,value="0xefffeb7c"
(gdb)
411-data-evaluate-expression A+3
411^done,value="4"
(gdb)
511-data-evaluate-expression "A + 3"
511^done,value="4"
(gdb)
```

The `-data-list-changed-registers` Command

Synopsis

```
-data-list-changed-registers
```

Display a list of the registers that have changed.

GDB Command

GDB doesn't have a direct analog for this command; `gdbtk` has the corresponding command '`gdb_changed_register_list`'.

Example

On a PPC MBX board:

```
(gdb)
-exec-continue
^running

(gdb)
*stopped,reason="breakpoint-hit",disp="keep",bkptno="1",frame={
func="main",args=[],file="try.c",fullname="/home/foo/bar/try.c",
line="5"}
(gdb)
-data-list-changed-registers
^done,changed-registers=["0","1","2","4","5","6","7","8","9",
"10","11","13","14","15","16","17","18","19","20","21","22","23",
"24","25","26","27","28","30","31","64","65","66","67","69"]
(gdb)
```

The `-data-list-register-names` Command

Synopsis

```
-data-list-register-names [ ( regno )+ ]
```

Show a list of register names for the current target. If no arguments are given, it shows a list of the names of all the registers. If integer numbers are given as arguments, it will print a list of the names of the registers corresponding to the arguments. To ensure consistency between a register name and its number, the output list may include empty register names.

GDB Command

GDB does not have a command which corresponds to '`-data-list-register-names`'. In `gdbtk` there is a corresponding command '`gdb_regnames`'.

Example

For the PPC MBX board:

```
(gdb)
-data-list-register-names
^done,register-names=["r0","r1","r2","r3","r4","r5","r6","r7",
"r8","r9","r10","r11","r12","r13","r14","r15","r16","r17","r18",
"r19","r20","r21","r22","r23","r24","r25","r26","r27","r28","r29",
"r30","r31","f0","f1","f2","f3","f4","f5","f6","f7","f8","f9",
"f10","f11","f12","f13","f14","f15","f16","f17","f18","f19","f20",
"f21","f22","f23","f24","f25","f26","f27","f28","f29","f30","f31",
"", "pc","ps","cr","lr","ctr","xer"]
(gdb)
-data-list-register-names 1 2 3
^done,register-names=["r1","r2","r3"]
(gdb)
```

The `-data-list-register-values` Command

Synopsis

```
-data-list-register-values fmt [ ( regno )*]
```

Display the registers' contents. *fmt* is the format according to which the registers' contents are to be returned, followed by an optional list of numbers specifying the registers to display. A missing list of numbers indicates that the contents of all the registers must be returned.

Allowed formats for *fmt* are:

`x` Hexadecimal

`o` Octal

`t` Binary

`d` Decimal

`r` Raw

`N` Natural

GDB Command

The corresponding GDB commands are '`info reg`', '`info all-reg`', and (in `gdbtk`) '`gdb_fetch_registers`'.

Example

For a PPC MBX board (note: line breaks are for readability only, they don't appear in the actual output):

```
(gdb)
-data-list-register-values r 64 65
^done,register-values=[{number="64",value="0xfe00a300"},
{number="65",value="0x00029002"}]
(gdb)
-data-list-register-values x
^done,register-values=[{number="0",value="0xfe0043c8"},
{number="1",value="0x3fff88"},{number="2",value="0xfffffffe"},
{number="3",value="0x0"},{number="4",value="0xa"},
{number="5",value="0x3fff68"},{number="6",value="0x3fff58"},
{number="7",value="0xfe011e98"},{number="8",value="0x2"},
{number="9",value="0xfa202820"},{number="10",value="0xfa202808"},
{number="11",value="0x1"},{number="12",value="0x0"},
{number="13",value="0x4544"},{number="14",value="0xffdfffff"},
{number="15",value="0xffffffff"},{number="16",value="0xfffffeff"},
{number="17",value="0xefffffed"},{number="18",value="0xfffffffe"},
{number="19",value="0xffffffff"},{number="20",value="0xffffffff"},
{number="21",value="0xffffffff"},{number="22",value="0xfffffff7"},
{number="23",value="0xffffffff"},{number="24",value="0xffffffff"},
{number="25",value="0xffffffff"},{number="26",value="0xfffffffb"},
{number="27",value="0xffffffff"},{number="28",value="0xf7bfffff"},
{number="29",value="0x0"},{number="30",value="0xfe010000"},
{number="31",value="0x0"},{number="32",value="0x0"},
{number="33",value="0x0"},{number="34",value="0x0"},
{number="35",value="0x0"},{number="36",value="0x0"},
{number="37",value="0x0"},{number="38",value="0x0"},
{number="39",value="0x0"},{number="40",value="0x0"},
{number="41",value="0x0"},{number="42",value="0x0"},
{number="43",value="0x0"},{number="44",value="0x0"},
{number="45",value="0x0"},{number="46",value="0x0"},
{number="47",value="0x0"},{number="48",value="0x0"},
{number="49",value="0x0"},{number="50",value="0x0"},
{number="51",value="0x0"},{number="52",value="0x0"},
{number="53",value="0x0"},{number="54",value="0x0"},
{number="55",value="0x0"},{number="56",value="0x0"},
{number="57",value="0x0"},{number="58",value="0x0"},
```

```
{number="59",value="0x0"},{number="60",value="0x0"},
{number="61",value="0x0"},{number="62",value="0x0"},
{number="63",value="0x0"},{number="64",value="0xfe00a300"},
{number="65",value="0x29002"},{number="66",value="0x202f04b5"},
{number="67",value="0xfe0043b0"},{number="68",value="0xfe00b3e4"},
{number="69",value="0x20002b03"}]
(gdb)
```

The `-data-read-memory` Command

This command is deprecated, use `-data-read-memory-bytes` instead.

Synopsis

```
-data-read-memory [ -o byte-offset ]
  address word-format word-size
  nr-rows nr-cols [ aschar ]
```

where:

‘*address*’ An expression specifying the address of the first memory word to be read. Complex expressions containing embedded white space should be quoted using the C convention.

‘*word-format*’
The format to be used to print the memory words. The notation is the same as for GDB’s `print` command (see Section 10.5 [Output Formats], page 110).

‘*word-size*’
The size of each memory word in bytes.

‘*nr-rows*’ The number of rows in the output table.

‘*nr-cols*’ The number of columns in the output table.

‘*aschar*’ If present, indicates that each row should include an ASCII dump. The value of *aschar* is used as a padding character when a byte is not a member of the printable ASCII character set (printable ASCII characters are those whose code is between 32 and 126, inclusively).

‘*byte-offset*’
An offset to add to the *address* before fetching memory.

This command displays memory contents as a table of *nr-rows* by *nr-cols* words, each word being *word-size* bytes. In total, *nr-rows* * *nr-cols* * *word-size* bytes are read (returned as ‘`total-bytes`’). Should less than the requested number of bytes be returned by the target, the missing words are identified using ‘`N/A`’. The number of bytes read from the target is returned in ‘`nr-bytes`’ and the starting address used to read memory in ‘`addr`’.

The address of the next/previous row or page is available in ‘`next-row`’ and ‘`prev-row`’, ‘`next-page`’ and ‘`prev-page`’.

GDB Command

The corresponding GDB command is ‘`x`’. `gdbtk` has ‘`gdb_get_mem`’ memory read command.

Example

Read six bytes of memory starting at `bytes+6` but then offset by `-6` bytes. Format as three rows of two columns. One byte per word. Display each word in hex.

```
(gdb)
9-data-read-memory -o -6 -- bytes+6 x 1 3 2
9^done,addr="0x00001390",nr-bytes="6",total-bytes="6",
next-row="0x00001396",prev-row="0x0000138e",next-page="0x00001396",
prev-page="0x0000138a",memory=[
{addr="0x00001390",data=["0x00","0x01"]},
{addr="0x00001392",data=["0x02","0x03"]},
{addr="0x00001394",data=["0x04","0x05"]}]
(gdb)
```

Read two bytes of memory starting at address `shorts + 64` and display as a single word formatted in decimal.

```
(gdb)
5-data-read-memory shorts+64 d 2 1 1
5^done,addr="0x00001510",nr-bytes="2",total-bytes="2",
next-row="0x00001512",prev-row="0x0000150e",
next-page="0x00001512",prev-page="0x0000150e",memory=[
{addr="0x00001510",data=["128"]}]
(gdb)
```

Read thirty two bytes of memory starting at `bytes+16` and format as eight rows of four columns. Include a string encoding with '`x`' used as the non-printable character.

```
(gdb)
4-data-read-memory bytes+16 x 1 8 4 x
4^done,addr="0x000013a0",nr-bytes="32",total-bytes="32",
next-row="0x000013c0",prev-row="0x0000139c",
next-page="0x000013c0",prev-page="0x00001380",memory=[
{addr="0x000013a0",data=["0x10","0x11","0x12","0x13"],ascii="xxxx"},
{addr="0x000013a4",data=["0x14","0x15","0x16","0x17"],ascii="xxxx"},
{addr="0x000013a8",data=["0x18","0x19","0x1a","0x1b"],ascii="xxxx"},
{addr="0x000013ac",data=["0x1c","0x1d","0x1e","0x1f"],ascii="xxxx"},
{addr="0x000013b0",data=["0x20","0x21","0x22","0x23"],ascii=" !\"#"},
{addr="0x000013b4",data=["0x24","0x25","0x26","0x27"],ascii="$%&'"},
{addr="0x000013b8",data=["0x28","0x29","0x2a","0x2b"],ascii="()*+"},
{addr="0x000013bc",data=["0x2c","0x2d","0x2e","0x2f"],ascii=",-./"}]
(gdb)
```

The `-data-read-memory-bytes` Command

Synopsis

```
-data-read-memory-bytes [ -o byte-offset ]
  address count
```

where:

'*address*' An expression specifying the address of the first memory word to be read. Complex expressions containing embedded white space should be quoted using the C convention.

'*count*' The number of bytes to read. This should be an integer literal.

‘*byte-offset*’
: The offsets in bytes relative to *address* at which to start reading. This should be an integer literal. This option is provided so that a frontend is not required to first evaluate address and then perform address arithmetics itself.

This command attempts to read all accessible memory regions in the specified range. First, all regions marked as unreadable in the memory map (if one is defined) will be skipped. See Section 10.17 [Memory Region Attributes], page 132. Second, GDB will attempt to read the remaining regions. For each one, if reading full region results in an errors, GDB will try to read a subset of the region.

In general, every single byte in the region may be readable or not, and the only way to read every readable byte is to try a read at every address, which is not practical. Therefore, GDB will attempt to read all accessible bytes at either beginning or the end of the region, using a binary division scheme. This heuristic works well for reading accross a memory map boundary. Note that if a region has a readable range that is neither at the beginning or the end, GDB will not read it.

The result record (see Section 27.7.1 [GDB/MI Result Records], page 371) that is output of the command includes a field named ‘`memory`’ whose content is a list of tuples. Each tuple represent a successfully read memory block and has the following fields:

`begin` The start address of the memory block, as hexadecimal literal.

`end` The end address of the memory block, as hexadecimal literal.

`offset` The offset of the memory block, as hexadecimal literal, relative to the start address passed to `-data-read-memory-bytes`.

`contents` The contents of the memory block, in hex.

GDB Command

The corresponding GDB command is ‘`x`’.

Example

```
(gdb)
-data-read-memory-bytes &a 10
^done,memory=[{begin="0xbffff154",offset="0x00000000",
               end="0xbffff15e",
               contents="01000000020000000300"}]
(gdb)
```

The `-data-write-memory-bytes` Command

Synopsis

```
-data-write-memory-bytes address contents
-data-write-memory-bytes address contents [count]
```

where:

‘*address*’ An expression specifying the address of the first memory word to be read. Complex expressions containing embedded white space should be quoted using the C convention.

‘*contents*’
The hex-encoded bytes to write.

‘*count*’ Optional argument indicating the number of bytes to be written. If *count* is greater than *contents*’ length, GDB will repeatedly write *contents* until it fills *count* bytes.

GDB Command

There’s no corresponding GDB command.

Example

```
(gdb)
-data-write-memory-bytes &a "aabbccdd"
^done
(gdb)
(gdb)
-data-write-memory-bytes &a "aabbccdd" 16e
^done
(gdb)
```

27.19 GDB/MI Tracepoint Commands

The commands defined in this section implement MI support for tracepoints. For detailed introduction, see Chapter 13 [Tracepoints], page 149.

The `-trace-find` Command

Synopsis

```
-trace-find mode [parameters...]
```

Find a trace frame using criteria defined by *mode* and *parameters*. The following table lists permissible modes and their parameters. For details of operation, see Section 13.2.1 [tfind], page 161.

‘`none`’ No parameters are required. Stops examining trace frames.

‘`frame-number`’
An integer is required as parameter. Selects tracepoint frame with that index.

‘`tracepoint-number`’
An integer is required as parameter. Finds next trace frame that corresponds to tracepoint with the specified number.

‘`pc`’ An address is required as parameter. Finds next trace frame that corresponds to any tracepoint at the specified address.

‘`pc-inside-range`’
Two addresses are required as parameters. Finds next trace frame that corresponds to a tracepoint at an address inside the specified range. Both bounds are considered to be inside the range.

‘`pc-outside-range`’
Two addresses are required as parameters. Finds next trace frame that corresponds to a tracepoint at an address outside the specified range. Both bounds are considered to be inside the range.

‘`line`’ Line specification is required as parameter. See Section 9.2 [Specify Location], page 94. Finds next trace frame that corresponds to a tracepoint at the specified location.

If ‘`none`’ was passed as *mode*, the response does not have fields. Otherwise, the response may have the following fields:

‘`found`’ This field has either ‘`0`’ or ‘`1`’ as the value, depending on whether a matching tracepoint was found.

‘`traceframe`’
The index of the found traceframe. This field is present iff the ‘`found`’ field has value of ‘`1`’.

‘`tracepoint`’
The index of the found tracepoint. This field is present iff the ‘`found`’ field has value of ‘`1`’.

‘`frame`’ The information about the frame corresponding to the found trace frame. This field is present only if a trace frame was found. See Section 27.7.5 [GDB/MI Frame Information], page 377, for description of this field.

GDB Command

The corresponding GDB command is ‘`tfind`’.

-trace-define-variable

Synopsis

```
-trace-define-variable name [ value ]
```

Create trace variable *name* if it does not exist. If *value* is specified, sets the initial value of the specified trace variable to that value. Note that the *name* should start with the ‘`$`’ character.

GDB Command

The corresponding GDB command is ‘`tvariable`’.

-trace-list-variables

Synopsis

```
-trace-list-variables
```

Return a table of all defined trace variables. Each element of the table has the following fields:

‘`name`’ The name of the trace variable. This field is always present.

‘`initial`’ The initial value. This is a 64-bit signed integer. This field is always present.

‘`current`’ The value the trace variable has at the moment. This is a 64-bit signed integer. This field is absent iff current value is not defined, for example if the trace was never run, or is presently running.

GDB Command

The corresponding GDB command is '`tvariables`'.

Example

```
(gdb)
-trace-list-variables
^done,trace-variables={nr_rows="1",nr_cols="3",
hdr=[{width="15",alignment="-1",col_name="name",colhdr="Name"},
     {width="11",alignment="-1",col_name="initial",colhdr="Initial"},
     {width="11",alignment="-1",col_name="current",colhdr="Current"}],
body=[variable={name="$trace_timestamp",initial="0"}
      variable={name="$foo",initial="10",current="15"}]}
(gdb)
```

-trace-save

Synopsis

```
-trace-save [-r ] filename
```

Saves the collected trace data to *filename*. Without the '`-r`' option, the data is downloaded from the target and saved in a local file. With the '`-r`' option the target is asked to perform the save.

GDB Command

The corresponding GDB command is '`tsave`'.

-trace-start

Synopsis

```
-trace-start
```

Starts a tracing experiments. The result of this command does not have any fields.

GDB Command

The corresponding GDB command is '`tstart`'.

-trace-status

Synopsis

```
-trace-status
```

Obtains the status of a tracing experiment. The result may include the following fields:

'`supported`'
: May have a value of either '`0`', when no tracing operations are supported, '`1`', when all tracing operations are supported, or '`file`' when examining trace file. In the latter case, examining of trace frame is possible but new tracing experiement cannot be started. This field is always present.

'`running`'
: May have a value of either '`0`' or '`1`' depending on whether tracing experiement is in progress on target. This field is present if '`supported`' field is not '`0`'.

‘stop-reason’
: Report the reason why the tracing was stopped last time. This field may be absent iff tracing was never stopped on target yet. The value of ‘request’ means the tracing was stopped as result of the -trace-stop command. The value of ‘overflow’ means the tracing buffer is full. The value of ‘disconnection’ means tracing was automatically stopped when GDB has disconnected. The value of ‘passcount’ means tracing was stopped when a tracepoint was passed a maximal number of times for that tracepoint. This field is present if ‘supported’ field is not ‘0’.

‘stopping-tracepoint’
: The number of tracepoint whose passcount as exceeded. This field is present iff the ‘stop-reason’ field has the value of ‘passcount’.

‘frames’
‘frames-created’
: The ‘frames’ field is a count of the total number of trace frames in the trace buffer, while ‘frames-created’ is the total created during the run, including ones that were discarded, such as when a circular trace buffer filled up. Both fields are optional.

‘buffer-size’
‘buffer-free’
: These fields tell the current size of the tracing buffer and the remaining space. These fields are optional.

‘circular’
: The value of the circular trace buffer flag. 1 means that the trace buffer is circular and old trace frames will be discarded if necessary to make room, 0 means that the trace buffer is linear and may fill up.

‘disconnected’
: The value of the disconnected tracing flag. 1 means that tracing will continue after GDB disconnects, 0 means that the trace run will stop.

‘trace-file’
: The filename of the trace file being examined. This field is optional, and only present when examining a trace file.

GDB Command

The corresponding GDB command is ‘tstatus’.

-trace-stop

Synopsis

```
-trace-stop
```

Stops a tracing experiment. The result of this command has the same fields as -trace-status, except that the ‘supported’ and ‘running’ fields are not output.

GDB Command

The corresponding GDB command is ‘tstop’.

27.20 GDB/MI Symbol Query Commands

The `-symbol-list-lines` Command

Synopsis

```
-symbol-list-lines filename
```

Print the list of lines that contain code and their associated program addresses for the given source filename. The entries are sorted in ascending PC order.

GDB Command

There is no corresponding GDB command.

Example

```
(gdb)
-symbol-list-lines basics.c
^done,lines=[{pc="0x08048554",line="7"},{pc="0x0804855a",line="8"}]
(gdb)
```

27.21 GDB/MI File Commands

This section describes the GDB/MI commands to specify executable file names and to read in and obtain symbol table information.

The `-file-exec-and-symbols` Command

Synopsis

```
-file-exec-and-symbols file
```

Specify the executable file to be debugged. This file is the one from which the symbol table is also read. If no file is specified, the command clears the executable and symbol information. If breakpoints are set when using this command with no arguments, GDB will produce error messages. Otherwise, no output is produced, except a completion notification.

GDB Command

The corresponding GDB command is '`file`'.

Example

```
(gdb)
-file-exec-and-symbols /kwikemart/marge/ezannoni/TRUNK/mbx/hello.mbx
^done
(gdb)
```

The `-file-exec-file` Command

Synopsis

```
-file-exec-file file
```

Specify the executable file to be debugged. Unlike '`-file-exec-and-symbols`', the symbol table is *not* read from this file. If used without argument, GDB clears the information about the executable file. No output is produced, except a completion notification.

GDB Command

The corresponding GDB command is '`exec-file`'.

Example

```
(gdb)
-file-exec-file /kwikemart/marge/ezannoni/TRUNK/mbx/hello.mbx
^done
(gdb)
```

The `-file-list-exec-source-file` Command

Synopsis

```
-file-list-exec-source-file
```

List the line number, the current source file, and the absolute path to the current source file for the current executable. The macro information field has a value of '`1`' or '`0`' depending on whether or not the file includes preprocessor macro information.

GDB Command

The GDB equivalent is '`info source`'

Example

```
(gdb)
123-file-list-exec-source-file
123^done,line="1",file="foo.c",fullname="/home/bar/foo.c,macro-info="1"
(gdb)
```

The `-file-list-exec-source-files` Command

Synopsis

```
-file-list-exec-source-files
```

List the source files for the current executable.

It will always output both the filename and fullname (absolute file name) of a source file.

GDB Command

The GDB equivalent is '`info sources`'. `gdbtk` has an analogous command '`gdb_listfiles`'.

Example

```
(gdb)
-file-list-exec-source-files
^done,files=[
{file=foo.c,fullname=/home/foo.c},
{file=/home/bar.c,fullname=/home/bar.c},
{file=gdb_could_not_find_fullpath.c}]
(gdb)
```

The `-file-symbol-file` Command

Synopsis

```
-file-symbol-file file
```

Read symbol table info from the specified *file* argument. When used without arguments, clears GDB's symbol table info. No output is produced, except for a completion notification.

GDB Command

The corresponding GDB command is '`symbol-file`'.

Example

```
(gdb)
-file-symbol-file /kwikemart/marge/ezannoni/TRUNK/mbx/hello.mbx
^done
(gdb)
```

27.22 GDB/MI Target Manipulation Commands

The `-target-attach` Command

Synopsis

```
-target-attach pid | gid | file
```

Attach to a process *pid* or a file *file* outside of GDB, or a thread group *gid*. If attaching to a thread group, the id previously returned by '`-list-thread-groups --available`' must be used.

GDB Command

The corresponding GDB command is '`attach`'.

Example

```
(gdb)
-target-attach 34
=thread-created,id="1"
*stopped,thread-id="1",frame={addr="0xb7f7e410",func="bar",args=[]}
^done
(gdb)
```

The `-target-detach` Command

Synopsis

```
-target-detach [ pid | gid ]
```

Detach from the remote target which normally resumes its execution. If either *pid* or *gid* is specified, detaches from either the specified process, or specified thread group. There's no output.

GDB Command

The corresponding GDB command is '`detach`'.

Example

```
(gdb)
-target-detach
^done
(gdb)
```

The `-target-disconnect` Command

Synopsis

```
-target-disconnect
```

Disconnect from the remote target. There's no output and the target is generally not resumed.

GDB Command

The corresponding GDB command is '`disconnect`'.

Example

```
(gdb)
-target-disconnect
^done
(gdb)
```

The `-target-download` Command

Synopsis

```
-target-download
```

Loads the executable onto the remote target. It prints out an update message every half second, which includes the fields:

'`section`' The name of the section.

'`section-sent`'
The size of what has been sent so far for that section.

'`section-size`'
The size of the section.

'`total-sent`'
The total size of what was sent so far (the current and the previous sections).

'`total-size`'
The size of the overall executable to download.

Each message is sent as status record (see Section 27.4.2 [GDB/MI Output Syntax], page 369).

In addition, it prints the name and size of the sections, as they are downloaded. These messages include the following fields:

'`section`' The name of the section.

'`section-size`'
The size of the section.

‘`total-size`’
: The size of the overall executable to download.

At the end, a summary is printed.

GDB Command

The corresponding GDB command is ‘`load`’.

Example

Note: each status message appears on a single line. Here the messages have been broken down so that they can fit onto a page.

```
(gdb)
-target-download
+download,{section=".text",section-size="6668",total-size="9880"}
+download,{section=".text",section-sent="512",section-size="6668",
total-sent="512",total-size="9880"}
+download,{section=".text",section-sent="1024",section-size="6668",
total-sent="1024",total-size="9880"}
+download,{section=".text",section-sent="1536",section-size="6668",
total-sent="1536",total-size="9880"}
+download,{section=".text",section-sent="2048",section-size="6668",
total-sent="2048",total-size="9880"}
+download,{section=".text",section-sent="2560",section-size="6668",
total-sent="2560",total-size="9880"}
+download,{section=".text",section-sent="3072",section-size="6668",
total-sent="3072",total-size="9880"}
+download,{section=".text",section-sent="3584",section-size="6668",
total-sent="3584",total-size="9880"}
+download,{section=".text",section-sent="4096",section-size="6668",
total-sent="4096",total-size="9880"}
+download,{section=".text",section-sent="4608",section-size="6668",
total-sent="4608",total-size="9880"}
+download,{section=".text",section-sent="5120",section-size="6668",
total-sent="5120",total-size="9880"}
+download,{section=".text",section-sent="5632",section-size="6668",
total-sent="5632",total-size="9880"}
+download,{section=".text",section-sent="6144",section-size="6668",
total-sent="6144",total-size="9880"}
+download,{section=".text",section-sent="6656",section-size="6668",
total-sent="6656",total-size="9880"}
+download,{section=".init",section-size="28",total-size="9880"}
+download,{section=".fini",section-size="28",total-size="9880"}
+download,{section=".data",section-size="3156",total-size="9880"}
+download,{section=".data",section-sent="512",section-size="3156",
total-sent="7236",total-size="9880"}
+download,{section=".data",section-sent="1024",section-size="3156",
total-sent="7748",total-size="9880"}
+download,{section=".data",section-sent="1536",section-size="3156",
total-sent="8260",total-size="9880"}
+download,{section=".data",section-sent="2048",section-size="3156",
total-sent="8772",total-size="9880"}
+download,{section=".data",section-sent="2560",section-size="3156",
total-sent="9284",total-size="9880"}
+download,{section=".data",section-sent="3072",section-size="3156",
total-sent="9796",total-size="9880"}
^done,address="0x10004",load-size="9880",transfer-rate="6586",
```

```
write-rate="429"
(gdb)
```

GDB Command

No equivalent.

Example

N.A.

The -target-select Command

Synopsis

```
-target-select type parameters ...
```

Connect GDB to the remote target. This command takes two args:

'*type*' The type of target, for instance '`remote`', etc.

'*parameters*'
Device names, host names and the like. See Section 19.2 [Commands for Managing Targets], page 231, for more details.

The output is a connection notification, followed by the address at which the target program is, in the following form:

```
^connected,addr="address",func="function name",
  args=[arg list]
```

GDB Command

The corresponding GDB command is '`target`'.

Example

```
(gdb)
-target-select remote /dev/ttya
^connected,addr="0xfe00a300",func="??",args=[]
(gdb)
```

27.23 GDB/MI File Transfer Commands

The -target-file-put Command

Synopsis

```
-target-file-put hostfile targetfile
```

Copy file *hostfile* from the host system (the machine running GDB) to *targetfile* on the target system.

GDB Command

The corresponding GDB command is '`remote put`'.

Example

```
(gdb)
-target-file-put localfile remotefile
^done
(gdb)
```

The `-target-file-get` Command

Synopsis

```
-target-file-get targetfile hostfile
```

Copy file *targetfile* from the target system to *hostfile* on the host system.

GDB Command

The corresponding GDB command is '`remote get`'.

Example

```
(gdb)
-target-file-get remotefile localfile
^done
(gdb)
```

The `-target-file-delete` Command

Synopsis

```
-target-file-delete targetfile
```

Delete *targetfile* from the target system.

GDB Command

The corresponding GDB command is '`remote delete`'.

Example

```
(gdb)
-target-file-delete remotefile
^done
(gdb)
```

27.24 Miscellaneous GDB/MI Commands

The `-gdb-exit` Command

Synopsis

```
-gdb-exit
```

Exit GDB immediately.

GDB Command

Approximately corresponds to '`quit`'.

Example

```
(gdb)
-gdb-exit
^exit
```

The `-gdb-set` Command

Synopsis

```
-gdb-set
```

Set an internal GDB variable.

GDB Command

The corresponding GDB command is '`set`'.

Example

```
(gdb)
-gdb-set $foo=3
^done
(gdb)
```

The `-gdb-show` Command

Synopsis

```
-gdb-show
```

Show the current value of a GDB variable.

GDB Command

The corresponding GDB command is '`show`'.

Example

```
(gdb)
-gdb-show annotate
^done,value="0"
(gdb)
```

The `-gdb-version` Command

Synopsis

```
-gdb-version
```

Show version information for GDB. Used mostly in testing.

GDB Command

The GDB equivalent is '`show version`'. GDB by default shows this information when you start an interactive session.

Example

```
(gdb)
-gdb-version
```

```
~GNU gdb 5.2.1
~Copyright 2000 Free Software Foundation, Inc.
~GDB is free software, covered by the GNU General Public License, and
~you are welcome to change it and/or distribute copies of it under
~ certain conditions.
~Type "show copying" to see the conditions.
~There is absolutely no warranty for GDB.  Type "show warranty" for
~ details.
~This GDB was configured as
 "--host=sparc-sun-solaris2.5.1 --target=ppc-eabi".
^done
(gdb)
```

The `-list-features` Command

Returns a list of particular features of the MI protocol that this version of gdb implements. A feature can be a command, or a new field in an output of some command, or even an important bugfix. While a frontend can sometimes detect presence of a feature at runtime, it is easier to perform detection at debugger startup.

The command returns a list of strings, with each string naming an available feature. Each returned string is just a name, it does not have any internal structure. The list of possible feature names is given below.

Example output:

```
(gdb) -list-features
^done,result=["feature1","feature2"]
```

The current list of features is:

‘`frozen-varobjs`’
: Indicates support for the `-var-set-frozen` command, as well as possible presense of the `frozen` field in the output of `-varobj-create`.

‘`pending-breakpoints`’
: Indicates support for the ‘`-f`’ option to the `-break-insert` command.

‘`python`’
: Indicates Python scripting support, Python-based pretty-printing commands, and possible presence of the ‘`display_hint`’ field in the output of `-var-list-children`

‘`thread-info`’
: Indicates support for the `-thread-info` command.

‘`data-read-memory-bytes`’
: Indicates support for the `-data-read-memory-bytes` and the `-data-write-memory-bytes` commands.

‘`breakpoint-notifications`’
: Indicates that changes to breakpoints and breakpoints created via the CLI will be announced via async records.

‘`ada-task-info`’
: Indicates support for the `-ada-task-info` command.

The `-list-target-features` Command

Returns a list of particular features that are supported by the target. Those features affect the permitted MI commands, but unlike the features reported by the `-list-features` command, the features depend on which target GDB is using at the moment. Whenever a target can change, due to commands such as `-target-select`, `-target-attach` or `-exec-run`, the list of target features may change, and the frontend should obtain it again. Example output:

```
(gdb) -list-features
^done,result=["async"]
```

The current list of features is:

'`async`' Indicates that the target is capable of asynchronous command execution, which means that GDB will accept further commands while the target is running.

'`reverse`' Indicates that the target is capable of reverse execution. See Chapter 6 [Reverse Execution], page 79, for more information.

The `-list-thread-groups` Command

Synopsis

```
-list-thread-groups [ --available ] [ --recurse 1 ] [ group ... ]
```

Lists thread groups (see Section 27.3.3 [Thread groups], page 367). When a single thread group is passed as the argument, lists the children of that group. When several thread group are passed, lists information about those thread groups. Without any parameters, lists information about all top-level thread groups.

Normally, thread groups that are being debugged are reported. With the '`--available`' option, GDB reports thread groups available on the target.

The output of this command may have either a '`threads`' result or a '`groups`' result. The '`thread`' result has a list of tuples as value, with each tuple describing a thread (see Section 27.7.6 [GDB/MI Thread Information], page 378). The '`groups`' result has a list of tuples as value, each tuple describing a thread group. If top-level groups are requested (that is, no parameter is passed), or when several groups are passed, the output always has a '`groups`' result. The format of the '`group`' result is described below.

To reduce the number of roundtrips it's possible to list thread groups together with their children, by passing the '`--recurse`' option and the recursion depth. Presently, only recursion depth of 1 is permitted. If this option is present, then every reported thread group will also include its children, either as '`group`' or '`threads`' field.

In general, any combination of option and parameters is permitted, with the following caveats:

- When a single thread group is passed, the output will typically be the '`threads`' result. Because threads may not contain anything, the '`recurse`' option will be ignored.
- When the '`--available`' option is passed, limited information may be available. In particular, the list of threads of a process might be inaccessible. Further, specifying specific thread groups might not give any performance advantage over listing all thread groups. The frontend should assume that '`-list-thread-groups --available`' is always an expensive operation and cache the results.

The '`groups`' result is a list of tuples, where each tuple may have the following fields:

`id` Identifier of the thread group. This field is always present. The identifier is an opaque string; frontends should not try to convert it to an integer, even though it might look like one.

`type` The type of the thread group. At present, only '`process`' is a valid type.

`pid` The target-specific process identifier. This field is only present for thread groups of type '`process`' and only if the process exists.

`num_children`
The number of children this thread group has. This field may be absent for an available thread group.

`threads` This field has a list of tuples as value, each tuple describing a thread. It may be present if the '`--recurse`' option is specified, and it's actually possible to obtain the threads.

`cores` This field is a list of integers, each identifying a core that one thread of the group is running on. This field may be absent if such information is not available.

`executable`
The name of the executable file that corresponds to this thread group. The field is only present for thread groups of type '`process`', and only if there is a corresponding executable file.

Example

```
gdb
-list-thread-groups
^done,groups=[{id="17",type="process",pid="yyy",num_children="2"}]
-list-thread-groups 17
^done,threads=[{id="2",target-id="Thread 0xb7e14b90 (LWP 21257)",
   frame={level="0",addr="0xffffe410",func="__kernel_vsyscall",args=[]},state="running"},
{id="1",target-id="Thread 0xb7e156b0 (LWP 21254)",
   frame={level="0",addr="0x0804891f",func="foo",args=[{name="i",value="10"}],
          file="/tmp/a.c",fullname="/tmp/a.c",line="158"},state="running"}]
-list-thread-groups --available
^done,groups=[{id="17",type="process",pid="yyy",num_children="2",cores=[1,2]}]
-list-thread-groups --available --recurse 1
 ^done,groups=[{id="17", types="process",pid="yyy",num_children="2",cores=[1,2],
                threads=[{id="1",target-id="Thread 0xb7e14b90",cores=[1]},
                         {id="2",target-id="Thread 0xb7e14b90",cores=[2]}]},..]
-list-thread-groups --available --recurse 1 17 18
^done,groups=[{id="17", types="process",pid="yyy",num_children="2",cores=[1,2],
               threads=[{id="1",target-id="Thread 0xb7e14b90",cores=[1]},
                        {id="2",target-id="Thread 0xb7e14b90",cores=[2]}]},...]
```

The `-info-os` Command

Synopsis

```
-info-os [ type ]
```

If no argument is supplied, the command returns a table of available operating-system-specific information types. If one of these types is supplied as an argument *type*, then the command returns a table of data of that type.

The types of information available depend on the target operating system.

GDB Command

The corresponding GDB command is '`info os`'.

Example

When run on a GNU/Linux system, the output will look something like this:

```
gdb
-info-os
^done,OSDataTable={nr_rows="9",nr_cols="3",
hdr=[{width="10",alignment="-1",col_name="col0",colhdr="Type"},
     {width="10",alignment="-1",col_name="col1",colhdr="Description"},
     {width="10",alignment="-1",col_name="col2",colhdr="Title"}],
body=[item={col0="processes",col1="Listing of all processes",
            col2="Processes"},
      item={col0="procgroups",col1="Listing of all process groups",
            col2="Process groups"},
      item={col0="threads",col1="Listing of all threads",
            col2="Threads"},
      item={col0="files",col1="Listing of all file descriptors",
            col2="File descriptors"},
      item={col0="sockets",col1="Listing of all internet-domain sockets",
            col2="Sockets"},
      item={col0="shm",col1="Listing of all shared-memory regions",
            col2="Shared-memory regions"},
      item={col0="semaphores",col1="Listing of all semaphores",
            col2="Semaphores"},
      item={col0="msg",col1="Listing of all message queues",
            col2="Message queues"},
      item={col0="modules",col1="Listing of all loaded kernel modules",
            col2="Kernel modules"}]}
gdb
-info-os processes
^done,OSDataTable={nr_rows="190",nr_cols="4",
hdr=[{width="10",alignment="-1",col_name="col0",colhdr="pid"},
     {width="10",alignment="-1",col_name="col1",colhdr="user"},
     {width="10",alignment="-1",col_name="col2",colhdr="command"},
     {width="10",alignment="-1",col_name="col3",colhdr="cores"}],
body=[item={col0="1",col1="root",col2="/sbin/init",col3="0"},
      item={col0="2",col1="root",col2="[kthreadd]",col3="1"},
      item={col0="3",col1="root",col2="[ksoftirqd/0]",col3="0"},
      ...
      item={col0="26446",col1="stan",col2="bash",col3="0"},
      item={col0="28152",col1="stan",col2="bash",col3="1"}]}
(gdb)
```

(Note that the MI output here includes a `"Title"` column that does not appear in command-line `info os`; this column is useful for MI clients that want to enumerate the types of data, such as in a popup menu, but is needless clutter on the command line, and `info os` omits it.)

The `-add-inferior` Command

Synopsis

```
-add-inferior
```

Creates a new inferior (see Section 4.9 [Inferiors and Programs], page 32). The created inferior is not associated with any executable. Such association may be established with the '`-file-exec-and-symbols`' command (see Section 27.21 [GDB/MI File Commands], page 429). The command response has a single field, '`thread-group`', whose value is the identifier of the thread group corresponding to the new inferior.

Example

```
gdb
-add-inferior
^done,thread-group="i3"
```

The `-interpreter-exec` Command

Synopsis

```
-interpreter-exec interpreter command
```

Execute the specified *command* in the given *interpreter*.

GDB Command

The corresponding GDB command is '`interpreter-exec`'.

Example

```
(gdb)
-interpreter-exec console "break main"
&"During symbol reading, couldn't parse type; debugger out of date?.\n"
&"During symbol reading, bad structure-type format.\n"
~"Breakpoint 1 at 0x8074fc6: file ../../src/gdb/main.c, line 743.\n"
^done
(gdb)
```

The `-inferior-tty-set` Command

Synopsis

```
-inferior-tty-set /dev/pts/1
```

Set terminal for future runs of the program being debugged.

GDB Command

The corresponding GDB command is '`set inferior-tty`' /dev/pts/1.

Example

```
(gdb)
-inferior-tty-set /dev/pts/1
^done
(gdb)
```

The `-inferior-tty-show` Command

Synopsis

```
-inferior-tty-show
```

Show terminal for future runs of program being debugged.

GDB Command

The corresponding GDB command is '`show inferior-tty`'.

Example

```
(gdb)
-inferior-tty-set /dev/pts/1
^done
(gdb)
-inferior-tty-show
^done,inferior_tty_terminal="/dev/pts/1"
(gdb)
```

The `-enable-timings` Command

Synopsis

```
-enable-timings [yes | no]
```

Toggle the printing of the wallclock, user and system times for an MI command as a field in its output. This command is to help frontend developers optimize the performance of their code. No argument is equivalent to '`yes`'.

GDB Command

No equivalent.

Example

```
(gdb)
-enable-timings
^done
(gdb)
-break-insert main
^done,bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x080484ed",func="main",file="myprog.c",
fullname="/home/nickrob/myprog.c",line="73",thread-groups=["i1"],
times="0"},
time={wallclock="0.05185",user="0.00800",system="0.00000"}
(gdb)
-enable-timings no
^done
(gdb)
-exec-run
^running
(gdb)
*stopped,reason="breakpoint-hit",disp="keep",bkptno="1",thread-id="0",
frame={addr="0x080484ed",func="main",args=[{name="argc",value="1"},
{name="argv",value="0xbfb60364"}],file="myprog.c",
fullname="/home/nickrob/myprog.c",line="73"}
(gdb)
```

28 GDB Annotations

This chapter describes annotations in GDB. Annotations were designed to interface GDB to graphical user interfaces or other similar programs which want to interact with GDB at a relatively high level.

The annotation mechanism has largely been superseded by GDB/MI (see Chapter 27 [GDB/MI], page 365).

28.1 What is an Annotation?

Annotations start with a newline character, two '`control-z`' characters, and the name of the annotation. If there is no additional information associated with this annotation, the name of the annotation is followed immediately by a newline. If there is additional information, the name of the annotation is followed by a space, the additional information, and a newline. The additional information cannot contain newline characters.

Any output not beginning with a newline and two '`control-z`' characters denotes literal output from GDB. Currently there is no need for GDB to output a newline followed by two '`control-z`' characters, but if there was such a need, the annotations could be extended with an '`escape`' annotation which means those three characters as output.

The annotation *level*, which is specified using the '`--annotate`' command line option (see Section 2.1.2 [Mode Options], page 13), controls how much information GDB prints together with its prompt, values of expressions, source lines, and other types of output. Level 0 is for no annotations, level 1 is for use when GDB is run as a subprocess of GNU Emacs, level 3 is the maximum annotation suitable for programs that control GDB, and level 2 annotations have been made obsolete (see Section "Limitations of the Annotation Interface" in *GDB's Obsolete Annotations*).

`set annotate` *`level`*
: The GDB command `set annotate` sets the level of annotations to the specified *level*.

`show annotate`
: Show the current annotation level.

This chapter describes level 3 annotations.

A simple example of starting up GDB with annotations is:

```
$ gdb --annotate=3
GNU gdb 6.0
Copyright 2003 Free Software Foundation, Inc.
GDB is free software, covered by the GNU General Public License,
and you are welcome to change it and/or distribute copies of it
under certain conditions.
Type "show copying" to see the conditions.
There is absolutely no warranty for GDB.  Type "show warranty"
for details.
This GDB was configured as "i386-pc-linux-gnu"

^Z^Zpre-prompt
(gdb)
^Z^Zprompt
quit
```

```
^Z^Zpost-prompt
$
```

Here '`quit`' is input to GDB; the rest is output from GDB. The three lines beginning '`^Z^Z`' (where '`^Z`' denotes a '`control-z`' character) are annotations; the rest is output from GDB.

28.2 The Server Prefix

If you prefix a command with '`server` ' then it will not affect the command history, nor will it affect GDB's notion of which command to repeat if RET is pressed on a line by itself. This means that commands can be run behind a user's back by a front-end in a transparent manner.

The `server` prefix does not affect the recording of values into the value history; to print a value without recording it into the value history, use the `output` command instead of the `print` command.

Using this prefix also disables confirmation requests (see [confirmation requests], page 291).

28.3 Annotation for GDB Input

When GDB prompts for input, it annotates this fact so it is possible to know when to send output, when the output from a given command is over, etc.

Different kinds of input each have a different *input type*. Each input type has three annotations: a `pre-` annotation, which denotes the beginning of any prompt which is being output, a plain annotation, which denotes the end of the prompt, and then a `post-` annotation which denotes the end of any echo which may (or may not) be associated with the input. For example, the `prompt` input type features the following annotations:

```
^Z^Zpre-prompt
^Z^Zprompt
^Z^Zpost-prompt
```

The input types are

`prompt` When GDB is prompting for a command (the main GDB prompt).

`commands` When GDB prompts for a set of commands, like in the `commands` command. The annotations are repeated for each command which is input.

`overload-choice`
When GDB wants the user to select between various overloaded functions.

`query` When GDB wants the user to confirm a potentially dangerous operation.

`prompt-for-continue`
When GDB is asking the user to press return to continue. Note: Don't expect this to work well; instead use `set height 0` to disable prompting. This is because the counting of lines is buggy in the presence of annotations.

28.4 Errors

```
^Z^Zquit
```

This annotation occurs right before GDB responds to an interrupt.

```
^Z^Zerror
```

This annotation occurs right before GDB responds to an error.

Quit and error annotations indicate that any annotations which GDB was in the middle of may end abruptly. For example, if a `value-history-begin` annotation is followed by a `error`, one cannot expect to receive the matching `value-history-end`. One cannot expect not to receive it either, however; an error annotation does not necessarily mean that GDB is immediately returning all the way to the top level.

A quit or error annotation may be preceded by

```
^Z^Zerror-begin
```

Any output between that and the quit or error annotation is the error message.

Warning messages are not yet annotated.

28.5 Invalidation Notices

The following annotations say that certain pieces of state may have changed.

`^Z^Zframes-invalid`
: The frames (for example, output from the `backtrace` command) may have changed.

`^Z^Zbreakpoints-invalid`
: The breakpoints may have changed. For example, the user just added or deleted a breakpoint.

28.6 Running the Program

When the program starts executing due to a GDB command such as `step` or `continue`,

```
^Z^Zstarting
```

is output. When the program stops,

```
^Z^Zstopped
```

is output. Before the `stopped` annotation, a variety of annotations describe how the program stopped.

`^Z^Zexited` *exit-status*
: The program exited, and *exit-status* is the exit status (zero for successful exit, otherwise nonzero).

`^Z^Zsignalled`
: The program exited with a signal. After the `^Z^Zsignalled`, the annotation continues:

```
intro-text
^Z^Zsignal-name
name
^Z^Zsignal-name-end
middle-text
^Z^Zsignal-string
```

```
string
^Z^Zsignal-string-end
end-text
```

where *name* is the name of the signal, such as `SIGILL` or `SIGSEGV`, and *string* is the explanation of the signal, such as `Illegal Instruction` or `Segmentation fault`. *intro-text*, *middle-text*, and *end-text* are for the user's benefit and have no particular format.

`^Z^Zsignal`
: The syntax of this annotation is just like `signalled`, but GDB is just saying that the program received the signal, not that it was terminated with it.

`^Z^Zbreakpoint` *number*
: The program hit breakpoint number *number*.

`^Z^Zwatchpoint` *number*
: The program hit watchpoint number *number*.

28.7 Displaying Source

The following annotation is used instead of displaying source code:

```
^Z^Zsource filename:line:character:middle:addr
```

where *filename* is an absolute file name indicating which source file, *line* is the line number within that file (where 1 is the first line in the file), *character* is the character position within the file (where 0 is the first character in the file) (for most debug formats this will necessarily point to the beginning of a line), *middle* is '`middle`' if *addr* is in the middle of the line, or '`beg`' if *addr* is at the beginning of the line, and *addr* is the address in the target program associated with the source which is being displayed. *addr* is in the form '`0x`' followed by one or more lowercase hex digits (note that this does not depend on the language).

29 JIT Compilation Interface

This chapter documents GDB's *just-in-time* (JIT) compilation interface. A JIT compiler is a program or library that generates native executable code at runtime and executes it, usually in order to achieve good performance while maintaining platform independence.

Programs that use JIT compilation are normally difficult to debug because portions of their code are generated at runtime, instead of being loaded from object files, which is where GDB normally finds the program's symbols and debug information. In order to debug programs that use JIT compilation, GDB has an interface that allows the program to register in-memory symbol files with GDB at runtime.

If you are using GDB to debug a program that uses this interface, then it should work transparently so long as you have not stripped the binary. If you are developing a JIT compiler, then the interface is documented in the rest of this chapter. At this time, the only known client of this interface is the LLVM JIT.

Broadly speaking, the JIT interface mirrors the dynamic loader interface. The JIT compiler communicates with GDB by writing data into a global variable and calling a fuction at a well-known symbol. When GDB attaches, it reads a linked list of symbol files from the global variable to find existing code, and puts a breakpoint in the function so that it can find out about additional code.

29.1 JIT Declarations

These are the relevant struct declarations that a C program should include to implement the interface:

```
typedef enum
{
  JIT_NOACTION = 0,
  JIT_REGISTER_FN,
  JIT_UNREGISTER_FN
} jit_actions_t;

struct jit_code_entry
{
  struct jit_code_entry *next_entry;
  struct jit_code_entry *prev_entry;
  const char *symfile_addr;
  uint64_t symfile_size;
};

struct jit_descriptor
{
  uint32_t version;
  /* This type should be jit_actions_t, but we use uint32_t
     to be explicit about the bitwidth.  */
  uint32_t action_flag;
  struct jit_code_entry *relevant_entry;
  struct jit_code_entry *first_entry;
};

/* GDB puts a breakpoint in this function.  */
void __attribute__((noinline)) __jit_debug_register_code() { };
```

```
/* Make sure to specify the version statically, because the
   debugger may check the version before we can set it.  */
struct jit_descriptor __jit_debug_descriptor = { 1, 0, 0, 0 };
```

If the JIT is multi-threaded, then it is important that the JIT synchronize any modifications to this global data properly, which can easily be done by putting a global mutex around modifications to these structures.

29.2 Registering Code

To register code with GDB, the JIT should follow this protocol:

- Generate an object file in memory with symbols and other desired debug information. The file must include the virtual addresses of the sections.
- Create a code entry for the file, which gives the start and size of the symbol file.
- Add it to the linked list in the JIT descriptor.
- Point the relevant_entry field of the descriptor at the entry.
- Set `action_flag` to `JIT_REGISTER` and call `__jit_debug_register_code`.

When GDB is attached and the breakpoint fires, GDB uses the `relevant_entry` pointer so it doesn't have to walk the list looking for new code. However, the linked list must still be maintained in order to allow GDB to attach to a running process and still find the symbol files.

29.3 Unregistering Code

If code is freed, then the JIT should use the following protocol:

- Remove the code entry corresponding to the code from the linked list.
- Point the `relevant_entry` field of the descriptor at the code entry.
- Set `action_flag` to `JIT_UNREGISTER` and call `__jit_debug_register_code`.

If the JIT frees or recompiles code without unregistering it, then GDB and the JIT will leak the memory used for the associated symbol files.

29.4 Custom Debug Info

Generating debug information in platform-native file formats (like ELF or COFF) may be an overkill for JIT compilers; especially if all the debug info is used for is displaying a meaningful backtrace. The issue can be resolved by having the JIT writers decide on a debug info format and also provide a reader that parses the debug info generated by the JIT compiler. This section gives a brief overview on writing such a parser. More specific details can be found in the source file '`gdb/jit-reader.in`', which is also installed as a header at '*`includedir`*`/gdb/jit-reader.h`' for easy inclusion.

The reader is implemented as a shared object (so this functionality is not available on platforms which don't allow loading shared objects at runtime). Two GDB commands, `jit-reader-load` and `jit-reader-unload` are provided, to be used to load and unload the readers from a preconfigured directory. Once loaded, the shared object is used the parse the debug information emitted by the JIT compiler.

29.4.1 Using JIT Debug Info Readers

Readers can be loaded and unloaded using the `jit-reader-load` and `jit-reader-unload` commands.

`jit-reader-load` *reader*

Load the JIT reader named *reader*. *reader* is a shared object specified as either an absolute or a relative file name. In the latter case, GDB will try to load the reader from a pre-configured directory, usually '*libdir*`/gdb/`' on a UNIX system (here *libdir* is the system library directory, often '`/usr/local/lib`').

Only one reader can be active at a time; trying to load a second reader when one is already loaded will result in GDB reporting an error. A new JIT reader can be loaded by first unloading the current one using `jit-reader-unload` and then invoking `jit-reader-load`.

`jit-reader-unload`

Unload the currently loaded JIT reader.

29.4.2 Writing JIT Debug Info Readers

As mentioned, a reader is essentially a shared object conforming to a certain ABI. This ABI is described in '`jit-reader.h`'.

'`jit-reader.h`' defines the structures, macros and functions required to write a reader. It is installed (along with GDB), in '*includedir*`/gdb`' where *includedir* is the system include directory.

Readers need to be released under a GPL compatible license. A reader can be declared as released under such a license by placing the macro `GDB_DECLARE_GPL_COMPATIBLE_READER` in a source file.

The entry point for readers is the symbol `gdb_init_reader`, which is expected to be a function with the prototype

```
extern struct gdb_reader_funcs *gdb_init_reader (void);
```

`struct gdb_reader_funcs` contains a set of pointers to callback functions. These functions are executed to read the debug info generated by the JIT compiler (`read`), to unwind stack frames (`unwind`) and to create canonical frame IDs (`get_Frame_id`). It also has a callback that is called when the reader is being unloaded (`destroy`). The struct looks like this

```
struct gdb_reader_funcs
{
  /* Must be set to GDB_READER_INTERFACE_VERSION.  */
  int reader_version;

  /* For use by the reader.  */
  void *priv_data;

  gdb_read_debug_info *read;
  gdb_unwind_frame *unwind;
  gdb_get_frame_id *get_frame_id;
  gdb_destroy_reader *destroy;
};
```

The callbacks are provided with another set of callbacks by GDB to do their job. For `read`, these callbacks are passed in a `struct gdb_symbol_callbacks` and for `unwind` and

`get_frame_id`, in a `struct gdb_unwind_callbacks`. `struct gdb_symbol_callbacks` has callbacks to create new object files and new symbol tables inside those object files. `struct gdb_unwind_callbacks` has callbacks to read registers off the current frame and to write out the values of the registers in the previous frame. Both have a callback (`target_read`) to read bytes off the target's address space.

30 In-Process Agent

The traditional debugging model is conceptually low-speed, but works fine, because most bugs can be reproduced in debugging-mode execution. However, as multi-core or many-core processors are becoming mainstream, and multi-threaded programs become more and more popular, there should be more and more bugs that only manifest themselves at normal-mode execution, for example, thread races, because debugger's interference with the program's timing may conceal the bugs. On the other hand, in some applications, it is not feasible for the debugger to interrupt the program's execution long enough for the developer to learn anything helpful about its behavior. If the program's correctness depends on its real-time behavior, delays introduced by a debugger might cause the program to fail, even when the code itself is correct. It is useful to be able to observe the program's behavior without interrupting it.

Therefore, traditional debugging model is too intrusive to reproduce some bugs. In order to reduce the interference with the program, we can reduce the number of operations performed by debugger. The *In-Process Agent*, a shared library, is running within the same process with inferior, and is able to perform some debugging operations itself. As a result, debugger is only involved when necessary, and performance of debugging can be improved accordingly. Note that interference with program can be reduced but can't be removed completely, because the in-process agent will still stop or slow down the program.

The in-process agent can interpret and execute Agent Expressions (see Appendix F [Agent Expressions], page 565) during performing debugging operations. The agent expressions can be used for different purposes, such as collecting data in tracepoints, and condition evaluation in breakpoints.

You can control whether the in-process agent is used as an aid for debugging with the following commands:

`set agent on`
: Causes the in-process agent to perform some operations on behalf of the debugger. Just which operations requested by the user will be done by the in-process agent depends on the its capabilities. For example, if you request to evaluate breakpoint conditions in the in-process agent, and the in-process agent has such capability as well, then breakpoint conditions will be evaluated in the in-process agent.

`set agent off`
: Disables execution of debugging operations by the in-process agent. All of the operations will be performed by GDB.

`show agent`
: Display the current setting of execution of debugging operations by the in-process agent.

30.1 In-Process Agent Protocol

The in-process agent is able to communicate with both GDB and GDBserver (see Chapter 30 [In-Process Agent], page 451). This section documents the protocol used for communications between GDB or GDBserver and the IPA. In general, GDB or GDBserver sends commands

(see Section 30.1.2 [IPA Protocol Commands], page 453) and data to in-process agent, and then in-process agent replies back with the return result of the command, or some other information. The data sent to in-process agent is composed of primitive data types, such as 4-byte or 8-byte type, and composite types, which are called objects (see Section 30.1.1 [IPA Protocol Objects], page 452).

30.1.1 IPA Protocol Objects

The commands sent to and results received from agent may contain some complex data types called *objects*.

The in-process agent is running on the same machine with GDB or GDBserver, so it doesn't have to handle as much differences between two ends as remote protocol (see Appendix E [Remote Protocol], page 503) tries to handle. However, there are still some differences of two ends in two processes:

1. word size. On some 64-bit machines, GDB or GDBserver can be compiled as a 64-bit executable, while in-process agent is a 32-bit one.
2. ABI. Some machines may have multiple types of ABI, GDB or GDBserver is compiled with one, and in-process agent is compiled with the other one.

Here are the IPA Protocol Objects:

1. agent expression object. It represents an agent expression (see Appendix F [Agent Expressions], page 565).
2. tracepoint action object. It represents a tracepoint action (see Section 13.1.6 [Tracepoint Action Lists], page 154) to collect registers, memory, static trace data and to evaluate expression.
3. tracepoint object. It represents a tracepoint (see Chapter 13 [Tracepoints], page 149).

The following table describes important attributes of each IPA protocol object:

Name	**Size**	**Description**
agent expression object		
length	4	length of bytes code
byte code	*length*	contents of byte code
tracepoint action for collecting memory		
'M'	1	type of tracepoint action
addr	8	if *basereg* is '`-1`', *addr* is the address of the lowest byte to collect, otherwise *addr* is the offset of *basereg* for memory collecting.
len	8	length of memory for collecting
basereg	4	the register number containing the starting memory address for collecting.
tracepoint action for collecting registers		
'R'	1	type of tracepoint action

tracepoint action for collecting static trace data		
'L'	1	type of tracepoint action
tracepoint action for expression evaluation		
'X'	1	type of tracepoint action
agent expression	length of	[agent expression object], page 452
tracepoint object		
number	4	number of tracepoint
address	8	address of tracepoint inserted on
type	4	type of tracepoint
enabled	1	enable or disable of tracepoint
step_count	8	step
pass_count	8	pass
numactions	4	number of tracepoint actions
hit count	8	hit count
trace frame usage	8	trace frame usage
compiled_cond	8	compiled condition
orig_size	8	orig size
condition	4 if condition is NULL otherwise length of [agent expression object], page 452	zero if condition is NULL, otherwise is [agent expression object], page 452
actions	variable	numactions number of [tracepoint action object], page 452

30.1.2 IPA Protocol Commands

The spaces in each command are delimiters to ease reading this commands specification. They don't exist in real commands.

'`FastTrace:`*`tracepoint_object gdb_jump_pad_head`*'
: Installs a new fast tracepoint described by *tracepoint_object* (see [tracepoint object], page 452). *gdb_jump_pad_head*, 8-byte long, is the head of *jumppad*, which is used to jump to data collection routine in IPA finally.

  Replies:

  '`OK` *`target_address gdb_jump_pad_head fjump_size fjump`*'
  : *target_address* is address of tracepoint in the inferior. *gdb_jump_pad_head* is updated head of jumppad. Both of *target_address* and *gdb_jump_pad_head* are 8-byte long. *fjump* contains a sequence of instructions jump to jumppad entry. *fjump_size*, 4-byte long, is the size of *fjump*.

  '`E` *`NN`*' for an error

‘`close`’ Closes the in-process agent. This command is sent when GDB or GDBserver is about to kill inferiors.

‘`qTfSTM`’ See [qTfSTM], page 540.

‘`qTsSTM`’ See [qTsSTM], page 540.

‘`qTSTMat`’ See [qTSTMat], page 541.

‘`probe_marker_at:`*address*’
Asks in-process agent to probe the marker at *address*.

Replies:

‘`E` *NN*’ for an error

‘`unprobe_marker_at:`*address*’
Asks in-process agent to unprobe the marker at *address*.

31 Reporting Bugs in GDB

Your bug reports play an essential role in making GDB reliable.

Reporting a bug may help you by bringing a solution to your problem, or it may not. But in any case the principal function of a bug report is to help the entire community by making the next version of GDB work better. Bug reports are your contribution to the maintenance of GDB.

In order for a bug report to serve its purpose, you must include the information that enables us to fix the bug.

31.1 Have You Found a Bug?

If you are not sure whether you have found a bug, here are some guidelines:

- If the debugger gets a fatal signal, for any input whatever, that is a GDB bug. Reliable debuggers never crash.
- If GDB produces an error message for valid input, that is a bug. (Note that if you're cross debugging, the problem may also be somewhere in the connection to the target.)
- If GDB does not produce an error message for invalid input, that is a bug. However, you should note that your idea of "invalid input" might be our idea of "an extension" or "support for traditional practice".
- If you are an experienced user of debugging tools, your suggestions for improvement of GDB are welcome in any case.

31.2 How to Report Bugs

A number of companies and individuals offer support for GNU products. If you obtained GDB from a support organization, we recommend you contact that organization first.

You can find contact information for many support companies and individuals in the file '`etc/SERVICE`' in the GNU Emacs distribution.

In any event, we also recommend that you submit bug reports for GDB to `http://www.intel.com/software/products/support/`.

The fundamental principle of reporting bugs usefully is this: **report all the facts**. If you are not sure whether to state a fact or leave it out, state it!

Often people omit facts because they think they know what causes the problem and assume that some details do not matter. Thus, you might assume that the name of the variable you use in an example does not matter. Well, probably it does not, but one cannot be sure. Perhaps the bug is a stray memory reference which happens to fetch from the location where that name is stored in memory; perhaps, if the name were different, the contents of that location would fool the debugger into doing the right thing despite the bug. Play it safe and give a specific, complete example. That is the easiest thing for you to do, and the most helpful.

Keep in mind that the purpose of a bug report is to enable us to fix the bug. It may be that the bug has been reported previously, but neither you nor we can know that unless your bug report is complete and self-contained.

Sometimes people give a few sketchy facts and ask, "Does this ring a bell?" Those bug reports are useless, and we urge everyone to *refuse to respond to them* except to chide the sender to report bugs properly.

To enable us to fix the bug, you should include all these things:

- The version of GDB. GDB announces it if you start with no arguments; you can also print it at any time using `show version`.

  Without this, we will not know whether there is any point in looking for the bug in the current version of GDB.
- The type of machine you are using, and the operating system name and version number.
- What compiler (and its version) was used to compile GDB—e.g. "gcc–2.8.1".
- What compiler (and its version) was used to compile the program you are debugging—e.g. "gcc–2.8.1", or "HP92453-01 A.10.32.03 HP C Compiler". For GCC, you can say *`gcc --version`* to get this information; for other compilers, see the documentation for those compilers.
- The command arguments you gave the compiler to compile your example and observe the bug. For example, did you use '`-O`'? To guarantee you will not omit something important, list them all. A copy of the Makefile (or the output from make) is sufficient.

  If we were to try to guess the arguments, we would probably guess wrong and then we might not encounter the bug.
- A complete input script, and all necessary source files, that will reproduce the bug.
- A description of what behavior you observe that you believe is incorrect. For example, "It gets a fatal signal."

  Of course, if the bug is that GDB gets a fatal signal, then we will certainly notice it. But if the bug is incorrect output, we might not notice unless it is glaringly wrong. You might as well not give us a chance to make a mistake.

  Even if the problem you experience is a fatal signal, you should still say so explicitly. Suppose something strange is going on, such as, your copy of GDB is out of synch, or you have encountered a bug in the C library on your system. (This has happened!) Your copy might crash and ours would not. If you told us to expect a crash, then when ours fails to crash, we would know that the bug was not happening for us. If you had not told us to expect a crash, then we would not be able to draw any conclusion from our observations.

  To collect all this information, you can use a session recording program such as `script`, which is available on many Unix systems. Just run your GDB session inside `script` and then include the '`typescript`' file with your bug report.

  Another way to record a GDB session is to run GDB inside Emacs and then save the entire buffer to a file.
- If you wish to suggest changes to the GDB source, send us context diffs. If you even discuss something in the GDB source, refer to it by context, not by line number.

  The line numbers in our development sources will not match those in your sources. Your line numbers would convey no useful information to us.

Here are some things that are not necessary:

- A description of the envelope of the bug.

  Often people who encounter a bug spend a lot of time investigating which changes to the input file will make the bug go away and which changes will not affect it.

  This is often time consuming and not very useful, because the way we will find the bug is by running a single example under the debugger with breakpoints, not by pure deduction from a series of examples. We recommend that you save your time for something else.

  Of course, if you can find a simpler example to report *instead* of the original one, that is a convenience for us. Errors in the output will be easier to spot, running under the debugger will take less time, and so on.

  However, simplification is not vital; if you do not want to do this, report the bug anyway and send us the entire test case you used.

- A patch for the bug.

  A patch for the bug does help us if it is a good one. But do not omit the necessary information, such as the test case, on the assumption that a patch is all we need. We might see problems with your patch and decide to fix the problem another way, or we might not understand it at all.

  Sometimes with a program as complicated as GDB it is very hard to construct an example that will make the program follow a certain path through the code. If you do not send us the example, we will not be able to construct one, so we will not be able to verify that the bug is fixed.

  And if we cannot understand what bug you are trying to fix, or why your patch should be an improvement, we will not install it. A test case will help us to understand.

- A guess about what the bug is or what it depends on.

  Such guesses are usually wrong. Even we cannot guess right about such things without first using the debugger to find the facts.

32 Command Line Editing

This chapter describes the basic features of the GNU command line editing interface.

32.1 Introduction to Line Editing

The following paragraphs describe the notation used to represent keystrokes.

The text `C-k` is read as 'Control-K' and describes the character produced when the K key is pressed while the Control key is depressed.

The text `M-k` is read as 'Meta-K' and describes the character produced when the Meta key (if you have one) is depressed, and the K key is pressed. The Meta key is labeled ALT on many keyboards. On keyboards with two keys labeled ALT (usually to either side of the space bar), the ALT on the left side is generally set to work as a Meta key. The ALT key on the right may also be configured to work as a Meta key or may be configured as some other modifier, such as a Compose key for typing accented characters.

If you do not have a Meta or ALT key, or another key working as a Meta key, the identical keystroke can be generated by typing ESC *first*, and then typing K. Either process is known as *metafying* the K key.

The text `M-C-k` is read as 'Meta-Control-k' and describes the character produced by *metafying* `C-k`.

In addition, several keys have their own names. Specifically, DEL, ESC, LFD, SPC, RET, and TAB all stand for themselves when seen in this text, or in an init file (see Section 32.3 [Readline Init File], page 462). If your keyboard lacks a LFD key, typing C-J will produce the desired character. The RET key may be labeled RETURN or ENTER on some keyboards.

32.2 Readline Interaction

Often during an interactive session you type in a long line of text, only to notice that the first word on the line is misspelled. The Readline library gives you a set of commands for manipulating the text as you type it in, allowing you to just fix your typo, and not forcing you to retype the majority of the line. Using these editing commands, you move the cursor to the place that needs correction, and delete or insert the text of the corrections. Then, when you are satisfied with the line, you simply press RET. You do not have to be at the end of the line to press RET; the entire line is accepted regardless of the location of the cursor within the line.

32.2.1 Readline Bare Essentials

In order to enter characters into the line, simply type them. The typed character appears where the cursor was, and then the cursor moves one space to the right. If you mistype a character, you can use your erase character to back up and delete the mistyped character.

Sometimes you may mistype a character, and not notice the error until you have typed several other characters. In that case, you can type `C-b` to move the cursor to the left, and then correct your mistake. Afterwards, you can move the cursor to the right with `C-f`.

When you add text in the middle of a line, you will notice that characters to the right of the cursor are 'pushed over' to make room for the text that you have inserted. Likewise,

when you delete text behind the cursor, characters to the right of the cursor are 'pulled back' to fill in the blank space created by the removal of the text. A list of the bare essentials for editing the text of an input line follows.

`C-b` Move back one character.

`C-f` Move forward one character.

DEL or BACKSPACE
Delete the character to the left of the cursor.

`C-d` Delete the character underneath the cursor.

Printing characters
Insert the character into the line at the cursor.

`C-_` or `C-x C-u`
Undo the last editing command. You can undo all the way back to an empty line.

(Depending on your configuration, the BACKSPACE key be set to delete the character to the left of the cursor and the DEL key set to delete the character underneath the cursor, like `C-d`, rather than the character to the left of the cursor.)

32.2.2 Readline Movement Commands

The above table describes the most basic keystrokes that you need in order to do editing of the input line. For your convenience, many other commands have been added in addition to `C-b`, `C-f`, `C-d`, and DEL. Here are some commands for moving more rapidly about the line.

`C-a` Move to the start of the line.

`C-e` Move to the end of the line.

`M-f` Move forward a word, where a word is composed of letters and digits.

`M-b` Move backward a word.

`C-l` Clear the screen, reprinting the current line at the top.

Notice how `C-f` moves forward a character, while `M-f` moves forward a word. It is a loose convention that control keystrokes operate on characters while meta keystrokes operate on words.

32.2.3 Readline Killing Commands

Killing text means to delete the text from the line, but to save it away for later use, usually by *yanking* (re-inserting) it back into the line. ('Cut' and 'paste' are more recent jargon for 'kill' and 'yank'.)

If the description for a command says that it 'kills' text, then you can be sure that you can get the text back in a different (or the same) place later.

When you use a kill command, the text is saved in a *kill-ring*. Any number of consecutive kills save all of the killed text together, so that when you yank it back, you get it all. The kill ring is not line specific; the text that you killed on a previously typed line is available to be yanked back later, when you are typing another line.

Here is the list of commands for killing text.

`C-k` Kill the text from the current cursor position to the end of the line.

`M-d` Kill from the cursor to the end of the current word, or, if between words, to the end of the next word. Word boundaries are the same as those used by `M-f`.

`M-DEL` Kill from the cursor the start of the current word, or, if between words, to the start of the previous word. Word boundaries are the same as those used by `M-b`.

`C-w` Kill from the cursor to the previous whitespace. This is different than `M-DEL` because the word boundaries differ.

Here is how to *yank* the text back into the line. Yanking means to copy the most-recently-killed text from the kill buffer.

`C-y` Yank the most recently killed text back into the buffer at the cursor.

`M-y` Rotate the kill-ring, and yank the new top. You can only do this if the prior command is `C-y` or `M-y`.

32.2.4 Readline Arguments

You can pass numeric arguments to Readline commands. Sometimes the argument acts as a repeat count, other times it is the *sign* of the argument that is significant. If you pass a negative argument to a command which normally acts in a forward direction, that command will act in a backward direction. For example, to kill text back to the start of the line, you might type '`M-- C-k`'.

The general way to pass numeric arguments to a command is to type meta digits before the command. If the first 'digit' typed is a minus sign ('`-`'), then the sign of the argument will be negative. Once you have typed one meta digit to get the argument started, you can type the remainder of the digits, and then the command. For example, to give the `C-d` command an argument of 10, you could type '`M-1 0 C-d`', which will delete the next ten characters on the input line.

32.2.5 Searching for Commands in the History

Readline provides commands for searching through the command history for lines containing a specified string. There are two search modes: *incremental* and *non-incremental*.

Incremental searches begin before the user has finished typing the search string. As each character of the search string is typed, Readline displays the next entry from the history matching the string typed so far. An incremental search requires only as many characters as needed to find the desired history entry. To search backward in the history for a particular string, type `C-r`. Typing `C-s` searches forward through the history. The characters present in the value of the `isearch-terminators` variable are used to terminate an incremental search. If that variable has not been assigned a value, the ESC and `C-J` characters will terminate an incremental search. `C-g` will abort an incremental search and restore the original line. When the search is terminated, the history entry containing the search string becomes the current line.

To find other matching entries in the history list, type `C-r` or `C-s` as appropriate. This will search backward or forward in the history for the next entry matching the search string typed so far. Any other key sequence bound to a Readline command will terminate the

search and execute that command. For instance, a RET will terminate the search and accept the line, thereby executing the command from the history list. A movement command will terminate the search, make the last line found the current line, and begin editing.

Readline remembers the last incremental search string. If two *C-r*s are typed without any intervening characters defining a new search string, any remembered search string is used.

Non-incremental searches read the entire search string before starting to search for matching history lines. The search string may be typed by the user or be part of the contents of the current line.

32.3 Readline Init File

Although the Readline library comes with a set of Emacs-like keybindings installed by default, it is possible to use a different set of keybindings. Any user can customize programs that use Readline by putting commands in an *inputrc* file, conventionally in his home directory. The name of this file is taken from the value of the environment variable `INPUTRC`. If that variable is unset, the default is '`~/.inputrc`'. If that file does not exist or cannot be read, the ultimate default is '`/etc/inputrc`'.

When a program which uses the Readline library starts up, the init file is read, and the key bindings are set.

In addition, the `C-x C-r` command re-reads this init file, thus incorporating any changes that you might have made to it.

32.3.1 Readline Init File Syntax

There are only a few basic constructs allowed in the Readline init file. Blank lines are ignored. Lines beginning with a '`#`' are comments. Lines beginning with a '`$`' indicate conditional constructs (see Section 32.3.2 [Conditional Init Constructs], page 468). Other lines denote variable settings and key bindings.

Variable Settings

You can modify the run-time behavior of Readline by altering the values of variables in Readline using the `set` command within the init file. The syntax is simple:

```
set variable value
```

Here, for example, is how to change from the default Emacs-like key binding to use `vi` line editing commands:

```
set editing-mode vi
```

Variable names and values, where appropriate, are recognized without regard to case. Unrecognized variable names are ignored.

Boolean variables (those that can be set to on or off) are set to on if the value is null or empty, *on* (case-insensitive), or 1. Any other value results in the variable being set to off.

A great deal of run-time behavior is changeable with the following variables.

`bell-style`

Controls what happens when Readline wants to ring the terminal bell. If set to '`none`', Readline never rings the bell. If set to

'`visible`', Readline uses a visible bell if one is available. If set to '`audible`' (the default), Readline attempts to ring the terminal's bell.

`bind-tty-special-chars`
: If set to '`on`', Readline attempts to bind the control characters treated specially by the kernel's terminal driver to their Readline equivalents.

`comment-begin`
: The string to insert at the beginning of the line when the `insert-comment` command is executed. The default value is `"#"`.

`completion-display-width`
: The number of screen columns used to display possible matches when performing completion. The value is ignored if it is less than 0 or greater than the terminal screen width. A value of 0 will cause matches to be displayed one per line. The default value is -1.

`completion-ignore-case`
: If set to '`on`', Readline performs filename matching and completion in a case-insensitive fashion. The default value is '`off`'.

`completion-map-case`
: If set to '`on`', and *completion-ignore-case* is enabled, Readline treats hyphens ('`-`') and underscores ('`_`') as equivalent when performing case-insensitive filename matching and completion.

`completion-prefix-display-length`
: The length in characters of the common prefix of a list of possible completions that is displayed without modification. When set to a value greater than zero, common prefixes longer than this value are replaced with an ellipsis when displaying possible completions.

`completion-query-items`
: The number of possible completions that determines when the user is asked whether the list of possibilities should be displayed. If the number of possible completions is greater than this value, Readline will ask the user whether or not he wishes to view them; otherwise, they are simply listed. This variable must be set to an integer value greater than or equal to 0. A negative value means Readline should never ask. The default limit is `100`.

`convert-meta`
: If set to '`on`', Readline will convert characters with the eighth bit set to an ASCII key sequence by stripping the eighth bit and prefixing an ESC character, converting them to a meta-prefixed key sequence. The default value is '`on`'.

`disable-completion`
: If set to '`On`', Readline will inhibit word completion. Completion characters will be inserted into the line as if they had been mapped to `self-insert`. The default is '`off`'.

`editing-mode`
: The `editing-mode` variable controls which default set of key bindings is used. By default, Readline starts up in Emacs editing mode, where the keystrokes are most similar to Emacs. This variable can be set to either '`emacs`' or '`vi`'.

`echo-control-characters`
: When set to '`on`', on operating systems that indicate they support it, readline echoes a character corresponding to a signal generated from the keyboard. The default is '`on`'.

`enable-keypad`
: When set to '`on`', Readline will try to enable the application keypad when it is called. Some systems need this to enable the arrow keys. The default is '`off`'.

`enable-meta-key`
: When set to '`on`', Readline will try to enable any meta modifier key the terminal claims to support when it is called. On many terminals, the meta key is used to send eight-bit characters. The default is '`on`'.

`expand-tilde`
: If set to '`on`', tilde expansion is performed when Readline attempts word completion. The default is '`off`'.

`history-preserve-point`
: If set to '`on`', the history code attempts to place the point (the current cursor position) at the same location on each history line retrieved with `previous-history` or `next-history`. The default is '`off`'.

`history-size`
: Set the maximum number of history entries saved in the history list. If set to zero, the number of entries in the history list is not limited.

`horizontal-scroll-mode`
: This variable can be set to either '`on`' or '`off`'. Setting it to '`on`' means that the text of the lines being edited will scroll horizontally on a single screen line when they are longer than the width of the screen, instead of wrapping onto a new screen line. By default, this variable is set to '`off`'.

`input-meta`
: If set to '`on`', Readline will enable eight-bit input (it will not clear the eighth bit in the characters it reads), regardless of what the terminal claims it can support. The default value is '`off`'. The name `meta-flag` is a synonym for this variable.

`isearch-terminators`
: The string of characters that should terminate an incremental search without subsequently executing the character as a command

(see Section 32.2.5 [Searching], page 461). If this variable has not been given a value, the characters ESC and C-J will terminate an incremental search.

keymap
: Sets Readline's idea of the current keymap for key binding commands. Acceptable keymap names are emacs, emacs-standard, emacs-meta, emacs-ctlx, vi, vi-move, vi-command, and vi-insert. vi is equivalent to vi-command; emacs is equivalent to emacs-standard. The default value is emacs. The value of the editing-mode variable also affects the default keymap.

mark-directories
: If set to 'on', completed directory names have a slash appended. The default is 'on'.

mark-modified-lines
: This variable, when set to 'on', causes Readline to display an asterisk ('*') at the start of history lines which have been modified. This variable is 'off' by default.

mark-symlinked-directories
: If set to 'on', completed names which are symbolic links to directories have a slash appended (subject to the value of mark-directories). The default is 'off'.

match-hidden-files
: This variable, when set to 'on', causes Readline to match files whose names begin with a '.' (hidden files) when performing filename completion. If set to 'off', the leading '.' must be supplied by the user in the filename to be completed. This variable is 'on' by default.

menu-complete-display-prefix
: If set to 'on', menu completion displays the common prefix of the list of possible completions (which may be empty) before cycling through the list. The default is 'off'.

output-meta
: If set to 'on', Readline will display characters with the eighth bit set directly rather than as a meta-prefixed escape sequence. The default is 'off'.

page-completions
: If set to 'on', Readline uses an internal more-like pager to display a screenful of possible completions at a time. This variable is 'on' by default.

print-completions-horizontally
: If set to 'on', Readline will display completions with matches sorted horizontally in alphabetical order, rather than down the screen. The default is 'off'.

`revert-all-at-newline`
: If set to '`on`', Readline will undo all changes to history lines before returning when `accept-line` is executed. By default, history lines may be modified and retain individual undo lists across calls to `readline`. The default is '`off`'.

`show-all-if-ambiguous`
: This alters the default behavior of the completion functions. If set to '`on`', words which have more than one possible completion cause the matches to be listed immediately instead of ringing the bell. The default value is '`off`'.

`show-all-if-unmodified`
: This alters the default behavior of the completion functions in a fashion similar to *show-all-if-ambiguous*. If set to '`on`', words which have more than one possible completion without any possible partial completion (the possible completions don't share a common prefix) cause the matches to be listed immediately instead of ringing the bell. The default value is '`off`'.

`skip-completed-text`
: If set to '`on`', this alters the default completion behavior when inserting a single match into the line. It's only active when performing completion in the middle of a word. If enabled, readline does not insert characters from the completion that match characters after point in the word being completed, so portions of the word following the cursor are not duplicated. For instance, if this is enabled, attempting completion when the cursor is after the '`e`' in '`Makefile`' will result in '`Makefile`' rather than '`Makefilefile`', assuming there is a single possible completion. The default value is '`off`'.

`visible-stats`
: If set to '`on`', a character denoting a file's type is appended to the filename when listing possible completions. The default is '`off`'.

Key Bindings
: The syntax for controlling key bindings in the init file is simple. First you need to find the name of the command that you want to change. The following sections contain tables of the command name, the default keybinding, if any, and a short description of what the command does.

  Once you know the name of the command, simply place on a line in the init file the name of the key you wish to bind the command to, a colon, and then the name of the command. There can be no space between the key name and the colon – that will be interpreted as part of the key name. The name of the key can be expressed in different ways, depending on what you find most comfortable.

  In addition to command names, readline allows keys to be bound to a string that is inserted when the key is pressed (a *macro*).

keyname: *function-name* or *macro*

keyname is the name of a key spelled out in English. For example:

```
Control-u: universal-argument
Meta-Rubout: backward-kill-word
Control-o: "> output"
```

In the above example, *C-u* is bound to the function `universal-argument`, *M-DEL* is bound to the function `backward-kill-word`, and *C-o* is bound to run the macro expressed on the right hand side (that is, to insert the text '`> output`' into the line).

A number of symbolic character names are recognized while processing this key binding syntax: *DEL*, *ESC*, *ESCAPE*, *LFD*, *NEWLINE*, *RET*, *RETURN*, *RUBOUT*, *SPACE*, *SPC*, and *TAB*.

"*keyseq*": *function-name* or *macro*

keyseq differs from *keyname* above in that strings denoting an entire key sequence can be specified, by placing the key sequence in double quotes. Some GNU Emacs style key escapes can be used, as in the following example, but the special character names are not recognized.

```
"\C-u": universal-argument
"\C-x\C-r": re-read-init-file
"\e[11~": "Function Key 1"
```

In the above example, *C-u* is again bound to the function `universal-argument` (just as it was in the first example), '*C-x C-r*' is bound to the function `re-read-init-file`, and '`ESC [ 1 1 ~`' is bound to insert the text '`Function Key 1`'.

The following GNU Emacs style escape sequences are available when specifying key sequences:

`\C-`	control prefix
`\M-`	meta prefix
`\e`	an escape character
`\\`	backslash
`\"`	", a double quotation mark
`\'`	', a single quote or apostrophe

In addition to the GNU Emacs style escape sequences, a second set of backslash escapes is available:

`\a`	alert (bell)
`\b`	backspace
`\d`	delete
`\f`	form feed
`\n`	newline

`\r` carriage return

`\t` horizontal tab

`\v` vertical tab

`\nnn` the eight-bit character whose value is the octal value *nnn* (one to three digits)

`\xHH` the eight-bit character whose value is the hexadecimal value *HH* (one or two hex digits)

When entering the text of a macro, single or double quotes must be used to indicate a macro definition. Unquoted text is assumed to be a function name. In the macro body, the backslash escapes described above are expanded. Backslash will quote any other character in the macro text, including '`"`' and '`'`'. For example, the following binding will make '*`C-x`* `\`' insert a single '`\`' into the line:

```
"\C-x\\": "\\"
```

32.3.2 Conditional Init Constructs

Readline implements a facility similar in spirit to the conditional compilation features of the C preprocessor which allows key bindings and variable settings to be performed as the result of tests. There are four parser directives used.

`$if` The `$if` construct allows bindings to be made based on the editing mode, the terminal being used, or the application using Readline. The text of the test extends to the end of the line; no characters are required to isolate it.

`mode` The `mode=` form of the `$if` directive is used to test whether Readline is in `emacs` or `vi` mode. This may be used in conjunction with the '`set keymap`' command, for instance, to set bindings in the `emacs-standard` and `emacs-ctlx` keymaps only if Readline is starting out in `emacs` mode.

`term` The `term=` form may be used to include terminal-specific key bindings, perhaps to bind the key sequences output by the terminal's function keys. The word on the right side of the '`=`' is tested against both the full name of the terminal and the portion of the terminal name before the first '`-`'. This allows `sun` to match both `sun` and `sun-cmd`, for instance.

`application`
The *application* construct is used to include application-specific settings. Each program using the Readline library sets the *application name*, and you can test for a particular value. This could be used to bind key sequences to functions useful for a specific program. For instance, the following command adds a key sequence that quotes the current or previous word in Bash:

```
$if Bash
# Quote the current or previous word
"\C-xq": "\eb\"\ef\""
$endif
```

`$endif` This command, as seen in the previous example, terminates an `$if` command.

`$else` Commands in this branch of the `$if` directive are executed if the test fails.

`$include` This directive takes a single filename as an argument and reads commands and bindings from that file. For example, the following directive reads from '`/etc/inputrc`':

```
$include /etc/inputrc
```

32.3.3 Sample Init File

Here is an example of an *inputrc* file. This illustrates key binding, variable assignment, and conditional syntax.

```
# This file controls the behaviour of line input editing for
# programs that use the GNU Readline library.  Existing
# programs include FTP, Bash, and GDB.
#
# You can re-read the inputrc file with C-x C-r.
# Lines beginning with '#' are comments.
#
# First, include any systemwide bindings and variable
# assignments from /etc/Inputrc
$include /etc/Inputrc

#
# Set various bindings for emacs mode.

set editing-mode emacs

$if mode=emacs

Meta-Control-h:  backward-kill-word Text after the function name is ignored

#
# Arrow keys in keypad mode
#
#"\M-OD":        backward-char
#"\M-OC":        forward-char
#"\M-OA":        previous-history
#"\M-OB":        next-history
#
# Arrow keys in ANSI mode
#
"\M-[D":        backward-char
"\M-[C":        forward-char
"\M-[A":        previous-history
"\M-[B":        next-history
#
# Arrow keys in 8 bit keypad mode
#
#"\M-\C-OD":       backward-char
#"\M-\C-OC":       forward-char
#"\M-\C-OA":       previous-history
#"\M-\C-OB":       next-history
#
# Arrow keys in 8 bit ANSI mode
#
#"\M-\C-[D":       backward-char
#"\M-\C-[C":       forward-char
```

```
#"\M-\C-[A":       previous-history
#"\M-\C-[B":       next-history

C-q: quoted-insert

$endif

# An old-style binding.  This happens to be the default.
TAB: complete

# Macros that are convenient for shell interaction
$if Bash
# edit the path
"\C-xp": "PATH=${PATH}\e\C-e\C-a\ef\C-f"
# prepare to type a quoted word --
# insert open and close double quotes
# and move to just after the open quote
"\C-x\"": "\"\"\C-b"
# insert a backslash (testing backslash escapes
# in sequences and macros)
"\C-x\\": "\\"
# Quote the current or previous word
"\C-xq": "\eb\"\ef\""
# Add a binding to refresh the line, which is unbound
"\C-xr": redraw-current-line
# Edit variable on current line.
"\M-\C-v": "\C-a\C-k$\C-y\M-\C-e\C-a\C-y="
$endif

# use a visible bell if one is available
set bell-style visible

# don't strip characters to 7 bits when reading
set input-meta on

# allow iso-latin1 characters to be inserted rather
# than converted to prefix-meta sequences
set convert-meta off

# display characters with the eighth bit set directly
# rather than as meta-prefixed characters
set output-meta on

# if there are more than 150 possible completions for
# a word, ask the user if he wants to see all of them
set completion-query-items 150
```

```
# For FTP
$if Ftp
"\C-xg": "get \M-?"
"\C-xt": "put \M-?"
"\M-.": yank-last-arg
$endif
```

32.4 Bindable Readline Commands

This section describes Readline commands that may be bound to key sequences. Command names without an accompanying key sequence are unbound by default.

In the following descriptions, *point* refers to the current cursor position, and *mark* refers to a cursor position saved by the `set-mark` command. The text between the point and mark is referred to as the *region*.

32.4.1 Commands For Moving

`beginning-of-line (C-a)`
: Move to the start of the current line.

`end-of-line (C-e)`
: Move to the end of the line.

`forward-char (C-f)`
: Move forward a character.

`backward-char (C-b)`
: Move back a character.

`forward-word (M-f)`
: Move forward to the end of the next word. Words are composed of letters and digits.

`backward-word (M-b)`
: Move back to the start of the current or previous word. Words are composed of letters and digits.

`clear-screen (C-l)`
: Clear the screen and redraw the current line, leaving the current line at the top of the screen.

`redraw-current-line ()`
: Refresh the current line. By default, this is unbound.

32.4.2 Commands For Manipulating The History

`accept-line (Newline or Return)`
: Accept the line regardless of where the cursor is. If this line is non-empty, it may be added to the history list for future recall with `add_history()`. If this line is a modified history line, the history line is restored to its original state.

`previous-history (C-p)`
: Move ‘back’ through the history list, fetching the previous command.

`next-history (C-n)`
: Move 'forward' through the history list, fetching the next command.

`beginning-of-history (M-<)`
: Move to the first line in the history.

`end-of-history (M->)`
: Move to the end of the input history, i.e., the line currently being entered.

`reverse-search-history (C-r)`
: Search backward starting at the current line and moving 'up' through the history as necessary. This is an incremental search.

`forward-search-history (C-s)`
: Search forward starting at the current line and moving 'down' through the the history as necessary. This is an incremental search.

`non-incremental-reverse-search-history (M-p)`
: Search backward starting at the current line and moving 'up' through the history as necessary using a non-incremental search for a string supplied by the user.

`non-incremental-forward-search-history (M-n)`
: Search forward starting at the current line and moving 'down' through the the history as necessary using a non-incremental search for a string supplied by the user.

`history-search-forward ()`
: Search forward through the history for the string of characters between the start of the current line and the point. This is a non-incremental search. By default, this command is unbound.

`history-search-backward ()`
: Search backward through the history for the string of characters between the start of the current line and the point. This is a non-incremental search. By default, this command is unbound.

`yank-nth-arg (M-C-y)`
: Insert the first argument to the previous command (usually the second word on the previous line) at point. With an argument *n*, insert the *n*th word from the previous command (the words in the previous command begin with word 0). A negative argument inserts the *n*th word from the end of the previous command. Once the argument *n* is computed, the argument is extracted as if the '`!`*n*' history expansion had been specified.

`yank-last-arg (M-. or M-_)`
: Insert last argument to the previous command (the last word of the previous history entry). With a numeric argument, behave exactly like `yank-nth-arg`. Successive calls to `yank-last-arg` move back through the history list, inserting the last word (or the word specified by the argument to the first call) of each line in turn. Any numeric argument supplied to these successive calls determines the direction to move through the history. A negative argument switches the

direction through the history (back or forward). The history expansion facilities are used to extract the last argument, as if the '`!$`' history expansion had been specified.

32.4.3 Commands For Changing Text

`delete-char (C-d)`
: Delete the character at point. If point is at the beginning of the line, there are no characters in the line, and the last character typed was not bound to `delete-char`, then return EOF.

`backward-delete-char (Rubout)`
: Delete the character behind the cursor. A numeric argument means to kill the characters instead of deleting them.

`forward-backward-delete-char ()`
: Delete the character under the cursor, unless the cursor is at the end of the line, in which case the character behind the cursor is deleted. By default, this is not bound to a key.

`quoted-insert (C-q or C-v)`
: Add the next character typed to the line verbatim. This is how to insert key sequences like *C-q*, for example.

`tab-insert (M-TAB)`
: Insert a tab character.

`self-insert (a, b, A, 1, !, ...)`
: Insert yourself.

`transpose-chars (C-t)`
: Drag the character before the cursor forward over the character at the cursor, moving the cursor forward as well. If the insertion point is at the end of the line, then this transposes the last two characters of the line. Negative arguments have no effect.

`transpose-words (M-t)`
: Drag the word before point past the word after point, moving point past that word as well. If the insertion point is at the end of the line, this transposes the last two words on the line.

`upcase-word (M-u)`
: Uppercase the current (or following) word. With a negative argument, uppercase the previous word, but do not move the cursor.

`downcase-word (M-l)`
: Lowercase the current (or following) word. With a negative argument, lowercase the previous word, but do not move the cursor.

`capitalize-word (M-c)`
: Capitalize the current (or following) word. With a negative argument, capitalize the previous word, but do not move the cursor.

`overwrite-mode ()`
: Toggle overwrite mode. With an explicit positive numeric argument, switches to overwrite mode. With an explicit non-positive numeric argument, switches to insert mode. This command affects only `emacs` mode; `vi` mode does overwrite differently. Each call to `readline()` starts in insert mode.

  In overwrite mode, characters bound to `self-insert` replace the text at point rather than pushing the text to the right. Characters bound to `backward-delete-char` replace the character before point with a space.

  By default, this command is unbound.

32.4.4 Killing And Yanking

`kill-line (C-k)`
: Kill the text from point to the end of the line.

`backward-kill-line (C-x Rubout)`
: Kill backward to the beginning of the line.

`unix-line-discard (C-u)`
: Kill backward from the cursor to the beginning of the current line.

`kill-whole-line ()`
: Kill all characters on the current line, no matter where point is. By default, this is unbound.

`kill-word (M-d)`
: Kill from point to the end of the current word, or if between words, to the end of the next word. Word boundaries are the same as `forward-word`.

`backward-kill-word (M-DEL)`
: Kill the word behind point. Word boundaries are the same as `backward-word`.

`unix-word-rubout (C-w)`
: Kill the word behind point, using white space as a word boundary. The killed text is saved on the kill-ring.

`unix-filename-rubout ()`
: Kill the word behind point, using white space and the slash character as the word boundaries. The killed text is saved on the kill-ring.

`delete-horizontal-space ()`
: Delete all spaces and tabs around point. By default, this is unbound.

`kill-region ()`
: Kill the text in the current region. By default, this command is unbound.

`copy-region-as-kill ()`
: Copy the text in the region to the kill buffer, so it can be yanked right away. By default, this command is unbound.

`copy-backward-word ()`
: Copy the word before point to the kill buffer. The word boundaries are the same as `backward-word`. By default, this command is unbound.

`copy-forward-word ()`
: Copy the word following point to the kill buffer. The word boundaries are the same as `forward-word`. By default, this command is unbound.

`yank (C-y)`
: Yank the top of the kill ring into the buffer at point.

`yank-pop (M-y)`
: Rotate the kill-ring, and yank the new top. You can only do this if the prior command is `yank` or `yank-pop`.

32.4.5 Specifying Numeric Arguments

`digit-argument (`*`M-0`*`, `*`M-1`*`, ... `*`M--`*`)`
: Add this digit to the argument already accumulating, or start a new argument. *M--* starts a negative argument.

`universal-argument ()`
: This is another way to specify an argument. If this command is followed by one or more digits, optionally with a leading minus sign, those digits define the argument. If the command is followed by digits, executing `universal-argument` again ends the numeric argument, but is otherwise ignored. As a special case, if this command is immediately followed by a character that is neither a digit or minus sign, the argument count for the next command is multiplied by four. The argument count is initially one, so executing this function the first time makes the argument count four, a second time makes the argument count sixteen, and so on. By default, this is not bound to a key.

32.4.6 Letting Readline Type For You

`complete (TAB)`
: Attempt to perform completion on the text before point. The actual completion performed is application-specific. The default is filename completion.

`possible-completions (M-?)`
: List the possible completions of the text before point. When displaying completions, Readline sets the number of columns used for display to the value of `completion-display-width`, the value of the environment variable `COLUMNS`, or the screen width, in that order.

`insert-completions (M-*)`
: Insert all completions of the text before point that would have been generated by `possible-completions`.

`menu-complete ()`
: Similar to `complete`, but replaces the word to be completed with a single match from the list of possible completions. Repeated execution of `menu-complete` steps through the list of possible completions, inserting each match in turn. At the end of the list of completions, the bell is rung (subject to the setting of `bell-style`) and the original text is restored. An argument of *n* moves *n* positions forward in the list of matches; a negative argument may be used to

move backward through the list. This command is intended to be bound to TAB, but is unbound by default.

`menu-complete-backward ()`
: Identical to `menu-complete`, but moves backward through the list of possible completions, as if `menu-complete` had been given a negative argument.

`delete-char-or-list ()`
: Deletes the character under the cursor if not at the beginning or end of the line (like `delete-char`). If at the end of the line, behaves identically to `possible-completions`. This command is unbound by default.

32.4.7 Keyboard Macros

`start-kbd-macro (C-x ()`
: Begin saving the characters typed into the current keyboard macro.

`end-kbd-macro (C-x ))`
: Stop saving the characters typed into the current keyboard macro and save the definition.

`call-last-kbd-macro (C-x e)`
: Re-execute the last keyboard macro defined, by making the characters in the macro appear as if typed at the keyboard.

32.4.8 Some Miscellaneous Commands

`re-read-init-file (C-x C-r)`
: Read in the contents of the *inputrc* file, and incorporate any bindings or variable assignments found there.

`abort (C-g)`
: Abort the current editing command and ring the terminal's bell (subject to the setting of `bell-style`).

`do-uppercase-version (M-a, M-b, M-x, ...)`
: If the metafied character *x* is lowercase, run the command that is bound to the corresponding uppercase character.

`prefix-meta (ESC)`
: Metafy the next character typed. This is for keyboards without a meta key. Typing '`ESC f`' is equivalent to typing *`M-f`*.

`undo (C-_ or C-x C-u)`
: Incremental undo, separately remembered for each line.

`revert-line (M-r)`
: Undo all changes made to this line. This is like executing the `undo` command enough times to get back to the beginning.

`tilde-expand (M-~)`
: Perform tilde expansion on the current word.

`set-mark (C-@)`
: Set the mark to the point. If a numeric argument is supplied, the mark is set to that position.

`exchange-point-and-mark (C-x C-x)`
: Swap the point with the mark. The current cursor position is set to the saved position, and the old cursor position is saved as the mark.

`character-search (C-])`
: A character is read and point is moved to the next occurrence of that character. A negative count searches for previous occurrences.

`character-search-backward (M-C-])`
: A character is read and point is moved to the previous occurrence of that character. A negative count searches for subsequent occurrences.

`skip-csi-sequence ()`
: Read enough characters to consume a multi-key sequence such as those defined for keys like Home and End. Such sequences begin with a Control Sequence Indicator (CSI), usually ESC-[. If this sequence is bound to `"\e["`, keys producing such sequences will have no effect unless explicitly bound to a readline command, instead of inserting stray characters into the editing buffer. This is unbound by default, but usually bound to ESC-[.

`insert-comment (M-#)`
: Without a numeric argument, the value of the `comment-begin` variable is inserted at the beginning of the current line. If a numeric argument is supplied, this command acts as a toggle: if the characters at the beginning of the line do not match the value of `comment-begin`, the value is inserted, otherwise the characters in `comment-begin` are deleted from the beginning of the line. In either case, the line is accepted as if a newline had been typed.

`dump-functions ()`
: Print all of the functions and their key bindings to the Readline output stream. If a numeric argument is supplied, the output is formatted in such a way that it can be made part of an *inputrc* file. This command is unbound by default.

`dump-variables ()`
: Print all of the settable variables and their values to the Readline output stream. If a numeric argument is supplied, the output is formatted in such a way that it can be made part of an *inputrc* file. This command is unbound by default.

`dump-macros ()`
: Print all of the Readline key sequences bound to macros and the strings they output. If a numeric argument is supplied, the output is formatted in such a way that it can be made part of an *inputrc* file. This command is unbound by default.

`emacs-editing-mode (C-e)`
: When in `vi` command mode, this causes a switch to `emacs` editing mode.

`vi-editing-mode (M-C-j)`
: When in `emacs` editing mode, this causes a switch to `vi` editing mode.

32.5 Readline vi Mode

While the Readline library does not have a full set of `vi` editing functions, it does contain enough to allow simple editing of the line. The Readline `vi` mode behaves as specified in the POSIX standard.

In order to switch interactively between `emacs` and `vi` editing modes, use the command *M-C-j* (bound to emacs-editing-mode when in `vi` mode and to vi-editing-mode in `emacs` mode). The Readline default is `emacs` mode.

When you enter a line in `vi` mode, you are already placed in 'insertion' mode, as if you had typed an '`i`'. Pressing ESC switches you into 'command' mode, where you can edit the text of the line with the standard `vi` movement keys, move to previous history lines with '`k`' and subsequent lines with '`j`', and so forth.

33 Using History Interactively

This chapter describes how to use the GNU History Library interactively, from a user's standpoint. It should be considered a user's guide. For information on using the GNU History Library in your own programs, see Section "Programming with GNU History" in *GNU History Library*.

33.1 History Expansion

The History library provides a history expansion feature that is similar to the history expansion provided by `csh`. This section describes the syntax used to manipulate the history information.

History expansions introduce words from the history list into the input stream, making it easy to repeat commands, insert the arguments to a previous command into the current input line, or fix errors in previous commands quickly.

History expansion takes place in two parts. The first is to determine which line from the history list should be used during substitution. The second is to select portions of that line for inclusion into the current one. The line selected from the history is called the *event*, and the portions of that line that are acted upon are called *words*. Various *modifiers* are available to manipulate the selected words. The line is broken into words in the same fashion that Bash does, so that several words surrounded by quotes are considered one word. History expansions are introduced by the appearance of the history expansion character, which is '`!`' by default.

33.1.1 Event Designators

An event designator is a reference to a command line entry in the history list. Unless the reference is absolute, events are relative to the current position in the history list.

`!` Start a history substitution, except when followed by a space, tab, the end of the line, or '`=`'.

`!`*n* Refer to command line *n*.

`!-`*n* Refer to the command *n* lines back.

`!!` Refer to the previous command. This is a synonym for '`!-1`'.

`!`*string* Refer to the most recent command preceding the current position in the history list starting with *string*.

`!?`*string*`[?]`
Refer to the most recent command preceding the current position in the history list containing *string*. The trailing '`?`' may be omitted if the *string* is followed immediately by a newline.

`^`*string1*`^`*string2*`^`
Quick Substitution. Repeat the last command, replacing *string1* with *string2*. Equivalent to `!!:s/`*string1*`/`*string2*`/`.

`!#` The entire command line typed so far.

33.1.2 Word Designators

Word designators are used to select desired words from the event. A ‘`:`’ separates the event specification from the word designator. It may be omitted if the word designator begins with a ‘`^`’, ‘`$`’, ‘`*`’, ‘`-`’, or ‘`%`’. Words are numbered from the beginning of the line, with the first word being denoted by 0 (zero). Words are inserted into the current line separated by single spaces.

For example,

`!!` designates the preceding command. When you type this, the preceding command is repeated in toto.

`!!:$` designates the last argument of the preceding command. This may be shortened to `!$`.

`!fi:2` designates the second argument of the most recent command starting with the letters `fi`.

Here are the word designators:

`0 (zero)` The `0`th word. For many applications, this is the command word.

n The *n*th word.

`^` The first argument; that is, word 1.

`$` The last argument.

`%` The word matched by the most recent ‘`?`*string*`?`’ search.

x`-`*y* A range of words; ‘`-`*y*’ abbreviates ‘`0-`*y*’.

`*` All of the words, except the `0`th. This is a synonym for ‘`1-$`’. It is not an error to use ‘`*`’ if there is just one word in the event; the empty string is returned in that case.

x`*` Abbreviates ‘*x*`-$`’

x`-` Abbreviates ‘*x*`-$`’ like ‘*x*`*`’, but omits the last word.

If a word designator is supplied without an event specification, the previous command is used as the event.

33.1.3 Modifiers

After the optional word designator, you can add a sequence of one or more of the following modifiers, each preceded by a ‘`:`’.

`h` Remove a trailing pathname component, leaving only the head.

`t` Remove all leading pathname components, leaving the tail.

`r` Remove a trailing suffix of the form ‘`.`*suffix*’, leaving the basename.

`e` Remove all but the trailing suffix.

`p` Print the new command but do not execute it.

`s/old/new/`
: Substitute *new* for the first occurrence of *old* in the event line. Any delimiter may be used in place of '`/`'. The delimiter may be quoted in *old* and *new* with a single backslash. If '`&`' appears in *new*, it is replaced by *old*. A single backslash will quote the '`&`'. The final delimiter is optional if it is the last character on the input line.

`&`
: Repeat the previous substitution.

`g`
`a`
: Cause changes to be applied over the entire event line. Used in conjunction with '`s`', as in `gs/old/new/`, or with '`&`'.

`G`
: Apply the following '`s`' modifier once to each word in the event.

Appendix A In Memoriam

The GDB project mourns the loss of the following long-time contributors:

`Fred Fish` Fred was a long-standing contributor to GDB (1991-2006), and to Free Software in general. Outside of GDB, he was known in the Amiga world for his series of Fish Disks, and the GeekGadget project.

`Michael Snyder`
Michael was one of the Global Maintainers of the GDB project, with contributions recorded as early as 1996, until 2011. In addition to his day to day participation, he was a large driving force behind adding Reverse Debugging to GDB.

Beyond their technical contributions to the project, they were also enjoyable members of the Free Software Community. We will miss them.

Appendix B Formatting Documentation

The GDB 4 release includes an already-formatted reference card, ready for printing with PostScript or Ghostscript, in the 'gdb' subdirectory of the main source directory[1]. If you can use PostScript or Ghostscript with your printer, you can print the reference card immediately with 'refcard.ps'.

The release also includes the source for the reference card. You can format it, using TEX, by typing:

```
make refcard.dvi
```

The GDB reference card is designed to print in *landscape* mode on US "letter" size paper; that is, on a sheet 11 inches wide by 8.5 inches high. You will need to specify this form of printing as an option to your DVI output program.

All the documentation for GDB comes as part of the machine-readable distribution. The documentation is written in Texinfo format, which is a documentation system that uses a single source file to produce both on-line information and a printed manual. You can use one of the Info formatting commands to create the on-line version of the documentation and TEX (or `texi2roff`) to typeset the printed version.

GDB includes an already formatted copy of the on-line Info version of this manual in the 'gdb' subdirectory. The main Info file is 'gdb-7.6-18.0.31/gdb/gdb.info', and it refers to subordinate files matching 'gdb.info*' in the same directory. If necessary, you can print out these files, or read them with any editor; but they are easier to read using the `info` subsystem in GNU Emacs or the standalone `info` program, available as part of the GNU Texinfo distribution.

If you want to format these Info files yourself, you need one of the Info formatting programs, such as `texinfo-format-buffer` or `makeinfo`.

If you have `makeinfo` installed, and are in the top level GDB source directory ('gdb-7.6-18.0.31', in the case of version 7.6-18.0.31), you can make the Info file by typing:

```
cd gdb
make gdb.info
```

If you want to typeset and print copies of this manual, you need TEX, a program to print its DVI output files, and 'texinfo.tex', the Texinfo definitions file.

TEX is a typesetting program; it does not print files directly, but produces output files called DVI files. To print a typeset document, you need a program to print DVI files. If your system has TEX installed, chances are it has such a program. The precise command to use depends on your system; *`lpr -d`* is common; another (for PostScript devices) is *`dvips`*. The DVI print command may require a file name without any extension or a '.dvi' extension.

TEX also requires a macro definitions file called 'texinfo.tex'. This file tells TEX how to typeset a document written in Texinfo format. On its own, TEX cannot either read or typeset a Texinfo file. 'texinfo.tex' is distributed with GDB and is located in the 'gdb-*version-number*/texinfo' directory.

If you have TEX and a DVI printer program installed, you can typeset and print this manual. First switch to the 'gdb' subdirectory of the main source directory (for example, to 'gdb-7.6-18.0.31/gdb') and type:

[1] In 'gdb-7.6-18.0.31/gdb/refcard.ps' of the version 7.6-18.0.31 release.

```
make gdb.dvi
```

Then give '`gdb.dvi`' to your DVI printing program.

Appendix C Installing GDB

C.1 Requirements for Building GDB

Building GDB requires various tools and packages to be available. Other packages will be used only if they are found.

Tools/Packages Necessary for Building GDB

ISO C90 compiler
: GDB is written in ISO C90. It should be buildable with any working C90 compiler, e.g. GCC.

Tools/Packages Optional for Building GDB

Expat
: GDB can use the Expat XML parsing library. This library may be included with your operating system distribution; if it is not, you can get the latest version from `http://expat.sourceforge.net`. The '`configure`' script will search for this library in several standard locations; if it is installed in an unusual path, you can use the '`--with-libexpat-prefix`' option to specify its location.

  Expat is used for:

  - Remote protocol memory maps (see Section E.16 [Memory Map Format], page 561)
  - Target descriptions (see Appendix G [Target Descriptions], page 577)
  - Remote shared library lists (See Section E.14 [Library List Format], page 559, or alternatively see Section E.15 [Library List Format for SVR4 Targets], page 560)
  - MS-Windows shared libraries (see [Shared Libraries], page 219)
  - Traceframe info (see Section E.18 [Traceframe Info Format], page 562)
  - Branch trace (see Section E.19 [Branch Trace Format], page 563)

zlib
: GDB will use the '`zlib`' library, if available, to read compressed debug sections. Some linkers, such as GNU gold, are capable of producing binaries with compressed debug sections. If GDB is compiled with '`zlib`', it will be able to read the debug information in such binaries.

  The '`zlib`' library is likely included with your operating system distribution; if it is not, you can get the latest version from `http://zlib.net`.

iconv
: GDB's features related to character sets (see Section 10.20 [Character Sets], page 135) require a functioning `iconv` implementation. If you are on a GNU system, then this is provided by the GNU C Library. Some other systems also provide a working `iconv`.

  If GDB is using the `iconv` program which is installed in a non-standard place, you will need to tell GDB where to find it. This is done with '`--with-iconv-bin`' which specifies the directory that contains the `iconv` program.

On systems without `iconv`, you can install GNU Libiconv. If you have previously installed Libiconv, you can use the '`--with-libiconv-prefix`' option to configure.

GDB's top-level '`configure`' and '`Makefile`' will arrange to build Libiconv if a directory named '`libiconv`' appears in the top-most source directory. If Libiconv is built this way, and if the operating system does not provide a suitable `iconv` implementation, then the just-built library will automatically be used by GDB. One easy way to set this up is to download GNU Libiconv, unpack it, and then rename the directory holding the Libiconv source code to '`libiconv`'.

C.2 Invoking the GDB '`configure`' Script

GDB comes with a '`configure`' script that automates the process of preparing GDB for installation; you can then use `make` to build the `gdb` program.[1]

The GDB distribution includes all the source code you need for GDB in a single directory, whose name is usually composed by appending the version number to '`gdb`'.

For example, the GDB version 7.6-18.0.31 distribution is in the '`gdb-7.6-18.0.31`' directory. That directory contains:

`gdb-7.6-18.0.31/configure` (and supporting files)
: script for configuring GDB and all its supporting libraries

`gdb-7.6-18.0.31/gdb`
: the source specific to GDB itself

`gdb-7.6-18.0.31/bfd`
: source for the Binary File Descriptor library

`gdb-7.6-18.0.31/include`
: GNU include files

`gdb-7.6-18.0.31/libiberty`
: source for the '`-liberty`' free software library

`gdb-7.6-18.0.31/opcodes`
: source for the library of opcode tables and disassemblers

`gdb-7.6-18.0.31/readline`
: source for the GNU command-line interface

`gdb-7.6-18.0.31/glob`
: source for the GNU filename pattern-matching subroutine

`gdb-7.6-18.0.31/mmalloc`
: source for the GNU memory-mapped malloc package

The simplest way to configure and build GDB is to run '`configure`' from the '`gdb-`*`version-number`*' source directory, which in this example is the '`gdb-7.6-18.0.31`' directory.

[1] If you have a more recent version of GDB than 7.6-18.0.31, look at the '`README`' file in the sources; we may have improved the installation procedures since publishing this manual.

First switch to the '`gdb-version-number`' source directory if you are not already in it; then run '`configure`'. Pass the identifier for the platform on which GDB will run as an argument.

For example:

```
cd gdb-7.6-18.0.31
./configure host
make
```

where *host* is an identifier such as '`sun4`' or '`decstation`', that identifies the platform where GDB will run. (You can often leave off *host*; '`configure`' tries to guess the correct value by examining your system.)

Running '`configure host`' and then running `make` builds the '`bfd`', '`readline`', '`mmalloc`', and '`libiberty`' libraries, then `gdb` itself. The configured source files, and the binaries, are left in the corresponding source directories.

'`configure`' is a Bourne-shell (`/bin/sh`) script; if your system does not recognize this automatically when you run a different shell, you may need to run `sh` on it explicitly:

```
sh configure host
```

If you run '`configure`' from a directory that contains source directories for multiple libraries or programs, such as the '`gdb-7.6-18.0.31`' source directory for version 7.6-18.0.31, '`configure`' creates configuration files for every directory level underneath (unless you tell it not to, with the '`--norecursion`' option).

You should run the '`configure`' script from the top directory in the source tree, the '`gdb-version-number`' directory. If you run '`configure`' from one of the subdirectories, you will configure only that subdirectory. That is usually not what you want. In particular, if you run the first '`configure`' from the '`gdb`' subdirectory of the '`gdb-version-number`' directory, you will omit the configuration of '`bfd`', '`readline`', and other sibling directories of the '`gdb`' subdirectory. This leads to build errors about missing include files such as '`bfd/bfd.h`'.

You can install `gdb` anywhere; it has no hardwired paths. However, you should make sure that the shell on your path (named by the '`SHELL`' environment variable) is publicly readable. Remember that GDB uses the shell to start your program—some systems refuse to let GDB debug child processes whose programs are not readable.

C.3 Compiling GDB in Another Directory

If you want to run GDB versions for several host or target machines, you need a different `gdb` compiled for each combination of host and target. '`configure`' is designed to make this easy by allowing you to generate each configuration in a separate subdirectory, rather than in the source directory. If your `make` program handles the '`VPATH`' feature (GNU `make` does), running `make` in each of these directories builds the `gdb` program specified there.

To build `gdb` in a separate directory, run '`configure`' with the '`--srcdir`' option to specify where to find the source. (You also need to specify a path to find '`configure`' itself from your working directory. If the path to '`configure`' would be the same as the argument to '`--srcdir`', you can leave out the '`--srcdir`' option; it is assumed.)

For example, with version 7.6-18.0.31, you can build GDB in a separate directory for a Sun 4 like this:

```
cd gdb-7.6-18.0.31
mkdir ../gdb-sun4
cd ../gdb-sun4
../gdb-7.6-18.0.31/configure sun4
make
```

When '`configure`' builds a configuration using a remote source directory, it creates a tree for the binaries with the same structure (and using the same names) as the tree under the source directory. In the example, you'd find the Sun 4 library '`libiberty.a`' in the directory '`gdb-sun4/libiberty`', and GDB itself in '`gdb-sun4/gdb`'.

Make sure that your path to the '`configure`' script has just one instance of '`gdb`' in it. If your path to '`configure`' looks like '`../gdb-7.6-18.0.31/gdb/configure`', you are configuring only one subdirectory of GDB, not the whole package. This leads to build errors about missing include files such as '`bfd/bfd.h`'.

One popular reason to build several GDB configurations in separate directories is to configure GDB for cross-compiling (where GDB runs on one machine—the *host*—while debugging programs that run on another machine—the *target*). You specify a cross-debugging target by giving the '`--target=`*`target`*' option to '`configure`'.

When you run `make` to build a program or library, you must run it in a configured directory—whatever directory you were in when you called '`configure`' (or one of its subdirectories).

The `Makefile` that '`configure`' generates in each source directory also runs recursively. If you type `make` in a source directory such as '`gdb-7.6-18.0.31`' (or in a separate configured directory configured with '`--srcdir=`*`dirname`*`/gdb-7.6-18.0.31`'), you will build all the required libraries, and then build GDB.

When you have multiple hosts or targets configured in separate directories, you can run `make` on them in parallel (for example, if they are NFS-mounted on each of the hosts); they will not interfere with each other.

C.4 Specifying Names for Hosts and Targets

The specifications used for hosts and targets in the '`configure`' script are based on a three-part naming scheme, but some short predefined aliases are also supported. The full naming scheme encodes three pieces of information in the following pattern:

```
architecture-vendor-os
```

For example, you can use the alias `sun4` as a *host* argument, or as the value for *target* in a `--target=`*`target`* option. The equivalent full name is '`sparc-sun-sunos4`'.

The '`configure`' script accompanying GDB does not provide any query facility to list all supported host and target names or aliases. '`configure`' calls the Bourne shell script `config.sub` to map abbreviations to full names; you can read the script, if you wish, or you can use it to test your guesses on abbreviations—for example:

```
% sh config.sub i386-linux
i386-pc-linux-gnu
% sh config.sub alpha-linux
alpha-unknown-linux-gnu
% sh config.sub hp9k700
hppa1.1-hp-hpux
% sh config.sub sun4
sparc-sun-sunos4.1.1
```

```
% sh config.sub sun3
m68k-sun-sunos4.1.1
% sh config.sub i986v
Invalid configuration ‘i986v’: machine ‘i986v’ not recognized
```

`config.sub` is also distributed in the GDB source directory (‘`gdb-7.6-18.0.31`’, for version 7.6-18.0.31).

C.5 ‘`configure`’ Options

Here is a summary of the ‘`configure`’ options and arguments that are most often useful for building GDB. ‘`configure`’ also has several other options not listed here. See Info file ‘`configure.info`’, node ‘`What Configure Does`’, for a full explanation of ‘`configure`’.

```
configure [--help]
          [--prefix=dir]
          [--exec-prefix=dir]
          [--srcdir=dirname]
          [--norecursion] [--rm]
          [--target=target]
          host
```

You may introduce options with a single ‘`-`’ rather than ‘`--`’ if you prefer; but you may abbreviate option names if you use ‘`--`’.

`--help` Display a quick summary of how to invoke ‘`configure`’.

`--prefix=`*`dir`*
: Configure the source to install programs and files under directory ‘*`dir`*’.

`--exec-prefix=`*`dir`*
: Configure the source to install programs under directory ‘*`dir`*’.

`--srcdir=`*`dirname`*
: **Warning: using this option requires GNU `make`, or another `make` that implements the `VPATH` feature.**
Use this option to make configurations in directories separate from the GDB source directories. Among other things, you can use this to build (or maintain) several configurations simultaneously, in separate directories. ‘`configure`’ writes configuration-specific files in the current directory, but arranges for them to use the source in the directory *dirname*. ‘`configure`’ creates directories under the working directory in parallel to the source directories below *dirname*.

`--norecursion`
: Configure only the directory level where ‘`configure`’ is executed; do not propagate configuration to subdirectories.

`--target=`*`target`*
: Configure GDB for cross-debugging programs running on the specified *target*. Without this option, GDB is configured to debug programs that run on the same machine (*host*) as GDB itself.
There is no convenient way to generate a list of all available targets.

`host ...` Configure GDB to run on the specified *host*.
There is no convenient way to generate a list of all available hosts.

There are many other options available as well, but they are generally needed for special purposes only.

C.6 System-wide configuration and settings

GDB can be configured to have a system-wide init file; this file will be read and executed at startup (see Section 2.1.3 [What GDB does during startup], page 16).

Here is the corresponding configure option:

`--with-system-gdbinit=`*file*
: Specify that the default location of the system-wide init file is *file*.

If GDB has been configured with the option '`--prefix=$prefix`', it may be subject to relocation. Two possible cases:

- If the default location of this init file contains '`$prefix`', it will be subject to relocation. Suppose that the configure options are '`--prefix=$prefix --with-system-gdbinit=$prefix/etc/gdbinit`'; if GDB is moved from '`$prefix`' to '`$install`', the system init file is looked for as '`$install/etc/gdbinit`' instead of '`$prefix/etc/gdbinit`'.
- By contrast, if the default location does not contain the prefix, it will not be relocated. E.g. if GDB has been configured with '`--prefix=/usr/local --with-system-gdbinit=/usr/share/gdb/gdbinit`', then GDB will always look for '`/usr/share/gdb/gdbinit`', wherever GDB is installed.

If the configured location of the system-wide init file (as given by the '`--with-system-gdbinit`' option at configure time) is in the data-directory (as specified by '`--with-gdb-datadir`' at configure time) or in one of its subdirectories, then GDB will look for the system-wide init file in the directory specified by the '`--data-directory`' command-line option. Note that the system-wide init file is only read once, during GDB initialization. If the data-directory is changed after GDB has started with the `set data-directory` command, the file will not be reread.

Appendix D Maintenance Commands

In addition to commands intended for GDB users, GDB includes a number of commands intended for GDB developers, that are not documented elsewhere in this manual. These commands are provided here for reference. (For commands that turn on debugging messages, see Section 22.9 [Debugging Output], page 292.)

`maint agent` [`-at` *location*,] *expression*
`maint agent-eval` [`-at` *location*,] *expression*
: Translate the given *expression* into remote agent bytecodes. This command is useful for debugging the Agent Expression mechanism (see Appendix F [Agent Expressions], page 565). The '`agent`' version produces an expression useful for data collection, such as by tracepoints, while '`maint agent-eval`' produces an expression that evaluates directly to a result. For instance, a collection expression for `globa + globb` will include bytecodes to record four bytes of memory at each of the addresses of `globa` and `globb`, while discarding the result of the addition, while an evaluation expression will do the addition and return the sum. If `-at` is given, generate remote agent bytecode for *location*. If not, generate remote agent bytecode for current frame PC address.

`maint agent-printf` *format*,*expr*,...
: Translate the given format string and list of argument expressions into remote agent bytecodes and display them as a disassembled list. This command is useful for debugging the agent version of dynamic printf (see Section 5.1.8 [Dynamic Printf], page 61.

`maint info breakpoints`
: Using the same format as '`info breakpoints`', display both the breakpoints you've set explicitly, and those GDB is using for internal purposes. Internal breakpoints are shown with negative breakpoint numbers. The type column identifies what kind of breakpoint is shown:

  `breakpoint`
  : Normal, explicitly set breakpoint.

  `watchpoint`
  : Normal, explicitly set watchpoint.

  `longjmp` Internal breakpoint, used to handle correctly stepping through `longjmp` calls.

  `longjmp resume`
  : Internal breakpoint at the target of a `longjmp`.

  `until` Temporary internal breakpoint used by the GDB `until` command.

  `finish` Temporary internal breakpoint used by the GDB `finish` command.

  `shlib events`
  : Shared library events.

`maint info bfds`
: This prints information about each `bfd` object that is known to GDB. See Section "BFD" in *The Binary File Descriptor Library*.

`set displaced-stepping`
`show displaced-stepping`
: Control whether or not GDB will do *displaced stepping* if the target supports it. Displaced stepping is a way to single-step over breakpoints without removing them from the inferior, by executing an out-of-line copy of the instruction that was originally at the breakpoint location. It is also known as out-of-line single-stepping.

  `set displaced-stepping on`
  : If the target architecture supports it, GDB will use displaced stepping to step over breakpoints.

  `set displaced-stepping off`
  : GDB will not use displaced stepping to step over breakpoints, even if such is supported by the target architecture.

  `set displaced-stepping auto`
  : This is the default mode. GDB will use displaced stepping only if non-stop mode is active (see Section 5.5.2 [Non-Stop Mode], page 74) and the target architecture supports displaced stepping.

`maint check-symtabs`
: Check the consistency of psymtabs and symtabs.

`maint cplus first_component` *`name`*
: Print the first C++ class/namespace component of *name*.

`maint cplus namespace`
: Print the list of possible C++ namespaces.

`maint demangle` *`name`*
: Demangle a C++ or Objective-C mangled *name*.

`maint deprecate` *`command`* [*`replacement`*]
`maint undeprecate` *`command`*
: Deprecate or undeprecate the named *command*. Deprecated commands cause GDB to issue a warning when you use them. The optional argument *replacement* says which newer command should be used in favor of the deprecated one; if it is given, GDB will mention the replacement as part of the warning.

`maint dump-me`
: Cause a fatal signal in the debugger and force it to dump its core. This is supported only on systems which support aborting a program with the `SIGQUIT` signal.

`maint internal-error` [*`message-text`*]
`maint internal-warning` [*`message-text`*]
: Cause GDB to call the internal function `internal_error` or `internal_warning` and hence behave as though an internal error or internal warning has been detected. In addition to reporting the internal problem, these functions give the user the opportunity to either quit GDB or create a core file of the current GDB session.

These commands take an optional parameter *message-text* that is used as the text of the error or warning message.

Here's an example of using `internal-error`:

```
(gdb) maint internal-error testing, 1, 2
.../maint.c:121: internal-error: testing, 1, 2
A problem internal to GDB has been detected.  Further
debugging may prove unreliable.
Quit this debugging session? (y or n) n
Create a core file? (y or n) n
(gdb)
```

`maint set internal-error` *action* [ask|yes|no]
`maint show internal-error` *action*
`maint set internal-warning` *action* [ask|yes|no]
`maint show internal-warning` *action*

When GDB reports an internal problem (error or warning) it gives the user the opportunity to both quit GDB and create a core file of the current GDB session. These commands let you override the default behaviour for each particular *action*, described in the table below.

'`quit`' You can specify that GDB should always (yes) or never (no) quit. The default is to ask the user what to do.

'`corefile`'
You can specify that GDB should always (yes) or never (no) create a core file. The default is to ask the user what to do.

`maint packet` *text*

If GDB is talking to an inferior via the serial protocol, then this command sends the string *text* to the inferior, and displays the response packet. GDB supplies the initial '`$`' character, the terminating '`#`' character, and the checksum.

`maint print architecture` [*file*]

Print the entire architecture configuration. The optional argument *file* names the file where the output goes.

`maint print c-tdesc`

Print the current target description (see Appendix G [Target Descriptions], page 577) as a C source file. The created source file can be used in GDB when an XML parser is not available to parse the description.

`maint print dummy-frames`

Prints the contents of GDB's internal dummy-frame stack.

```
(gdb) b add
...
(gdb) print add(2,3)
Breakpoint 2, add (a=2, b=3) at ...
58   return (a + b);
The program being debugged stopped while in a function called from GDB.
...
(gdb) maint print dummy-frames
0x1a57c80: pc=0x01014068 fp=0x0200bddc sp=0x0200bdd6
 top=0x0200bdd4 id={stack=0x200bddc,code=0x101405c}
 call_lo=0x01014000 call_hi=0x01014001
```

```
(gdb)
```

Takes an optional file parameter.

`maint print registers` [*file*]
`maint print raw-registers` [*file*]
`maint print cooked-registers` [*file*]
`maint print register-groups` [*file*]
`maint print remote-registers` [*file*]

Print GDB's internal register data structures.

The command `maint print raw-registers` includes the contents of the raw register cache; the command `maint print cooked-registers` includes the (cooked) value of all registers, including registers which aren't available on the target nor visible to user; the command `maint print register-groups` includes the groups that each register is a member of; and the command `maint print remote-registers` includes the remote target's register numbers and offsets in the 'G' packets. See Section "Registers" in GDB *Internals*.

These commands take an optional parameter, a file name to which to write the information.

`maint print reggroups` [*file*]

Print GDB's internal register group data structures. The optional argument *file* tells to what file to write the information.

The register groups info looks like this:

```
(gdb) maint print reggroups
 Group      Type
 general    user
 float      user
 all        user
 vector     user
 system     user
 save       internal
 restore    internal
```

`flushregs`

This command forces GDB to flush its internal register cache.

`maint print objfiles`

Print a dump of all known object files. For each object file, this command prints its name, address in memory, and all of its psymtabs and symtabs.

`maint print section-scripts` [*regexp*]

Print a dump of scripts specified in the `.debug_gdb_section` section. If *regexp* is specified, only print scripts loaded by object files matching *regexp*. For each script, this command prints its name as specified in the objfile, and the full path if known. See Section 23.2.3.2 [dotdebug_gdb_scripts section], page 348.

`maint print statistics`

This command prints, for each object file in the program, various data about that object file followed by the byte cache (*bcache*) statistics for the object file. The objfile data includes the number of minimal, partial, full, and stabs symbols, the number of types defined by the objfile, the number of as yet

unexpanded psym tables, the number of line tables and string tables, and the amount of memory used by the various tables. The bcache statistics include the counts, sizes, and counts of duplicates of all and unique objects, max, average, and median entry size, total memory used and its overhead and savings, and various measures of the hash table size and chain lengths.

`maint print target-stack`

A *target* is an interface between the debugger and a particular kind of file or process. Targets can be stacked in *strata*, so that more than one target can potentially respond to a request. In particular, memory accesses will walk down the stack of targets until they find a target that is interested in handling that particular address.

This command prints a short description of each layer that was pushed on the *target stack*, starting from the top layer down to the bottom one.

`maint print type` *expr*

Print the type chain for a type specified by *expr*. The argument can be either a type name or a symbol. If it is a symbol, the type of that symbol is described. The type chain produced by this command is a recursive definition of the data type as stored in GDB's data structures, including its flags and contained types.

`maint set dwarf2 always-disassemble`
`maint show dwarf2 always-disassemble`

Control the behavior of `info address` when using DWARF debugging information.

The default is `off`, which means that GDB should try to describe a variable's location in an easily readable format. When `on`, GDB will instead display the DWARF location expression in an assembly-like format. Note that some locations are too complex for GDB to describe simply; in this case you will always see the disassembly form.

Here is an example of the resulting disassembly:

```
(gdb) info addr argc
Symbol "argc" is a complex DWARF expression:
     1: DW_OP_fbreg 0
```

For more information on these expressions, see the DWARF standard.

`maint set dwarf2 max-cache-age`
`maint show dwarf2 max-cache-age`

Control the DWARF 2 compilation unit cache.

In object files with inter-compilation-unit references, such as those produced by the GCC option '`-feliminate-dwarf2-dups`', the DWARF 2 reader needs to frequently refer to previously read compilation units. This setting controls how long a compilation unit will remain in the cache if it is not referenced. A higher limit means that cached compilation units will be stored in memory longer, and more total memory will be used. Setting it to zero disables caching, which will slow down GDB startup, but reduce memory consumption.

`maint set profile`
`maint show profile`

Control profiling of GDB.

Profiling will be disabled until you use the '`maint set profile`' command to enable it. When you enable profiling, the system will begin collecting timing and execution count data; when you disable profiling or exit GDB, the results will be written to a log file. Remember that if you use profiling, GDB will overwrite the profiling log file (often called '`gmon.out`'). If you have a record of important profiling data in a '`gmon.out`' file, be sure to move it to a safe location.

Configuring with '`--enable-profiling`' arranges for GDB to be compiled with the '`-pg`' compiler option.

`maint set show-debug-regs`
`maint show show-debug-regs`

Control whether to show variables that mirror the hardware debug registers. Use `ON` to enable, `OFF` to disable. If enabled, the debug registers values are shown when GDB inserts or removes a hardware breakpoint or watchpoint, and when the inferior triggers a hardware-assisted breakpoint or watchpoint.

`maint set show-all-tib`
`maint show show-all-tib`

Control whether to show all non zero areas within a 1k block starting at thread local base, when using the '`info w32 thread-information-block`' command.

`maint space`

Control whether to display memory usage for each command. If set to a nonzero value, GDB will display how much memory each command took, following the command's own output. This can also be requested by invoking GDB with the '`--statistics`' command-line switch (see Section 2.1.2 [Mode Options], page 13).

`maint time`

Control whether to display the execution time of GDB for each command. If set to a nonzero value, GDB will display how much time it took to execute each command, following the command's own output. Both CPU time and wallclock time are printed. Printing both is useful when trying to determine whether the cost is CPU or, e.g., disk/network, latency. Note that the CPU time printed is for GDB only, it does not include the execution time of the inferior because there's no mechanism currently to compute how much time was spent by GDB and how much time was spent by the program been debugged. This can also be requested by invoking GDB with the '`--statistics`' command-line switch (see Section 2.1.2 [Mode Options], page 13).

`maint translate-address` [*section*] *addr*

Find the symbol stored at the location specified by the address *addr* and an optional section name *section*. If found, GDB prints the name of the closest symbol and an offset from the symbol's location to the specified address. This is similar to the `info address` command (see Chapter 16 [Symbols], page 201), except that this command also allows to find symbols in other sections.

If section was not specified, the section in which the symbol was found is also printed. For dynamically linked executables, the name of executable or shared library containing the symbol is printed as well.

The following command is useful for non-interactive invocations of GDB, such as in the test suite.

`set watchdog` *nsec*
: Set the maximum number of seconds GDB will wait for the target operation to finish. If this time expires, GDB reports and error and the command is aborted.

`show watchdog`
: Show the current setting of the target wait timeout.

Appendix E GDB Remote Serial Protocol

E.1 Overview

There may be occasions when you need to know something about the protocol—for example, if there is only one serial port to your target machine, you might want your program to do something special if it recognizes a packet meant for GDB.

In the examples below, '`->`' and '`<-`' are used to indicate transmitted and received data, respectively.

All GDB commands and responses (other than acknowledgments and notifications, see Section E.9 [Notification Packets], page 544) are sent as a *packet*. A *packet* is introduced with the character '`$`', the actual *packet-data*, and the terminating character '`#`' followed by a two-digit *checksum*:

```
$packet-data#checksum
```

The two-digit *checksum* is computed as the modulo 256 sum of all characters between the leading '`$`' and the trailing '`#`' (an eight bit unsigned checksum).

Implementors should note that prior to GDB 5.0 the protocol specification also included an optional two-digit *sequence-id*:

```
$sequence-id:packet-data#checksum
```

That *sequence-id* was appended to the acknowledgment. GDB has never output *sequence-id*s. Stubs that handle packets added since GDB 5.0 must not accept *sequence-id*.

When either the host or the target machine receives a packet, the first response expected is an acknowledgment: either '`+`' (to indicate the package was received correctly) or '`-`' (to request retransmission):

```
-> $packet-data#checksum
<- +
```

The '`+`'/'`-`' acknowledgments can be disabled once a connection is established. See Section E.11 [Packet Acknowledgment], page 546, for details.

The host (GDB) sends *command*s, and the target (the debugging stub incorporated in your program) sends a *response*. In the case of step and continue *command*s, the response is only sent when the operation has completed, and the target has again stopped all threads in all attached processes. This is the default all-stop mode behavior, but the remote protocol also supports GDB's non-stop execution mode; see Section E.10 [Remote Non-Stop], page 546, for details.

packet-data consists of a sequence of characters with the exception of '`#`' and '`$`' (see '`X`' packet for additional exceptions).

Fields within the packet should be separated using '`,`' '`;`' or '`:`'. Except where otherwise noted all numbers are represented in HEX with leading zeros suppressed.

Implementors should note that prior to GDB 5.0, the character '`:`' could not appear as the third character in a packet (as it would potentially conflict with the *sequence-id*).

Binary data in most packets is encoded either as two hexadecimal digits per byte of binary data. This allowed the traditional remote protocol to work over connections which were only seven-bit clean. Some packets designed more recently assume an eight-bit clean connection, and use a more efficient encoding to send and receive binary data.

The binary data representation uses `7d` (ASCII '`}`') as an escape character. Any escaped byte is transmitted as the escape character followed by the original character XORed with `0x20`. For example, the byte `0x7d` would be transmitted as the two bytes `0x7d 0x5d`. The bytes `0x23` (ASCII '`#`'), `0x24` (ASCII '`$`'), and `0x7d` (ASCII '`}`') must always be escaped. Responses sent by the stub must also escape `0x2a` (ASCII '`*`'), so that it is not interpreted as the start of a run-length encoded sequence (described next).

Response *data* can be run-length encoded to save space. Run-length encoding replaces runs of identical characters with one instance of the repeated character, followed by a '`*`' and a repeat count. The repeat count is itself sent encoded, to avoid binary characters in *data*: a value of *n* is sent as *n*`+29`. For a repeat count greater or equal to 3, this produces a printable ASCII character, e.g. a space (ASCII code 32) for a repeat count of 3. (This is because run-length encoding starts to win for counts 3 or more.) Thus, for example, '`0* `' is a run-length encoding of "0000": the space character after '`*`' means repeat the leading `0` `32 - 29 = 3` more times.

The printable characters '`#`' and '`$`' or with a numeric value greater than 126 must not be used. Runs of six repeats ('`#`') or seven repeats ('`$`') can be expanded using a repeat count of only five ('`"`'). For example, '`00000000`' can be encoded as '`0*"00`'.

The error response returned for some packets includes a two character error number. That number is not well defined.

For any *command* not supported by the stub, an empty response ('`$#00`') should be returned. That way it is possible to extend the protocol. A newer GDB can tell if a packet is supported based on that response.

At a minimum, a stub is required to support the '`g`' and '`G`' commands for register access, and the '`m`' and '`M`' commands for memory access. Stubs that only control single-threaded targets can implement run control with the '`c`' (continue), and '`s`' (step) commands. Stubs that support multi-threading targets should support the '`vCont`' command. All other commands are optional.

E.2 Packets

The following table provides a complete list of all currently defined *command*s and their corresponding response *data*. See Section E.13 [File-I/O Remote Protocol Extension], page 547, for details about the File I/O extension of the remote protocol.

Each packet's description has a template showing the packet's overall syntax, followed by an explanation of the packet's meaning. We include spaces in some of the templates for clarity; these are not part of the packet's syntax. No GDB packet uses spaces to separate its components. For example, a template like '`foo` *`bar`* *`baz`*' describes a packet beginning with the three ASCII bytes '`foo`', followed by a *bar*, followed directly by a *baz*. GDB does not transmit a space character between the '`foo`' and the *bar*, or between the *bar* and the *baz*.

Several packets and replies include a *thread-id* field to identify a thread. Normally these are positive numbers with a target-specific interpretation, formatted as big-endian hex strings. A *thread-id* can also be a literal '`-1`' to indicate all threads, or '`0`' to pick any thread.

In addition, the remote protocol supports a multiprocess feature in which the *thread-id* syntax is extended to optionally include both process and thread ID fields, as '`ppid.tid`'.

The *pid* (process) and *tid* (thread) components each have the format described above: a positive number with target-specific interpretation formatted as a big-endian hex string, literal '`-1`' to indicate all processes or threads (respectively), or '`0`' to indicate an arbitrary process or thread. Specifying just a process, as '`p`*pid*', is equivalent to '`p`*pid*`.-1`'. It is an error to specify all processes but a specific thread, such as '`p-1.`*tid*'. Note that the '`p`' prefix is *not* used for those packets and replies explicitly documented to include a process ID, rather than a *thread-id*.

The multiprocess *thread-id* syntax extensions are only used if both GDB and the stub report support for the '`multiprocess`' feature using '`qSupported`'. See [multiprocess extensions], page 527, for more information.

Note that all packet forms beginning with an upper- or lower-case letter, other than those described here, are reserved for future use.

Here are the packet descriptions.

'`!`' Enable extended mode. In extended mode, the remote server is made persistent. The '`R`' packet is used to restart the program being debugged.

Reply:

'`OK`' The remote target both supports and has enabled extended mode.

'`?`' Indicate the reason the target halted. The reply is the same as for step and continue. This packet has a special interpretation when the target is in non-stop mode; see Section E.10 [Remote Non-Stop], page 546.

Reply: See Section E.3 [Stop Reply Packets], page 514, for the reply specifications.

'`A` *arglen*`,`*argnum*`,`*arg*`,...`'
Initialized `argv[]` array passed into program. *arglen* specifies the number of bytes in the hex encoded byte stream *arg*. See `gdbserver` for more details.

Reply:

'`OK`' The arguments were set.

'`E` *NN*' An error occurred.

'`b` *baud*' (Don't use this packet; its behavior is not well-defined.) Change the serial line speed to *baud*.

JTC: *When does the transport layer state change? When it's received, or after the ACK is transmitted. In either case, there are problems if the command or the acknowledgment packet is dropped.*

Stan: *If people really wanted to add something like this, and get it working for the first time, they ought to modify ser-unix.c to send some kind of out-of-band message to a specially-setup stub and have the switch happen "in between" packets, so that from remote protocol's point of view, nothing actually happened.*

'`B` *addr*`,`*mode*'
Set (*mode* is '`S`') or clear (*mode* is '`C`') a breakpoint at *addr*.

Don't use this packet. Use the '`Z`' and '`z`' packets instead (see [insert breakpoint or watchpoint packet], page 512).

'`bc`' Backward continue. Execute the target system in reverse. No parameter. See Chapter 6 [Reverse Execution], page 79, for more information.

Reply: See Section E.3 [Stop Reply Packets], page 514, for the reply specifications.

'`bs`' Backward single step. Execute one instruction in reverse. No parameter. See Chapter 6 [Reverse Execution], page 79, for more information.

Reply: See Section E.3 [Stop Reply Packets], page 514, for the reply specifications.

'`c` [*addr*]' Continue. *addr* is address to resume. If *addr* is omitted, resume at current address.

This packet is deprecated for multi-threading support. See [vCont packet], page 509.

Reply: See Section E.3 [Stop Reply Packets], page 514, for the reply specifications.

'`C` *sig*[`;`*addr*]'
Continue with signal *sig* (hex signal number). If '`;`*addr*' is omitted, resume at same address.

This packet is deprecated for multi-threading support. See [vCont packet], page 509.

Reply: See Section E.3 [Stop Reply Packets], page 514, for the reply specifications.

'`d`' Toggle debug flag.

Don't use this packet; instead, define a general set packet (see Section E.4 [General Query Packets], page 516).

'`D`'
'`D;`*pid*' The first form of the packet is used to detach GDB from the remote system. It is sent to the remote target before GDB disconnects via the `detach` command.

The second form, including a process ID, is used when multiprocess protocol extensions are enabled (see [multiprocess extensions], page 527), to detach only a specific process. The *pid* is specified as a big-endian hex string.

Reply:

'`OK`' for success

'`E` *NN*' for an error

'`F` *RC*`,`*EE*`,`*CF*`;`*XX*'
A reply from GDB to an '`F`' packet sent by the target. This is part of the File-I/O protocol extension. See Section E.13 [File-I/O Remote Protocol Extension], page 547, for the specification.

'`g`' Read general registers.

Reply:

'*XX...*' Each byte of register data is described by two hex digits. The bytes with the register are transmitted in target byte order. The size of each register and their position within the '`g`' packet are determined by the GDB internal gdbarch functions `DEPRECATED_REGISTER_RAW_SIZE` and `gdbarch_register_name`. The specification of several standard '`g`' packets is specified below.

When reading registers from a trace frame (see Section 13.2 [Using the Collected Data], page 161), the stub may also return a string of literal '`x`''s in place of the register data digits, to indicate that the corresponding register has not been collected, thus its value is unavailable. For example, for an architecture with 4 registers of 4 bytes each, the following reply indicates to GDB that registers 0 and 2 have not been collected, while registers 1 and 3 have been collected, and both have zero value:

```
-> g
<- xxxxxxxx00000000xxxxxxxx00000000
```

'`E` *NN*' for an error.

'`G` *XX...*' Write general registers. See [read registers packet], page 506, for a description of the *XX...* data.

Reply:

'`OK`' for success

'`E` *NN*' for an error

'`H` *op thread-id*'

Set thread for subsequent operations ('`m`', '`M`', '`g`', '`G`', et.al.). *op* depends on the operation to be performed: it should be '`c`' for step and continue operations (note that this is deprecated, supporting the '`vCont`' command is a better option), '`g`' for other operations. The thread designator *thread-id* has the format and interpretation described in [thread-id syntax], page 504.

Reply:

'`OK`' for success

'`E` *NN*' for an error

'`i` [*addr*[`,`*nnn*]]'

Step the remote target by a single clock cycle. If '`,`*nnn*' is present, cycle step *nnn* cycles. If *addr* is present, cycle step starting at that address.

'`I`' Signal, then cycle step. See [step with signal packet], page 509. See [cycle step packet], page 507.

'`k`' Kill request.

FIXME: *There is no description of how to operate when a specific thread context has been selected (i.e. does 'k' kill only that thread?).*

'`m` *addr*`,`*length*'

Read *length* bytes of memory starting at address *addr*. Note that *addr* may not be aligned to any particular boundary.

The stub need not use any particular size or alignment when gathering data from memory for the response; even if *addr* is word-aligned and *length* is a multiple of the word size, the stub is free to use byte accesses, or not. For this reason, this packet may not be suitable for accessing memory-mapped I/O devices.

Reply:

'*XX...*' Memory contents; each byte is transmitted as a two-digit hexadecimal number. The reply may contain fewer bytes than requested if the server was able to read only part of the region of memory.

'E *NN*' *NN* is errno

'M *addr*,*length*:*XX...*'
Write *length* bytes of memory starting at address *addr*. *XX...* is the data; each byte is transmitted as a two-digit hexadecimal number.

Reply:

'OK' for success

'E *NN*' for an error (this includes the case where only part of the data was written).

'p *n*' Read the value of register *n*; *n* is in hex. See [read registers packet], page 506, for a description of how the returned register value is encoded.

Reply:

'*XX...*' the register's value

'E *NN*' for an error

'' Indicating an unrecognized *query*.

'P *n...*=*r...*'
Write register *n...* with value *r...*. The register number *n* is in hexadecimal, and *r...* contains two hex digits for each byte in the register (target byte order).

Reply:

'OK' for success

'E *NN*' for an error

'q *name params...*'
'Q *name params...*'
General query ('q') and set ('Q'). These packets are described fully in Section E.4 [General Query Packets], page 516.

'r' Reset the entire system.

Don't use this packet; use the 'R' packet instead.

'R *XX*' Restart the program being debugged. *XX*, while needed, is ignored. This packet is only available in extended mode (see [extended mode], page 505).

The 'R' packet has no reply.

'`s [addr]`' Single step. *addr* is the address at which to resume. If *addr* is omitted, resume at same address.

This packet is deprecated for multi-threading support. See [vCont packet], page 509.

Reply: See Section E.3 [Stop Reply Packets], page 514, for the reply specifications.

'`S sig[;addr]`'
Step with signal. This is analogous to the '`C`' packet, but requests a single-step, rather than a normal resumption of execution.

This packet is deprecated for multi-threading support. See [vCont packet], page 509.

Reply: See Section E.3 [Stop Reply Packets], page 514, for the reply specifications.

'`t addr:PP,MM`'
Search backwards starting at address *addr* for a match with pattern *PP* and mask *MM*. *PP* and *MM* are 4 bytes. *addr* must be at least 3 digits.

'`T thread-id`'
Find out if the thread *thread-id* is alive. See [thread-id syntax], page 504.

Reply:

'`OK`' thread is still alive

'`E NN`' thread is dead

'`v`' Packets starting with '`v`' are identified by a multi-letter name, up to the first '`;`' or '`?`' (or the end of the packet).

'`vAttach;pid`'
Attach to a new process with the specified process ID *pid*. The process ID is a hexadecimal integer identifying the process. In all-stop mode, all threads in the attached process are stopped; in non-stop mode, it may be attached without being stopped if that is supported by the target.

This packet is only available in extended mode (see [extended mode], page 505).

Reply:

'`E nn`' for an error

'Any stop packet'
for success in all-stop mode (see Section E.3 [Stop Reply Packets], page 514)

'`OK`' for success in non-stop mode (see Section E.10 [Remote Non-Stop], page 546)

'`vCont[;action[:thread-id]]...`'
Resume the inferior, specifying different actions for each thread. If an action is specified with no *thread-id*, then it is applied to any threads that don't have a specific action specified; if no default action is specified then other threads

should remain stopped in all-stop mode and in their current state in non-stop mode. Specifying multiple default actions is an error; specifying no actions is also an error. Thread IDs are specified using the syntax described in [thread-id syntax], page 504.

Currently supported actions are:

'`c`' Continue.

'`C sig`' Continue with signal *sig*. The signal *sig* should be two hex digits.

'`s`' Step.

'`S sig`' Step with signal *sig*. The signal *sig* should be two hex digits.

'`t`' Stop.

'`r start,end`'
Step once, and then keep stepping as long as the thread stops at addresses between *start* (inclusive) and *end* (exclusive). The remote stub reports a stop reply when either the thread goes out of the range or is stopped due to an unrelated reason, such as hitting a breakpoint. See [range stepping], page 68.

If the range is empty (*start* == *end*), then the action becomes equivalent to the '`s`' action. In other words, single-step once, and report the stop (even if the stepped instruction jumps to *start*).

(A stop reply may be sent at any point even if the PC is still within the stepping range; for example, it is valid to implement this packet in a degenerate way as a single instruction step operation.)

The optional argument *addr* normally associated with the '`c`', '`C`', '`s`', and '`S`' packets is not supported in '`vCont`'.

The '`t`' action is only relevant in non-stop mode (see Section E.10 [Remote Non-Stop], page 546) and may be ignored by the stub otherwise. A stop reply should be generated for any affected thread not already stopped. When a thread is stopped by means of a '`t`' action, the corresponding stop reply should indicate that the thread has stopped with signal '`0`', regardless of whether the target uses some other signal as an implementation detail.

The stub must support '`vCont`' if it reports support for multiprocess extensions (see [multiprocess extensions], page 527). Note that in this case '`vCont`' actions can be specified to apply to all threads in a process by using the '`pid.-1`' form of the *thread-id*.

Reply: See Section E.3 [Stop Reply Packets], page 514, for the reply specifications.

'`vCont?`' Request a list of actions supported by the '`vCont`' packet.

Reply:

'`vCont[;action...]`'
The '`vCont`' packet is supported. Each *action* is a supported command in the '`vCont`' packet.

‘’ The ‘vCont’ packet is not supported.

‘vFile:*operation*:*parameter*...’
Perform a file operation on the target system. For details, see Section E.7 [Host I/O Packets], page 542.

‘vFlashErase:*addr*,*length*’
Direct the stub to erase *length* bytes of flash starting at *addr*. The region may enclose any number of flash blocks, but its start and end must fall on block boundaries, as indicated by the flash block size appearing in the memory map (see Section E.16 [Memory Map Format], page 561). GDB groups flash memory programming operations together, and sends a ‘vFlashDone’ request after each group; the stub is allowed to delay erase operation until the ‘vFlashDone’ packet is received.

Reply:

‘OK’ for success

‘E *NN*’ for an error

‘vFlashWrite:*addr*:*XX*...’
Direct the stub to write data to flash address *addr*. The data is passed in binary form using the same encoding as for the ‘X’ packet (see [Binary Data], page 503). The memory ranges specified by ‘vFlashWrite’ packets preceding a ‘vFlashDone’ packet must not overlap, and must appear in order of increasing addresses (although ‘vFlashErase’ packets for higher addresses may already have been received; the ordering is guaranteed only between ‘vFlashWrite’ packets). If a packet writes to an address that was neither erased by a preceding ‘vFlashErase’ packet nor by some other target-specific method, the results are unpredictable.

Reply:

‘OK’ for success

‘E.memtype’
for vFlashWrite addressing non-flash memory

‘E *NN*’ for an error

‘vFlashDone’
Indicate to the stub that flash programming operation is finished. The stub is permitted to delay or batch the effects of a group of ‘vFlashErase’ and ‘vFlashWrite’ packets until a ‘vFlashDone’ packet is received. The contents of the affected regions of flash memory are unpredictable until the ‘vFlashDone’ request is completed.

‘vKill;*pid*’
Kill the process with the specified process ID. *pid* is a hexadecimal integer identifying the process. This packet is used in preference to ‘k’ when multiprocess protocol extensions are supported; see [multiprocess extensions], page 527.

Reply:

‘E *nn*’ for an error

‘OK’ for success

‘vRun;*filename*[;*argument*]...’
Run the program *filename*, passing it each *argument* on its command line. The file and arguments are hex-encoded strings. If *filename* is an empty string, the stub may use a default program (e.g. the last program run). The program is created in the stopped state.

This packet is only available in extended mode (see [extended mode], page 505).

Reply:

‘E *nn*’ for an error

‘Any stop packet’
for success (see Section E.3 [Stop Reply Packets], page 514)

‘vStopped’
See Section E.9 [Notification Packets], page 544.

‘X *addr*,*length*:*XX*...’
Write data to memory, where the data is transmitted in binary. *addr* is address, *length* is number of bytes, ‘*XX*...’ is binary data (see [Binary Data], page 503).

Reply:

‘OK’ for success

‘E *NN*’ for an error

‘z *type*,*addr*,*kind*’
‘Z *type*,*addr*,*kind*’
Insert (‘Z’) or remove (‘z’) a *type* breakpoint or watchpoint starting at address *address* of kind *kind*.

Each breakpoint and watchpoint packet *type* is documented separately.

Implementation notes: A remote target shall return an empty string for an unrecognized breakpoint or watchpoint packet type. A remote target shall support either both or neither of a given ‘Ztype...’ and ‘ztype...’ packet pair. To avoid potential problems with duplicate packets, the operations should be implemented in an idempotent way.

‘z0,*addr*,*kind*’
‘Z0,*addr*,*kind*[;*cond_list*...][;cmds:*persist*,*cmd_list*...]’
Insert (‘Z0’) or remove (‘z0’) a memory breakpoint at address *addr* of type *kind*.

A memory breakpoint is implemented by replacing the instruction at *addr* with a software breakpoint or trap instruction. The *kind* is target-specific and typically indicates the size of the breakpoint in bytes that should be inserted. E.g., the ARM and MIPS can insert either a 2 or 4 byte breakpoint. Some architectures have additional meanings for *kind*; *cond_list* is an optional list of conditional expressions in bytecode form that should be evaluated on the target's side. These are the conditions that should be taken into consideration when deciding if the breakpoint trigger should be reported back to *GDBN*.

The *cond_list* parameter is comprised of a series of expressions, concatenated without separators. Each expression has the following form:

‘`X` *len*`,`*expr*’

len is the length of the bytecode expression and *expr* is the actual conditional expression in bytecode form.

The optional *cmd_list* parameter introduces commands that may be run on the target, rather than being reported back to GDB. The parameter starts with a numeric flag *persist*; if the flag is nonzero, then the breakpoint may remain active and the commands continue to be run even when GDB disconnects from the target. Following this flag is a series of expressions concatenated with no separators. Each expression has the following form:

‘`X` *len*`,`*expr*’

len is the length of the bytecode expression and *expr* is the actual conditional expression in bytecode form.

see Section E.5 [Architecture-Specific Protocol Details], page 534.

Implementation note: It is possible for a target to copy or move code that contains memory breakpoints (e.g., when implementing overlays). The behavior of this packet, in the presence of such a target, is not defined.

Reply:

‘`OK`’ success

‘’ not supported

‘`E` *NN*’ for an error

‘`z1,`*addr*`,`*kind*’
‘`Z1,`*addr*`,`*kind*`[;`*cond_list*`...]`’

Insert (‘`Z1`’) or remove (‘`z1`’) a hardware breakpoint at address *addr*.

A hardware breakpoint is implemented using a mechanism that is not dependant on being able to modify the target’s memory. *kind* and *cond_list* have the same meaning as in ‘`Z0`’ packets.

Implementation note: A hardware breakpoint is not affected by code movement.

Reply:

‘`OK`’ success

‘’ not supported

‘`E` *NN*’ for an error

‘`z2,`*addr*`,`*kind*’
‘`Z2,`*addr*`,`*kind*’

Insert (‘`Z2`’) or remove (‘`z2`’) a write watchpoint at *addr*. *kind* is interpreted as the number of bytes to watch.

Reply:

‘`OK`’ success

‘’ not supported

‘E *NN*’ for an error

‘z3,*addr*,*kind*’
‘Z3,*addr*,*kind*’
Insert (‘Z3’) or remove (‘z3’) a read watchpoint at *addr*. *kind* is interpreted as the number of bytes to watch.

Reply:

‘OK’ success

‘’ not supported

‘E *NN*’ for an error

‘z4,*addr*,*kind*’
‘Z4,*addr*,*kind*’
Insert (‘Z4’) or remove (‘z4’) an access watchpoint at *addr*. *kind* is interpreted as the number of bytes to watch.

Reply:

‘OK’ success

‘’ not supported

‘E *NN*’ for an error

E.3 Stop Reply Packets

The ‘C’, ‘c’, ‘S’, ‘s’, ‘vCont’, ‘vAttach’, ‘vRun’, ‘vStopped’, and ‘?’ packets can receive any of the below as a reply. Except for ‘?’ and ‘vStopped’, that reply is only returned when the target halts. In the below the exact meaning of *signal number* is defined by the header ‘include/gdb/signals.h’ in the GDB source code.

As in the description of request packets, we include spaces in the reply templates for clarity; these are not part of the reply packet's syntax. No GDB stop reply packet uses spaces to separate its components.

‘S *AA*’ The program received signal number *AA* (a two-digit hexadecimal number). This is equivalent to a ‘T’ response with no *n*:*r* pairs.

‘T *AA n1*:*r1*;*n2*:*r2*;...’
The program received signal number *AA* (a two-digit hexadecimal number). This is equivalent to an ‘S’ response, except that the ‘*n*:*r*’ pairs can carry values of important registers and other information directly in the stop reply packet, reducing round-trip latency. Single-step and breakpoint traps are reported this way. Each ‘*n*:*r*’ pair is interpreted as follows:

- If *n* is a hexadecimal number, it is a register number, and the corresponding *r* gives that register's value. *r* is a series of bytes in target byte order, with each byte given by a two-digit hex number.
- If *n* is ‘thread’, then *r* is the *thread-id* of the stopped thread, as specified in [thread-id syntax], page 504.
- If *n* is ‘core’, then *r* is the hexadecimal number of the core on which the stop event was detected.

- If *n* is a recognized *stop reason*, it describes a more specific event that stopped the target. The currently defined stop reasons are listed below. *aa* should be '`05`', the trap signal. At most one stop reason should be present.
- Otherwise, GDB should ignore this '*n*`:`*r*' pair and go on to the next; this allows us to extend the protocol in the future.

The currently defined stop reasons are:

'`watch`'
'`rwatch`'
'`awatch`' The packet indicates a watchpoint hit, and *r* is the data address, in hex.

'`library`' The packet indicates that the loaded libraries have changed. GDB should use '`qXfer:libraries:read`' to fetch a new list of loaded libraries. *r* is ignored.

'`replaylog`'
The packet indicates that the target cannot continue replaying logged execution events, because it has reached the end (or the beginning when executing backward) of the log. The value of *r* will be either '`begin`' or '`end`'. See Chapter 6 [Reverse Execution], page 79, for more information.

'`W` *AA*'
'`W` *AA* `;process:`*pid*'
The process exited, and *AA* is the exit status. This is only applicable to certain targets.

The second form of the response, including the process ID of the exited process, can be used only when GDB has reported support for multiprocess protocol extensions; see [multiprocess extensions], page 527. The *pid* is formatted as a big-endian hex string.

'`X` *AA*'
'`X` *AA* `;process:`*pid*'
The process terminated with signal *AA*.

The second form of the response, including the process ID of the terminated process, can be used only when GDB has reported support for multiprocess protocol extensions; see [multiprocess extensions], page 527. The *pid* is formatted as a big-endian hex string.

'`O` *XX*`...`' '*XX*`...`' is hex encoding of ASCII data, to be written as the program's console output. This can happen at any time while the program is running and the debugger should continue to wait for '`W`', '`T`', etc. This reply is not permitted in non-stop mode.

'`F` *call-id*`,`*parameter*`...`'
call-id is the identifier which says which host system call should be called. This is just the name of the function. Translation into the correct system call is only applicable as it's defined in GDB. See Section E.13 [File-I/O Remote Protocol Extension], page 547, for a list of implemented system calls.

'*parameter...*' is a list of parameters as defined for this very system call.

The target replies with this packet when it expects GDB to call a host system call on behalf of the target. GDB replies with an appropriate '`F`' packet and keeps up waiting for the next reply packet from the target. The latest '`C`', '`c`', '`S`' or '`s`' action is expected to be continued. See Section E.13 [File-I/O Remote Protocol Extension], page 547, for more details.

E.4 General Query Packets

Packets starting with '`q`' are *general query packets*; packets starting with '`Q`' are *general set packets*. General query and set packets are a semi-unified form for retrieving and sending information to and from the stub.

The initial letter of a query or set packet is followed by a name indicating what sort of thing the packet applies to. For example, GDB may use a '`qSymbol`' packet to exchange symbol definitions with the stub. These packet names follow some conventions:

- The name must not contain commas, colons or semicolons.
- Most GDB query and set packets have a leading upper case letter.
- The names of custom vendor packets should use a company prefix, in lower case, followed by a period. For example, packets designed at the Acme Corporation might begin with '`qacme.foo`' (for querying foos) or '`Qacme.bar`' (for setting bars).

The name of a query or set packet should be separated from any parameters by a '`:`'; the parameters themselves should be separated by '`,`' or '`;`'. Stubs must be careful to match the full packet name, and check for a separator or the end of the packet, in case two packet names share a common prefix. New packets should not begin with '`qC`', '`qP`', or '`qL`'[1].

Like the descriptions of the other packets, each description here has a template showing the packet's overall syntax, followed by an explanation of the packet's meaning. We include spaces in some of the templates for clarity; these are not part of the packet's syntax. No GDB packet uses spaces to separate its components.

Here are the currently defined query and set packets:

'`QAgent:1`'
'`QAgent:0`'

Turn on or off the agent as a helper to perform some debugging operations delegated from GDB (see [Control Agent], page 451).

'`QAllow:`*op*`:`*val*`...`'

Specify which operations GDB expects to request of the target, as a semicolon-separated list of operation name and value pairs. Possible values for *op* include '`WriteReg`', '`WriteMem`', '`InsertBreak`', '`InsertTrace`', '`InsertFastTrace`', and '`Stop`'. *val* is either 0, indicating that GDB will not request the operation, or 1, indicating that it may. (The target can then use this to set up its own internals optimally, for instance if the debugger never expects to insert breakpoints, it may not need to install its own trap handler.)

[1] The '`qP`' and '`qL`' packets predate these conventions, and have arguments without any terminator for the packet name; we suspect they are in widespread use in places that are difficult to upgrade. The '`qC`' packet has no arguments, but some existing stubs (e.g. RedBoot) are known to not check for the end of the packet.

‘qC’ Return the current thread ID.

Reply:

‘QC *thread-id*’
Where *thread-id* is a thread ID as documented in [thread-id syntax], page 504.

‘(anything else)’
Any other reply implies the old thread ID.

‘qCRC:*addr*,*length*’
Compute the CRC checksum of a block of memory using CRC-32 defined in IEEE 802.3. The CRC is computed byte at a time, taking the most significant bit of each byte first. The initial pattern code `0xffffffff` is used to ensure leading zeros affect the CRC.

Note: This is the same CRC used in validating separate debug files (see Section 18.2 [Debugging Information in Separate Files], page 223). However the algorithm is slightly different. When validating separate debug files, the CRC is computed taking the *least* significant bit of each byte first, and the final result is inverted to detect trailing zeros.

Reply:

‘E *NN*’ An error (such as memory fault)

‘C *crc32*’ The specified memory region’s checksum is *crc32*.

‘QDisableRandomization:*value*’
Some target operating systems will randomize the virtual address space of the inferior process as a security feature, but provide a feature to disable such randomization, e.g. to allow for a more deterministic debugging experience. On such systems, this packet with a *value* of 1 directs the target to disable address space randomization for processes subsequently started via ‘vRun’ packets, while a packet with a *value* of 0 tells the target to enable address space randomization.

This packet is only available in extended mode (see [extended mode], page 505).

Reply:

‘OK’ The request succeeded.

‘E *nn*’ An error occurred. *nn* are hex digits.

‘’ An empty reply indicates that ‘QDisableRandomization’ is not supported by the stub.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [qSupported], page 522). This should only be done on targets that actually support disabling address space randomization.

‘qfThreadInfo’
‘qsThreadInfo’
Obtain a list of all active thread IDs from the target (OS). Since there may be too many active threads to fit into one reply packet, this query works iteratively:

it may require more than one query/reply sequence to obtain the entire list of threads. The first query of the sequence will be the '`qfThreadInfo`' query; subsequent queries in the sequence will be the '`qsThreadInfo`' query.

NOTE: This packet replaces the '`qL`' query (see below).

Reply:

'`m` *thread-id*'
: A single thread ID

'`m` *thread-id*`,`*thread-id*`...`'
: a comma-separated list of thread IDs

'`l`'
: (lower case letter '`L`') denotes end of list.

In response to each query, the target will reply with a list of one or more thread IDs, separated by commas. GDB will respond to each reply with a request for more thread ids (using the '`qs`' form of the query), until the target responds with '`l`' (lower-case ell, for *last*). Refer to [thread-id syntax], page 504, for the format of the *thread-id* fields.

'`qGetTLSAddr:`*thread-id*`,`*offset*`,`*lm*'
: Fetch the address associated with thread local storage specified by *thread-id*, *offset*, and *lm*.

thread-id is the thread ID associated with the thread for which to fetch the TLS address. See [thread-id syntax], page 504.

offset is the (big endian, hex encoded) offset associated with the thread local variable. (This offset is obtained from the debug information associated with the variable.)

lm is the (big endian, hex encoded) OS/ABI-specific encoding of the load module associated with the thread local storage. For example, a GNU/Linux system will pass the link map address of the shared object associated with the thread local storage under consideration. Other operating environments may choose to represent the load module differently, so the precise meaning of this parameter will vary.

Reply:

'*XX*`...`'
: Hex encoded (big endian) bytes representing the address of the thread local storage requested.

'`E` *nn*'
: An error occurred. *nn* are hex digits.

''
: An empty reply indicates that '`qGetTLSAddr`' is not supported by the stub.

'`qGetTIBAddr:`*thread-id*'
: Fetch address of the Windows OS specific Thread Information Block.

thread-id is the thread ID associated with the thread.

Reply:

'*XX*`...`'
: Hex encoded (big endian) bytes representing the linear address of the thread information block.

'`E nn`' An error occured. This means that either the thread was not found, or the address could not be retrieved.

'' An empty reply indicates that '`qGetTIBAddr`' is not supported by the stub.

'`qL startflag threadcount nextthread`'

Obtain thread information from RTOS. Where: *startflag* (one hex digit) is one to indicate the first query and zero to indicate a subsequent query; *threadcount* (two hex digits) is the maximum number of threads the response packet can contain; and *nextthread* (eight hex digits), for subsequent queries (*startflag* is zero), is returned in the response as *argthread*.

Don't use this packet; use the '`qfThreadInfo`' query instead (see above).

Reply:

'`qM count done argthread thread...`'

Where: *count* (two hex digits) is the number of threads being returned; *done* (one hex digit) is zero to indicate more threads and one indicates no further threads; *argthreadid* (eight hex digits) is *nextthread* from the request packet; *thread...* is a sequence of thread IDs from the target. *threadid* (eight hex digits). See `remote.c:parse_threadlist_response()`.

'`qOffsets`'

Get section offsets that the target used when relocating the downloaded image.

Reply:

'`Text=xxx;Data=yyy[;Bss=zzz]`'

Relocate the `Text` section by *xxx* from its original address. Relocate the `Data` section by *yyy* from its original address. If the object file format provides segment information (e.g. ELF '`PT_LOAD`' program headers), GDB will relocate entire segments by the supplied offsets.

Note: while a `Bss` *offset may be included in the response,* GDB *ignores this and instead applies the* `Data` *offset to the* `Bss` *section.*

'`TextSeg=xxx[;DataSeg=yyy]`'

Relocate the first segment of the object file, which conventionally contains program code, to a starting address of *xxx*. If '`DataSeg`' is specified, relocate the second segment, which conventionally contains modifiable data, to a starting address of *yyy*. GDB will report an error if the object file does not contain segment information, or does not contain at least as many segments as mentioned in the reply. Extra segments are kept at fixed offsets relative to the last relocated segment.

'`qP mode thread-id`'

Returns information on *thread-id*. Where: *mode* is a hex encoded 32 bit mode; *thread-id* is a thread ID (see [thread-id syntax], page 504).

Don't use this packet; use the '`qThreadExtraInfo`' query instead (see below).

Reply: see `remote.c:remote_unpack_thread_info_response()`.

'`QNonStop:1`'
'`QNonStop:0`'
: Enter non-stop ('`QNonStop:1`') or all-stop ('`QNonStop:0`') mode. See Section E.10 [Remote Non-Stop], page 546, for more information.

  Reply:

  '`OK`' The request succeeded.

  '`E` *nn*' An error occurred. *nn* are hex digits.

  '' An empty reply indicates that '`QNonStop`' is not supported by the stub.

  This packet is not probed by default; the remote stub must request it, by supplying an appropriate '`qSupported`' response (see [qSupported], page 522). Use of this packet is controlled by the `set non-stop` command; see Section 5.5.2 [Non-Stop Mode], page 74.

'`QPassSignals:` *signal* [`;`*signal*]`...`'
: Each listed *signal* should be passed directly to the inferior process. Signals are numbered identically to continue packets and stop replies (see Section E.3 [Stop Reply Packets], page 514). Each *signal* list item should be strictly greater than the previous item. These signals do not need to stop the inferior, or be reported to GDB. All other signals should be reported to GDB. Multiple '`QPassSignals`' packets do not combine; any earlier '`QPassSignals`' list is completely replaced by the new list. This packet improves performance when using '`handle` *signal* `nostop noprint pass`'.

  Reply:

  '`OK`' The request succeeded.

  '`E` *nn*' An error occurred. *nn* are hex digits.

  '' An empty reply indicates that '`QPassSignals`' is not supported by the stub.

  Use of this packet is controlled by the `set remote pass-signals` command (see Section 20.4 [Remote Configuration], page 242). This packet is not probed by default; the remote stub must request it, by supplying an appropriate '`qSupported`' response (see [qSupported], page 522).

'`QProgramSignals:` *signal* [`;`*signal*]`...`'
: Each listed *signal* may be delivered to the inferior process. Others should be silently discarded.

  In some cases, the remote stub may need to decide whether to deliver a signal to the program or not without GDB involvement. One example of that is while detaching — the program's threads may have stopped for signals that haven't yet had a chance of being reported to GDB, and so the remote stub can use the signal list specified by this packet to know whether to deliver or ignore those pending signals.

  This does not influence whether to deliver a signal as requested by a resumption packet (see [vCont packet], page 509).

Signals are numbered identically to continue packets and stop replies (see Section E.3 [Stop Reply Packets], page 514). Each *signal* list item should be strictly greater than the previous item. Multiple '`QProgramSignals`' packets do not combine; any earlier '`QProgramSignals`' list is completely replaced by the new list.

Reply:

'`OK`' The request succeeded.

'`E` *nn*' An error occurred. *nn* are hex digits.

'' An empty reply indicates that '`QProgramSignals`' is not supported by the stub.

Use of this packet is controlled by the `set remote program-signals` command (see Section 20.4 [Remote Configuration], page 242). This packet is not probed by default; the remote stub must request it, by supplying an appropriate '`qSupported`' response (see [qSupported], page 522).

'`qRcmd,`*command*'

command (hex encoded) is passed to the local interpreter for execution. Invalid commands should be reported using the output string. Before the final result packet, the target may also respond with a number of intermediate '`O`*output*' console output packets. *Implementors should note that providing access to a stubs's interpreter may have security implications.*

Reply:

'`OK`' A command response with no output.

'*OUTPUT*' A command response with the hex encoded output string *OUTPUT*.

'`E` *NN*' Indicate a badly formed request.

'' An empty reply indicates that '`qRcmd`' is not recognized.

(Note that the `qRcmd` packet's name is separated from the command by a '`,`', not a '`:`', contrary to the naming conventions above. Please don't use this packet as a model for new packets.)

'`qSearch:memory:`*address*`;`*length*`;`*search-pattern*'

Search *length* bytes at *address* for *search-pattern*. *address* and *length* are encoded in hex. *search-pattern* is a sequence of bytes, hex encoded.

Reply:

'`0`' The pattern was not found.

'`1,address`'

The pattern was found at *address*.

'`E` *NN*' A badly formed request or an error was encountered while searching memory.

'' An empty reply indicates that '`qSearch:memory`' is not recognized.

'`QStartNoAckMode`'
: Request that the remote stub disable the normal '`+`'/'`-`' protocol acknowledgments (see Section E.11 [Packet Acknowledgment], page 546).

  Reply:

  '`OK`'
  : The stub has switched to no-acknowledgment mode. GDB acknowledges this reponse, but neither the stub nor GDB shall send or expect further '`+`'/'`-`' acknowledgments in the current connection.

  ''
  : An empty reply indicates that the stub does not support no-acknowledgment mode.

'`qSupported` [`:`*gdbfeature* [`;`*gdbfeature*]`...`]'
: Tell the remote stub about features supported by GDB, and query the stub for features it supports. This packet allows GDB and the remote stub to take advantage of each others' features. '`qSupported`' also consolidates multiple feature probes at startup, to improve GDB performance—a single larger packet performs better than multiple smaller probe packets on high-latency links. Some features may enable behavior which must not be on by default, e.g. because it would confuse older clients or stubs. Other features may describe packets which could be automatically probed for, but are not. These features must be reported before GDB will use them. This "default unsupported" behavior is not appropriate for all packets, but it helps to keep the initial connection time under control with new versions of GDB which support increasing numbers of packets.

  Reply:

  '*stubfeature* [`;`*stubfeature*]`...`'
  : The stub supports or does not support each returned *stubfeature*, depending on the form of each *stubfeature* (see below for the possible forms).

  ''
  : An empty reply indicates that '`qSupported`' is not recognized, or that no features needed to be reported to GDB.

  The allowed forms for each feature (either a *gdbfeature* in the '`qSupported`' packet, or a *stubfeature* in the response) are:

  '*name*`=`*value*'
  : The remote protocol feature *name* is supported, and associated with the specified *value*. The format of *value* depends on the feature, but it must not include a semicolon.

  '*name*`+`'
  : The remote protocol feature *name* is supported, and does not need an associated value.

  '*name*`-`'
  : The remote protocol feature *name* is not supported.

  '*name*`?`'
  : The remote protocol feature *name* may be supported, and GDB should auto-detect support in some other way when it is needed. This form will not be used for *gdbfeature* notifications, but may be used for *stubfeature* responses.

Whenever the stub receives a '`qSupported`' request, the supplied set of GDB features should override any previous request. This allows GDB to put the stub in a known state, even if the stub had previously been communicating with a different version of GDB.

The following values of *gdbfeature* (for the packet sent by GDB) are defined:

'`multiprocess`'
: This feature indicates whether GDB supports multiprocess extensions to the remote protocol. GDB does not use such extensions unless the stub also reports that it supports them by including '`multiprocess+`' in its '`qSupported`' reply. See [multiprocess extensions], page 527, for details.

'`xmlRegisters`'
: This feature indicates that GDB supports the XML target description. If the stub sees '`xmlRegisters=`' with target specific strings separated by a comma, it will report register description.

'`qRelocInsn`'
: This feature indicates whether GDB supports the '`qRelocInsn`' packet (see Section E.6 [Relocate instruction reply packet], page 535).

Stubs should ignore any unknown values for *gdbfeature*. Any GDB which sends a '`qSupported`' packet supports receiving packets of unlimited length (earlier versions of GDB may reject overly long responses). Additional values for *gdbfeature* may be defined in the future to let the stub take advantage of new features in GDB, e.g. incompatible improvements in the remote protocol—the '`multiprocess`' feature is an example of such a feature. The stub's reply should be independent of the *gdbfeature* entries sent by GDB; first GDB describes all the features it supports, and then the stub replies with all the features it supports.

Similarly, GDB will silently ignore unrecognized stub feature responses, as long as each response uses one of the standard forms.

Some features are flags. A stub which supports a flag feature should respond with a '`+`' form response. Other features require values, and the stub should respond with an '`=`' form response.

Each feature has a default value, which GDB will use if '`qSupported`' is not available or if the feature is not mentioned in the '`qSupported`' response. The default values are fixed; a stub is free to omit any feature responses that match the defaults.

Not all features can be probed, but for those which can, the probing mechanism is useful: in some cases, a stub's internal architecture may not allow the protocol layer to know some information about the underlying target in advance. This is especially common in stubs which may be configured for multiple targets.

These are the currently defined stub features and their properties:

Feature Name	Value Required	Default	Probe Allowed

‘PacketSize’	Yes	‘-’	No
‘qXfer:auxv:read’	No	‘-’	Yes
‘qXfer:btrace:read’	No	‘-’	Yes
‘qXfer:features:read’	No	‘-’	Yes
‘qXfer:libraries:read’	No	‘-’	Yes
‘qXfer:memory-map:read’	No	‘-’	Yes
‘qXfer:sdata:read’	No	‘-’	Yes
‘qXfer:spu:read’	No	‘-’	Yes
‘qXfer:spu:write’	No	‘-’	Yes
‘qXfer:siginfo:read’	No	‘-’	Yes
‘qXfer:siginfo:write’	No	‘-’	Yes
‘qXfer:threads:read’	No	‘-’	Yes
‘qXfer:traceframe-info:read’	No	‘-’	Yes
‘qXfer:uib:read’	No	‘-’	Yes
‘qXfer:fdpic:read’	No	‘-’	Yes
‘Qbtrace:off’	Yes	‘-’	Yes
‘Qbtrace:bts’	Yes	‘-’	Yes
‘QNonStop’	No	‘-’	Yes
‘QPassSignals’	No	‘-’	Yes
‘QStartNoAckMode’	No	‘-’	Yes
‘multiprocess’	No	‘-’	No
‘ConditionalBreakpoints’	No	‘-’	No
‘ConditionalTracepoints’	No	‘-’	No

'ReverseContinue'	No	'-'	No
'ReverseStep'	No	'-'	No
'TracepointSource'	No	'-'	No
'QAgent'	No	'-'	No
'QAllow'	No	'-'	No
'QDisableRandomization'	No	'-'	No
'EnableDisableTracepoints'	No	'-'	No
'QTBuffer:size'	No	'-'	No
'tracenz'	No	'-'	No
'BreakpointCommands'	No	'-'	No

These are the currently defined stub features, in more detail:

'PacketSize=*bytes*'
: The remote stub can accept packets up to at least *bytes* in length. GDB will send packets up to this size for bulk transfers, and will never send larger packets. This is a limit on the data characters in the packet, including the frame and checksum. There is no trailing NUL byte in a remote protocol packet; if the stub stores packets in a NUL-terminated format, it should allow an extra byte in its buffer for the NUL. If this stub feature is not supported, GDB guesses based on the size of the 'g' packet response.

'qXfer:auxv:read'
: The remote stub understands the 'qXfer:auxv:read' packet (see [qXfer auxiliary vector read], page 530).

'qXfer:btrace:read'
: The remote stub understands the 'qXfer:btrace:read' packet (see [qXfer btrace read], page 530).

'qXfer:features:read'
: The remote stub understands the 'qXfer:features:read' packet (see [qXfer target description read], page 530).

'qXfer:libraries:read'
: The remote stub understands the 'qXfer:libraries:read' packet (see [qXfer library list read], page 530).

'qXfer:libraries-svr4:read'
: The remote stub understands the 'qXfer:libraries-svr4:read' packet (see [qXfer svr4 library list read], page 530).

‘`qXfer:memory-map:read`’
: The remote stub understands the ‘`qXfer:memory-map:read`’ packet (see [qXfer memory map read], page 531).

‘`qXfer:sdata:read`’
: The remote stub understands the ‘`qXfer:sdata:read`’ packet (see [qXfer sdata read], page 531).

‘`qXfer:spu:read`’
: The remote stub understands the ‘`qXfer:spu:read`’ packet (see [qXfer spu read], page 531).

‘`qXfer:spu:write`’
: The remote stub understands the ‘`qXfer:spu:write`’ packet (see [qXfer spu write], page 533).

‘`qXfer:siginfo:read`’
: The remote stub understands the ‘`qXfer:siginfo:read`’ packet (see [qXfer siginfo read], page 531).

‘`qXfer:siginfo:write`’
: The remote stub understands the ‘`qXfer:siginfo:write`’ packet (see [qXfer siginfo write], page 533).

‘`qXfer:threads:read`’
: The remote stub understands the ‘`qXfer:threads:read`’ packet (see [qXfer threads read], page 531).

‘`qXfer:traceframe-info:read`’
: The remote stub understands the ‘`qXfer:traceframe-info:read`’ packet (see [qXfer traceframe info read], page 532).

‘`qXfer:uib:read`’
: The remote stub understands the ‘`qXfer:uib:read`’ packet (see [qXfer unwind info block], page 532).

‘`qXfer:fdpic:read`’
: The remote stub understands the ‘`qXfer:fdpic:read`’ packet (see [qXfer fdpic loadmap read], page 532).

‘`QNonStop`’
: The remote stub understands the ‘`QNonStop`’ packet (see [QNonStop], page 520).

‘`QPassSignals`’
: The remote stub understands the ‘`QPassSignals`’ packet (see [QPassSignals], page 520).

‘`QStartNoAckMode`’
: The remote stub understands the ‘`QStartNoAckMode`’ packet and prefers to operate in no-acknowledgment mode. See Section E.11 [Packet Acknowledgment], page 546.

‘multiprocess’
: The remote stub understands the multiprocess extensions to the remote protocol syntax. The multiprocess extensions affect the syntax of thread IDs in both packets and replies (see [thread-id syntax], page 504), and add process IDs to the ‘D’ packet and ‘W’ and ‘X’ replies. Note that reporting this feature indicates support for the syntactic extensions only, not that the stub necessarily supports debugging of more than one process at a time. The stub must not use multiprocess extensions in packet replies unless GDB has also indicated it supports them in its ‘qSupported’ request.

‘qXfer:osdata:read’
: The remote stub understands the ‘qXfer:osdata:read’ packet ((see [qXfer osdata read], page 532).

‘ConditionalBreakpoints’
: The target accepts and implements evaluation of conditional expressions defined for breakpoints. The target will only report breakpoint triggers when such conditions are true (see Section 5.1.6 [Break Conditions], page 59).

‘ConditionalTracepoints’
: The remote stub accepts and implements conditional expressions defined for tracepoints (see Section 13.1.4 [Tracepoint Conditions], page 153).

‘ReverseContinue’
: The remote stub accepts and implements the reverse continue packet (see [bc], page 505).

‘ReverseStep’
: The remote stub accepts and implements the reverse step packet (see [bs], page 506).

‘TracepointSource’
: The remote stub understands the ‘QTDPsrc’ packet that supplies the source form of tracepoint definitions.

‘QAgent’ The remote stub understands the ‘QAgent’ packet.

‘QAllow’ The remote stub understands the ‘QAllow’ packet.

‘QDisableRandomization’
: The remote stub understands the ‘QDisableRandomization’ packet.

‘StaticTracepoint’
: The remote stub supports static tracepoints.

‘InstallInTrace’
: The remote stub supports installing tracepoint in tracing.

‘EnableDisableTracepoints’
: The remote stub supports the ‘QTEnable’ (see [QTEnable], page 538) and ‘QTDisable’ (see [QTDisable], page 538) packets

that allow tracepoints to be enabled and disabled while a trace experiment is running.

'QTBuffer:size'
: The remote stub supports the 'QTBuffer:size' (see [QTBuffer-size], page 541) packet that allows to change the size of the trace buffer.

'tracenz'
: The remote stub supports the 'tracenz' bytecode for collecting strings. See Section F.2 [Bytecode Descriptions], page 567 for details about the bytecode.

'BreakpointCommands'
: The remote stub supports running a breakpoint's command list itself, rather than reporting the hit to GDB.

'Qbtrace:off'
: The remote stub understands the 'Qbtrace:off' packet.

'Qbtrace:bts'
: The remote stub understands the 'Qbtrace:bts' packet.

'qSymbol::'
: Notify the target that GDB is prepared to serve symbol lookup requests. Accept requests from the target for the values of symbols.

  Reply:

  'OK'
  : The target does not need to look up any (more) symbols.

  'qSymbol:*sym_name*'
  : The target requests the value of symbol *sym_name* (hex encoded). GDB may provide the value by using the 'qSymbol:*sym_value*:*sym_name*' message, described below.

'qSymbol:*sym_value*:*sym_name*'
: Set the value of *sym_name* to *sym_value*.

  sym_name (hex encoded) is the name of a symbol whose value the target has previously requested.

  sym_value (hex) is the value for symbol *sym_name*. If GDB cannot supply a value for *sym_name*, then this field will be empty.

  Reply:

  'OK'
  : The target does not need to look up any (more) symbols.

  'qSymbol:*sym_name*'
  : The target requests the value of a new symbol *sym_name* (hex encoded). GDB will continue to supply the values of symbols (if available), until the target ceases to request them.

'qTBuffer'
'QTBuffer'
'QTDisconnected'
'QTDP'
'QTDPsrc'
'QTDV'
'qTfP'
'qTfV'
'QTFrame'
'qTMinFTPILen'
: See Section E.6 [Tracepoint Packets], page 535.

'qThreadExtraInfo,*thread-id*'
: Obtain a printable string description of a thread's attributes from the target OS. *thread-id* is a thread ID; see [thread-id syntax], page 504. This string may contain anything that the target OS thinks is interesting for GDB to tell the user about the thread. The string is displayed in GDB's `info threads` display. Some examples of possible thread extra info strings are '`Runnable`', or '`Blocked on Mutex`'.

  Reply:

  '*XX*...' : Where '*XX*...' is a hex encoding of ASCII data, comprising the printable string containing the extra information about the thread's attributes.

  (Note that the `qThreadExtraInfo` packet's name is separated from the command by a '`,`', not a '`:`', contrary to the naming conventions above. Please don't use this packet as a model for new packets.)

'QTNotes'
'qTP'
'QTSave'
'qTsP'
'qTsV'
'QTStart'
'QTStop'
'QTEnable'
'QTDisable'
'QTinit'
'QTro'
'qTStatus'
'qTV'
'qTfSTM'
'qTsSTM'
'qTSTMat'
: See Section E.6 [Tracepoint Packets], page 535.

'qXfer:*object*:read:*annex*:*offset*,*length*'
: Read uninterpreted bytes from the target's special data area identified by the keyword *object*. Request *length* bytes starting at *offset* bytes into the data.

The content and encoding of *annex* is specific to *object*; it can supply additional details about what data to access.

Here are the specific requests of this form defined so far. All '`qXfer:`*`object`*`:read:...`' requests use the same reply formats, listed below.

'`qXfer:auxv:read::`*`offset`*`,`*`length`*'
: Access the target's *auxiliary vector*. See Section 10.16 [OS Information], page 130. Note *annex* must be empty.

  This packet is not probed by default; the remote stub must request it, by supplying an appropriate '`qSupported`' response (see [qSupported], page 522).

'`qXfer:btrace:read:`*`annex`*`:`*`offset`*`,`*`length`*'
: Return a description of the current branch trace. See Section E.19 [Branch Trace Format], page 563. The annex part of the generic '`qXfer`' packet may have one of the following values:

  `all` Returns all available branch trace.

  `new` Returns all available branch trace if the branch trace changed since the last read request.

  This packet is not probed by default; the remote stub must request it by supplying an appropriate '`qSupported`' response (see [qSupported], page 522).

'`qXfer:features:read:`*`annex`*`:`*`offset`*`,`*`length`*'
: Access the *target description*. See Appendix G [Target Descriptions], page 577. The annex specifies which XML document to access. The main description is always loaded from the '`target.xml`' annex.

  This packet is not probed by default; the remote stub must request it, by supplying an appropriate '`qSupported`' response (see [qSupported], page 522).

'`qXfer:libraries:read:`*`annex`*`:`*`offset`*`,`*`length`*'
: Access the target's list of loaded libraries. See Section E.14 [Library List Format], page 559. The annex part of the generic '`qXfer`' packet must be empty (see [qXfer read], page 529).

  Targets which maintain a list of libraries in the program's memory do not need to implement this packet; it is designed for platforms where the operating system manages the list of loaded libraries.

  This packet is not probed by default; the remote stub must request it, by supplying an appropriate '`qSupported`' response (see [qSupported], page 522).

'`qXfer:libraries-svr4:read:`*`annex`*`:`*`offset`*`,`*`length`*'
: Access the target's list of loaded libraries when the target is an SVR4 platform. See Section E.15 [Library List Format for SVR4 Targets], page 560. The annex part of the generic '`qXfer`' packet must be empty (see [qXfer read], page 529).

This packet is optional for better performance on SVR4 targets. GDB uses memory read packets to read the SVR4 library list otherwise.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate '`qSupported`' response (see [qSupported], page 522).

'`qXfer:memory-map:read::`*`offset`*`,`*`length`*'
Access the target's *memory-map*. See Section E.16 [Memory Map Format], page 561. The annex part of the generic '`qXfer`' packet must be empty (see [qXfer read], page 529).

This packet is not probed by default; the remote stub must request it, by supplying an appropriate '`qSupported`' response (see [qSupported], page 522).

'`qXfer:sdata:read::`*`offset`*`,`*`length`*'
Read contents of the extra collected static tracepoint marker information. The annex part of the generic '`qXfer`' packet must be empty (see [qXfer read], page 529). See Section 13.1.6 [Tracepoint Action Lists], page 154.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate '`qSupported`' response (see [qSupported], page 522).

'`qXfer:siginfo:read::`*`offset`*`,`*`length`*'
Read contents of the extra signal information on the target system. The annex part of the generic '`qXfer`' packet must be empty (see [qXfer read], page 529).

This packet is not probed by default; the remote stub must request it, by supplying an appropriate '`qSupported`' response (see [qSupported], page 522).

'`qXfer:spu:read:`*`annex`*`:`*`offset`*`,`*`length`*'
Read contents of an `spufs` file on the target system. The annex specifies which file to read; it must be of the form '`id/`*`name`*', where *id* specifies an SPU context ID in the target process, and *name* identifes the `spufs` file in that context to be accessed.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate '`qSupported`' response (see [qSupported], page 522).

'`qXfer:threads:read::`*`offset`*`,`*`length`*'
Access the list of threads on target. See Section E.17 [Thread List Format], page 562. The annex part of the generic '`qXfer`' packet must be empty (see [qXfer read], page 529).

This packet is not probed by default; the remote stub must request it, by supplying an appropriate '`qSupported`' response (see [qSupported], page 522).

‘`qXfer:traceframe-info:read::offset,length`’
: Return a description of the current traceframe's contents. See Section E.18 [Traceframe Info Format], page 562. The annex part of the generic ‘`qXfer`’ packet must be empty (see [qXfer read], page 529).

  This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘`qSupported`’ response (see [qSupported], page 522).

‘`qXfer:uib:read:pc:offset,length`’
: Return the unwind information block for *pc*. This packet is used on OpenVMS/ia64 to ask the kernel unwind information.

  This packet is not probed by default.

‘`qXfer:fdpic:read:annex:offset,length`’
: Read contents of `loadmap`s on the target system. The annex, either ‘`exec`’ or ‘`interp`’, specifies which `loadmap`, executable `loadmap` or interpreter `loadmap` to read.

  This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘`qSupported`’ response (see [qSupported], page 522).

‘`qXfer:osdata:read::offset,length`’
: Access the target's *operating system information*. See Appendix H [Operating System Information], page 585.

Reply:

‘`m data`’
: Data *data* (see [Binary Data], page 503) has been read from the target. There may be more data at a higher address (although it is permitted to return ‘`m`’ even for the last valid block of data, as long as at least one byte of data was read). *data* may have fewer bytes than the *length* in the request.

‘`l data`’
: Data *data* (see [Binary Data], page 503) has been read from the target. There is no more data to be read. *data* may have fewer bytes than the *length* in the request.

‘`l`’
: The *offset* in the request is at the end of the data. There is no more data to be read.

‘`E00`’
: The request was malformed, or *annex* was invalid.

‘`E nn`’
: The offset was invalid, or there was an error encountered reading the data. *nn* is a hex-encoded `errno` value.

‘’
: An empty reply indicates the *object* string was not recognized by the stub, or that the object does not support reading.

‘`qXfer:object:write:annex:offset:data...`’
: Write uninterpreted bytes into the target's special data area identified by the keyword *object*, starting at *offset* bytes into the data. *data*... is the binary-encoded data (see [Binary Data], page 503) to be written. The content and

encoding of *annex* is specific to *object*; it can supply additional details about what data to access.

Here are the specific requests of this form defined so far. All '`qXfer:`*object*`:write:...`' requests use the same reply formats, listed below.

'`qXfer:siginfo:write::`*offset*`:`*data*`...`'
: Write *data* to the extra signal information on the target system. The annex part of the generic '`qXfer`' packet must be empty (see [qXfer write], page 532).

  This packet is not probed by default; the remote stub must request it, by supplying an appropriate '`qSupported`' response (see [qSupported], page 522).

'`qXfer:spu:write:`*annex*`:`*offset*`:`*data*`...`'
: Write *data* to an `spufs` file on the target system. The annex specifies which file to write; it must be of the form '*id*`/`*name*', where *id* specifies an SPU context ID in the target process, and *name* identifes the `spufs` file in that context to be accessed.

  This packet is not probed by default; the remote stub must request it, by supplying an appropriate '`qSupported`' response (see [qSupported], page 522).

Reply:

'*nn*'
: *nn* (hex encoded) is the number of bytes written. This may be fewer bytes than supplied in the request.

'`E00`'
: The request was malformed, or *annex* was invalid.

'`E` *nn*'
: The offset was invalid, or there was an error encountered writing the data. *nn* is a hex-encoded `errno` value.

''
: An empty reply indicates the *object* string was not recognized by the stub, or that the object does not support writing.

'`qXfer:`*object*`:`*operation*`:...`'
: Requests of this form may be added in the future. When a stub does not recognize the *object* keyword, or its support for *object* does not recognize the *operation* keyword, the stub must respond with an empty packet.

'`qAttached:`*pid*'
: Return an indication of whether the remote server attached to an existing process or created a new process. When the multiprocess protocol extensions are supported (see [multiprocess extensions], page 527), *pid* is an integer in hexadecimal format identifying the target process. Otherwise, GDB will omit the *pid* field and the query packet will be simplified as '`qAttached`'.

  This query is used, for example, to know whether the remote process should be detached or killed when a GDB session is ended with the `quit` command.

  Reply:

  '`1`'
  : The remote server attached to an existing process.

‘`O`’ The remote server created a new process.

‘`E` *NN*’ A badly formed request or an error was encountered.

‘`Qbtrace:bts`’
Enable branch tracing for the current thread using bts tracing.

Reply:

‘`OK`’ Branch tracing has been enabled.

‘`E.errtext`’
A badly formed request or an error was encountered.

‘`Qbtrace:off`’
Disable branch tracing for the current thread.

Reply:

‘`OK`’ Branch tracing has been disabled.

‘`E.errtext`’
A badly formed request or an error was encountered.

E.5 Architecture-Specific Protocol Details

This section describes how the remote protocol is applied to specific target architectures. Also see Section G.4 [Standard Target Features], page 582, for details of XML target descriptions for each architecture.

E.5.1 ARM-specific Protocol Details

E.5.1.1 ARM Breakpoint Kinds

These breakpoint kinds are defined for the ‘`Z0`’ and ‘`Z1`’ packets.

2 16-bit Thumb mode breakpoint.

3 32-bit Thumb mode (Thumb-2) breakpoint.

4 32-bit ARM mode breakpoint.

E.5.2 MIPS-specific Protocol Details

E.5.2.1 MIPS Register Packet Format

The following `g`/`G` packets have previously been defined. In the below, some thirty-two bit registers are transferred as sixty-four bits. Those registers should be zero/sign extended (which?) to fill the space allocated. Register bytes are transferred in target byte order. The two nibbles within a register byte are transferred most-significant – least-significant.

MIPS32 All registers are transferred as thirty-two bit quantities in the order: 32 general-purpose; sr; lo; hi; bad; cause; pc; 32 floating-point registers; fsr; fir; fp.

MIPS64 All registers are transferred as sixty-four bit quantities (including thirty-two bit registers such as `sr`). The ordering is the same as `MIPS32`.

E.5.2.2 MIPS Breakpoint Kinds

These breakpoint kinds are defined for the 'Z0' and 'Z1' packets.

2 16-bit MIPS16 mode breakpoint.

3 16-bit microMIPS mode breakpoint.

4 32-bit standard MIPS mode breakpoint.

5 32-bit microMIPS mode breakpoint.

E.6 Tracepoint Packets

Here we describe the packets GDB uses to implement tracepoints (see Chapter 13 [Tracepoints], page 149).

'QTDP:*n*:*addr*:*ena*:*step*:*pass*[:F*flen*][:X*len*,*bytes*][-]'

Create a new tracepoint, number *n*, at *addr*. If *ena* is 'E', then the tracepoint is enabled; if it is 'D', then the tracepoint is disabled. *step* is the tracepoint's step count, and *pass* is its pass count. If an 'F' is present, then the tracepoint is to be a fast tracepoint, and the *flen* is the number of bytes that the target should copy elsewhere to make room for the tracepoint. If an 'X' is present, it introduces a tracepoint condition, which consists of a hexadecimal length, followed by a comma and hex-encoded bytes, in a manner similar to action encodings as described below. If the trailing '-' is present, further 'QTDP' packets will follow to specify this tracepoint's actions.

Replies:

'OK' The packet was understood and carried out.

'qRelocInsn'
See Section E.6 [Relocate instruction reply packet], page 535.

'' The packet was not recognized.

'QTDP:-*n*:*addr*:[S]*action*...[-]'

Define actions to be taken when a tracepoint is hit. *n* and *addr* must be the same as in the initial 'QTDP' packet for this tracepoint. This packet may only be sent immediately after another 'QTDP' packet that ended with a '-'. If the trailing '-' is present, further 'QTDP' packets will follow, specifying more actions for this tracepoint.

In the series of action packets for a given tracepoint, at most one can have an 'S' before its first *action*. If such a packet is sent, it and the following packets define "while-stepping" actions. Any prior packets define ordinary actions — that is, those taken when the tracepoint is first hit. If no action packet has an 'S', then all the packets in the series specify ordinary tracepoint actions.

The '*action*...' portion of the packet is a series of actions, concatenated without separators. Each action has one of the following forms:

'R *mask*' Collect the registers whose bits are set in *mask*. *mask* is a hexadecimal number whose *i*'th bit is set if register number *i* should be collected. (The least significant bit is numbered zero.) Note that

mask may be any number of digits long; it may not fit in a 32-bit word.

'`M` *basereg*`,`*offset*`,`*len*'
Collect *len* bytes of memory starting at the address in register number *basereg*, plus *offset*. If *basereg* is '`-1`', then the range has a fixed address: *offset* is the address of the lowest byte to collect. The *basereg*, *offset*, and *len* parameters are all unsigned hexadecimal values (the '`-1`' value for *basereg* is a special case).

'`X` *len*`,`*expr*'
Evaluate *expr*, whose length is *len*, and collect memory as it directs. *expr* is an agent expression, as described in Appendix F [Agent Expressions], page 565. Each byte of the expression is encoded as a two-digit hex number in the packet; *len* is the number of bytes in the expression (and thus one-half the number of hex digits in the packet).

Any number of actions may be packed together in a single '`QTDP`' packet, as long as the packet does not exceed the maximum packet length (400 bytes, for many stubs). There may be only one '`R`' action per tracepoint, and it must precede any '`M`' or '`X`' actions. Any registers referred to by '`M`' and '`X`' actions must be collected by a preceding '`R`' action. (The "while-stepping" actions are treated as if they were attached to a separate tracepoint, as far as these restrictions are concerned.)

Replies:

'`OK`' The packet was understood and carried out.

'`qRelocInsn`'
See Section E.6 [Relocate instruction reply packet], page 535.

'' The packet was not recognized.

'`QTDPsrc:`*n*`:`*addr*`:`*type*`:`*start*`:`*slen*`:`*bytes*'
Specify a source string of tracepoint *n* at address *addr*. This is useful to get accurate reproduction of the tracepoints originally downloaded at the beginning of the trace run. *type* is the name of the tracepoint part, such as '`cond`' for the tracepoint's conditional expression (see below for a list of types), while *bytes* is the string, encoded in hexadecimal.

start is the offset of the *bytes* within the overall source string, while *slen* is the total length of the source string. This is intended for handling source strings that are longer than will fit in a single packet.

The available string types are '`at`' for the location, '`cond`' for the conditional, and '`cmd`' for an action command. GDB sends a separate packet for each command in the action list, in the same order in which the commands are stored in the list.

The target does not need to do anything with source strings except report them back as part of the replies to the '`qTfP`'/'`qTsP`' query packets.

Although this packet is optional, and GDB will only send it if the target replies with '`TracepointSource`' See Section E.4 [General Query Packets], page 516, it makes both disconnected tracing and trace files much easier to use. Otherwise the user must be careful that the tracepoints in effect while looking at trace frames are identical to the ones in effect during the trace run; even a small discrepancy could cause '`tdump`' not to work, or a particular trace frame not be found.

'`QTDV:`*n*`:`*value*'
: Create a new trace state variable, number *n*, with an initial value of *value*, which is a 64-bit signed integer. Both *n* and *value* are encoded as hexadecimal values. GDB has the option of not using this packet for initial values of zero; the target should simply create the trace state variables as they are mentioned in expressions.

'`QTFrame:`*n*'
: Select the *n*'th tracepoint frame from the buffer, and use the register and memory contents recorded there to answer subsequent request packets from GDB.

  A successful reply from the stub indicates that the stub has found the requested frame. The response is a series of parts, concatenated without separators, describing the frame we selected. Each part has one of the following forms:

  '`F` *f*'
  : The selected frame is number *n* in the trace frame buffer; *f* is a hexadecimal number. If *f* is '`-1`', then there was no frame matching the criteria in the request packet.

  '`T` *t*'
  : The selected trace frame records a hit of tracepoint number *t*; *t* is a hexadecimal number.

'`QTFrame:pc:`*addr*'
: Like '`QTFrame:`*n*', but select the first tracepoint frame after the currently selected frame whose PC is *addr*; *addr* is a hexadecimal number.

'`QTFrame:tdp:`*t*'
: Like '`QTFrame:`*n*', but select the first tracepoint frame after the currently selected frame that is a hit of tracepoint *t*; *t* is a hexadecimal number.

'`QTFrame:range:`*start*`:`*end*'
: Like '`QTFrame:`*n*', but select the first tracepoint frame after the currently selected frame whose PC is between *start* (inclusive) and *end* (inclusive); *start* and *end* are hexadecimal numbers.

'`QTFrame:outside:`*start*`:`*end*'
: Like '`QTFrame:range:`*start*`:`*end*', but select the first frame *outside* the given range of addresses (exclusive).

'`qTMinFTPILen`'
: This packet requests the minimum length of instruction at which a fast tracepoint (see Section 13.1 [Set Tracepoints], page 149) may be placed. For instance, on the 32-bit x86 architecture, it is possible to use a 4-byte jump, but it depends on the target system being able to create trampolines in the first 64K of

memory, which might or might not be possible for that system. So the reply to this packet will be 4 if it is able to arrange for that.

Replies:

'0' The minimum instruction length is currently unknown.

'*length*' The minimum instruction length is *length*, where *length* is greater or equal to 1. *length* is a hexadecimal number. A reply of 1 means that a fast tracepoint may be placed on any instruction regardless of size.

'E' An error has occurred.

'' An empty reply indicates that the request is not supported by the stub.

'QTStart' Begin the tracepoint experiment. Begin collecting data from tracepoint hits in the trace frame buffer. This packet supports the 'qRelocInsn' reply (see Section E.6 [Relocate instruction reply packet], page 535).

'QTStop' End the tracepoint experiment. Stop collecting trace frames.

'QTEnable:*n*:*addr*'
Enable tracepoint *n* at address *addr* in a started tracepoint experiment. If the tracepoint was previously disabled, then collection of data from it will resume.

'QTDisable:*n*:*addr*'
Disable tracepoint *n* at address *addr* in a started tracepoint experiment. No more data will be collected from the tracepoint unless 'QTEnable:*n*:*addr*' is subsequently issued.

'QTinit' Clear the table of tracepoints, and empty the trace frame buffer.

'QTro:*start1*,*end1*:*start2*,*end2*:...'
Establish the given ranges of memory as "transparent". The stub will answer requests for these ranges from memory's current contents, if they were not collected as part of the tracepoint hit.

GDB uses this to mark read-only regions of memory, like those containing program code. Since these areas never change, they should still have the same contents they did when the tracepoint was hit, so there's no reason for the stub to refuse to provide their contents.

'QTDisconnected:*value*'
Set the choice to what to do with the tracing run when GDB disconnects from the target. A *value* of 1 directs the target to continue the tracing run, while 0 tells the target to stop tracing if GDB is no longer in the picture.

'qTStatus'
Ask the stub if there is a trace experiment running right now.

The reply has the form:

'T*running*[;*field*]...'
running is a single digit 1 if the trace is presently running, or 0 if not. It is followed by semicolon-separated optional fields that an agent may use to report additional status.

If the trace is not running, the agent may report any of several explanations as one of the optional fields:

‘`tnotrun:0`’
No trace has been run yet.

‘`tstop[:`*text*`]:0`’
The trace was stopped by a user-originated stop command. The optional *text* field is a user-supplied string supplied as part of the stop command (for instance, an explanation of why the trace was stopped manually). It is hex-encoded.

‘`tfull:0`’ The trace stopped because the trace buffer filled up.

‘`tdisconnected:0`’
The trace stopped because GDB disconnected from the target.

‘`tpasscount:`*tpnum*’
The trace stopped because tracepoint *tpnum* exceeded its pass count.

‘`terror:`*text*`:`*tpnum*’
The trace stopped because tracepoint *tpnum* had an error. The string *text* is available to describe the nature of the error (for instance, a divide by zero in the condition expression). *text* is hex encoded.

‘`tunknown:0`’
The trace stopped for some other reason.

Additional optional fields supply statistical and other information. Although not required, they are extremely useful for users monitoring the progress of a trace run. If a trace has stopped, and these numbers are reported, they must reflect the state of the just-stopped trace.

‘`tframes:`*n*’
The number of trace frames in the buffer.

‘`tcreated:`*n*’
The total number of trace frames created during the run. This may be larger than the trace frame count, if the buffer is circular.

‘`tsize:`*n*’ The total size of the trace buffer, in bytes.

‘`tfree:`*n*’ The number of bytes still unused in the buffer.

‘`circular:`*n*’
The value of the circular trace buffer flag. `1` means that the trace buffer is circular and old trace frames will be discarded if necessary to make room, `0` means that the trace buffer is linear and may fill up.

‘`disconn:`*n*’
The value of the disconnected tracing flag. `1` means that tracing will continue after GDB disconnects, `0` means that the trace run will stop.

'qTP:*tp*:*addr*'
: Ask the stub for the current state of tracepoint number *tp* at address *addr*.

  Replies:

  'V*hits*:*usage*'
  : The tracepoint has been hit *hits* times so far during the trace run, and accounts for *usage* in the trace buffer. Note that `while-stepping` steps are not counted as separate hits, but the steps' space consumption is added into the usage number.

'qTV:*var*'
: Ask the stub for the value of the trace state variable number *var*.

  Replies:

  'V*value*'
  : The value of the variable is *value*. This will be the current value of the variable if the user is examining a running target, or a saved value if the variable was collected in the trace frame that the user is looking at. Note that multiple requests may result in different reply values, such as when requesting values while the program is running.

  'U'
  : The value of the variable is unknown. This would occur, for example, if the user is examining a trace frame in which the requested variable was not collected.

'qTfP'
'qTsP'
: These packets request data about tracepoints that are being used by the target. GDB sends `qTfP` to get the first piece of data, and multiple `qTsP` to get additional pieces. Replies to these packets generally take the form of the `QTDP` packets that define tracepoints. (FIXME add detailed syntax)

'qTfV'
'qTsV'
: These packets request data about trace state variables that are on the target. GDB sends `qTfV` to get the first vari of data, and multiple `qTsV` to get additional variables. Replies to these packets follow the syntax of the `QTDV` packets that define trace state variables.

'qTfSTM'
'qTsSTM'
: These packets request data about static tracepoint markers that exist in the target program. GDB sends `qTfSTM` to get the first piece of data, and multiple `qTsSTM` to get additional pieces. Replies to these packets take the following form:

  Reply:

  'm *address*:*id*:*extra*'
  : A single marker

  'm *address*:*id*:*extra*,*address*:*id*:*extra*...'
  : a comma-separated list of markers

  'l'
  : (lower case letter 'L') denotes end of list.

  'E *nn*'
  : An error occurred. *nn* are hex digits.

‘’ An empty reply indicates that the request is not supported by the stub.

address is encoded in hex. *id* and *extra* are strings encoded in hex.

In response to each query, the target will reply with a list of one or more markers, separated by commas. GDB will respond to each reply with a request for more markers (using the ‘`qs`’ form of the query), until the target responds with ‘`l`’ (lower-case ell, for *last*).

‘`qTSTMat:`*address*’
This packets requests data about static tracepoint markers in the target program at *address*. Replies to this packet follow the syntax of the ‘`qTfSTM`’ and `qTsSTM` packets that list static tracepoint markers.

‘`QTSave:`*filename*’
This packet directs the target to save trace data to the file name *filename* in the target's filesystem. *filename* is encoded as a hex string; the interpretation of the file name (relative vs absolute, wild cards, etc) is up to the target.

‘`qTBuffer:`*offset*`,`*len*’
Return up to *len* bytes of the current contents of trace buffer, starting at *offset*. The trace buffer is treated as if it were a contiguous collection of traceframes, as per the trace file format. The reply consists as many hex-encoded bytes as the target can deliver in a packet; it is not an error to return fewer than were asked for. A reply consisting of just `l` indicates that no bytes are available.

‘`QTBuffer:circular:`*value*’
This packet directs the target to use a circular trace buffer if *value* is 1, or a linear buffer if the value is 0.

‘`QTBuffer:size:`*size*’
This packet directs the target to make the trace buffer be of size *size* if possible. A value of `-1` tells the target to use whatever size it prefers.

‘`QTNotes:`[*type*`:`*text*][`;`*type*`:`*text*]`...`’
This packet adds optional textual notes to the trace run. Allowable types include `user`, `notes`, and `tstop`, the *text* fields are arbitrary strings, hex-encoded.

E.6.1 Relocate instruction reply packet

When installing fast tracepoints in memory, the target may need to relocate the instruction currently at the tracepoint address to a different address in memory. For most instructions, a simple copy is enough, but, for example, call instructions that implicitly push the return address on the stack, and relative branches or other PC-relative instructions require offset adjustment, so that the effect of executing the instruction at a different address is the same as if it had executed in the original location.

In response to several of the tracepoint packets, the target may also respond with a number of intermediate ‘`qRelocInsn`’ request packets before the final result packet, to have GDB handle this relocation operation. If a packet supports this mechanism, its documentation will explicitly say so. See for example the above descriptions for the ‘`QTStart`’ and ‘`QTDP`’ packets. The format of the request is:

‘`qRelocInsn:`*`from`*`;`*`to`*’
: This requests GDB to copy instruction at address *from* to address *to*, possibly adjusted so that executing the instruction at *to* has the same effect as executing it at *from*. GDB writes the adjusted instruction to target memory starting at *to*.

Replies:

‘`qRelocInsn:`*`adjusted_size`*’
: Informs the stub the relocation is complete. *adjusted_size* is the length in bytes of resulting relocated instruction sequence.

‘`E` *`NN`*’
: A badly formed request was detected, or an error was encountered while relocating the instruction.

E.7 Host I/O Packets

The *Host I/O* packets allow GDB to perform I/O operations on the far side of a remote link. For example, Host I/O is used to upload and download files to a remote target with its own filesystem. Host I/O uses the same constant values and data structure layout as the target-initiated File-I/O protocol. However, the Host I/O packets are structured differently. The target-initiated protocol relies on target memory to store parameters and buffers. Host I/O requests are initiated by GDB, and the target's memory is not involved. See Section E.13 [File-I/O Remote Protocol Extension], page 547, for more details on the target-initiated protocol.

The Host I/O request packets all encode a single operation along with its arguments. They have this format:

‘`vFile:`*`operation`*`:` *`parameter`*`...`’
: *operation* is the name of the particular request; the target should compare the entire packet name up to the second colon when checking for a supported operation. The format of *parameter* depends on the operation. Numbers are always passed in hexadecimal. Negative numbers have an explicit minus sign (i.e. two's complement is not used). Strings (e.g. filenames) are encoded as a series of hexadecimal bytes. The last argument to a system call may be a buffer of escaped binary data (see [Binary Data], page 503).

The valid responses to Host I/O packets are:

‘`F` *`result`* `[,` *`errno`*`] [;` *`attachment`*`]`’
: *result* is the integer value returned by this operation, usually non-negative for success and -1 for errors. If an error has occured, *errno* will be included in the result. *errno* will have a value defined by the File-I/O protocol (see [Errno Values], page 558). For operations which return data, *attachment* supplies the data as a binary buffer. Binary buffers in response packets are escaped in the normal way (see [Binary Data], page 503). See the individual packet documentation for the interpretation of *result* and *attachment*.

‘’
: An empty response indicates that this operation is not recognized.

These are the supported Host I/O operations:

‘`vFile:open: pathname, flags, mode`’
: Open a file at *pathname* and return a file descriptor for it, or return -1 if an error occurs. *pathname* is a string, *flags* is an integer indicating a mask of open flags (see [Open Flags], page 558), and *mode* is an integer indicating a mask of mode bits to use if the file is created (see [mode_t Values], page 558). See [open], page 550, for details of the open flags and mode values.

‘`vFile:close: fd`’
: Close the open file corresponding to *fd* and return 0, or -1 if an error occurs.

‘`vFile:pread: fd, count, offset`’
: Read data from the open file corresponding to *fd*. Up to *count* bytes will be read from the file, starting at *offset* relative to the start of the file. The target may read fewer bytes; common reasons include packet size limits and an end-of-file condition. The number of bytes read is returned. Zero should only be returned for a successful read at the end of the file, or if *count* was zero.

  The data read should be returned as a binary attachment on success. If zero bytes were read, the response should include an empty binary attachment (i.e. a trailing semicolon). The return value is the number of target bytes read; the binary attachment may be longer if some characters were escaped.

‘`vFile:pwrite: fd, offset, data`’
: Write *data* (a binary buffer) to the open file corresponding to *fd*. Start the write at *offset* from the start of the file. Unlike many `write` system calls, there is no separate *count* argument; the length of *data* in the packet is used. ‘`vFile:write`’ returns the number of bytes written, which may be shorter than the length of *data*, or -1 if an error occurred.

‘`vFile:unlink: pathname`’
: Delete the file at *pathname* on the target. Return 0, or -1 if an error occurs. *pathname* is a string.

‘`vFile:readlink: filename`’
: Read value of symbolic link *filename* on the target. Return the number of bytes read, or -1 if an error occurs.

  The data read should be returned as a binary attachment on success. If zero bytes were read, the response should include an empty binary attachment (i.e. a trailing semicolon). The return value is the number of target bytes read; the binary attachment may be longer if some characters were escaped.

E.8 Interrupts

When a program on the remote target is running, GDB may attempt to interrupt it by sending a ‘`Ctrl-C`’, `BREAK` or a `BREAK` followed by `g`, control of which is specified via GDB’s ‘`interrupt-sequence`’.

The precise meaning of `BREAK` is defined by the transport mechanism and may, in fact, be undefined. GDB does not currently define a `BREAK` mechanism for any of the network interfaces except for TCP, in which case GDB sends the `telnet` BREAK sequence.

‘`Ctrl-C`’, on the other hand, is defined and implemented for all transport mechanisms. It is represented by sending the single byte `0x03` without any of the usual packet overhead

described in the Overview section (see Section E.1 [Overview], page 503). When a `0x03` byte is transmitted as part of a packet, it is considered to be packet data and does *not* represent an interrupt. E.g., an '`X`' packet (see [X packet], page 512), used for binary downloads, may include an unescaped `0x03` as part of its packet.

`BREAK` followed by `g` is also known as Magic SysRq g. When Linux kernel receives this sequence from serial port, it stops execution and connects to gdb.

Stubs are not required to recognize these interrupt mechanisms and the precise meaning associated with receipt of the interrupt is implementation defined. If the target supports debugging of multiple threads and/or processes, it should attempt to interrupt all currently-executing threads and processes. If the stub is successful at interrupting the running program, it should send one of the stop reply packets (see Section E.3 [Stop Reply Packets], page 514) to GDB as a result of successfully stopping the program in all-stop mode, and a stop reply for each stopped thread in non-stop mode. Interrupts received while the program is stopped are discarded.

E.9 Notification Packets

The GDB remote serial protocol includes *notifications*, packets that require no acknowledgment. Both the GDB and the stub may send notifications (although the only notifications defined at present are sent by the stub). Notifications carry information without incurring the round-trip latency of an acknowledgment, and so are useful for low-impact communications where occasional packet loss is not a problem.

A notification packet has the form '`% data # checksum`', where *data* is the content of the notification, and *checksum* is a checksum of *data*, computed and formatted as for ordinary GDB packets. A notification's *data* never contains '`$`', '`%`' or '`#`' characters. Upon receiving a notification, the recipient sends no '`+`' or '`-`' to acknowledge the notification's receipt or to report its corruption.

Every notification's *data* begins with a name, which contains no colon characters, followed by a colon character.

Recipients should silently ignore corrupted notifications and notifications they do not understand. Recipients should restart timeout periods on receipt of a well-formed notification, whether or not they understand it.

Senders should only send the notifications described here when this protocol description specifies that they are permitted. In the future, we may extend the protocol to permit existing notifications in new contexts; this rule helps older senders avoid confusing newer recipients.

(Older versions of GDB ignore bytes received until they see the '`$`' byte that begins an ordinary packet, so new stubs may transmit notifications without fear of confusing older clients. There are no notifications defined for GDB to send at the moment, but we assume that most older stubs would ignore them, as well.)

Each notification is comprised of three parts:

'*name*`:`*event*'
: The notification packet is sent by the side that initiates the exchange (currently, only the stub does that), with *event* carrying the specific information about the notification. *name* is the name of the notification.

‘*ack*’ The acknowledge sent by the other side, usually GDB, to acknowledge the exchange and request the event.

The purpose of an asynchronous notification mechanism is to report to GDB that something interesting happened in the remote stub.

The remote stub may send notification *name*:*event* at any time, but GDB acknowledges the notification when appropriate. The notification event is pending before GDB acknowledges. Only one notification at a time may be pending; if additional events occur before GDB has acknowledged the previous notification, they must be queued by the stub for later synchronous transmission in response to *ack* packets from GDB. Because the notification mechanism is unreliable, the stub is permitted to resend a notification if it believes GDB may not have received it.

Specifically, notifications may appear when GDB is not otherwise reading input from the stub, or when GDB is expecting to read a normal synchronous response or a ‘+’/‘-’ acknowledgment to a packet it has sent. Notification packets are distinct from any other communication from the stub so there is no ambiguity.

After receiving a notification, GDB shall acknowledge it by sending a *ack* packet as a regular, synchronous request to the stub. Such acknowledgment is not required to happen immediately, as GDB is permitted to send other, unrelated packets to the stub first, which the stub should process normally.

Upon receiving a *ack* packet, if the stub has other queued events to report to GDB, it shall respond by sending a normal *event*. GDB shall then send another *ack* packet to solicit further responses; again, it is permitted to send other, unrelated packets as well which the stub should process normally.

If the stub receives a *ack* packet and there are no additional *event* to report, the stub shall return an ‘OK’ response. At this point, GDB has finished processing a notification and the stub has completed sending any queued events. GDB won't accept any new notifications until the final ‘OK’ is received . If further notification events occur, the stub shall send a new notification, GDB shall accept the notification, and the process shall be repeated.

The process of asynchronous notification can be illustrated by the following example:

```
<- %%Stop:T0505:98e7ffbf;04:4ce6ffbf;08:b1b6e54c;thread:p7526.7526;core:0;
...
-> vStopped
<- T0505:68f37db7;04:40f37db7;08:63850408;thread:p7526.7528;core:0;
-> vStopped
<- T0505:68e3fdb6;04:40e3fdb6;08:63850408;thread:p7526.7529;core:0;
-> vStopped
<- OK
```

The following notifications are defined:

Notification	Ack	Event	Description

Stop	vStopped *reply*.	The *reply* has the form of a stop reply, as described in Section E.3 [Stop Reply Packets], page 514. Refer to Section E.10 [Remote Non-Stop], page 546, for information on how these notifications are acknowledged by GDB.	Report an asynchronous stop event in non-stop mode.

E.10 Remote Protocol Support for Non-Stop Mode

GDB's remote protocol supports non-stop debugging of multi-threaded programs, as described in Section 5.5.2 [Non-Stop Mode], page 74. If the stub supports non-stop mode, it should report that to GDB by including '`QNonStop+`' in its '`qSupported`' response (see [qSupported], page 522).

GDB typically sends a '`QNonStop`' packet only when establishing a new connection with the stub. Entering non-stop mode does not alter the state of any currently-running threads, but targets must stop all threads in any already-attached processes when entering all-stop mode. GDB uses the '`?`' packet as necessary to probe the target state after a mode change.

In non-stop mode, when an attached process encounters an event that would otherwise be reported with a stop reply, it uses the asynchronous notification mechanism (see Section E.9 [Notification Packets], page 544) to inform GDB. In contrast to all-stop mode, where all threads in all processes are stopped when a stop reply is sent, in non-stop mode only the thread reporting the stop event is stopped. That is, when reporting a '`S`' or '`T`' response to indicate completion of a step operation, hitting a breakpoint, or a fault, only the affected thread is stopped; any other still-running threads continue to run. When reporting a '`W`' or '`X`' response, all running threads belonging to other attached processes continue to run.

In non-stop mode, the target shall respond to the '`?`' packet as follows. First, any incomplete stop reply notification/'`vStopped`' sequence in progress is abandoned. The target must begin a new sequence reporting stop events for all stopped threads, whether or not it has previously reported those events to GDB. The first stop reply is sent as a synchronous reply to the '`?`' packet, and subsequent stop replies are sent as responses to '`vStopped`' packets using the mechanism described above. The target must not send asynchronous stop reply notifications until the sequence is complete. If all threads are running when the target receives the '`?`' packet, or if the target is not attached to any process, it shall respond '`OK`'.

E.11 Packet Acknowledgment

By default, when either the host or the target machine receives a packet, the first response expected is an acknowledgment: either '`+`' (to indicate the package was received correctly) or '`-`' (to request retransmission). This mechanism allows the GDB remote protocol to operate over unreliable transport mechanisms, such as a serial line.

In cases where the transport mechanism is itself reliable (such as a pipe or TCP connection), the '`+`'/'`-`' acknowledgments are redundant. It may be desirable to disable them in that case to reduce communication overhead, or for other reasons. This can be accomplished by means of the '`QStartNoAckMode`' packet; see [QStartNoAckMode], page 522.

When in no-acknowledgment mode, neither the stub nor GDB shall send or expect '+'/'-' protocol acknowledgments. The packet and response format still includes the normal checksum, as described in Section E.1 [Overview], page 503, but the checksum may be ignored by the receiver.

If the stub supports 'QStartNoAckMode' and prefers to operate in no-acknowledgment mode, it should report that to GDB by including 'QStartNoAckMode+' in its response to 'qSupported'; see [qSupported], page 522. If GDB also supports 'QStartNoAckMode' and it has not been disabled via the `set remote noack-packet off` command (see Section 20.4 [Remote Configuration], page 242), GDB may then send a 'QStartNoAckMode' packet to the stub. Only then may the stub actually turn off packet acknowledgments. GDB sends a final '+' acknowledgment of the stub's 'OK' response, which can be safely ignored by the stub.

Note that `set remote noack-packet` command only affects negotiation between GDB and the stub when subsequent connections are made; it does not affect the protocol acknowledgment state for any current connection. Since '+'/'-' acknowledgments are enabled by default when a new connection is established, there is also no protocol request to re-enable the acknowledgments for the current connection, once disabled.

E.12 Examples

Example sequence of a target being re-started. Notice how the restart does not get any direct output:

```
-> R00
<- +
target restarts
-> ?
<- +
<- T001:1234123412341234
-> +
```

Example sequence of a target being stepped by a single instruction:

```
-> G1445...
<- +
-> s
<- +
time passes
<- T001:1234123412341234
-> +
-> g
<- +
<- 1455...
-> +
```

E.13 File-I/O Remote Protocol Extension

E.13.1 File-I/O Overview

The *File I/O remote protocol extension* (short: File-I/O) allows the target to use the host's file system and console I/O to perform various system calls. System calls on the target system are translated into a remote protocol packet to the host system, which then performs the needed actions and returns a response packet to the target system. This simulates file system operations even on targets that lack file systems.

The protocol is defined to be independent of both the host and target systems. It uses its own internal representation of datatypes and values. Both GDB and the target's GDB stub are responsible for translating the system-dependent value representations into the internal protocol representations when data is transmitted.

The communication is synchronous. A system call is possible only when GDB is waiting for a response from the '`C`', '`c`', '`S`' or '`s`' packets. While GDB handles the request for a system call, the target is stopped to allow deterministic access to the target's memory. Therefore File-I/O is not interruptible by target signals. On the other hand, it is possible to interrupt File-I/O by a user interrupt ('`Ctrl-C`') within GDB.

The target's request to perform a host system call does not finish the latest '`C`', '`c`', '`S`' or '`s`' action. That means, after finishing the system call, the target returns to continuing the previous activity (continue, step). No additional continue or step request from GDB is required.

```
(gdb) continue
  <- target requests 'system call X'
  target is stopped, GDB executes system call
  -> GDB returns result
  ... target continues, GDB returns to wait for the target
  <- target hits breakpoint and sends a Txx packet
```

The protocol only supports I/O on the console and to regular files on the host file system. Character or block special devices, pipes, named pipes, sockets or any other communication method on the host system are not supported by this protocol.

File I/O is not supported in non-stop mode.

E.13.2 Protocol Basics

The File-I/O protocol uses the `F` packet as the request as well as reply packet. Since a File-I/O system call can only occur when GDB is waiting for a response from the continuing or stepping target, the File-I/O request is a reply that GDB has to expect as a result of a previous '`C`', '`c`', '`S`' or '`s`' packet. This `F` packet contains all information needed to allow GDB to call the appropriate host system call:

- A unique identifier for the requested system call.
- All parameters to the system call. Pointers are given as addresses in the target memory address space. Pointers to strings are given as pointer/length pair. Numerical values are given as they are. Numerical control flags are given in a protocol-specific representation.

At this point, GDB has to perform the following actions.

- If the parameters include pointer values to data needed as input to a system call, GDB requests this data from the target with a standard `m` packet request. This additional communication has to be expected by the target implementation and is handled as any other `m` packet.
- GDB translates all value from protocol representation to host representation as needed. Datatypes are coerced into the host types.
- GDB calls the system call.
- It then coerces datatypes back to protocol representation.
- If the system call is expected to return data in buffer space specified by pointer parameters to the call, the data is transmitted to the target using a `M` or `X` packet. This

packet has to be expected by the target implementation and is handled as any other `M` or `X` packet.

Eventually GDB replies with another `F` packet which contains all necessary information for the target to continue. This at least contains

- Return value.
- `errno`, if has been changed by the system call.
- "Ctrl-C" flag.

After having done the needed type and value coercion, the target continues the latest continue or step action.

E.13.3 The `F` Request Packet

The `F` request packet has the following format:

'`Fcall-id,parameter...`'

call-id is the identifier to indicate the host system call to be called. This is just the name of the function.

parameter... are the parameters to the system call. Parameters are hexadecimal integer values, either the actual values in case of scalar datatypes, pointers to target buffer space in case of compound datatypes and unspecified memory areas, or pointer/length pairs in case of string parameters. These are appended to the *call-id* as a comma-delimited list. All values are transmitted in ASCII string representation, pointer/length pairs separated by a slash.

E.13.4 The `F` Reply Packet

The `F` reply packet has the following format:

'`Fretcode,errno,Ctrl-C flag;call-specific attachment`'

retcode is the return code of the system call as hexadecimal value.

errno is the `errno` set by the call, in protocol-specific representation. This parameter can be omitted if the call was successful.

Ctrl-C flag is only sent if the user requested a break. In this case, *errno* must be sent as well, even if the call was successful. The *Ctrl-C flag* itself consists of the character '`C`':

```
F0,0,C
```

or, if the call was interrupted before the host call has been performed:

```
F-1,4,C
```

assuming 4 is the protocol-specific representation of `EINTR`.

E.13.5 The '`Ctrl-C`' Message

If the '`Ctrl-C`' flag is set in the GDB reply packet (see Section E.13.4 [The F Reply Packet], page 549), the target should behave as if it had gotten a break message. The meaning for the target is "system call interrupted by `SIGINT`". Consequentially, the target should actually stop (as with a break message) and return to GDB with a `T02` packet.

It's important for the target to know in which state the system call was interrupted. There are two possible cases:

- The system call hasn't been performed on the host yet.
- The system call on the host has been finished.

These two states can be distinguished by the target by the value of the returned `errno`. If it's the protocol representation of `EINTR`, the system call hasn't been performed. This is equivalent to the `EINTR` handling on POSIX systems. In any other case, the target may presume that the system call has been finished — successfully or not — and should behave as if the break message arrived right after the system call.

GDB must behave reliably. If the system call has not been called yet, GDB may send the `F` reply immediately, setting `EINTR` as `errno` in the packet. If the system call on the host has been finished before the user requests a break, the full action must be finished by GDB. This requires sending `M` or `X` packets as necessary. The `F` packet may only be sent when either nothing has happened or the full action has been completed.

E.13.6 Console I/O

By default and if not explicitly closed by the target system, the file descriptors 0, 1 and 2 are connected to the GDB console. Output on the GDB console is handled as any other file output operation (`write(1, ...)` or `write(2, ...)`). Console input is handled by GDB so that after the target read request from file descriptor 0 all following typing is buffered until either one of the following conditions is met:

- The user types *`Ctrl-c`*. The behaviour is as explained above, and the `read` system call is treated as finished.
- The user presses RET. This is treated as end of input with a trailing newline.
- The user types *`Ctrl-d`*. This is treated as end of input. No trailing character (neither newline nor '`Ctrl-D`') is appended to the input.

If the user has typed more characters than fit in the buffer given to the `read` call, the trailing characters are buffered in GDB until either another `read(0, ...)` is requested by the target, or debugging is stopped at the user's request.

E.13.7 List of Supported Calls

open

Synopsis:

```
int open(const char *pathname, int flags);
int open(const char *pathname, int flags, mode_t mode);
```

Request: '`Fopen,`*`pathptr/len`*`,`*`flags`*`,`*`mode`*'

flags is the bitwise `OR` of the following values:

`O_CREAT` If the file does not exist it will be created. The host rules apply as far as file ownership and time stamps are concerned.

`O_EXCL` When used with `O_CREAT`, if the file already exists it is an error and open() fails.

`O_TRUNC` If the file already exists and the open mode allows writing (`O_RDWR` or `O_WRONLY` is given) it will be truncated to zero length.

`O_APPEND` The file is opened in append mode.

`O_RDONLY` The file is opened for reading only.

`O_WRONLY` The file is opened for writing only.

`O_RDWR` The file is opened for reading and writing.

Other bits are silently ignored.

mode is the bitwise `OR` of the following values:

`S_IRUSR` User has read permission.

`S_IWUSR` User has write permission.

`S_IRGRP` Group has read permission.

`S_IWGRP` Group has write permission.

`S_IROTH` Others have read permission.

`S_IWOTH` Others have write permission.

Other bits are silently ignored.

Return value:

`open` returns the new file descriptor or -1 if an error occurred.

Errors:

`EEXIST` *pathname* already exists and `O_CREAT` and `O_EXCL` were used.

`EISDIR` *pathname* refers to a directory.

`EACCES` The requested access is not allowed.

`ENAMETOOLONG`
pathname was too long.

`ENOENT` A directory component in *pathname* does not exist.

`ENODEV` *pathname* refers to a device, pipe, named pipe or socket.

`EROFS` *pathname* refers to a file on a read-only filesystem and write access was requested.

`EFAULT` *pathname* is an invalid pointer value.

`ENOSPC` No space on device to create the file.

`EMFILE` The process already has the maximum number of files open.

`ENFILE` The limit on the total number of files open on the system has been reached.

`EINTR` The call was interrupted by the user.

close

Synopsis:

```
int close(int fd);
```

Request: '`Fclose,`*`fd`*'

Return value:

`close` returns zero on success, or -1 if an error occurred.

Errors:

`EBADF` *fd* isn't a valid open file descriptor.

`EINTR` The call was interrupted by the user.

read

Synopsis:

```
int read(int fd, void *buf, unsigned int count);
```

Request: '`Fread,`*`fd`*`,`*`bufptr`*`,`*`count`*'

Return value:

On success, the number of bytes read is returned. Zero indicates end of file. If count is zero, read returns zero as well. On error, -1 is returned.

Errors:

`EBADF` *fd* is not a valid file descriptor or is not open for reading.

`EFAULT` *bufptr* is an invalid pointer value.

`EINTR` The call was interrupted by the user.

write

Synopsis:

```
int write(int fd, const void *buf, unsigned int count);
```

Request: '`Fwrite,`*`fd`*`,`*`bufptr`*`,`*`count`*'

Return value:

On success, the number of bytes written are returned. Zero indicates nothing was written. On error, -1 is returned.

Errors:

`EBADF` *fd* is not a valid file descriptor or is not open for writing.

`EFAULT` *bufptr* is an invalid pointer value.

`EFBIG` An attempt was made to write a file that exceeds the host-specific maximum file size allowed.

`ENOSPC` No space on device to write the data.

`EINTR` The call was interrupted by the user.

lseek

Synopsis:

```
long lseek (int fd, long offset, int flag);
```

Request: '`Flseek,`*`fd`*`,`*`offset`*`,`*`flag`*'

flag is one of:

`SEEK_SET` The offset is set to *offset* bytes.

`SEEK_CUR` The offset is set to its current location plus *offset* bytes.

`SEEK_END` The offset is set to the size of the file plus *offset* bytes.

Return value:

On success, the resulting unsigned offset in bytes from the beginning of the file is returned. Otherwise, a value of -1 is returned.

Errors:

`EBADF` *fd* is not a valid open file descriptor.

`ESPIPE` *fd* is associated with the GDB console.

`EINVAL` *flag* is not a proper value.

`EINTR` The call was interrupted by the user.

rename

Synopsis:

```
int rename(const char *oldpath, const char *newpath);
```

Request: '`Frename,`*`oldpathptr/len`*`,`*`newpathptr/len`*'

Return value:

On success, zero is returned. On error, -1 is returned.

Errors:

`EISDIR` *newpath* is an existing directory, but *oldpath* is not a directory.

`EEXIST` *newpath* is a non-empty directory.

`EBUSY` *oldpath* or *newpath* is a directory that is in use by some process.

`EINVAL` An attempt was made to make a directory a subdirectory of itself.

`ENOTDIR` A component used as a directory in *oldpath* or new path is not a directory. Or *oldpath* is a directory and *newpath* exists but is not a directory.

`EFAULT` *oldpathptr* or *newpathptr* are invalid pointer values.

`EACCES` No access to the file or the path of the file.

`ENAMETOOLONG`
oldpath or *newpath* was too long.

`ENOENT` A directory component in *oldpath* or *newpath* does not exist.

`EROFS` The file is on a read-only filesystem.

`ENOSPC` The device containing the file has no room for the new directory entry.

`EINTR` The call was interrupted by the user.

unlink

Synopsis:

```
int unlink(const char *pathname);
```

Request: '`Funlink,`*`pathnameptr/len`*'

Return value:
On success, zero is returned. On error, -1 is returned.

Errors:

`EACCES` No access to the file or the path of the file.

`EPERM` The system does not allow unlinking of directories.

`EBUSY` The file *pathname* cannot be unlinked because it's being used by another process.

`EFAULT` *pathnameptr* is an invalid pointer value.

`ENAMETOOLONG`
pathname was too long.

`ENOENT` A directory component in *pathname* does not exist.

`ENOTDIR` A component of the path is not a directory.

`EROFS` The file is on a read-only filesystem.

`EINTR` The call was interrupted by the user.

stat/fstat

Synopsis:

```
int stat(const char *pathname, struct stat *buf);
int fstat(int fd, struct stat *buf);
```

Request: '`Fstat,`*`pathnameptr/len`*`,`*`bufptr`*'
'`Ffstat,`*`fd`*`,`*`bufptr`*'

Return value:
On success, zero is returned. On error, -1 is returned.

Errors:

`EBADF` *fd* is not a valid open file.

`ENOENT` A directory component in *pathname* does not exist or the path is an empty string.

`ENOTDIR` A component of the path is not a directory.

`EFAULT` *pathnameptr* is an invalid pointer value.

`EACCES` No access to the file or the path of the file.

`ENAMETOOLONG`
pathname was too long.

`EINTR` The call was interrupted by the user.

gettimeofday

Synopsis:

```
int gettimeofday(struct timeval *tv, void *tz);
```

Request: '`Fgettimeofday,`*`tvptr`*`,`*`tzptr`*'

Return value:
On success, 0 is returned, -1 otherwise.

Errors:

`EINVAL` *tz* is a non-NULL pointer.

`EFAULT` *tvptr* and/or *tzptr* is an invalid pointer value.

isatty

Synopsis:

```
int isatty(int fd);
```

Request: '`Fisatty,`*`fd`*'

Return value:
Returns 1 if *fd* refers to the GDB console, 0 otherwise.

Errors:

`EINTR` The call was interrupted by the user.

Note that the `isatty` call is treated as a special case: it returns 1 to the target if the file descriptor is attached to the GDB console, 0 otherwise. Implementing through system calls would require implementing `ioctl` and would be more complex than needed.

system

Synopsis:

```
int system(const char *command);
```

Request: '`Fsystem,`*`commandptr/len`*'

Return value:
If *len* is zero, the return value indicates whether a shell is available. A zero return value indicates a shell is not available. For non-zero *len*, the value returned is -1 on error and the return status of the command otherwise. Only the exit status of the command is returned, which is extracted from the host's `system` return value by calling `WEXITSTATUS(retval)`. In case '`/bin/sh`' could not be executed, 127 is returned.

Errors:

`EINTR` The call was interrupted by the user.

GDB takes over the full task of calling the necessary host calls to perform the `system` call. The return value of `system` on the host is simplified before it's returned to the target. Any termination signal information from the child process is discarded, and the return value consists entirely of the exit status of the called command.

Due to security concerns, the `system` call is by default refused by GDB. The user has to allow this call explicitly with the `set remote system-call-allowed 1` command.

`set remote system-call-allowed`
: Control whether to allow the `system` calls in the File I/O protocol for the remote target. The default is zero (disabled).

`show remote system-call-allowed`
: Show whether the `system` calls are allowed in the File I/O protocol.

E.13.8 Protocol-specific Representation of Datatypes

Integral Datatypes

The integral datatypes used in the system calls are `int`, `unsigned int`, `long`, `unsigned long`, `mode_t`, and `time_t`.

`int`, `unsigned int`, `mode_t` and `time_t` are implemented as 32 bit values in this protocol.

`long` and `unsigned long` are implemented as 64 bit types.

See [Limits], page 559, for corresponding MIN and MAX values (similar to those in '`limits.h`') to allow range checking on host and target.

`time_t` datatypes are defined as seconds since the Epoch.

All integral datatypes transferred as part of a memory read or write of a structured datatype e.g. a `struct stat` have to be given in big endian byte order.

Pointer Values

Pointers to target data are transmitted as they are. An exception is made for pointers to buffers for which the length isn't transmitted as part of the function call, namely strings. Strings are transmitted as a pointer/length pair, both as hex values, e.g.

```
1aaf/12
```

which is a pointer to data of length 18 bytes at position 0x1aaf. The length is defined as the full string length in bytes, including the trailing null byte. For example, the string `"hello world"` at address 0x123456 is transmitted as

```
123456/d
```

Memory Transfer

Structured data which is transferred using a memory read or write (for example, a `struct stat`) is expected to be in a protocol-specific format with all scalar multibyte datatypes being big endian. Translation to this representation needs to be done both by the target before the `F` packet is sent, and by GDB before it transfers memory to the target. Transferred pointers to structured data should point to the already-coerced data at any time.

struct stat

The buffer of type `struct stat` used by the target and GDB is defined as follows:

```
struct stat {
    unsigned int  st_dev;      /* device */
    unsigned int  st_ino;      /* inode */
    mode_t        st_mode;     /* protection */
    unsigned int  st_nlink;    /* number of hard links */
    unsigned int  st_uid;      /* user ID of owner */
    unsigned int  st_gid;      /* group ID of owner */
    unsigned int  st_rdev;     /* device type (if inode device) */
    unsigned long st_size;     /* total size, in bytes */
    unsigned long st_blksize;  /* blocksize for filesystem I/O */
    unsigned long st_blocks;   /* number of blocks allocated */
    time_t        st_atime;    /* time of last access */
    time_t        st_mtime;    /* time of last modification */
    time_t        st_ctime;    /* time of last change */
};
```

The integral datatypes conform to the definitions given in the appropriate section (see [Integral Datatypes], page 556, for details) so this structure is of size 64 bytes.

The values of several fields have a restricted meaning and/or range of values.

`st_dev` A value of 0 represents a file, 1 the console.

`st_ino` No valid meaning for the target. Transmitted unchanged.

`st_mode` Valid mode bits are described in Section E.13.9 [Constants], page 558. Any other bits have currently no meaning for the target.

`st_uid`
`st_gid`
`st_rdev` No valid meaning for the target. Transmitted unchanged.

`st_atime`
`st_mtime`
`st_ctime` These values have a host and file system dependent accuracy. Especially on Windows hosts, the file system may not support exact timing values.

The target gets a `struct stat` of the above representation and is responsible for coercing it to the target representation before continuing.

Note that due to size differences between the host, target, and protocol representations of `struct stat` members, these members could eventually get truncated on the target.

struct timeval

The buffer of type `struct timeval` used by the File-I/O protocol is defined as follows:

```
struct timeval {
    time_t tv_sec;  /* second */
    long   tv_usec; /* microsecond */
};
```

The integral datatypes conform to the definitions given in the appropriate section (see [Integral Datatypes], page 556, for details) so this structure is of size 8 bytes.

E.13.9 Constants

The following values are used for the constants inside of the protocol. GDB and target are responsible for translating these values before and after the call as needed.

Open Flags

All values are given in hexadecimal representation.

```
O_RDONLY        0x0
O_WRONLY        0x1
O_RDWR          0x2
O_APPEND        0x8
O_CREAT       0x200
O_TRUNC       0x400
O_EXCL        0x800
```

mode_t Values

All values are given in octal representation.

```
S_IFREG       0100000
S_IFDIR        040000
S_IRUSR          0400
S_IWUSR          0200
S_IXUSR          0100
S_IRGRP           040
S_IWGRP           020
S_IXGRP           010
S_IROTH            04
S_IWOTH            02
S_IXOTH            01
```

Errno Values

All values are given in decimal representation.

```
EPERM           1
ENOENT          2
EINTR           4
EBADF           9
EACCES         13
EFAULT         14
EBUSY          16
EEXIST         17
ENODEV         19
ENOTDIR        20
EISDIR         21
EINVAL         22
ENFILE         23
EMFILE         24
EFBIG          27
ENOSPC         28
ESPIPE         29
EROFS          30
ENAMETOOLONG   91
EUNKNOWN     9999
```

`EUNKNOWN` is used as a fallback error value if a host system returns any error value not in the list of supported error numbers.

Lseek Flags

```
SEEK_SET      0
SEEK_CUR      1
SEEK_END      2
```

Limits

All values are given in decimal representation.

```
INT_MIN       -2147483648
INT_MAX        2147483647
UINT_MAX       4294967295
LONG_MIN      -9223372036854775808
LONG_MAX       9223372036854775807
ULONG_MAX      18446744073709551615
```

E.13.10 File-I/O Examples

Example sequence of a write call, file descriptor 3, buffer is at target address 0x1234, 6 bytes should be written:

```
<- Fwrite,3,1234,6
request memory read from target
-> m1234,6
<- XXXXXX
return "6 bytes written"
-> F6
```

Example sequence of a read call, file descriptor 3, buffer is at target address 0x1234, 6 bytes should be read:

```
<- Fread,3,1234,6
request memory write to target
-> X1234,6:XXXXXX
return "6 bytes read"
-> F6
```

Example sequence of a read call, call fails on the host due to invalid file descriptor (EBADF):

```
<- Fread,3,1234,6
-> F-1,9
```

Example sequence of a read call, user presses *Ctrl-c* before syscall on host is called:

```
<- Fread,3,1234,6
-> F-1,4,C
<- T02
```

Example sequence of a read call, user presses *Ctrl-c* after syscall on host is called:

```
<- Fread,3,1234,6
-> X1234,6:XXXXXX
<- T02
```

E.14 Library List Format

On some platforms, a dynamic loader (e.g. 'ld.so') runs in the same process as your application to manage libraries. In this case, GDB can use the loader's symbol table and normal memory operations to maintain a list of shared libraries. On other platforms, the operating system manages loaded libraries. GDB can not retrieve the list of currently loaded libraries

through memory operations, so it uses the '`qXfer:libraries:read`' packet (see [qXfer library list read], page 530) instead. The remote stub queries the target's operating system and reports which libraries are loaded.

The '`qXfer:libraries:read`' packet returns an XML document which lists loaded libraries and their offsets. Each library has an associated name and one or more segment or section base addresses, which report where the library was loaded in memory.

For the common case of libraries that are fully linked binaries, the library should have a list of segments. If the target supports dynamic linking of a relocatable object file, its library XML element should instead include a list of allocated sections. The segment or section bases are start addresses, not relocation offsets; they do not depend on the library's link-time base addresses.

GDB must be linked with the Expat library to support XML library lists. See [Expat], page 489.

A simple memory map, with one loaded library relocated by a single offset, looks like this:

```
<library-list>
  <library name="/lib/libc.so.6">
    <segment address="0x10000000"/>
  </library>
</library-list>
```

Another simple memory map, with one loaded library with three allocated sections (.text, .data, .bss), looks like this:

```
<library-list>
  <library name="sharedlib.o">
    <section address="0x10000000"/>
    <section address="0x20000000"/>
    <section address="0x30000000"/>
  </library>
</library-list>
```

The format of a library list is described by this DTD:

```
<!-- library-list: Root element with versioning -->
<!ELEMENT library-list  (library)*>
<!ATTLIST library-list  version CDATA   #FIXED  "1.0">
<!ELEMENT library       (segment*, section*)>
<!ATTLIST library       name    CDATA   #REQUIRED>
<!ELEMENT segment       EMPTY>
<!ATTLIST segment       address CDATA   #REQUIRED>
<!ELEMENT section       EMPTY>
<!ATTLIST section       address CDATA   #REQUIRED>
```

In addition, segments and section descriptors cannot be mixed within a single library element, and you must supply at least one segment or section for each library.

E.15 Library List Format for SVR4 Targets

On SVR4 platforms GDB can use the symbol table of a dynamic loader (e.g. '`ld.so`') and normal memory operations to maintain a list of shared libraries. Still a special library list provided by this packet is more efficient for the GDB remote protocol.

The '`qXfer:libraries-svr4:read`' packet returns an XML document which lists loaded libraries and their SVR4 linker parameters. For each library on SVR4 target, the following parameters are reported:

– `name`, the absolute file name from the `l_name` field of `struct link_map`.
– `lm` with address of `struct link_map` used for TLS (Thread Local Storage) access.
– `l_addr`, the displacement as read from the field `l_addr` of `struct link_map`. For prelinked libraries this is not an absolute memory address. It is a displacement of absolute memory address against address the file was prelinked to during the library load.
– `l_ld`, which is memory address of the `PT_DYNAMIC` segment

Additionally the single `main-lm` attribute specifies address of `struct link_map` used for the main executable. This parameter is used for TLS access and its presence is optional.

GDB must be linked with the Expat library to support XML SVR4 library lists. See [Expat], page 489.

A simple memory map, with two loaded libraries (which do not use prelink), looks like this:

```
<library-list-svr4 version="1.0" main-lm="0xe4f8f8">
  <library name="/lib/ld-linux.so.2" lm="0xe4f51c" l_addr="0xe2d000"
           l_ld="0xe4eefc"/>
  <library name="/lib/libc.so.6" lm="0xe4fbe8" l_addr="0x154000"
           l_ld="0x152350"/>
</library-list-svr>
```

The format of an SVR4 library list is described by this DTD:

```
<!-- library-list-svr4: Root element with versioning -->
<!ELEMENT library-list-svr4  (library)*>
<!ATTLIST library-list-svr4  version CDATA   #FIXED  "1.0">
<!ATTLIST library-list-svr4  main-lm CDATA   #IMPLIED>
<!ELEMENT library            EMPTY>
<!ATTLIST library            name    CDATA   #REQUIRED>
<!ATTLIST library            lm      CDATA   #REQUIRED>
<!ATTLIST library            l_addr  CDATA   #REQUIRED>
<!ATTLIST library            l_ld    CDATA   #REQUIRED>
```

E.16 Memory Map Format

To be able to write into flash memory, GDB needs to obtain a memory map from the target. This section describes the format of the memory map.

The memory map is obtained using the '`qXfer:memory-map:read`' (see [qXfer memory map read], page 531) packet and is an XML document that lists memory regions.

GDB must be linked with the Expat library to support XML memory maps. See [Expat], page 489.

The top-level structure of the document is shown below:

```
<?xml version="1.0"?>
<!DOCTYPE memory-map
          PUBLIC "+//IDN gnu.org//DTD GDB Memory Map V1.0//EN"
                 "http://sourceware.org/gdb/gdb-memory-map.dtd">
<memory-map>
    region...
</memory-map>
```

Each region can be either:

- A region of RAM starting at *addr* and extending for *length* bytes from there:

```
<memory type="ram" start="addr" length="length"/>
```

- A region of read-only memory:

```
<memory type="rom" start="addr" length="length"/>
```

- A region of flash memory, with erasure blocks *blocksize* bytes in length:

```
<memory type="flash" start="addr" length="length">
  <property name="blocksize">blocksize</property>
</memory>
```

Regions must not overlap. GDB assumes that areas of memory not covered by the memory map are RAM, and uses the ordinary '`M`' and '`X`' packets to write to addresses in such ranges.

The formal DTD for memory map format is given below:

```
<!-- ................................................ -->
<!-- Memory Map XML DTD ............................. -->
<!-- File: memory-map.dtd ........................... -->
<!-- ..................................... ............ -->
<!-- memory-map.dtd -->
<!-- memory-map: Root element with versioning -->
<!ELEMENT memory-map (memory | property)>
<!ATTLIST memory-map    version CDATA   #FIXED  "1.0.0">
<!ELEMENT memory (property)>
<!-- memory: Specifies a memory region,
             and its type, or device. -->
<!ATTLIST memory        type    CDATA   #REQUIRED
                        start   CDATA   #REQUIRED
                        length  CDATA   #REQUIRED
                        device  CDATA   #IMPLIED>
<!-- property: Generic attribute tag -->
<!ELEMENT property (#PCDATA | property)*>
<!ATTLIST property      name    CDATA   #REQUIRED>
```

E.17 Thread List Format

To efficiently update the list of threads and their attributes, GDB issues the '`qXfer:threads:read`' packet (see [qXfer threads read], page 531) and obtains the XML document with the following structure:

```
<?xml version="1.0"?>
<threads>
    <thread id="id" core="0">
    ... description ...
    </thread>
</threads>
```

Each '`thread`' element must have the '`id`' attribute that identifies the thread (see [thread-id syntax], page 504). The '`core`' attribute, if present, specifies which processor core the thread was last executing on. The content of the of '`thread`' element is interpreted as human-readable auxilliary information.

E.18 Traceframe Info Format

To be able to know which objects in the inferior can be examined when inspecting a tracepoint hit, GDB needs to obtain the list of memory ranges, registers and trace state variables that have been collected in a traceframe.

This list is obtained using the '`qXfer:traceframe-info:read`' (see [qXfer traceframe info read], page 532) packet and is an XML document.

GDB must be linked with the Expat library to support XML traceframe info discovery. See [Expat], page 489.

The top-level structure of the document is shown below:

```
<?xml version="1.0"?>
<!DOCTYPE traceframe-info
          PUBLIC "+//IDN gnu.org//DTD GDB Memory Map V1.0//EN"
                 "http://sourceware.org/gdb/gdb-traceframe-info.dtd">
<traceframe-info>
   block...
</traceframe-info>
```

Each traceframe block can be either:

- A region of collected memory starting at *addr* and extending for *length* bytes from there:

```
<memory start="addr" length="length"/>
```

The formal DTD for the traceframe info format is given below:

```
<!ELEMENT traceframe-info  (memory)* >
<!ATTLIST traceframe-info  version CDATA   #FIXED  "1.0">

<!ELEMENT memory        EMPTY>
<!ATTLIST memory        start   CDATA   #REQUIRED
                        length  CDATA   #REQUIRED>
```

E.19 Branch Trace Format

In order to display the branch trace of an inferior thread, GDB needs to obtain the list of branches. This list is represented as list of sequential code blocks that are connected via branches. The code in each block has been executed sequentially.

This list is obtained using the '`qXfer:btrace:read`' (see [qXfer btrace read], page 530) packet and is an XML document.

GDB must be linked with the Expat library to support XML traceframe info discovery. See [Expat], page 489.

The top-level structure of the document is shown below:

```
<?xml version="1.0"?>
<!DOCTYPE btrace
          PUBLIC "+//IDN gnu.org//DTD GDB Branch Trace V1.0//EN"
                 "http://sourceware.org/gdb/gdb-btrace.dtd">
<btrace>
   block...
</btrace>
```

- A block of sequentially executed instructions starting at *begin* and ending at *end*:

```
<block begin="begin" end="end"/>
```

The formal DTD for the branch trace format is given below:

```
<!ELEMENT btrace  (block)* >
<!ATTLIST btrace  version CDATA   #FIXED "1.0">

<!ELEMENT block        EMPTY>
<!ATTLIST block        begin  CDATA   #REQUIRED
                       end    CDATA   #REQUIRED>
```

Appendix F The GDB Agent Expression Mechanism

In some applications, it is not feasible for the debugger to interrupt the program's execution long enough for the developer to learn anything helpful about its behavior. If the program's correctness depends on its real-time behavior, delays introduced by a debugger might cause the program to fail, even when the code itself is correct. It is useful to be able to observe the program's behavior without interrupting it.

Using GDB's `trace` and `collect` commands, the user can specify locations in the program, and arbitrary expressions to evaluate when those locations are reached. Later, using the `tfind` command, she can examine the values those expressions had when the program hit the trace points. The expressions may also denote objects in memory — structures or arrays, for example — whose values GDB should record; while visiting a particular tracepoint, the user may inspect those objects as if they were in memory at that moment. However, because GDB records these values without interacting with the user, it can do so quickly and unobtrusively, hopefully not disturbing the program's behavior.

When GDB is debugging a remote target, the GDB *agent* code running on the target computes the values of the expressions itself. To avoid having a full symbolic expression evaluator on the agent, GDB translates expressions in the source language into a simpler bytecode language, and then sends the bytecode to the agent; the agent then executes the bytecode, and records the values for GDB to retrieve later.

The bytecode language is simple; there are forty-odd opcodes, the bulk of which are the usual vocabulary of C operands (addition, subtraction, shifts, and so on) and various sizes of literals and memory reference operations. The bytecode interpreter operates strictly on machine-level values — various sizes of integers and floating point numbers — and requires no information about types or symbols; thus, the interpreter's internal data structures are simple, and each bytecode requires only a few native machine instructions to implement it. The interpreter is small, and strict limits on the memory and time required to evaluate an expression are easy to determine, making it suitable for use by the debugging agent in real-time applications.

F.1 General Bytecode Design

The agent represents bytecode expressions as an array of bytes. Each instruction is one byte long (thus the term *bytecode*). Some instructions are followed by operand bytes; for example, the `goto` instruction is followed by a destination for the jump.

The bytecode interpreter is a stack-based machine; most instructions pop their operands off the stack, perform some operation, and push the result back on the stack for the next instruction to consume. Each element of the stack may contain either a integer or a floating point value; these values are as many bits wide as the largest integer that can be directly manipulated in the source language. Stack elements carry no record of their type; bytecode could push a value as an integer, then pop it as a floating point value. However, GDB will not generate code which does this. In C, one might define the type of a stack element as follows:

```
union agent_val {
  LONGEST l;
  DOUBLEST d;
```

```
};
```

where `LONGEST` and `DOUBLEST` are `typedef` names for the largest integer and floating point types on the machine.

By the time the bytecode interpreter reaches the end of the expression, the value of the expression should be the only value left on the stack. For tracing applications, `trace` bytecodes in the expression will have recorded the necessary data, and the value on the stack may be discarded. For other applications, like conditional breakpoints, the value may be useful.

Separate from the stack, the interpreter has two registers:

`pc` The address of the next bytecode to execute.

`start` The address of the start of the bytecode expression, necessary for interpreting the `goto` and `if_goto` instructions.

Neither of these registers is directly visible to the bytecode language itself, but they are useful for defining the meanings of the bytecode operations.

There are no instructions to perform side effects on the running program, or call the program's functions; we assume that these expressions are only used for unobtrusive debugging, not for patching the running code.

Most bytecode instructions do not distinguish between the various sizes of values, and operate on full-width values; the upper bits of the values are simply ignored, since they do not usually make a difference to the value computed. The exceptions to this rule are:

memory reference instructions (`ref`*n*)
: There are distinct instructions to fetch different word sizes from memory. Once on the stack, however, the values are treated as full-size integers. They may need to be sign-extended; the `ext` instruction exists for this purpose.

the sign-extension instruction (`ext` *n*)
: These clearly need to know which portion of their operand is to be extended to occupy the full length of the word.

If the interpreter is unable to evaluate an expression completely for some reason (a memory location is inaccessible, or a divisor is zero, for example), we say that interpretation "terminates with an error". This means that the problem is reported back to the interpreter's caller in some helpful way. In general, code using agent expressions should assume that they may attempt to divide by zero, fetch arbitrary memory locations, and misbehave in other ways.

Even complicated C expressions compile to a few bytecode instructions; for example, the expression `x + y * z` would typically produce code like the following, assuming that `x` and `y` live in registers, and `z` is a global variable holding a 32-bit `int`:

```
reg 1
reg 2
const32 address of z
ref32
ext 32
mul
add
```

```
end
```

In detail, these mean:

`reg 1` Push the value of register 1 (presumably holding `x`) onto the stack.

`reg 2` Push the value of register 2 (holding `y`).

`const32` *address of z*
: Push the address of `z` onto the stack.

`ref32` Fetch a 32-bit word from the address at the top of the stack; replace the address on the stack with the value. Thus, we replace the address of `z` with `z`'s value.

`ext 32` Sign-extend the value on the top of the stack from 32 bits to full length. This is necessary because `z` is a signed integer.

`mul` Pop the top two numbers on the stack, multiply them, and push their product. Now the top of the stack contains the value of the expression `y * z`.

`add` Pop the top two numbers, add them, and push the sum. Now the top of the stack contains the value of `x + y * z`.

`end` Stop executing; the value left on the stack top is the value to be recorded.

F.2 Bytecode Descriptions

Each bytecode description has the following form:

`add` (0x02): *a b* ⇒ *a*+*b*
: Pop the top two stack items, *a* and *b*, as integers; push their sum, as an integer.

In this example, `add` is the name of the bytecode, and `(0x02)` is the one-byte value used to encode the bytecode, in hexadecimal. The phrase "*a b* ⇒ *a*+*b*" shows the stack before and after the bytecode executes. Beforehand, the stack must contain at least two values, *a* and *b*; since the top of the stack is to the right, *b* is on the top of the stack, and *a* is underneath it. After execution, the bytecode will have popped *a* and *b* from the stack, and replaced them with a single value, *a*+*b*. There may be other values on the stack below those shown, but the bytecode affects only those shown.

Here is another example:

`const8` (0x22) *n*: ⇒ *n*
: Push the 8-bit integer constant *n* on the stack, without sign extension.

In this example, the bytecode `const8` takes an operand *n* directly from the bytecode stream; the operand follows the `const8` bytecode itself. We write any such operands immediately after the name of the bytecode, before the colon, and describe the exact encoding of the operand in the bytecode stream in the body of the bytecode description.

For the `const8` bytecode, there are no stack items given before the ⇒; this simply means that the bytecode consumes no values from the stack. If a bytecode consumes no values, or produces no values, the list on either side of the ⇒ may be empty.

If a value is written as *a*, *b*, or *n*, then the bytecode treats it as an integer. If a value is written is *addr*, then the bytecode treats it as an address.

We do not fully describe the floating point operations here; although this design can be extended in a clean way to handle floating point values, they are not of immediate interest to the customer, so we avoid describing them, to save time.

`float` (0x01): ⇒
Prefix for floating-point bytecodes. Not implemented yet.

`add` (0x02): *a b* ⇒ *a*+*b*
Pop two integers from the stack, and push their sum, as an integer.

`sub` (0x03): *a b* ⇒ *a*-*b*
Pop two integers from the stack, subtract the top value from the next-to-top value, and push the difference.

`mul` (0x04): *a b* ⇒ *a***b*
Pop two integers from the stack, multiply them, and push the product on the stack. Note that, when one multiplies two *n*-bit numbers yielding another *n*-bit number, it is irrelevant whether the numbers are signed or not; the results are the same.

`div_signed` (0x05): *a b* ⇒ *a*/*b*
Pop two signed integers from the stack; divide the next-to-top value by the top value, and push the quotient. If the divisor is zero, terminate with an error.

`div_unsigned` (0x06): *a b* ⇒ *a*/*b*
Pop two unsigned integers from the stack; divide the next-to-top value by the top value, and push the quotient. If the divisor is zero, terminate with an error.

`rem_signed` (0x07): *a b* ⇒ *a modulo b*
Pop two signed integers from the stack; divide the next-to-top value by the top value, and push the remainder. If the divisor is zero, terminate with an error.

`rem_unsigned` (0x08): *a b* ⇒ *a modulo b*
Pop two unsigned integers from the stack; divide the next-to-top value by the top value, and push the remainder. If the divisor is zero, terminate with an error.

`lsh` (0x09): *a b* ⇒ *a*<<*b*
Pop two integers from the stack; let *a* be the next-to-top value, and *b* be the top value. Shift *a* left by *b* bits, and push the result.

`rsh_signed` (0x0a): *a b* ⇒ `(signed)`*a*>>*b*
Pop two integers from the stack; let *a* be the next-to-top value, and *b* be the top value. Shift *a* right by *b* bits, inserting copies of the top bit at the high end, and push the result.

`rsh_unsigned` (0x0b): *a b* ⇒ *a*>>*b*
Pop two integers from the stack; let *a* be the next-to-top value, and *b* be the top value. Shift *a* right by *b* bits, inserting zero bits at the high end, and push the result.

`log_not` (0x0e): *a* ⇒ *!a*
Pop an integer from the stack; if it is zero, push the value one; otherwise, push the value zero.

`bit_and` (0x0f): *a b* ⇒ *a&b*
: Pop two integers from the stack, and push their bitwise `and`.

`bit_or` (0x10): *a b* ⇒ *a|b*
: Pop two integers from the stack, and push their bitwise `or`.

`bit_xor` (0x11): *a b* ⇒ *a^b*
: Pop two integers from the stack, and push their bitwise exclusive-`or`.

`bit_not` (0x12): *a* ⇒ *~a*
: Pop an integer from the stack, and push its bitwise complement.

`equal` (0x13): *a b* ⇒ *a=b*
: Pop two integers from the stack; if they are equal, push the value one; otherwise, push the value zero.

`less_signed` (0x14): *a b* ⇒ *a<b*
: Pop two signed integers from the stack; if the next-to-top value is less than the top value, push the value one; otherwise, push the value zero.

`less_unsigned` (0x15): *a b* ⇒ *a<b*
: Pop two unsigned integers from the stack; if the next-to-top value is less than the top value, push the value one; otherwise, push the value zero.

`ext` (0x16) *n*: *a* ⇒ *a*, sign-extended from *n* bits
: Pop an unsigned value from the stack; treating it as an *n*-bit twos-complement value, extend it to full length. This means that all bits to the left of bit *n-1* (where the least significant bit is bit 0) are set to the value of bit *n-1*. Note that *n* may be larger than or equal to the width of the stack elements of the bytecode engine; in this case, the bytecode should have no effect.

  The number of source bits to preserve, *n*, is encoded as a single byte unsigned integer following the `ext` bytecode.

`zero_ext` (0x2a) *n*: *a* ⇒ *a*, zero-extended from *n* bits
: Pop an unsigned value from the stack; zero all but the bottom *n* bits. This means that all bits to the left of bit *n-1* (where the least significant bit is bit 0) are set to the value of bit *n-1*.

  The number of source bits to preserve, *n*, is encoded as a single byte unsigned integer following the `zero_ext` bytecode.

`ref8` (0x17): *addr* ⇒ *a*
`ref16` (0x18): *addr* ⇒ *a*
`ref32` (0x19): *addr* ⇒ *a*
`ref64` (0x1a): *addr* ⇒ *a*
: Pop an address *addr* from the stack. For bytecode `refn`, fetch an *n*-bit value from *addr*, using the natural target endianness. Push the fetched value as an unsigned integer.

  Note that *addr* may not be aligned in any particular way; the `refn` bytecodes should operate correctly for any address.

  If attempting to access memory at *addr* would cause a processor exception of some sort, terminate with an error.

`ref_float` (0x1b): *addr* ⇒ *d*
`ref_double` (0x1c): *addr* ⇒ *d*
`ref_long_double` (0x1d): *addr* ⇒ *d*
`l_to_d` (0x1e): *a* ⇒ *d*
`d_to_l` (0x1f): *d* ⇒ *a*
Not implemented yet.

`dup` (0x28): *a* => *a a*
Push another copy of the stack's top element.

`swap` (0x2b): *a b* => *b a*
Exchange the top two items on the stack.

`pop` (0x29): *a* =>
Discard the top value on the stack.

`pick` (0x32) *n*: *a . . . b* => *a . . . b a*
Duplicate an item from the stack and push it on the top of the stack. *n*, a single byte, indicates the stack item to copy. If *n* is zero, this is the same as `dup`; if *n* is one, it copies the item under the top item, etc. If *n* exceeds the number of items on the stack, terminate with an error.

`rot` (0x33): *a b c* => *c b a*
Rotate the top three items on the stack.

`if_goto` (0x20) *offset*: *a* ⇒
Pop an integer off the stack; if it is non-zero, branch to the given offset in the bytecode string. Otherwise, continue to the next instruction in the bytecode stream. In other words, if *a* is non-zero, set the `pc` register to `start +` *offset*. Thus, an offset of zero denotes the beginning of the expression.

The *offset* is stored as a sixteen-bit unsigned value, stored immediately following the `if_goto` bytecode. It is always stored most significant byte first, regardless of the target's normal endianness. The offset is not guaranteed to fall at any particular alignment within the bytecode stream; thus, on machines where fetching a 16-bit on an unaligned address raises an exception, you should fetch the offset one byte at a time.

`goto` (0x21) *offset*: ⇒
Branch unconditionally to *offset*; in other words, set the `pc` register to `start +` *offset*.

The offset is stored in the same way as for the `if_goto` bytecode.

`const8` (0x22) *n*: ⇒ *n*
`const16` (0x23) *n*: ⇒ *n*
`const32` (0x24) *n*: ⇒ *n*
`const64` (0x25) *n*: ⇒ *n*
Push the integer constant *n* on the stack, without sign extension. To produce a small negative value, push a small twos-complement value, and then sign-extend it using the `ext` bytecode.

The constant *n* is stored in the appropriate number of bytes following the `const`*b* bytecode. The constant *n* is always stored most significant byte first,

regardless of the target's normal endianness. The constant is not guaranteed to fall at any particular alignment within the bytecode stream; thus, on machines where fetching a 16-bit on an unaligned address raises an exception, you should fetch *n* one byte at a time.

`reg` (0x26) *n*: ⇒ *a*

Push the value of register number *n*, without sign extension. The registers are numbered following GDB's conventions.

The register number *n* is encoded as a 16-bit unsigned integer immediately following the `reg` bytecode. It is always stored most significant byte first, regardless of the target's normal endianness. The register number is not guaranteed to fall at any particular alignment within the bytecode stream; thus, on machines where fetching a 16-bit on an unaligned address raises an exception, you should fetch the register number one byte at a time.

`getv` (0x2c) *n*: ⇒ *v*

Push the value of trace state variable number *n*, without sign extension.

The variable number *n* is encoded as a 16-bit unsigned integer immediately following the `getv` bytecode. It is always stored most significant byte first, regardless of the target's normal endianness. The variable number is not guaranteed to fall at any particular alignment within the bytecode stream; thus, on machines where fetching a 16-bit on an unaligned address raises an exception, you should fetch the register number one byte at a time.

`setv` (0x2d) *n*: ⇒ *v*

Set trace state variable number *n* to the value found on the top of the stack. The stack is unchanged, so that the value is readily available if the assignment is part of a larger expression. The handling of *n* is as described for `getv`.

`trace` (0x0c): *addr size* ⇒

Record the contents of the *size* bytes at *addr* in a trace buffer, for later retrieval by GDB.

`trace_quick` (0x0d) *size*: *addr* ⇒ *addr*

Record the contents of the *size* bytes at *addr* in a trace buffer, for later retrieval by GDB. *size* is a single byte unsigned integer following the `trace` opcode.

This bytecode is equivalent to the sequence `dup const8` *size* `trace`, but we provide it anyway to save space in bytecode strings.

`trace16` (0x30) *size*: *addr* ⇒ *addr*

Identical to trace_quick, except that *size* is a 16-bit big-endian unsigned integer, not a single byte. This should probably have been named `trace_quick16`, for consistency.

`tracev` (0x2e) *n*: ⇒ *a*

Record the value of trace state variable number *n* in the trace buffer. The handling of *n* is as described for `getv`.

`tracenz` (0x2f) *addr size* ⇒

Record the bytes at *addr* in a trace buffer, for later retrieval by GDB. Stop at either the first zero byte, or when *size* bytes have been recorded, whichever occurs first.

`printf` (0x34) *numargs string* ⇒
: Do a formatted print, in the style of the C function `printf`). The value of *numargs* is the number of arguments to expect on the stack, while *string* is the format string, prefixed with a two-byte length. The last byte of the string must be zero, and is included in the length. The format string includes escaped sequences just as it appears in C source, so for instance the format string `"\t%d\n"` is six characters long, and the output will consist of a tab character, a decimal number, and a newline. At the top of the stack, above the values to be printed, this bytecode will pop a "function" and "channel". If the function is nonzero, then the target may treat it as a function and call it, passing the channel as a first argument, as with the C function `fprintf`. If the function is zero, then the target may simply call a standard formatted print function of its choice. In all, this bytecode pops 2 + *numargs* stack elements, and pushes nothing.

`end` (0x27): ⇒
: Stop executing bytecode; the result should be the top element of the stack. If the purpose of the expression was to compute an lvalue or a range of memory, then the next-to-top of the stack is the lvalue's address, and the top of the stack is the lvalue's size, in bytes.

F.3 Using Agent Expressions

Agent expressions can be used in several different ways by GDB, and the debugger can generate different bytecode sequences as appropriate.

One possibility is to do expression evaluation on the target rather than the host, such as for the conditional of a conditional tracepoint. In such a case, GDB compiles the source expression into a bytecode sequence that simply gets values from registers or memory, does arithmetic, and returns a result.

Another way to use agent expressions is for tracepoint data collection. GDB generates a different bytecode sequence for collection; in addition to bytecodes that do the calculation, GDB adds `trace` bytecodes to save the pieces of memory that were used.

- The user selects trace points in the program's code at which GDB should collect data.
- The user specifies expressions to evaluate at each trace point. These expressions may denote objects in memory, in which case those objects' contents are recorded as the program runs, or computed values, in which case the values themselves are recorded.
- GDB transmits the tracepoints and their associated expressions to the GDB agent, running on the debugging target.
- The agent arranges to be notified when a trace point is hit.
- When execution on the target reaches a trace point, the agent evaluates the expressions associated with that trace point, and records the resulting values and memory ranges.
- Later, when the user selects a given trace event and inspects the objects and expression values recorded, GDB talks to the agent to retrieve recorded data as necessary to meet the user's requests. If the user asks to see an object whose contents have not been recorded, GDB reports an error.

F.4 Varying Target Capabilities

Some targets don't support floating-point, and some would rather not have to deal with `long long` operations. Also, different targets will have different stack sizes, and different bytecode buffer lengths.

Thus, GDB needs a way to ask the target about itself. We haven't worked out the details yet, but in general, GDB should be able to send the target a packet asking it to describe itself. The reply should be a packet whose length is explicit, so we can add new information to the packet in future revisions of the agent, without confusing old versions of GDB, and it should contain a version number. It should contain at least the following information:

- whether floating point is supported
- whether `long long` is supported
- maximum acceptable size of bytecode stack
- maximum acceptable length of bytecode expressions
- which registers are actually available for collection
- whether the target supports disabled tracepoints

F.5 Rationale

Some of the design decisions apparent above are arguable.

What about stack overflow/underflow?

GDB should be able to query the target to discover its stack size. Given that information, GDB can determine at translation time whether a given expression will overflow the stack. But this spec isn't about what kinds of error-checking GDB ought to do.

Why are you doing everything in LONGEST?

Speed isn't important, but agent code size is; using LONGEST brings in a bunch of support code to do things like division, etc. So this is a serious concern.

First, note that you don't need different bytecodes for different operand sizes. You can generate code without *knowing* how big the stack elements actually are on the target. If the target only supports 32-bit ints, and you don't send any 64-bit bytecodes, everything just works. The observation here is that the MIPS and the Alpha have only fixed-size registers, and you can still get C's semantics even though most instructions only operate on full-sized words. You just need to make sure everything is properly sign-extended at the right times. So there is no need for 32- and 64-bit variants of the bytecodes. Just implement everything using the largest size you support.

GDB should certainly check to see what sizes the target supports, so the user can get an error earlier, rather than later. But this information is not necessary for correctness.

Why don't you have > or <= operators?

I want to keep the interpreter small, and we don't need them. We can combine the `less_` opcodes with `log_not`, and swap the order of the operands, yielding all four asymmetrical comparison operators. For example, `(x <= y)` is `! (x > y)`, which is `! (y < x)`.

Why do you have `log_not`?
Why do you have `ext`?
Why do you have `zero_ext`?

These are all easily synthesized from other instructions, but I expect them to be used frequently, and they're simple, so I include them to keep bytecode strings short.

`log_not` is equivalent to `const8 0 equal`; it's used in half the relational operators.

`ext` *n* is equivalent to `const8` *s-n* `lsh const8` *s-n* `rsh_signed`, where *s* is the size of the stack elements; it follows `ref`*m* and *reg* bytecodes when the value should be signed. See the next bulleted item.

`zero_ext` *n* is equivalent to `const`*m mask* `log_and`; it's used whenever we push the value of a register, because we can't assume the upper bits of the register aren't garbage.

Why not have sign-extending variants of the `ref` operators?

Because that would double the number of `ref` operators, and we need the `ext` bytecode anyway for accessing bitfields.

Why not have constant-address variants of the `ref` operators?

Because that would double the number of `ref` operators again, and `const32` *address* `ref32` is only one byte longer.

Why do the `ref`*n* operators have to support unaligned fetches?

GDB will generate bytecode that fetches multi-byte values at unaligned addresses whenever the executable's debugging information tells it to. Furthermore, GDB does not know the value the pointer will have when GDB generates the bytecode, so it cannot determine whether a particular fetch will be aligned or not.

In particular, structure bitfields may be several bytes long, but follow no alignment rules; members of packed structures are not necessarily aligned either.

In general, there are many cases where unaligned references occur in correct C code, either at the programmer's explicit request, or at the compiler's discretion. Thus, it is simpler to make the GDB agent bytecodes work correctly in all circumstances than to make GDB guess in each case whether the compiler did the usual thing.

Why are there no side-effecting operators?

Because our current client doesn't want them? That's a cheap answer. I think the real answer is that I'm afraid of implementing function calls. We should re-visit this issue after the present contract is delivered.

Why aren't the `goto` ops PC-relative?

The interpreter has the base address around anyway for PC bounds checking, and it seemed simpler.

Why is there only one offset size for the `goto` ops?

Offsets are currently sixteen bits. I'm not happy with this situation either:

Suppose we have multiple branch ops with different offset sizes. As I generate code left-to-right, all my jumps are forward jumps (there are no loops in expressions), so I never know the target when I emit the jump opcode. Thus, I have to either always assume the largest offset size, or do jump relaxation on the code after I generate it, which seems like a big waste of time.

I can imagine a reasonable expression being longer than 256 bytes. I can't imagine one being longer than 64k. Thus, we need 16-bit offsets. This kind of reasoning is so bogus, but relaxation is pathetic.

The other approach would be to generate code right-to-left. Then I'd always know my offset size. That might be fun.

Where is the function call bytecode?

When we add side-effects, we should add this.

Why does the `reg` bytecode take a 16-bit register number?

Intel's IA-64 architecture has 128 general-purpose registers, and 128 floating-point registers, and I'm sure it has some random control registers.

Why do we need `trace` and `trace_quick`?

Because GDB needs to record all the memory contents and registers an expression touches. If the user wants to evaluate an expression `x->y->z`, the agent must record the values of `x` and `x->y` as well as the value of `x->y->z`.

Don't the `trace` bytecodes make the interpreter less general?

They do mean that the interpreter contains special-purpose code, but that doesn't mean the interpreter can only be used for that purpose. If an expression doesn't use the `trace` bytecodes, they don't get in its way.

Why doesn't `trace_quick` consume its arguments the way everything else does?

In general, you do want your operators to consume their arguments; it's consistent, and generally reduces the amount of stack rearrangement necessary. However, `trace_quick` is a kludge to save space; it only exists so we needn't write `dup const8` *`SIZE`* `trace` before every memory reference. Therefore, it's okay for it not to consume its arguments; it's meant for a specific context in which we know exactly what it should do with the stack. If we're going to have a kludge, it should be an effective kludge.

Why does `trace16` exist?

That opcode was added by the customer that contracted Cygnus for the data tracing work. I personally think it is unnecessary; objects that large will be quite rare, so it is okay to use `dup const16` *`size`* `trace` in those cases.

Whatever we decide to do with `trace16`, we should at least leave opcode 0x30 reserved, to remain compatible with the customer who added it.

Appendix G Target Descriptions

One of the challenges of using GDB to debug embedded systems is that there are so many minor variants of each processor architecture in use. It is common practice for vendors to start with a standard processor core — ARM, PowerPC, or MIPS, for example — and then make changes to adapt it to a particular market niche. Some architectures have hundreds of variants, available from dozens of vendors. This leads to a number of problems:

- With so many different customized processors, it is difficult for the GDB maintainers to keep up with the changes.
- Since individual variants may have short lifetimes or limited audiences, it may not be worthwhile to carry information about every variant in the GDB source tree.
- When GDB does support the architecture of the embedded system at hand, the task of finding the correct architecture name to give the `set architecture` command can be error-prone.

To address these problems, the GDB remote protocol allows a target system to not only identify itself to GDB, but to actually describe its own features. This lets GDB support processor variants it has never seen before — to the extent that the descriptions are accurate, and that GDB understands them.

GDB must be linked with the Expat library to support XML target descriptions. See [Expat], page 489.

G.1 Retrieving Descriptions

Target descriptions can be read from the target automatically, or specified by the user manually. The default behavior is to read the description from the target. GDB retrieves it via the remote protocol using '`qXfer`' requests (see Section E.4 [General Query Packets], page 516). The *annex* in the '`qXfer`' packet will be '`target.xml`'. The contents of the '`target.xml`' annex are an XML document, of the form described in Section G.2 [Target Description Format], page 577.

Alternatively, you can specify a file to read for the target description. If a file is set, the target will not be queried. The commands to specify a file are:

`set tdesc filename` *path*
: Read the target description from *path*.

`unset tdesc filename`
: Do not read the XML target description from a file. GDB will use the description supplied by the current target.

`show tdesc filename`
: Show the filename to read for a target description, if any.

G.2 Target Description Format

A target description annex is an XML document which complies with the Document Type Definition provided in the GDB sources in '`gdb/features/gdb-target.dtd`'. This means you can use generally available tools like `xmllint` to check that your feature descriptions

are well-formed and valid. However, to help people unfamiliar with XML write descriptions for their targets, we also describe the grammar here.

Target descriptions can identify the architecture of the remote target and (for some architectures) provide information about custom register sets. They can also identify the OS ABI of the remote target. GDB can use this information to autoconfigure for your target, or to warn you if you connect to an unsupported target.

Here is a simple target description:

```
<target version="1.0">
  <architecture>i386:x86-64</architecture>
</target>
```

This minimal description only says that the target uses the x86-64 architecture.

A target description has the following overall form, with [ ] marking optional elements and ... marking repeatable elements. The elements are explained further below.

```
<?xml version="1.0"?>
<!DOCTYPE target SYSTEM "gdb-target.dtd">
<target version="1.0">
  [architecture]
  [osabi]
  [compatible]
  [feature...]
</target>
```

The description is generally insensitive to whitespace and line breaks, under the usual common-sense rules. The XML version declaration and document type declaration can generally be omitted (GDB does not require them), but specifying them may be useful for XML validation tools. The '`version`' attribute for '`<target>`' may also be omitted, but we recommend including it; if future versions of GDB use an incompatible revision of '`gdb-target.dtd`', they will detect and report the version mismatch.

G.2.1 Inclusion

It can sometimes be valuable to split a target description up into several different annexes, either for organizational purposes, or to share files between different possible target descriptions. You can divide a description into multiple files by replacing any element of the target description with an inclusion directive of the form:

```
<xi:include href="document"/>
```

When GDB encounters an element of this form, it will retrieve the named XML *document*, and replace the inclusion directive with the contents of that document. If the current description was read using '`qXfer`', then so will be the included document; *document* will be interpreted as the name of an annex. If the current description was read from a file, GDB will look for *document* as a file in the same directory where it found the original description.

G.2.2 Architecture

An '`<architecture>`' element has this form:

```
<architecture>arch</architecture>
```

arch is one of the architectures from the set accepted by `set architecture` (see Chapter 19 [Specifying a Debugging Target], page 231).

G.2.3 OS ABI

This optional field was introduced in GDB version 7.0. Previous versions of GDB ignore it.

An '`<osabi>`' element has this form:

```
<osabi>abi-name</osabi>
```

abi-name is an OS ABI name from the same selection accepted by `set osabi` (see Section 22.6 [Configuring the Current ABI], page 285).

G.2.4 Compatible Architecture

This optional field was introduced in GDB version 7.0. Previous versions of GDB ignore it.

A '`<compatible>`' element has this form:

```
<compatible>arch</compatible>
```

arch is one of the architectures from the set accepted by `set architecture` (see Chapter 19 [Specifying a Debugging Target], page 231).

A '`<compatible>`' element is used to specify that the target is able to run binaries in some other than the main target architecture given by the '`<architecture>`' element. For example, on the Cell Broadband Engine, the main architecture is `powerpc:common` or `powerpc:common64`, but the system is able to run binaries in the `spu` architecture as well. The way to describe this capability with '`<compatible>`' is as follows:

```
<architecture>powerpc:common</architecture>
<compatible>spu</compatible>
```

G.2.5 Features

Each '`<feature>`' describes some logical portion of the target system. Features are currently used to describe available CPU registers and the types of their contents. A '`<feature>`' element has this form:

```
<feature name="name">
  [type...]
  reg...
</feature>
```

Each feature's name should be unique within the description. The name of a feature does not matter unless GDB has some special knowledge of the contents of that feature; if it does, the feature should have its standard name. See Section G.4 [Standard Target Features], page 582.

G.2.6 Types

Any register's value is a collection of bits which GDB must interpret. The default interpretation is a two's complement integer, but other types can be requested by name in the register description. Some predefined types are provided by GDB (see Section G.3 [Predefined Target Types], page 581), and the description can define additional composite types.

Each type element must have an '`id`' attribute, which gives a unique (within the containing '`<feature>`') name to the type. Types must be defined before they are used.

Some targets offer vector registers, which can be treated as arrays of scalar elements. These types are written as '`<vector>`' elements, specifying the array element type, *type*, and the number of elements, *count*:

```
<vector id="id" type="type" count="count"/>
```

If a register's value is usefully viewed in multiple ways, define it with a union type containing the useful representations. The '`<union>`' element contains one or more '`<field>`' elements, each of which has a *name* and a *type*:

```
<union id="id">
  <field name="name" type="type"/>
  ...
</union>
```

If a register's value is composed from several separate values, define it with a structure type. There are two forms of the '`<struct>`' element; a '`<struct>`' element must either contain only bitfields or contain no bitfields. If the structure contains only bitfields, its total size in bytes must be specified, each bitfield must have an explicit start and end, and bitfields are automatically assigned an integer type. The field's *start* should be less than or equal to its *end*, and zero represents the least significant bit.

```
<struct id="id" size="size">
  <field name="name" start="start" end="end"/>
  ...
</struct>
```

If the structure contains no bitfields, then each field has an explicit type, and no implicit padding is added.

```
<struct id="id">
  <field name="name" type="type"/>
  ...
</struct>
```

If a register's value is a series of single-bit flags, define it with a flags type. The '`<flags>`' element has an explicit *size* and contains one or more '`<field>`' elements. Each field has a *name*, a *start*, and an *end*. Only single-bit flags are supported.

```
<flags id="id" size="size">
  <field name="name" start="start" end="end"/>
  ...
</flags>
```

G.2.7 Registers

Each register is represented as an element with this form:

```
<reg name="name"
     bitsize="size"
     [regnum="num"]
     [save-restore="save-restore"]
     [type="type"]
     [group="group"]/>
```

The components are as follows:

name The register's name; it must be unique within the target description.

bitsize The register's size, in bits.

regnum The register's number. If omitted, a register's number is one greater than that of the previous register (either in the current feature or in a preceding feature); the first register in the target description defaults to zero. This register number is used to read or write the register; e.g. it is used in the remote `p` and `P`

packets, and registers appear in the `g` and `G` packets in order of increasing register number.

save-restore
: Whether the register should be preserved across inferior function calls; this must be either `yes` or `no`. The default is `yes`, which is appropriate for most registers except for some system control registers; this is not related to the target's ABI.

type
: The type of the register. *type* may be a predefined type, a type defined in the current feature, or one of the special types `int` and `float`. `int` is an integer type of the correct size for *bitsize*, and `float` is a floating point type (in the architecture's normal floating point format) of the correct size for *bitsize*. The default is `int`.

group
: The register group to which this register belongs. *group* must be either `general`, `float`, or `vector`. If no *group* is specified, GDB will not display the register in `info registers`.

G.3 Predefined Target Types

Type definitions in the self-description can build up composite types from basic building blocks, but can not define fundamental types. Instead, standard identifiers are provided by GDB for the fundamental types. The currently supported types are:

`int8`
`int16`
`int32`
`int64`
`int128`
: Signed integer types holding the specified number of bits.

`uint8`
`uint16`
`uint32`
`uint64`
`uint128`
: Unsigned integer types holding the specified number of bits.

`code_ptr`
`data_ptr`
: Pointers to unspecified code and data. The program counter and any dedicated return address register may be marked as code pointers; printing a code pointer converts it into a symbolic address. The stack pointer and any dedicated address registers may be marked as data pointers.

`ieee_single`
: Single precision IEEE floating point.

`ieee_double`
: Double precision IEEE floating point.

`arm_fpa_ext`
: The 12-byte extended precision format used by ARM FPA registers.

`i387_ext`
: The 10-byte extended precision format used by x87 registers.

`i386_eflags`
: 32bit EFLAGS register used by x86.

`i386_mxcsr`
: 32bit MXCSR register used by x86.

G.4 Standard Target Features

A target description must contain either no registers or all the target's registers. If the description contains no registers, then GDB will assume a default register layout, selected based on the architecture. If the description contains any registers, the default layout will not be used; the standard registers must be described in the target description, in such a way that GDB can recognize them.

This is accomplished by giving specific names to feature elements which contain standard registers. GDB will look for features with those names and verify that they contain the expected registers; if any known feature is missing required registers, or if any required feature is missing, GDB will reject the target description. You can add additional registers to any of the standard features — GDB will display them just as if they were added to an unrecognized feature.

This section lists the known features and their expected contents. Sample XML documents for these features are included in the GDB source tree, in the directory '`gdb/features`'.

Names recognized by GDB should include the name of the company or organization which selected the name, and the overall architecture to which the feature applies; so e.g. the feature containing ARM core registers is named '`org.gnu.gdb.arm.core`'.

The names of registers are not case sensitive for the purpose of recognizing standard features, but GDB will only display registers using the capitalization used in the description.

G.4.1 AArch64 Features

The '`org.gnu.gdb.aarch64.core`' feature is required for AArch64 targets. It should contain registers '`x0`' through '`x30`', '`sp`', '`pc`', and '`cpsr`'.

The '`org.gnu.gdb.aarch64.fpu`' feature is optional. If present, it should contain registers '`v0`' through '`v31`', '`fpsr`', and '`fpcr`'.

G.4.2 ARM Features

The '`org.gnu.gdb.arm.core`' feature is required for non-M-profile ARM targets. It should contain registers '`r0`' through '`r13`', '`sp`', '`lr`', '`pc`', and '`cpsr`'.

For M-profile targets (e.g. Cortex-M3), the '`org.gnu.gdb.arm.core`' feature is replaced by '`org.gnu.gdb.arm.m-profile`'. It should contain registers '`r0`' through '`r13`', '`sp`', '`lr`', '`pc`', and '`xpsr`'.

The '`org.gnu.gdb.arm.fpa`' feature is optional. If present, it should contain registers '`f0`' through '`f7`' and '`fps`'.

The '`org.gnu.gdb.xscale.iwmmxt`' feature is optional. If present, it should contain at least registers '`wR0`' through '`wR15`' and '`wCGR0`' through '`wCGR3`'. The '`wCID`', '`wCon`', '`wCSSF`', and '`wCASF`' registers are optional.

The '`org.gnu.gdb.arm.vfp`' feature is optional. If present, it should contain at least registers '`d0`' through '`d15`'. If they are present, '`d16`' through '`d31`' should also be included.

GDB will synthesize the single-precision registers from halves of the double-precision registers.

The '`org.gnu.gdb.arm.neon`' feature is optional. It does not need to contain registers; it instructs GDB to display the VFP double-precision registers as vectors and to synthesize the quad-precision registers from pairs of double-precision registers. If this feature is present, '`org.gnu.gdb.arm.vfp`' must also be present and include 32 double-precision registers.

G.4.3 i386 Features

The '`org.gnu.gdb.i386.core`' feature is required for i386/amd64 targets. It should describe the following registers:

- '`eax`' through '`edi`' plus '`eip`' for i386
- '`rax`' through '`r15`' plus '`rip`' for amd64
- '`eflags`', '`cs`', '`ss`', '`ds`', '`es`', '`fs`', '`gs`'
- '`st0`' through '`st7`'
- '`fctrl`', '`fstat`', '`ftag`', '`fiseg`', '`fioff`', '`foseg`', '`fooff`' and '`fop`'

The register sets may be different, depending on the target.

The '`org.gnu.gdb.i386.sse`' feature is optional. It should describe registers:

- '`xmm0`' through '`xmm7`' for i386
- '`xmm0`' through '`xmm15`' for amd64
- '`mxcsr`'

The '`org.gnu.gdb.i386.avx`' feature is optional and requires the '`org.gnu.gdb.i386.sse`' feature. It should describe the upper 128 bits of YMM registers:

- '`ymm0h`' through '`ymm7h`' for i386
- '`ymm0h`' through '`ymm15h`' for amd64

The '`org.gnu.gdb.i386.linux`' feature is optional. It should describe a single register, '`orig_eax`'.

G.4.4 MIPS Features

The '`org.gnu.gdb.mips.cpu`' feature is required for MIPS targets. It should contain registers '`r0`' through '`r31`', '`lo`', '`hi`', and '`pc`'. They may be 32-bit or 64-bit depending on the target.

The '`org.gnu.gdb.mips.cp0`' feature is also required. It should contain at least the '`status`', '`badvaddr`', and '`cause`' registers. They may be 32-bit or 64-bit depending on the target.

The '`org.gnu.gdb.mips.fpu`' feature is currently required, though it may be optional in a future version of GDB. It should contain registers '`f0`' through '`f31`', '`fcsr`', and '`fir`'. They may be 32-bit or 64-bit depending on the target.

The '`org.gnu.gdb.mips.dsp`' feature is optional. It should contain registers '`hi1`' through '`hi3`', '`lo1`' through '`lo3`', and '`dspctl`'. The '`dspctl`' register should be 32-bit and the rest may be 32-bit or 64-bit depending on the target.

The '`org.gnu.gdb.mips.linux`' feature is optional. It should contain a single register, '`restart`', which is used by the Linux kernel to control restartable syscalls.

G.4.5 M68K Features

‘org.gnu.gdb.m68k.core’
‘org.gnu.gdb.coldfire.core’
‘org.gnu.gdb.fido.core’
: One of those features must be always present. The feature that is present determines which flavor of m68k is used. The feature that is present should contain registers ‘d0’ through ‘d7’, ‘a0’ through ‘a5’, ‘fp’, ‘sp’, ‘ps’ and ‘pc’.

‘org.gnu.gdb.coldfire.fp’
: This feature is optional. If present, it should contain registers ‘fp0’ through ‘fp7’, ‘fpcontrol’, ‘fpstatus’ and ‘fpiaddr’.

G.4.6 PowerPC Features

The ‘org.gnu.gdb.power.core’ feature is required for PowerPC targets. It should contain registers ‘r0’ through ‘r31’, ‘pc’, ‘msr’, ‘cr’, ‘lr’, ‘ctr’, and ‘xer’. They may be 32-bit or 64-bit depending on the target.

The ‘org.gnu.gdb.power.fpu’ feature is optional. It should contain registers ‘f0’ through ‘f31’ and ‘fpscr’.

The ‘org.gnu.gdb.power.altivec’ feature is optional. It should contain registers ‘vr0’ through ‘vr31’, ‘vscr’, and ‘vrsave’.

The ‘org.gnu.gdb.power.vsx’ feature is optional. It should contain registers ‘vs0h’ through ‘vs31h’. GDB will combine these registers with the floating point registers (‘f0’ through ‘f31’) and the altivec registers (‘vr0’ through ‘vr31’) to present the 128-bit wide registers ‘vs0’ through ‘vs63’, the set of vector registers for POWER7.

The ‘org.gnu.gdb.power.spe’ feature is optional. It should contain registers ‘ev0h’ through ‘ev31h’, ‘acc’, and ‘spefscr’. SPE targets should provide 32-bit registers in ‘org.gnu.gdb.power.core’ and provide the upper halves in ‘ev0h’ through ‘ev31h’. GDB will combine these to present registers ‘ev0’ through ‘ev31’ to the user.

G.4.7 TMS320C6x Features

The ‘org.gnu.gdb.tic6x.core’ feature is required for TMS320C6x targets. It should contain registers ‘A0’ through ‘A15’, registers ‘B0’ through ‘B15’, ‘CSR’ and ‘PC’.

The ‘org.gnu.gdb.tic6x.gp’ feature is optional. It should contain registers ‘A16’ through ‘A31’ and ‘B16’ through ‘B31’.

The ‘org.gnu.gdb.tic6x.c6xp’ feature is optional. It should contain registers ‘TSR’, ‘ILC’ and ‘RILC’.

Appendix H Operating System Information

Users of GDB often wish to obtain information about the state of the operating system running on the target—for example the list of processes, or the list of open files. This section describes the mechanism that makes it possible. This mechanism is similar to the target features mechanism (see Appendix G [Target Descriptions], page 577), but focuses on a different aspect of target.

Operating system information is retrived from the target via the remote protocol, using '`qXfer`' requests (see [qXfer osdata read], page 532). The object name in the request should be '`osdata`', and the *annex* identifies the data to be fetched.

H.1 Process list

When requesting the process list, the *annex* field in the '`qXfer`' request should be '`processes`'. The returned data is an XML document. The formal syntax of this document is defined in '`gdb/features/osdata.dtd`'.

An example document is:

```
<?xml version="1.0"?>
<!DOCTYPE target SYSTEM "osdata.dtd">
<osdata type="processes">
  <item>
    <column name="pid">1</column>
    <column name="user">root</column>
    <column name="command">/sbin/init</column>
    <column name="cores">1,2,3</column>
  </item>
</osdata>
```

Each item should include a column whose name is '`pid`'. The value of that column should identify the process on the target. The '`user`' and '`command`' columns are optional, and will be displayed by GDB. The '`cores`' column, if present, should contain a comma-separated list of cores that this process is running on. Target may provide additional columns, which GDB currently ignores.

Appendix I Trace File Format

The trace file comes in three parts: a header, a textual description section, and a trace frame section with binary data.

The header has the form `\x7fTRACE0\n`. The first byte is `0x7f` so as to indicate that the file contains binary data, while the `0` is a version number that may have different values in the future.

The description section consists of multiple lines of ASCII text separated by newline characters (`0xa`). The lines may include a variety of optional descriptive or context-setting information, such as tracepoint definitions or register set size. GDB will ignore any line that it does not recognize. An empty line marks the end of this section.

The trace frame section consists of a number of consecutive frames. Each frame begins with a two-byte tracepoint number, followed by a four-byte size giving the amount of data in the frame. The data in the frame consists of a number of blocks, each introduced by a character indicating its type (at least register, memory, and trace state variable). The data in this section is raw binary, not a hexadecimal or other encoding; its endianness matches the target's endianness.

`R` *bytes*
: Register block. The number and ordering of bytes matches that of a `g` packet in the remote protocol. Note that these are the actual bytes, in target order and GDB register order, not a hexadecimal encoding.

`M` *address length bytes...*
: Memory block. This is a contiguous block of memory, at the 8-byte address *address*, with a 2-byte length *length*, followed by *length* bytes.

`V` *number value*
: Trace state variable block. This records the 8-byte signed value *value* of trace state variable numbered *number*.

Future enhancements of the trace file format may include additional types of blocks.

Appendix J .gdb_index section format

This section documents the index section that is created by `save gdb-index` (see Section 18.4 [Index Files], page 227). The index section is DWARF-specific; some knowledge of DWARF is assumed in this description.

The mapped index file format is designed to be directly `mmap`able on any architecture. In most cases, a datum is represented using a little-endian 32-bit integer value, called an `offset_type`. Big endian machines must byte-swap the values before using them. Exceptions to this rule are noted. The data is laid out such that alignment is always respected.

A mapped index consists of several areas, laid out in order.

1. The file header. This is a sequence of values, of `offset_type` unless otherwise noted:
    1. The version number, currently 8. Versions 1, 2 and 3 are obsolete. Version 4 uses a different hashing function from versions 5 and 6. Version 6 includes symbols for inlined functions, whereas versions 4 and 5 do not. Version 7 adds attributes to the CU indices in the symbol table. Version 8 specifies that symbols from DWARF type units (‘`DW_TAG_type_unit`’) refer to the type unit's symbol table and not the compilation unit (‘`DW_TAG_comp_unit`’) using the type.

       GDB will only read version 4, 5, or 6 indices by specifying `set use-deprecated-index-sections on`. GDB has a workaround for potentially broken version 7 indices so it is currently not flagged as deprecated.
    2. The offset, from the start of the file, of the CU list.
    3. The offset, from the start of the file, of the types CU list. Note that this area can be empty, in which case this offset will be equal to the next offset.
    4. The offset, from the start of the file, of the address area.
    5. The offset, from the start of the file, of the symbol table.
    6. The offset, from the start of the file, of the constant pool.
2. The CU list. This is a sequence of pairs of 64-bit little-endian values, sorted by the CU offset. The first element in each pair is the offset of a CU in the `.debug_info` section. The second element in each pair is the length of that CU. References to a CU elsewhere in the map are done using a CU index, which is just the 0-based index into this table. Note that if there are type CUs, then conceptually CUs and type CUs form a single list for the purposes of CU indices.
3. The types CU list. This is a sequence of triplets of 64-bit little-endian values. In a triplet, the first value is the CU offset, the second value is the type offset in the CU, and the third value is the type signature. The types CU list is not sorted.
4. The address area. The address area consists of a sequence of address entries. Each address entry has three elements:
    1. The low address. This is a 64-bit little-endian value.
    2. The high address. This is a 64-bit little-endian value. Like `DW_AT_high_pc`, the value is one byte beyond the end.
    3. The CU index. This is an `offset_type` value.
5. The symbol table. This is an open-addressed hash table. The size of the hash table is always a power of 2.

Each slot in the hash table consists of a pair of `offset_type` values. The first value is the offset of the symbol's name in the constant pool. The second value is the offset of the CU vector in the constant pool.

If both values are 0, then this slot in the hash table is empty. This is ok because while 0 is a valid constant pool index, it cannot be a valid index for both a string and a CU vector.

The hash value for a table entry is computed by applying an iterative hash function to the symbol's name. Starting with an initial value of `r = 0`, each (unsigned) character '`c`' in the string is incorporated into the hash using the formula depending on the index version:

Version 4 The formula is `r = r * 67 + c - 113`.

Versions 5 to 7
The formula is `r = r * 67 + tolower (c) - 113`.

The terminating '`\0`' is not incorporated into the hash.

The step size used in the hash table is computed via `((hash * 17) & (size - 1)) | 1`, where '`hash`' is the hash value, and '`size`' is the size of the hash table. The step size is used to find the next candidate slot when handling a hash collision.

The names of C++ symbols in the hash table are canonicalized. We don't currently have a simple description of the canonicalization algorithm; if you intend to create new index sections, you must read the code.

6. The constant pool. This is simply a bunch of bytes. It is organized so that alignment is correct: CU vectors are stored first, followed by strings.

   A CU vector in the constant pool is a sequence of `offset_type` values. The first value is the number of CU indices in the vector. Each subsequent value is the index and symbol attributes of a CU in the CU list. This element in the hash table is used to indicate which CUs define the symbol and how the symbol is used. See below for the format of each CU index+attributes entry.

   A string in the constant pool is zero-terminated.

Attributes were added to CU index values in `.gdb_index` version 7. If a symbol has multiple uses within a CU then there is one CU index+attributes value for each use.

The format of each CU index+attributes entry is as follows (bit 0 = LSB):

Bits 0-23 This is the index of the CU in the CU list.

Bits 24-27 These bits are reserved for future purposes and must be zero.

Bits 28-30 The kind of the symbol in the CU.

- 0 This value is reserved and should not be used. By reserving zero the full `offset_type` value is backwards compatible with previous versions of the index.
- 1 The symbol is a type.
- 2 The symbol is a variable or an enum value.
- 3 The symbol is a function.

4 Any other kind of symbol.

5,6,7 These values are reserved.

Bit 31 This bit is zero if the value is global and one if it is static.

The determination of whether a symbol is global or static is complicated. The authorative reference is the file '`dwarf2read.c`' in GDB sources.

This pseudo-code describes the computation of a symbol's kind and global/static attributes in the index.

```
is_external = get_attribute (die, DW_AT_external);
language = get_attribute (cu_die, DW_AT_language);
switch (die->tag)
  {
  case DW_TAG_typedef:
  case DW_TAG_base_type:
  case DW_TAG_subrange_type:
    kind = TYPE;
    is_static = 1;
    break;
  case DW_TAG_enumerator:
    kind = VARIABLE;
    is_static = (language != CPLUS && language != JAVA);
    break;
  case DW_TAG_subprogram:
    kind = FUNCTION;
    is_static = ! (is_external || language == ADA);
    break;
  case DW_TAG_constant:
    kind = VARIABLE;
    is_static = ! is_external;
    break;
  case DW_TAG_variable:
    kind = VARIABLE;
    is_static = ! is_external;
    break;
  case DW_TAG_namespace:
    kind = TYPE;
    is_static = 0;
    break;
  case DW_TAG_class_type:
  case DW_TAG_interface_type:
  case DW_TAG_structure_type:
  case DW_TAG_union_type:
  case DW_TAG_enumeration_type:
    kind = TYPE;
    is_static = (language != CPLUS && language != JAVA);
    break;
  default:
    assert (0);
  }
```

Appendix K GNU GENERAL PUBLIC LICENSE

Version 3, 29 June 2007

Copyright © 2007 Free Software Foundation, Inc. http://fsf.org/

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Preamble

The GNU General Public License is a free, copyleft license for software and other kinds of works.

The licenses for most software and other practical works are designed to take away your freedom to share and change the works. By contrast, the GNU General Public License is intended to guarantee your freedom to share and change all versions of a program—to make sure it remains free software for all its users. We, the Free Software Foundation, use the GNU General Public License for most of our software; it applies also to any other work released this way by its authors. You can apply it to your programs, too.

When we speak of free software, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for them if you wish), that you receive source code or can get it if you want it, that you can change the software or use pieces of it in new free programs, and that you know you can do these things.

To protect your rights, we need to prevent others from denying you these rights or asking you to surrender the rights. Therefore, you have certain responsibilities if you distribute copies of the software, or if you modify it: responsibilities to respect the freedom of others.

For example, if you distribute copies of such a program, whether gratis or for a fee, you must pass on to the recipients the same freedoms that you received. You must make sure that they, too, receive or can get the source code. And you must show them these terms so they know their rights.

Developers that use the GNU GPL protect your rights with two steps: (1) assert copyright on the software, and (2) offer you this License giving you legal permission to copy, distribute and/or modify it.

For the developers' and authors' protection, the GPL clearly explains that there is no warranty for this free software. For both users' and authors' sake, the GPL requires that modified versions be marked as changed, so that their problems will not be attributed erroneously to authors of previous versions.

Some devices are designed to deny users access to install or run modified versions of the software inside them, although the manufacturer can do so. This is fundamentally incompatible with the aim of protecting users' freedom to change the software. The systematic pattern of such abuse occurs in the area of products for individuals to use, which is precisely where it is most unacceptable. Therefore, we have designed this version of the GPL to prohibit the practice for those products. If such problems arise substantially in other domains, we stand ready to extend this provision to those domains in future versions of the GPL, as needed to protect the freedom of users.

Finally, every program is threatened constantly by software patents. States should not allow patents to restrict development and use of software on general-purpose computers, but in those that do, we wish to avoid the special danger that patents applied to a free program could make it effectively proprietary. To prevent this, the GPL assures that patents cannot be used to render the program non-free.

The precise terms and conditions for copying, distribution and modification follow.

TERMS AND CONDITIONS

0. Definitions.

   "This License" refers to version 3 of the GNU General Public License.

   "Copyright" also means copyright-like laws that apply to other kinds of works, such as semiconductor masks.

   "The Program" refers to any copyrightable work licensed under this License. Each licensee is addressed as "you". "Licensees" and "recipients" may be individuals or organizations.

   To "modify" a work means to copy from or adapt all or part of the work in a fashion requiring copyright permission, other than the making of an exact copy. The resulting work is called a "modified version" of the earlier work or a work "based on" the earlier work.

   A "covered work" means either the unmodified Program or a work based on the Program.

   To "propagate" a work means to do anything with it that, without permission, would make you directly or secondarily liable for infringement under applicable copyright law, except executing it on a computer or modifying a private copy. Propagation includes copying, distribution (with or without modification), making available to the public, and in some countries other activities as well.

   To "convey" a work means any kind of propagation that enables other parties to make or receive copies. Mere interaction with a user through a computer network, with no transfer of a copy, is not conveying.

   An interactive user interface displays "Appropriate Legal Notices" to the extent that it includes a convenient and prominently visible feature that (1) displays an appropriate copyright notice, and (2) tells the user that there is no warranty for the work (except to the extent that warranties are provided), that licensees may convey the work under this License, and how to view a copy of this License. If the interface presents a list of user commands or options, such as a menu, a prominent item in the list meets this criterion.

1. Source Code.

   The "source code" for a work means the preferred form of the work for making modifications to it. "Object code" means any non-source form of a work.

   A "Standard Interface" means an interface that either is an official standard defined by a recognized standards body, or, in the case of interfaces specified for a particular programming language, one that is widely used among developers working in that language.

The "System Libraries" of an executable work include anything, other than the work as a whole, that (a) is included in the normal form of packaging a Major Component, but which is not part of that Major Component, and (b) serves only to enable use of the work with that Major Component, or to implement a Standard Interface for which an implementation is available to the public in source code form. A "Major Component", in this context, means a major essential component (kernel, window system, and so on) of the specific operating system (if any) on which the executable work runs, or a compiler used to produce the work, or an object code interpreter used to run it.

The "Corresponding Source" for a work in object code form means all the source code needed to generate, install, and (for an executable work) run the object code and to modify the work, including scripts to control those activities. However, it does not include the work's System Libraries, or general-purpose tools or generally available free programs which are used unmodified in performing those activities but which are not part of the work. For example, Corresponding Source includes interface definition files associated with source files for the work, and the source code for shared libraries and dynamically linked subprograms that the work is specifically designed to require, such as by intimate data communication or control flow between those subprograms and other parts of the work.

The Corresponding Source need not include anything that users can regenerate automatically from other parts of the Corresponding Source.

The Corresponding Source for a work in source code form is that same work.

2. Basic Permissions.

   All rights granted under this License are granted for the term of copyright on the Program, and are irrevocable provided the stated conditions are met. This License explicitly affirms your unlimited permission to run the unmodified Program. The output from running a covered work is covered by this License only if the output, given its content, constitutes a covered work. This License acknowledges your rights of fair use or other equivalent, as provided by copyright law.

   You may make, run and propagate covered works that you do not convey, without conditions so long as your license otherwise remains in force. You may convey covered works to others for the sole purpose of having them make modifications exclusively for you, or provide you with facilities for running those works, provided that you comply with the terms of this License in conveying all material for which you do not control copyright. Those thus making or running the covered works for you must do so exclusively on your behalf, under your direction and control, on terms that prohibit them from making any copies of your copyrighted material outside their relationship with you.

   Conveying under any other circumstances is permitted solely under the conditions stated below. Sublicensing is not allowed; section 10 makes it unnecessary.

3. Protecting Users' Legal Rights From Anti-Circumvention Law.

   No covered work shall be deemed part of an effective technological measure under any applicable law fulfilling obligations under article 11 of the WIPO copyright treaty adopted on 20 December 1996, or similar laws prohibiting or restricting circumvention of such measures.

When you convey a covered work, you waive any legal power to forbid circumvention of technological measures to the extent such circumvention is effected by exercising rights under this License with respect to the covered work, and you disclaim any intention to limit operation or modification of the work as a means of enforcing, against the work's users, your or third parties' legal rights to forbid circumvention of technological measures.

4. Conveying Verbatim Copies.

   You may convey verbatim copies of the Program's source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an appropriate copyright notice; keep intact all notices stating that this License and any non-permissive terms added in accord with section 7 apply to the code; keep intact all notices of the absence of any warranty; and give all recipients a copy of this License along with the Program.

   You may charge any price or no price for each copy that you convey, and you may offer support or warranty protection for a fee.

5. Conveying Modified Source Versions.

   You may convey a work based on the Program, or the modifications to produce it from the Program, in the form of source code under the terms of section 4, provided that you also meet all of these conditions:

   a. The work must carry prominent notices stating that you modified it, and giving a relevant date.

   b. The work must carry prominent notices stating that it is released under this License and any conditions added under section 7. This requirement modifies the requirement in section 4 to "keep intact all notices".

   c. You must license the entire work, as a whole, under this License to anyone who comes into possession of a copy. This License will therefore apply, along with any applicable section 7 additional terms, to the whole of the work, and all its parts, regardless of how they are packaged. This License gives no permission to license the work in any other way, but it does not invalidate such permission if you have separately received it.

   d. If the work has interactive user interfaces, each must display Appropriate Legal Notices; however, if the Program has interactive interfaces that do not display Appropriate Legal Notices, your work need not make them do so.

   A compilation of a covered work with other separate and independent works, which are not by their nature extensions of the covered work, and which are not combined with it such as to form a larger program, in or on a volume of a storage or distribution medium, is called an "aggregate" if the compilation and its resulting copyright are not used to limit the access or legal rights of the compilation's users beyond what the individual works permit. Inclusion of a covered work in an aggregate does not cause this License to apply to the other parts of the aggregate.

6. Conveying Non-Source Forms.

   You may convey a covered work in object code form under the terms of sections 4 and 5, provided that you also convey the machine-readable Corresponding Source under the terms of this License, in one of these ways:

a. Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by the Corresponding Source fixed on a durable physical medium customarily used for software interchange.

b. Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by a written offer, valid for at least three years and valid for as long as you offer spare parts or customer support for that product model, to give anyone who possesses the object code either (1) a copy of the Corresponding Source for all the software in the product that is covered by this License, on a durable physical medium customarily used for software interchange, for a price no more than your reasonable cost of physically performing this conveying of source, or (2) access to copy the Corresponding Source from a network server at no charge.

c. Convey individual copies of the object code with a copy of the written offer to provide the Corresponding Source. This alternative is allowed only occasionally and noncommercially, and only if you received the object code with such an offer, in accord with subsection 6b.

d. Convey the object code by offering access from a designated place (gratis or for a charge), and offer equivalent access to the Corresponding Source in the same way through the same place at no further charge. You need not require recipients to copy the Corresponding Source along with the object code. If the place to copy the object code is a network server, the Corresponding Source may be on a different server (operated by you or a third party) that supports equivalent copying facilities, provided you maintain clear directions next to the object code saying where to find the Corresponding Source. Regardless of what server hosts the Corresponding Source, you remain obligated to ensure that it is available for as long as needed to satisfy these requirements.

e. Convey the object code using peer-to-peer transmission, provided you inform other peers where the object code and Corresponding Source of the work are being offered to the general public at no charge under subsection 6d.

A separable portion of the object code, whose source code is excluded from the Corresponding Source as a System Library, need not be included in conveying the object code work.

A "User Product" is either (1) a "consumer product", which means any tangible personal property which is normally used for personal, family, or household purposes, or (2) anything designed or sold for incorporation into a dwelling. In determining whether a product is a consumer product, doubtful cases shall be resolved in favor of coverage. For a particular product received by a particular user, "normally used" refers to a typical or common use of that class of product, regardless of the status of the particular user or of the way in which the particular user actually uses, or expects or is expected to use, the product. A product is a consumer product regardless of whether the product has substantial commercial, industrial or non-consumer uses, unless such uses represent the only significant mode of use of the product.

"Installation Information" for a User Product means any methods, procedures, authorization keys, or other information required to install and execute modified versions of a covered work in that User Product from a modified version of its Corresponding Source.

The information must suffice to ensure that the continued functioning of the modified object code is in no case prevented or interfered with solely because modification has been made.

If you convey an object code work under this section in, or with, or specifically for use in, a User Product, and the conveying occurs as part of a transaction in which the right of possession and use of the User Product is transferred to the recipient in perpetuity or for a fixed term (regardless of how the transaction is characterized), the Corresponding Source conveyed under this section must be accompanied by the Installation Information. But this requirement does not apply if neither you nor any third party retains the ability to install modified object code on the User Product (for example, the work has been installed in ROM).

The requirement to provide Installation Information does not include a requirement to continue to provide support service, warranty, or updates for a work that has been modified or installed by the recipient, or for the User Product in which it has been modified or installed. Access to a network may be denied when the modification itself materially and adversely affects the operation of the network or violates the rules and protocols for communication across the network.

Corresponding Source conveyed, and Installation Information provided, in accord with this section must be in a format that is publicly documented (and with an implementation available to the public in source code form), and must require no special password or key for unpacking, reading or copying.

7. Additional Terms.

   "Additional permissions" are terms that supplement the terms of this License by making exceptions from one or more of its conditions. Additional permissions that are applicable to the entire Program shall be treated as though they were included in this License, to the extent that they are valid under applicable law. If additional permissions apply only to part of the Program, that part may be used separately under those permissions, but the entire Program remains governed by this License without regard to the additional permissions.

   When you convey a copy of a covered work, you may at your option remove any additional permissions from that copy, or from any part of it. (Additional permissions may be written to require their own removal in certain cases when you modify the work.) You may place additional permissions on material, added by you to a covered work, for which you have or can give appropriate copyright permission.

   Notwithstanding any other provision of this License, for material you add to a covered work, you may (if authorized by the copyright holders of that material) supplement the terms of this License with terms:

   a. Disclaiming warranty or limiting liability differently from the terms of sections 15 and 16 of this License; or
   b. Requiring preservation of specified reasonable legal notices or author attributions in that material or in the Appropriate Legal Notices displayed by works containing it; or
   c. Prohibiting misrepresentation of the origin of that material, or requiring that modified versions of such material be marked in reasonable ways as different from the original version; or

d. Limiting the use for publicity purposes of names of licensors or authors of the material; or

e. Declining to grant rights under trademark law for use of some trade names, trademarks, or service marks; or

f. Requiring indemnification of licensors and authors of that material by anyone who conveys the material (or modified versions of it) with contractual assumptions of liability to the recipient, for any liability that these contractual assumptions directly impose on those licensors and authors.

All other non-permissive additional terms are considered "further restrictions" within the meaning of section 10. If the Program as you received it, or any part of it, contains a notice stating that it is governed by this License along with a term that is a further restriction, you may remove that term. If a license document contains a further restriction but permits relicensing or conveying under this License, you may add to a covered work material governed by the terms of that license document, provided that the further restriction does not survive such relicensing or conveying.

If you add terms to a covered work in accord with this section, you must place, in the relevant source files, a statement of the additional terms that apply to those files, or a notice indicating where to find the applicable terms.

Additional terms, permissive or non-permissive, may be stated in the form of a separately written license, or stated as exceptions; the above requirements apply either way.

8. Termination.

You may not propagate or modify a covered work except as expressly provided under this License. Any attempt otherwise to propagate or modify it is void, and will automatically terminate your rights under this License (including any patent licenses granted under the third paragraph of section 11).

However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally terminates your license, and (b) permanently, if the copyright holder fails to notify you of the violation by some reasonable means prior to 60 days after the cessation.

Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice.

Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, you do not qualify to receive new licenses for the same material under section 10.

9. Acceptance Not Required for Having Copies.

You are not required to accept this License in order to receive or run a copy of the Program. Ancillary propagation of a covered work occurring solely as a consequence of using peer-to-peer transmission to receive a copy likewise does not require acceptance.

However, nothing other than this License grants you permission to propagate or modify any covered work. These actions infringe copyright if you do not accept this License. Therefore, by modifying or propagating a covered work, you indicate your acceptance of this License to do so.

10. Automatic Licensing of Downstream Recipients.

    Each time you convey a covered work, the recipient automatically receives a license from the original licensors, to run, modify and propagate that work, subject to this License. You are not responsible for enforcing compliance by third parties with this License.

    An "entity transaction" is a transaction transferring control of an organization, or substantially all assets of one, or subdividing an organization, or merging organizations. If propagation of a covered work results from an entity transaction, each party to that transaction who receives a copy of the work also receives whatever licenses to the work the party's predecessor in interest had or could give under the previous paragraph, plus a right to possession of the Corresponding Source of the work from the predecessor in interest, if the predecessor has it or can get it with reasonable efforts.

    You may not impose any further restrictions on the exercise of the rights granted or affirmed under this License. For example, you may not impose a license fee, royalty, or other charge for exercise of rights granted under this License, and you may not initiate litigation (including a cross-claim or counterclaim in a lawsuit) alleging that any patent claim is infringed by making, using, selling, offering for sale, or importing the Program or any portion of it.

11. Patents.

    A "contributor" is a copyright holder who authorizes use under this License of the Program or a work on which the Program is based. The work thus licensed is called the contributor's "contributor version".

    A contributor's "essential patent claims" are all patent claims owned or controlled by the contributor, whether already acquired or hereafter acquired, that would be infringed by some manner, permitted by this License, of making, using, or selling its contributor version, but do not include claims that would be infringed only as a consequence of further modification of the contributor version. For purposes of this definition, "control" includes the right to grant patent sublicenses in a manner consistent with the requirements of this License.

    Each contributor grants you a non-exclusive, worldwide, royalty-free patent license under the contributor's essential patent claims, to make, use, sell, offer for sale, import and otherwise run, modify and propagate the contents of its contributor version.

    In the following three paragraphs, a "patent license" is any express agreement or commitment, however denominated, not to enforce a patent (such as an express permission to practice a patent or covenant not to sue for patent infringement). To "grant" such a patent license to a party means to make such an agreement or commitment not to enforce a patent against the party.

    If you convey a covered work, knowingly relying on a patent license, and the Corresponding Source of the work is not available for anyone to copy, free of charge and under the terms of this License, through a publicly available network server or other readily accessible means, then you must either (1) cause the Corresponding Source to be so

available, or (2) arrange to deprive yourself of the benefit of the patent license for this particular work, or (3) arrange, in a manner consistent with the requirements of this License, to extend the patent license to downstream recipients. "Knowingly relying" means you have actual knowledge that, but for the patent license, your conveying the covered work in a country, or your recipient's use of the covered work in a country, would infringe one or more identifiable patents in that country that you have reason to believe are valid.

If, pursuant to or in connection with a single transaction or arrangement, you convey, or propagate by procuring conveyance of, a covered work, and grant a patent license to some of the parties receiving the covered work authorizing them to use, propagate, modify or convey a specific copy of the covered work, then the patent license you grant is automatically extended to all recipients of the covered work and works based on it.

A patent license is "discriminatory" if it does not include within the scope of its coverage, prohibits the exercise of, or is conditioned on the non-exercise of one or more of the rights that are specifically granted under this License. You may not convey a covered work if you are a party to an arrangement with a third party that is in the business of distributing software, under which you make payment to the third party based on the extent of your activity of conveying the work, and under which the third party grants, to any of the parties who would receive the covered work from you, a discriminatory patent license (a) in connection with copies of the covered work conveyed by you (or copies made from those copies), or (b) primarily for and in connection with specific products or compilations that contain the covered work, unless you entered into that arrangement, or that patent license was granted, prior to 28 March 2007.

Nothing in this License shall be construed as excluding or limiting any implied license or other defenses to infringement that may otherwise be available to you under applicable patent law.

12. No Surrender of Others' Freedom.

    If conditions are imposed on you (whether by court order, agreement or otherwise) that contradict the conditions of this License, they do not excuse you from the conditions of this License. If you cannot convey a covered work so as to satisfy simultaneously your obligations under this License and any other pertinent obligations, then as a consequence you may not convey it at all. For example, if you agree to terms that obligate you to collect a royalty for further conveying from those to whom you convey the Program, the only way you could satisfy both those terms and this License would be to refrain entirely from conveying the Program.

13. Use with the GNU Affero General Public License.

    Notwithstanding any other provision of this License, you have permission to link or combine any covered work with a work licensed under version 3 of the GNU Affero General Public License into a single combined work, and to convey the resulting work. The terms of this License will continue to apply to the part which is the covered work, but the special requirements of the GNU Affero General Public License, section 13, concerning interaction through a network will apply to the combination as such.

14. Revised Versions of this License.

The Free Software Foundation may publish revised and/or new versions of the GNU General Public License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns.

Each version is given a distinguishing version number. If the Program specifies that a certain numbered version of the GNU General Public License "or any later version" applies to it, you have the option of following the terms and conditions either of that numbered version or of any later version published by the Free Software Foundation. If the Program does not specify a version number of the GNU General Public License, you may choose any version ever published by the Free Software Foundation.

If the Program specifies that a proxy can decide which future versions of the GNU General Public License can be used, that proxy's public statement of acceptance of a version permanently authorizes you to choose that version for the Program.

Later license versions may give you additional or different permissions. However, no additional obligations are imposed on any author or copyright holder as a result of your choosing to follow a later version.

15. Disclaimer of Warranty.

    THERE IS NO WARRANTY FOR THE PROGRAM, TO THE EXTENT PERMITTED BY APPLICABLE LAW. EXCEPT WHEN OTHERWISE STATED IN WRITING THE COPYRIGHT HOLDERS AND/OR OTHER PARTIES PROVIDE THE PROGRAM "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE PROGRAM IS WITH YOU. SHOULD THE PROGRAM PROVE DEFECTIVE, YOU ASSUME THE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION.

16. Limitation of Liability.

    IN NO EVENT UNLESS REQUIRED BY APPLICABLE LAW OR AGREED TO IN WRITING WILL ANY COPYRIGHT HOLDER, OR ANY OTHER PARTY WHO MODIFIES AND/OR CONVEYS THE PROGRAM AS PERMITTED ABOVE, BE LIABLE TO YOU FOR DAMAGES, INCLUDING ANY GENERAL, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PROGRAM (INCLUDING BUT NOT LIMITED TO LOSS OF DATA OR DATA BEING RENDERED INACCURATE OR LOSSES SUSTAINED BY YOU OR THIRD PARTIES OR A FAILURE OF THE PROGRAM TO OPERATE WITH ANY OTHER PROGRAMS), EVEN IF SUCH HOLDER OR OTHER PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

17. Interpretation of Sections 15 and 16.

    If the disclaimer of warranty and limitation of liability provided above cannot be given local legal effect according to their terms, reviewing courts shall apply local law that most closely approximates an absolute waiver of all civil liability in connection with the Program, unless a warranty or assumption of liability accompanies a copy of the Program in return for a fee.

END OF TERMS AND CONDITIONS

How to Apply These Terms to Your New Programs

If you develop a new program, and you want it to be of the greatest possible use to the public, the best way to achieve this is to make it free software which everyone can redistribute and change under these terms.

To do so, attach the following notices to the program. It is safest to attach them to the start of each source file to most effectively state the exclusion of warranty; and each file should have at least the "copyright" line and a pointer to where the full notice is found.

```
one line to give the program's name and a brief idea of what it does.
Copyright (C) year name of author

This program is free software: you can redistribute it and/or modify
it under the terms of the GNU General Public License as published by
the Free Software Foundation, either version 3 of the License, or (at
your option) any later version.

This program is distributed in the hope that it will be useful, but
WITHOUT ANY WARRANTY; without even the implied warranty of
MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the GNU
General Public License for more details.

You should have received a copy of the GNU General Public License
along with this program.  If not, see http://www.gnu.org/licenses/.
```

Also add information on how to contact you by electronic and paper mail.

If the program does terminal interaction, make it output a short notice like this when it starts in an interactive mode:

```
program Copyright (C) year name of author
This program comes with ABSOLUTELY NO WARRANTY; for details type 'show w'.
This is free software, and you are welcome to redistribute it
under certain conditions; type 'show c' for details.
```

The hypothetical commands '`show w`' and '`show c`' should show the appropriate parts of the General Public License. Of course, your program's commands might be different; for a GUI interface, you would use an "about box".

You should also get your employer (if you work as a programmer) or school, if any, to sign a "copyright disclaimer" for the program, if necessary. For more information on this, and how to apply and follow the GNU GPL, see http://www.gnu.org/licenses/.

The GNU General Public License does not permit incorporating your program into proprietary programs. If your program is a subroutine library, you may consider it more useful to permit linking proprietary applications with the library. If this is what you want to do, use the GNU Lesser General Public License instead of this License. But first, please read http://www.gnu.org/philosophy/why-not-lgpl.html.

Appendix L GNU Free Documentation License

Version 1.3, 3 November 2008

Copyright © 2000, 2001, 2002, 2007, 2008 Free Software Foundation, Inc.
http://fsf.org/

Everyone is permitted to copy and distribute verbatim copies
of this license document, but changing it is not allowed.

0. PREAMBLE

The purpose of this License is to make a manual, textbook, or other functional and useful document *free* in the sense of freedom: to assure everyone the effective freedom to copy and redistribute it, with or without modifying it, either commercially or non-commercially. Secondarily, this License preserves for the author and publisher a way to get credit for their work, while not being considered responsible for modifications made by others.

This License is a kind of "copyleft", which means that derivative works of the document must themselves be free in the same sense. It complements the GNU General Public License, which is a copyleft license designed for free software.

We have designed this License in order to use it for manuals for free software, because free software needs free documentation: a free program should come with manuals providing the same freedoms that the software does. But this License is not limited to software manuals; it can be used for any textual work, regardless of subject matter or whether it is published as a printed book. We recommend this License principally for works whose purpose is instruction or reference.

1. APPLICABILITY AND DEFINITIONS

This License applies to any manual or other work, in any medium, that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. Such a notice grants a world-wide, royalty-free license, unlimited in duration, to use that work under the conditions stated herein. The "Document", below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as "you". You accept the license if you copy, modify or distribute the work in a way requiring permission under copyright law.

A "Modified Version" of the Document means any work containing the Document or a portion of it, either copied verbatim, or with modifications and/or translated into another language.

A "Secondary Section" is a named appendix or a front-matter section of the Document that deals exclusively with the relationship of the publishers or authors of the Document to the Document's overall subject (or to related matters) and contains nothing that could fall directly within that overall subject. (Thus, if the Document is in part a textbook of mathematics, a Secondary Section may not explain any mathematics.) The relationship could be a matter of historical connection with the subject or with related matters, or of legal, commercial, philosophical, ethical or political position regarding them.

The "Invariant Sections" are certain Secondary Sections whose titles are designated, as being those of Invariant Sections, in the notice that says that the Document is released

under this License. If a section does not fit the above definition of Secondary then it is not allowed to be designated as Invariant. The Document may contain zero Invariant Sections. If the Document does not identify any Invariant Sections then there are none.

The "Cover Texts" are certain short passages of text that are listed, as Front-Cover Texts or Back-Cover Texts, in the notice that says that the Document is released under this License. A Front-Cover Text may be at most 5 words, and a Back-Cover Text may be at most 25 words.

A "Transparent" copy of the Document means a machine-readable copy, represented in a format whose specification is available to the general public, that is suitable for revising the document straightforwardly with generic text editors or (for images composed of pixels) generic paint programs or (for drawings) some widely available drawing editor, and that is suitable for input to text formatters or for automatic translation to a variety of formats suitable for input to text formatters. A copy made in an otherwise Transparent file format whose markup, or absence of markup, has been arranged to thwart or discourage subsequent modification by readers is not Transparent. An image format is not Transparent if used for any substantial amount of text. A copy that is not "Transparent" is called "Opaque".

Examples of suitable formats for Transparent copies include plain ASCII without markup, Texinfo input format, LaTeX input format, SGML or XML using a publicly available DTD, and standard-conforming simple HTML, PostScript or PDF designed for human modification. Examples of transparent image formats include PNG, XCF and JPG. Opaque formats include proprietary formats that can be read and edited only by proprietary word processors, SGML or XML for which the DTD and/or processing tools are not generally available, and the machine-generated HTML, PostScript or PDF produced by some word processors for output purposes only.

The "Title Page" means, for a printed book, the title page itself, plus such following pages as are needed to hold, legibly, the material this License requires to appear in the title page. For works in formats which do not have any title page as such, "Title Page" means the text near the most prominent appearance of the work's title, preceding the beginning of the body of the text.

The "publisher" means any person or entity that distributes copies of the Document to the public.

A section "Entitled XYZ" means a named subunit of the Document whose title either is precisely XYZ or contains XYZ in parentheses following text that translates XYZ in another language. (Here XYZ stands for a specific section name mentioned below, such as "Acknowledgements", "Dedications", "Endorsements", or "History".) To "Preserve the Title" of such a section when you modify the Document means that it remains a section "Entitled XYZ" according to this definition.

The Document may include Warranty Disclaimers next to the notice which states that this License applies to the Document. These Warranty Disclaimers are considered to be included by reference in this License, but only as regards disclaiming warranties: any other implication that these Warranty Disclaimers may have is void and has no effect on the meaning of this License.

2. VERBATIM COPYING

You may copy and distribute the Document in any medium, either commercially or noncommercially, provided that this License, the copyright notices, and the license notice saying this License applies to the Document are reproduced in all copies, and that you add no other conditions whatsoever to those of this License. You may not use technical measures to obstruct or control the reading or further copying of the copies you make or distribute. However, you may accept compensation in exchange for copies. If you distribute a large enough number of copies you must also follow the conditions in section 3.

You may also lend copies, under the same conditions stated above, and you may publicly display copies.

3. COPYING IN QUANTITY

   If you publish printed copies (or copies in media that commonly have printed covers) of the Document, numbering more than 100, and the Document's license notice requires Cover Texts, you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects.

   If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages.

   If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque copy a computer-network location from which the general network-using public has access to download using public-standard network protocols a complete Transparent copy of the Document, free of added material. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public.

   It is requested, but not required, that you contact the authors of the Document well before redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document.

4. MODIFICATIONS

   You may copy and distribute a Modified Version of the Document under the conditions of sections 2 and 3 above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version:

   A. Use in the Title Page (and on the covers, if any) a title distinct from that of the Document, and from those of previous versions (which should, if there were any,

be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission.

B. List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has fewer than five), unless they release you from this requirement.

C. State on the Title page the name of the publisher of the Modified Version, as the publisher.

D. Preserve all the copyright notices of the Document.

E. Add an appropriate copyright notice for your modifications adjacent to the other copyright notices.

F. Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the Addendum below.

G. Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document's license notice.

H. Include an unaltered copy of this License.

I. Preserve the section Entitled "History", Preserve its Title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If there is no section Entitled "History" in the Document, create one stating the title, year, authors, and publisher of the Document as given on its Title Page, then add an item describing the Modified Version as stated in the previous sentence.

J. Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the "History" section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission.

K. For any section Entitled "Acknowledgements" or "Dedications", Preserve the Title of the section, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein.

L. Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles.

M. Delete any section Entitled "Endorsements". Such a section may not be included in the Modified Version.

N. Do not retitle any existing section to be Entitled "Endorsements" or to conflict in title with any Invariant Section.

O. Preserve any Warranty Disclaimers.

If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Sections and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their

titles to the list of Invariant Sections in the Modified Version's license notice. These titles must be distinct from any other section titles.

You may add a section Entitled "Endorsements", provided it contains nothing but endorsements of your Modified Version by various parties—for example, statements of peer review or that the text has been approved by an organization as the authoritative definition of a standard.

You may add a passage of up to five words as a Front-Cover Text, and a passage of up to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be added by (or through arrangements made by) any one entity. If the Document already includes a cover text for the same cover, previously added by you or by arrangement made by the same entity you are acting on behalf of, you may not add another; but you may replace the old one, on explicit permission from the previous publisher that added the old one.

The author(s) and publisher(s) of the Document do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version.

5. COMBINING DOCUMENTS

   You may combine the Document with other documents released under this License, under the terms defined in section 4 above for modified versions, provided that you include in the combination all of the Invariant Sections of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice, and that you preserve all their Warranty Disclaimers.

   The combined work need only contain one copy of this License, and multiple identical Invariant Sections may be replaced with a single copy. If there are multiple Invariant Sections with the same name but different contents, make the title of each such section unique by adding at the end of it, in parentheses, the name of the original author or publisher of that section if known, or else a unique number. Make the same adjustment to the section titles in the list of Invariant Sections in the license notice of the combined work.

   In the combination, you must combine any sections Entitled "History" in the various original documents, forming one section Entitled "History"; likewise combine any sections Entitled "Acknowledgements", and any sections Entitled "Dedications". You must delete all sections Entitled "Endorsements."

6. COLLECTIONS OF DOCUMENTS

   You may make a collection consisting of the Document and other documents released under this License, and replace the individual copies of this License in the various documents with a single copy that is included in the collection, provided that you follow the rules of this License for verbatim copying of each of the documents in all other respects.

   You may extract a single document from such a collection, and distribute it individually under this License, provided you insert a copy of this License into the extracted document, and follow this License in all other respects regarding verbatim copying of that document.

7. AGGREGATION WITH INDEPENDENT WORKS

   A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, is called an "aggregate" if the copyright resulting from the compilation is not used to limit the legal rights of the compilation's users beyond what the individual works permit. When the Document is included in an aggregate, this License does not apply to the other works in the aggregate which are not themselves derivative works of the Document.

   If the Cover Text requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one half of the entire aggregate, the Document's Cover Texts may be placed on covers that bracket the Document within the aggregate, or the electronic equivalent of covers if the Document is in electronic form. Otherwise they must appear on printed covers that bracket the whole aggregate.

8. TRANSLATION

   Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section 4. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License, and all the license notices in the Document, and any Warranty Disclaimers, provided that you also include the original English version of this License and the original versions of those notices and disclaimers. In case of a disagreement between the translation and the original version of this License or a notice or disclaimer, the original version will prevail.

   If a section in the Document is Entitled "Acknowledgements", "Dedications", or "History", the requirement (section 4) to Preserve its Title (section 1) will typically require changing the actual title.

9. TERMINATION

   You may not copy, modify, sublicense, or distribute the Document except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense, or distribute it is void, and will automatically terminate your rights under this License.

   However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally terminates your license, and (b) permanently, if the copyright holder fails to notify you of the violation by some reasonable means prior to 60 days after the cessation.

   Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice.

   Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, receipt of a copy of some or all of the same material does not give you any rights to use it.

10. FUTURE REVISIONS OF THIS LICENSE

    The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns. See http://www.gnu.org/copyleft/.

    Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License "or any later version" applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation. If the Document specifies that a proxy can decide which future versions of this License can be used, that proxy's public statement of acceptance of a version permanently authorizes you to choose that version for the Document.

11. RELICENSING

    "Massive Multiauthor Collaboration Site" (or "MMC Site") means any World Wide Web server that publishes copyrightable works and also provides prominent facilities for anybody to edit those works. A public wiki that anybody can edit is an example of such a server. A "Massive Multiauthor Collaboration" (or "MMC") contained in the site means any set of copyrightable works thus published on the MMC site.

    "CC-BY-SA" means the Creative Commons Attribution-Share Alike 3.0 license published by Creative Commons Corporation, a not-for-profit corporation with a principal place of business in San Francisco, California, as well as future copyleft versions of that license published by that same organization.

    "Incorporate" means to publish or republish a Document, in whole or in part, as part of another Document.

    An MMC is "eligible for relicensing" if it is licensed under this License, and if all works that were first published under this License somewhere other than this MMC, and subsequently incorporated in whole or in part into the MMC, (1) had no cover texts or invariant sections, and (2) were thus incorporated prior to November 1, 2008.

    The operator of an MMC Site may republish an MMC contained in the site under CC-BY-SA on the same site at any time before August 1, 2009, provided the MMC is eligible for relicensing.

ADDENDUM: How to use this License for your documents

To use this License in a document you have written, include a copy of the License in the document and put the following copyright and license notices just after the title page:

```
Copyright (C)  year  your name.
Permission is granted to copy, distribute and/or modify this document
under the terms of the GNU Free Documentation License, Version 1.3
or any later version published by the Free Software Foundation;
with no Invariant Sections, no Front-Cover Texts, and no Back-Cover
Texts.  A copy of the license is included in the section entitled ``GNU
Free Documentation License''.
```

If you have Invariant Sections, Front-Cover Texts and Back-Cover Texts, replace the "with. . . Texts." line with this:

```
with the Invariant Sections being list their titles, with
the Front-Cover Texts being list, and with the Back-Cover Texts
being list.
```

If you have Invariant Sections without Cover Texts, or some other combination of the three, merge those two alternatives to suit the situation.

If your document contains nontrivial examples of program code, we recommend releasing these examples in parallel under your choice of free software license, such as the GNU General Public License, to permit their use in free software.

Concept Index

!

'!' packet 505

#

in Modula-2 192

$

$ 125
$$ 125
$_ and info breakpoints 46
$_ and info line 100
$_, $__, and value history 113

-

--annotate 15
--args 15
'--attach', gdbserver option 238
--batch 13
--batch-silent 14
--baud 15
--cd 14
--command 12
--core 12
--data-directory 14
'--debug', gdbserver option 239
--directory 13
--eval-command 12
--exec 12
--fullname 15
--init-command 12
--init-eval-command 13
--interpreter 15
'--multi', gdbserver option 239
--nh 13
--nowindows 14
--nx 13
'--once', gdbserver option 239
--pid 12
--quiet 13
--readnow 13
'--remote-debug', gdbserver option 239
--return-child-result 14
--se 12
--silent 13
--statistics 16
--symbols 12
--tty 15
--tui 15
--version 16
--windows 14
'--with-gdb-datadir' 229
'--with-relocated-sources' 98
'--with-sysroot' 221
'--wrapper', gdbserver option 239
--write 16
-b 15
-c 12
-d 13
-e 12
-ex 12
-f 15
-iex 13
-ix 12
-l 15
-n 13
-nw 14
-p 12
-q 13
-r 13
-s 12
-t 15
-w 14
-x 12

.

., Modula-2 scope operator 191
'.build-id' directory 223
'.debug' subdirectories 223
.debug_gdb_scripts section 348
'.gdb_index' section 227
.gdb_index section format 589
'.gdbinit' 17
'.gnu_debugdata' section 227
.gnu_debuglink sections 224
.note.gnu.build-id sections 224
'.o' files, reading symbols from 217

/

/proc 251

:

::, context for variables/functions 107

<

<architecture> 578
<compatible> 579
<feature> 579
<flags> 580
<osabi> 579
<reg> 580
<struct> 580

<union> 580
<vector> 579
<xi:include> 578

?

'?' packet 505

_

_NSPrintForDebugger, and printing Objective-C objects 184

‘

“No symbol "foo" in current context” 108

{

{*type*} 105

A

'A' packet 505
AArch64 support 276
abbreviation 19
acknowledgment, for GDB remote 546
active targets 231
Ada 192
Ada exception catching 53
Ada mode, general 192
Ada task switching 197
Ada tasking and core file debugging 198
Ada, deviations from 194
Ada, omissions from 193
Ada, problems 199
Ada, tasking 196
add new commands for external monitor 236
address of a symbol 202
address size for remote targets 242
ADP (Angel Debugger Protocol) logging 265
aggregates (Ada) 193
AIX threads 293
aliases for commands 352
alignment of remote memory accesses 508
all-stop mode 72
Alpha stack 276
ambiguous expressions 106
annotations 443
annotations for errors, warnings and interrupts 445
annotations for invalidation messages 445
annotations for prompts 444
annotations for running programs 445
annotations for source display 446
append data to a file 134
apply command to several threads 36
architecture debugging info 292
argument count in user-defined commands 297
arguments (to your program) 28
arguments, to gdbserver 237
arguments, to user-defined commands 297
ARM 32-bit mode 264
ARM AArch64 292
ARM RDI 263
array aggregates (Ada) 193
arrays 109
arrays in expressions 105
artificial array 109
assembly instructions 100
assignment 209
async output in GDB/MI 370
async records in GDB/MI 372
asynchronous execution 75
asynchronous execution, and process record and replay 81
AT&T disassembly flavor 101
attach 31
attach to a program, gdbserver 238
auto-loading 286
auto-loading init file in the current directory 288
auto-loading libthread_db.so.1 288
auto-loading '*objfile*-gdb.gdb' 288
auto-loading safe-path 289
auto-loading verbose mode 290
auto-retry, for remote TCP target 244
automatic display 113
automatic hardware breakpoints 48
automatic overlay debugging 170
automatic thread selection 73
auxiliary vector 130
AVR 275

B

'b' packet 505
'B' packet 505
background execution 75
backtrace beyond main function 89
backtrace limit 90
base name differences 223
baud rate for remote targets 242
'bc' packet 505
bcache statistics 498
bits in remote address 242
blocks in python 336
bookmark 40
branch trace format 563
break in overloaded functions 181
break on a system call 53
break on fork/exec 53
BREAK signal instead of Ctrl-C 242
breakpoint address adjusted 64
breakpoint at static probe point 95
breakpoint commands 60
breakpoint commands for GDB/MI 380

breakpoint commands, in remote protocol 528
breakpoint conditions 59
breakpoint kinds, ARM 534
breakpoint kinds, MIPS 535
breakpoint numbers 43
breakpoint on events 43
breakpoint on memory address 43
breakpoint on variable modification 43
breakpoint ranges 43
`breakpoint` subroutine, remote 248
breakpointing Ada elaboration code 195
breakpoints 43
breakpoints and tasks, in Ada 198
breakpoints and threads 76
breakpoints at functions matching a regexp 45
breakpoints in overlays 170
breakpoints in python 342
breakpoints, multiple locations 47
'`bs`' packet 506
bug criteria 455
bug reports 455
bugs in GDB 455
build ID sections 224
build ID, and separate debugging files 223
building GDB, requirements for 489
built-in simulator target 232
builtin Go functions 183
builtin Go types 183

C

C and C++ 177
C and C++ checks 181
C and C++ constants 179
C and C++ defaults 181
C and C++ operators 177
'`c`' packet 506
'`C`' packet 506
C++ 177
C++ compilers 180
C++ exception handling 181
C++ overload debugging info 295
C++ scope resolution 108
C++ symbol decoding style 121
C++ symbol display 182
caching data of remote targets 138
call dummy stack unwinding 213
call dummy stack unwinding on unhandled exception. 213
call overloaded functions 180
call stack 87
call stack traces 88
calling functions 212
calling make 17
case sensitivity in symbol names 201
case-insensitive symbol names 201
casts, in expressions 105
casts, to view memory 105
catch Ada exceptions 53
catchpoints 43
catchpoints, setting 53
Cell Broadband Engine 278
change working directory 30
character sets 135
charset 135
checkpoint 40
checkpoints and process id 42
checks, range 176
checks, type 175
checksum, for GDB remote 503
choosing target byte order 234
circular trace buffer 159
clearing breakpoints, watchpoints, catchpoints 57
close, file-i/o system call 552
closest symbol and offset for an address 202
code address and its source line 99
code compression, MIPS 277
COFF/PE exported symbols 293
collected data discarded 158
colon, doubled as scope operator 191
colon-colon, context for variables/functions 107
command editing 459
command files 300
command history 282
command hooks 299
command interpreters 355
command line editing 281
command scripts, debugging 292
command tracing 292
commands for C++ 181
commands in python 326
commands to access python 303
comment 19
`COMMON` blocks, Fortran 186
common targets 232
compatibility, GDB/MI and CLI 370
compilation directory 98
compiling, on Sparclet 273
completion 19
completion of Python commands 327
completion of quoted strings 20
completion of structure field names 21
completion of union field names 21
compressed debug sections 489
conditional breakpoints 59
conditional tracepoints 153
configuring GDB 490
confirmation 292
connection timeout, for remote TCP target 244
console i/o as part of file-i/o 550
console interpreter 355
console output in GDB/MI 370
constants, in file-i/o protocol 558
continuing 65
continuing threads 72
control C, and remote debugging 249

controlling terminal 31
convenience functions 127
convenience functions in python 331
convenience variables 126
convenience variables for tracepoints 164
convenience variables, and trace state variables 154
convenience variables, initializing 126
core dump file 215
core dump file target 232
crash of debugger 455
CRC algorithm definition 225
CRC of memory block, remote request 517
CRIS 275
CRIS mode 275
CRIS version 275
Ctrl-BREAK, MS-Windows 255
ctrl-c message, in file-i/o protocol 549
current Ada task ID 197
current directory 98
current Go package 183
current stack frame 88
current thread 35
current thread, remote request 517
custom JIT debug info 448
Cygwin DLL, debugging 256
Cygwin-specific commands 255

D

D 183
'd' packet 506
'D' packet 506
Darwin 261
data breakpoints 43
data manipulation, in GDB/MI 416
dcache line-size 138
dcache size 138
dead names, GNU Hurd 260
debug expression parser 295
debug formats and C++ 180
debug link sections 224
debug remote protocol 295
debugger crash 455
debugging agent 451
debugging C++ programs 180
debugging information directory, global 223
debugging information in separate files 223
debugging libthread_db 38
debugging multiple processes 39
debugging optimized code 141
debugging stub, example 247
debugging target 231
debugging the Cygwin DLL 256
decimal floating point format 183
default collection action 156
default data directory 229
default source path substitution 98
default system root 221
define trace state variable, remote request 537
defining macros interactively 145
definition of a macro, showing 145
delete breakpoints 57
deleting breakpoints, watchpoints, catchpoints 57
deliver a signal to a program 211
demangling C++ names 121
deprecated commands 496
derived type of an object, printing 122
descriptor tables display 253
detach from task, GNU Hurd 259
detach from thread, GNU Hurd 260
direct memory access (DMA) on MS-DOS 254
directories for source files 96
directory, compilation 98
directory, current 98
disable address space randomization, remote request 517
disconnected tracing 158
displaced stepping debugging info 293
displaced stepping support 495
displaced stepping, and process record and replay 81
display command history 283
display derived types 122
display disabled out of scope 115
display GDB copyright 23
display of expressions 113
display remote monitor communications 233
display remote packets 295
DJGPP debugging 253
DLLs with no debugging symbols 257
do not print frame argument values 117
documentation 487
don't repeat command 298
don't repeat Python command 326
DOS file-name semantics of file names 222
DOS serial data link, remote debugging 255
DOS serial port status 255
download server address (M32R) 266
download to Sparclet 273
download to VxWorks 262
DPMI 253
dprintf 61
dump all data collected at tracepoint 163
dump core from inferior 135
dump data to a file 134
dump/restore files 134
DVC register 271
DWARF 2 compilation units cache 499
DWARF-2 CFI and CRIS 275
DWARF2 DIEs 293
DWARF2 Reading 293
dynamic linking 216
dynamic printf 61
dynamic varobj 408

E

editing ... 281
editing command lines ... 459
editing source files ... 95
eight-bit characters in strings ... 120
elaboration phase ... 27
Emacs ... 363
empty response, for unsupported packets ... 504
enable/disable a breakpoint ... 57
entering numbers ... 284
environment (of your program) ... 29
errno values, in file-i/o protocol ... 558
error on valid input ... 455
event debugging info ... 293
event designators ... 481
event handling ... 53
examine process image ... 251
examining data ... 103
examining memory ... 111
exception handlers ... 53
exceptions, python ... 308
executable file ... 215
executable file target ... 232
executable file, for remote target ... 243
execute commands from a file ... 300
execute forward or backward in time ... 80
execute remote command, remote request ... 521
execution, foreground, background and asynchronous ... 75
exiting GDB ... 17
expand macro once ... 145
expanding preprocessor macros ... 145
explore type ... 105
explore value ... 105
exploring hierarchical data structures ... 103
expression debugging info ... 294
expression parser, debugging info ... 295
expressions ... 105
expressions in Ada ... 192
expressions in C or C++ ... 177
expressions in C++ ... 180
expressions in Modula-2 ... 186
extend GDB for remote targets ... 236
extending GDB ... 297
extra signal information ... 71

F

'F' packet ... 506
F reply packet ... 549
F request packet ... 549
fast tracepoints ... 149
fast tracepoints, setting ... 151
fatal signal ... 455
fatal signals ... 70
features of the remote protocol ... 522
file name canonicalization ... 223
file transfer ... 237
file transfer, remote protocol ... 542
file-i/o examples ... 559
file-i/o overview ... 547
File-I/O remote protocol extension ... 547
file-i/o reply packet ... 549
file-i/o request packet ... 549
filename-display ... 90
find downloadable SREC files (M32R) ... 266
find trace snapshot ... 161
flinching ... 292
float promotion ... 285
floating point ... 130
floating point registers ... 128
floating point, MIPS remote ... 268
focus of debugging ... 35
foo ... 229
foreground execution ... 75
fork, debugging programs which call ... 38
format options ... 115
formatted output ... 110
Fortran ... 1
Fortran Defaults ... 185
Fortran operators and expressions ... 185
Fortran-specific support in GDB ... 185
FR-V shared-library debugging ... 295
frame debugging info ... 294
frame number ... 87
frame pointer ... 87
frame pointer register ... 128
frame, definition ... 87
frameless execution ... 87
frames in python ... 333
free memory information (MS-DOS) ... 253
fstat, file-i/o system call ... 554
Fujitsu ... 248
full symbol tables, listing GDB's internal ... 206
function call arguments, optimized out ... 89
function entry/exit, wrong values of variables ... 108
functions without line info, and stepping ... 66

G

'g' packet ... 506
'G' packet ... 507
g++, GNU C++ compiler ... 177
garbled pointers ... 253
GCC and C++ ... 180
GDB bugs, reporting ... 455
GDB internal error ... 497
gdb module ... 304
GDB reference card ... 487
GDB startup ... 16
GDB version number ... 23
'gdb.ini' ... 17
gdb.printing ... 349
gdb.prompt ... 351
gdb.types ... 350

`gdb.Value` ... 309
GDB/MI development ... 371
GDB/MI General Design ... 365
GDB/MI, async records ... 372
GDB/MI, breakpoint commands ... 380
GDB/MI, compatibility with CLI ... 370
GDB/MI, data manipulation ... 416
GDB/MI, input syntax ... 368
GDB/MI, its purpose ... 365
GDB/MI, output syntax ... 369
GDB/MI, result records ... 371
GDB/MI, simple examples ... 378
GDB/MI, stream records ... 372
gdbarch debugging info ... 292
`GDBHISTFILE`, environment variable ... 282
`gdbserver`, command-line arguments ... 237
`gdbserver`, multiple processes ... 238
gdbserver, search path for `libthread_db` ... 240
GDT ... 253
get thread information block address ... 518
get thread-local storage address, remote request ... 518
gettimeofday, file-i/o system call ... 555
global debugging information directories ... 223
GNU C++ ... 177
GNU Emacs ... 363
GNU Hurd debugging ... 258
GNU/Hurd debug messages ... 294
GNU/Linux LWP debug messages ... 294
Go (programming language) ... 183

H

'`H`' packet ... 507
handling signals ... 70
hardware breakpoints ... 45
hardware debug registers ... 500
hardware watchpoints ... 50
hash mark while downloading ... 233
`heuristic-fence-post` (Alpha, MIPS) ... 276
history events ... 481
history expansion ... 481
history expansion, turn on/off ... 282
history file ... 282
history number ... 125
history of values printed by GDB ... 125
history size ... 282
history substitution ... 282
`HISTSIZE`, environment variable ... 282
hooks, for commands ... 299
hooks, post-command ... 299
hooks, pre-command ... 299
host character set ... 135
Host I/O, remote protocol ... 542
how many arguments (user-defined commands) ... 297
HPPA support ... 278

I

'`i`' packet ... 507
'`I`' packet ... 507
i/o ... 30
I/O registers (Atmel AVR) ... 275
i386 ... 247
'`i386-stub.c`' ... 247
IDT ... 253
ignore count (of breakpoint) ... 60
in-process agent protocol ... 451
incomplete type ... 204
indentation in structure display ... 120
index files ... 227
index section format ... 589
inferior ... 32
inferior debugging info ... 294
inferior events in Python ... 323
inferior functions, calling ... 212
inferior tty ... 31
inferiors in Python ... 322
infinite recursion in user-defined commands ... 298
info for known .debug_gdb_scripts-loaded scripts ... 498
info for known object files ... 498
info proc cmdline ... 252
info proc cwd ... 252
info proc exe ... 252
information about static tracepoint markers ... 157
information about tracepoints ... 156
inheritance ... 181
init file ... 16
init file name ... 17
initial frame ... 87
initialization file, readline ... 462
inline functions, debugging ... 141
innermost frame ... 87
input syntax for GDB/MI ... 368
installation ... 489
instructions, assembly ... 100
integral datatypes, in file-i/o protocol ... 556
Intel ... 247
Intel disassembly flavor ... 101
interaction, readline ... 459
internal commands ... 495
internal errors, control of GDB behavior ... 497
internal GDB breakpoints ... 50
interrupt ... 17
interrupt debuggee on MS-Windows ... 255
interrupt remote programs ... 242, 243
interrupting remote programs ... 236
interrupting remote targets ... 249
interrupts (remote protocol) ... 543
invalid input ... 455
invoke another interpreter ... 355
ipa protocol commands ... 453
ipa protocol objects ... 452
isatty, file-i/o system call ... 555

J

JIT compilation interface 447
JIT debug info reader 448
just-in-time compilation 447
just-in-time compilation, debugging messages 294

K

'k' packet 507
kernel crash dump 251
kernel memory image 251
kill ring 460
killing text 460

L

languages 173
last tracepoint number 152
latest breakpoint 44
lazy strings in python 345
LDT 253
leaving GDB 17
libkvm 251
library list format, remote protocol 559, 560
limit hardware breakpoints and watchpoints .. 243
limit hardware watchpoints length 243
limit on number of printed array elements 117
limits, in file-i/o protocol 559
linespec 94
Linux lightweight processes 294
list active threads, remote request 517
list of supported file-i/o calls 550
list output in GDB/MI 370
list, how many lines to display 93
listing GDB's internal symbol tables 206
listing machine instructions 100
listing mapped overlays 169
load address, overlay's 167
load shared library 220
load symbols from memory 217
local variables 205
locate address 110
lock scheduler 73
log output in GDB/MI 370
logging file name 18
logging GDB output 18
lseek flags, in file-i/o protocol 559
lseek, file-i/o system call 553

M

'm' packet 507
'M' packet 508
M32-EVA target board address 266
M32R/Chaos debugging 266
m680x0 248
'm68k-stub.c' 248
Mach-O symbols processing 294
machine instructions 100
macro definition, showing 145
macro expansion, showing the results of preprocessor 145
macros, example of debugging with 146
macros, from debug info 145
macros, user-defined 145
mailing lists 371
maintenance commands 495
manual overlay debugging 169
map an overlay 169
mapinfo list, QNX Neutrino 253
mapped address 167
mapped overlays 167
markers, static tracepoints 149
maximum value for offset of closest symbol 116
member functions 180
memory address space mappings 252
memory map format 561
memory region attributes 132
memory tracing 43
memory transfer, in file-i/o protocol 556
memory used by commands 500
memory used for symbol tables 219
memory, alignment and size of remote accesses 508
memory, viewing as typed object 105
mi interpreter 355
mi1 interpreter 355
mi2 interpreter 355
minimal language 200
Minimal symbols and DLLs 257
MIPS addresses, masking 277
MIPS boards 267
MIPS remote floating point 268
MIPS stack 276
miscellaneous settings 296
MMX registers (x86) 129
mode_t values, in file-i/o protocol 558
Modula-2 1
Modula-2 built-ins 187
Modula-2 checks 191
Modula-2 constants 188
Modula-2 defaults 191
Modula-2 operators 186
Modula-2 types 189
Modula-2, deviations from 191
Modula-2, GDB support 186
monitor commands, for gdbserver 240
Motorola 680x0 248
MS Windows debugging 255
MS-DOS system info 253
MS-DOS-specific commands 253
multiple locations, breakpoints 47
multiple processes 38
multiple processes with gdbserver 238
multiple targets 231

multiple threads ... 35
multiple threads, backtrace ... 88
multiple-symbols menu ... 106
multiprocess extensions, in remote protocol ... 527

N

name a thread ... 37
names of symbols ... 201
namespace in C++ ... 180
native Cygwin debugging ... 255
native DJGPP debugging ... 253
negative breakpoint numbers ... 50
NetROM ROM emulator target ... 233
`New` *systag* message ... 35
Newlib OS ABI and its influence on the longjmp handling ... 285
non-member C++ functions, set breakpoint in ... 45
non-stop mode ... 74
non-stop mode, and `breakpoint always-inserted` ... 49
non-stop mode, and process record and replay ... 81
non-stop mode, and '`set displaced-stepping`' ... 496
non-stop mode, remote request ... 520
noninvasive task options ... 259
notation, readline ... 459
notational conventions, for GDB/MI ... 365
notification packets ... 544
notify output in GDB/MI ... 370
NULL elements in arrays ... 120
number of array elements to print ... 117
number representation ... 284
numbers for breakpoints ... 43

O

object files, relocatable, reading symbols from ... 217
Objective-C ... 184
Objective-C, classes and selectors ... 206
Objective-C, print objects ... 184
'*objfile*`-gdb.py`' ... 347
objfiles in python ... 333
observer debugging info ... 295
octal escapes in strings ... 120
online documentation ... 21
opaque data types ... 206
open flags, in file-i/o protocol ... 558
open, file-i/o system call ... 550
OpenCL C ... 185
OpenCL C Datatypes ... 185
OpenCL C Expressions ... 185
OpenCL C Operators ... 185
OpenRISC 1000 ... 269
OpenRISC 1000 htrace ... 270
operating system information ... 585
operating system information, process list ... 585
optimized code, debugging ... 141
optimized code, wrong values of variables ... 108
optimized out value in Python ... 309
optimized out, in backtrace ... 89
optional debugging messages ... 292
optional warnings ... 291
or1k boards ... 269
OS ABI ... 285
OS information ... 130
out-of-line single-stepping ... 495
outermost frame ... 87
output formats ... 110
output syntax of GDB/MI ... 369
overlay area ... 167
overlay example program ... 171
overlays ... 167
overlays, setting breakpoints in ... 170
overloaded functions, calling ... 180
overloaded functions, overload resolution ... 182
overloading in C++ ... 181

P

'`p`' packet ... 508
'`P`' packet ... 508
packet acknowledgment, for GDB remote ... 546
packet size, remote protocol ... 525
packets, notification ... 544
packets, reporting on stdout ... 295
packets, tracepoint ... 535
page tables display (MS-DOS) ... 254
parameters in python ... 329
partial symbol dump ... 206
partial symbol tables, listing GDB's internal ... 206
Pascal ... 1
Pascal objects, static members display ... 122
Pascal support in GDB, limitations ... 186
pass signals to inferior, remote request ... 520
patching binaries ... 213
patching object files ... 215
pause current task (GNU Hurd) ... 259
pause current thread (GNU Hurd) ... 260
pauses in output ... 283
pending breakpoints ... 47
physical address from linear address ... 254
physname ... 293
pipe, `target remote` to ... 236
pipes ... 26
pointer values, in file-i/o protocol ... 556
pointer, finding referent ... 116
port rights, GNU Hurd ... 260
port sets, GNU Hurd ... 260
PowerPC architecture ... 279
prefix for data files ... 229
prefix for shared library file names ... 221
premature return from system calls ... 76
preprocessor macro expansion, showing the results of ... 145

pretty print arrays ... 117
pretty print C++ virtual function tables ... 122
pretty-printer commands ... 124
print all frame argument values ... 117
print an Objective-C object description ... 184
print array indexes ... 117
print frame argument values for scalars only ... 117
print list of auto-loaded canned sequences of commands scripts ... 289
print list of auto-loaded Python scripts ... 347
print messages on inferior start and exit ... 34
print messages on thread start and exit ... 37
print settings ... 115
print structures in indented form ... 120
print/don't print memory addresses ... 115
printing byte arrays ... 111
printing data ... 103
printing frame argument values ... 117
printing strings ... 111
probe static tracepoint marker ... 151
probing markers, static tracepoints ... 149
process detailed status information ... 252
process ID ... 252
process info via '`/proc`' ... 251
process list, QNX Neutrino ... 253
process record and replay ... 81
process status register ... 128
processes, multiple ... 38
`procfs` API calls ... 252
profiling GDB ... 499
program counter register ... 128
program entry point ... 89
programming in python ... 304
progspaces in python ... 332
prompt ... 281
protocol basics, file-i/o ... 548
protocol, GDB remote serial ... 503
protocol-specific representation of datatypes, in file-i/o protocol ... 556
python api ... 304
Python architectures ... 346
Python auto-loading ... 346
python commands ... 303, 326
python convenience functions ... 331
python directory ... 303
python exceptions ... 308
python finish breakpoints ... 344
python functions ... 304
python module ... 304
python modules ... 349
python pagination ... 304
python parameters ... 329
python scripting ... 303
python stdout ... 304
Python, working with types ... 313
python, working with values from inferior ... 309

Q

'`q`' packet ... 508
'`Q`' packet ... 508
'`QAllow`' packet ... 516
'`qAttached`' packet ... 533
'`qC`' packet ... 517
'`qCRC`' packet ... 517
'`QDisableRandomization`' packet ... 517
'`qfThreadInfo`' packet ... 517
'`qGetTIBAddr`' packet ... 518
'`qGetTLSAddr`' packet ... 518
'`QNonStop`' packet ... 520
'`qOffsets`' packet ... 519
'`qP`' packet ... 519
'`QPassSignals`' packet ... 520
'`QProgramSignals`' packet ... 520
'`qRcmd`' packet ... 521
'`qSearch memory`' packet ... 521
'`qSearch:memory`' packet ... 521
'`QStartNoAckMode`' packet ... 522
'`qsThreadInfo`' packet ... 517
'`qSupported`' packet ... 522
'`qSymbol`' packet ... 528
'`qTBuffer`' packet ... 541
'`QTBuffer size`' packet ... 541
'`QTDisable`' packet ... 538
'`QTDisconnected`' packet ... 538
'`QTDP`' packet ... 535
'`QTDPsrc`' packet ... 536
'`QTDV`' packet ... 537
'`QTEnable`' packet ... 538
'`qTfP`' packet ... 540
'`QTFrame`' packet ... 537
'`qTfSTM`' packet ... 540
'`qTfV`' packet ... 540
'`qThreadExtraInfo`' packet ... 529
'`QTinit`' packet ... 538
'`qTMinFTPILen`' packet ... 537
'`QTNotes`' packet ... 541
'`qTP`' packet ... 540
'`QTro`' packet ... 538
'`QTSave`' packet ... 541
'`qTsP`' packet ... 540
'`qTsSTM`' packet ... 540
'`QTStart`' packet ... 538
'`qTStatus`' packet ... 538
'`qTSTMat`' packet ... 541
'`QTStop`' packet ... 538
'`qTsV`' packet ... 540
'`qTV`' packet ... 540
query attached, remote request ... 533
quotes in commands ... 20
quoting Ada internal identifiers ... 195
quoting names ... 201
'`qXfer`' packet ... 529

R

'r' packet 508
'R' packet 508
raise exceptions 56
range checking 176
range stepping 68
ranged breakpoint 271
ranges of breakpoints 43
Ravenscar Profile 199
raw printing 111
RDI heartbeat 265
read special object, remote request 529
read, file-i/o system call 552
read-only sections 219
reading symbols from relocatable object files .. 217
reading symbols immediately 216
readline 281
receive rights, GNU Hurd 260
recent tracepoint number 152
record aggregates (Ada) 193
record mode 81
record serial communications on file 243
recording a session script 456
recording inferior's execution and replaying it .. 81
redirection 30
reference card 487
reference declarations 180
register packet format, MIPS 534
registers 128
regular expression 45
reloading the overlay table 169
relocatable object files, reading symbols from .. 217
remote async notification debugging info 294
remote connection without stubs 237
remote debugging 235
remote memory comparison 113
remote monitor prompt 269
remote packets, enabling and disabling 244
remote programs, interrupting 236
remote protocol debugging 295
remote protocol, binary data 503
remote protocol, field separator 503
remote query requests 516
remote serial debugging summary 250
remote serial debugging, overview 247
remote serial protocol 503
remote serial stub 248
remote serial stub list 247
remote serial stub, initialization 248
remote serial stub, main routine 248
remote stub, example 247
remote stub, support routines 248
remote target 232
remote target, file transfer 237
remote target, limit break- and watchpoints ... 243
remote target, limit watchpoints length 243
remote timeout 243
remove actions from a tracepoint 154
rename, file-i/o system call 553
Renesas 248
repeated array elements 119
repeating command sequences 19
repeating commands 19
replay log events, remote reply 515
replay mode 81
reporting bugs in GDB 455
reprint the last value 103
reset SDI connection, M32R 266
response time, MIPS debugging 276
restart 40
restore data from a file 134
restrictions on Go expressions 183
result records in GDB/MI 371
resume threads of multiple processes simultaneously 73
resuming execution 65
retransmit-timeout, MIPS protocol 268
returning from a function 211
reverse execution 79
rewind program state 40
ROM at zero address, RDI 265
run to main procedure 27
run until specified location 67
running 26
running and debugging Sparclet programs 274
running programs backward 79
running VxWorks tasks 263
running, on Sparclet 273

S

's' packet 509
'S' packet 509
save breakpoints to a file for future sessions 63
save command history 282
save GDB output to a file 18
save tracepoints for future sessions 164
scheduler locking mode 73
scope 191
scripting commands 300
scripting with python 303
SDS protocol 272
search for a thread 37
search path for libthread_db 37
searching memory 139
searching memory, in remote debugging 521
searching source files 96
section offsets, remote request 519
segment descriptor tables 253
select Ctrl-C, BREAK or BREAK-g 243
select trace snapshot 161
selected frame 87
selecting frame silently 88
semaphores on static probe points 63
send command to remote monitor 236
send command to simulator 263

send interrupt-sequence on start 243
send PMON command 269
send rights, GNU Hurd 260
sending files to remote systems 237
separate debug sections 227
separate debugging information files 223
sequence-id, for GDB remote 503
serial connections, debugging 295
serial line, `target remote` 235
serial protocol, GDB remote 503
server prefix 444
`server`, command prefix 282
set ABI for MIPS 277
set breakpoints in many functions 45
set breakpoints on all functions 45
set fast tracepoint 151
set inferior controlling terminal 31
set static tracepoint 151
set tdesc filename 577
set tracepoint 150
setting variables 209
setting watchpoints 50
SH 248
'`sh-stub.c`' 248
shared libraries 219
shared library events, remote reply 515
shell escape 17
show all convenience functions 128
show all user variables and functions 126
show last commands 283
show tdesc filename 577
signals 70
signals the inferior may see, remote request ... 520
`SIGQUIT` signal, dump core of GDB 496
simulator, Z8000 274
size of remote memory accesses 508
size of screen 283
skipping over functions and files 69
snapshot of a process 40
software watchpoints 50
source file and line of a symbol 116
source line and its code address 99
source path 96
Sparc 248
'`sparc-stub.c`' 248
'`sparcl-stub.c`' 248
Sparclet 273
SparcLite 248
Special Fortran commands 186
specifying location 94
SPU 278
SSE registers (x86) 129
stack frame 87
stack on Alpha 276
stack on MIPS 276
stack pointer register 128
stacking targets 231
standard registers 128
start a new trace experiment 158
starting 26
startup code, and backtrace 89
stat, file-i/o system call 554
static members of C++ objects 122
static members of Pascal objects 122
static probe point, SystemTap 63
static tracepoints 149
static tracepoints, in remote protocol 527
static tracepoints, setting 151
status of trace data collection 158
status output in GDB/MI 370
stepping 65
stepping into functions with no line info 66
stop a running trace experiment 158
stop on C++ exceptions 53
stop reply packets 514
stopped threads 72
stream records in GDB/MI 372
string tracing, in remote protocol 528
`struct gdb_reader_funcs` 449
`struct gdb_symbol_callbacks` 449
`struct gdb_unwind_callbacks` 449
struct return convention 276
struct stat, in file-i/o protocol 557
struct timeval, in file-i/o protocol 557
struct/union returned in registers 276
structure field name completion 21
stub example, remote debugging 247
stupid questions 292
Super-H 275
supported packets, remote query 522
switching threads 35
switching threads automatically 73
symbol decoding style, C++ 121
symbol dump 206
symbol from address 202
symbol lookup, remote request 528
symbol names 201
symbol table 215
symbol table creation 295
symbol tables in python 340
symbol tables, listing GDB's internal 206
symbol, source file and line 116
symbols in python 337
symbols, reading from relocatable object files .. 217
symbols, reading immediately 216
synchronize with remote MIPS target 269
`syscall DSO` 217
system calls and thread breakpoints 76
system root, alternate 221
system, file-i/o system call 555
system-wide init file 494

T

'`t`' packet 509
'`T`' packet 509

'T' packet reply 514
tail call frames, debugging 142
target architecture 231
target byte order 234
target character set 135
target debugging info 295
target descriptions 577
target descriptions, AArch64 features 582
target descriptions, ARM features 582
target descriptions, i386 features 583
target descriptions, inclusion 578
target descriptions, M68K features 584
target descriptions, MIPS features 583
target descriptions, PowerPC features 584
target descriptions, predefined types 581
target descriptions, standard features 582
target descriptions, TIC6x features 584
target descriptions, TMS320C6x features 584
target descriptions, XML format 577
target output in GDB/MI 370
target remote 235
target stack description 499
target-assisted range stepping 68
task attributes (GNU Hurd) 259
task breakpoints, in Ada 198
task exception port, GNU Hurd 259
task suspend count 259
task switching with program using Ravenscar Profile 199
TCP port, target remote 235
terminal 30
Text User Interface 357
thread attributes info, remote request 529
thread breakpoints 76
thread breakpoints and system calls 76
thread default settings, GNU Hurd 260
thread identifier (GDB) 36
thread identifier (system) 35
thread info (Solaris) 36
thread information, remote request 519
thread list format 562
thread number 36
thread properties, GNU Hurd 260
thread suspend count, GNU Hurd 260
thread-id, in remote protocol 504
threads and watchpoints 52
threads in python 325
threads of execution 35
threads, automatic switching 73
threads, continuing 72
threads, stopped 72
time of command execution 500
timeout for commands 501
timeout for serial communications 243
timeout, for remote target connection 244
timeout, MIPS protocol 268
timestampping debugging info 296
trace experiment, status of 158
trace file format 587
trace files 165
trace state variable value, remote request 540
trace state variables 153
traceback 88
traceframe info format 562
tracepoint actions 154
tracepoint conditions 153
tracepoint data, display 163
tracepoint deletion 152
tracepoint number 152
tracepoint packets 535
tracepoint pass count 153
tracepoint restrictions 160
tracepoint status, remote request 540
tracepoint variables 164
tracepoints 149
tracepoints support in gdbserver 241
trailing underscore, in Fortran symbols 185
translating between character sets 135
TUI 357
TUI commands 359
TUI configuration variables 361
TUI key bindings 358
TUI single key mode 359
type casting memory 105
type chain of a data type 499
type checking 175
type conversions in C++ 180
type printer 321
type printing API for Python 321
types in Python 313

U

UDP port, target remote 236
union field name completion 21
unions in structures, printing 120
unknown address, locating 110
unlink, file-i/o system call 554
unlinked object files 215
unload symbols from shared libraries 220
unmap an overlay 169
unmapped overlays 167
unset tdesc filename 577
unsupported languages 200
unwind stack in called functions 213
unwind stack in called functions with unhandled exceptions 213
use only software watchpoints 51
user-defined command 297
user-defined macros 145
user-defined variables 126

V

value history 125
values from inferior, with Python 309

variable name conflict 107
variable object debugging info 296
variable objects in GDB/MI 406
variable values, wrong 108
variables, readline 462
variables, setting 209
'vAttach' packet 509
'vCont' packet 509
'vCont?' packet 510
vector unit 130
vector, auxiliary 130
verbose operation 291
verify remote memory image 113
'vFile' packet 511
'vFlashDone' packet 511
'vFlashErase' packet 511
'vFlashWrite' packet 511
virtual functions (C++) display 122
'vKill' packet 511
'vRun' packet 512
'vStopped' packet 512
VTBL display 122
VxWorks 261

W

watchdog timer 501
watchpoints 43
watchpoints and threads 52
weak alias functions 213
where to look for shared libraries 220
wild pointer, interpreting 116
word completion 19
working directory 98
working directory (of your program) 30
working language 173
write data into object, remote request 532
write, file-i/o system call 552
writing a pretty-printer 319
writing convenience functions 331
writing into corefiles 213
writing into executables 213
writing JIT debug info readers 449
wrong values 108

X

x command, default address 100
'X' packet 512
Xilinx MicroBlaze 267
XInclude 578
XMD, Xilinx Microprocessor Debugger 267
XML parser debugging 296

Y

yanking text 460

Z

'z' packet 512
'Z' packets 512
'z0' packet 512
'Z0' packet 512
'z1' packet 513
'Z1' packet 513
'z2' packet 513
'Z2' packet 513
'z3' packet 514
'Z3' packet 514
'z4' packet 514
'Z4' packet 514
Z8000 274
Zilog Z8000 simulator 274

Command, Variable, and Function Index

!

! 17

#

(a comment) 19

$

$_, convenience variable 127
$__, convenience variable 127
$_exitcode, convenience variable 127
$_memeq, convenience function 128
$_probe_arg, convenience variable 64
$_regex, convenience function 128
$_sdata, collect 155
$_sdata, inspect, convenience variable 127
$_siginfo, convenience variable 127
$_streq, convenience function 128
$_strlen, convenience function 128
$_thread, convenience variable 36
$_tlb, convenience variable 127
$bpnum, convenience variable 44
$cdir, convenience variable 98
$cwd, convenience variable 98
$tpnum 152
$trace_file 164
$trace_frame 164
$trace_func 164
$trace_line 164
$tracepoint 164

-

-ada-task-info 393
-add-inferior 440
-break-after 380
-break-commands 380
-break-condition 381
-break-delete 381
-break-disable 382
-break-enable 382
-break-info 383
-break-insert 383
-break-list 385
-break-passcount 386
-break-watch 386
-catch-load 388
-catch-unload 389
-data-disassemble 416
-data-evaluate-expression 419
-data-list-changed-registers 419
-data-list-register-names 420
-data-list-register-values 420
-data-read-memory 422
-data-read-memory-bytes 423
-data-write-memory-bytes 424
-enable-pretty-printing 408
-enable-timings 442
-environment-cd 389
-environment-directory 390
-environment-path 390
-environment-pwd 391
-exec-arguments 389
-exec-continue 394
-exec-finish 395
-exec-interrupt 396
-exec-jump 396
-exec-next 397
-exec-next-instruction 397
-exec-return 398
-exec-run 398
-exec-step 399
-exec-step-instruction 400
-exec-until 400
-file-exec-and-symbols 429
-file-exec-file 429
-file-list-exec-source-file 430
-file-list-exec-source-files 430
-file-symbol-file 430
-gdb-exit 435
-gdb-set 436
-gdb-show 436
-gdb-version 436
-inferior-tty-set 441
-inferior-tty-show 441
-info-os 439
-interpreter-exec 441
-list-features 437
-list-target-features 438
-list-thread-groups 438
-stack-info-depth 401
-stack-info-frame 401
-stack-list-arguments 402
-stack-list-frames 403
-stack-list-locals 405
-stack-list-variables 405
-stack-select-frame 406
-symbol-list-lines 429
-target-attach 431
-target-detach 431
-target-disconnect 432
-target-download 432
-target-file-delete 435
-target-file-get 435
-target-file-put 434
-target-select 434
-thread-info 391

-thread-list-ids ... 392
-thread-select ... 393
-trace-define-variable ... 426
-trace-find ... 425
-trace-list-variables ... 426
-trace-save ... 427
-trace-start ... 427
-trace-status ... 427
-trace-stop ... 428
-var-assign ... 413
-var-create ... 408
-var-delete ... 409
-var-evaluate-expression ... 412
-var-info-expression ... 412
-var-info-num-children ... 410
-var-info-path-expression ... 412
-var-info-type ... 411
-var-list-children ... 410
-var-set-format ... 409
-var-set-frozen ... 415
-var-set-update-range ... 415
-var-set-visualizer ... 415
-var-show-attributes ... 412
-var-show-format ... 410
-var-update ... 413

:

::, in Modula-2 ... 191

@

@, referencing memory as an array ... 109

^

^connected ... 371
^done ... 371
^error ... 371
^exit ... 371
^running ... 371

_

__init__ on TypePrinter ... 351

A

abort (C-g) ... 477
accept-line (Newline or Return) ... 472
actions ... 154
add-auto-load-safe-path ... 289
add-inferior ... 33
add-shared-symbol-files ... 217
add-symbol-file ... 216
add-symbol-file-from-memory ... 217
advance *location* ... 68
alias ... 352
append ... 134
apropos ... 22
Architecture.disassemble ... 346
Architecture.name ... 346
assf ... 217
attach ... 31
attach& ... 75
awatch ... 51

B

b (break) ... 44
backtrace ... 88
backward-char (C-b) ... 472
backward-delete-char (Rubout) ... 474
backward-kill-line (C-x Rubout) ... 475
backward-kill-word (M-DEL) ... 475
backward-word (M-b) ... 472
beginning-of-history (M-<) ... 473
beginning-of-line (C-a) ... 472
bell-style ... 462
bind-tty-special-chars ... 463
Block.end ... 337
Block.function ... 337
Block.global_block ... 337
Block.is_global ... 337
Block.is_static ... 337
Block.is_valid ... 336
Block.start ... 337
Block.static_block ... 337
Block.superblock ... 337
BP_ACCESS_WATCHPOINT ... 344
BP_BREAKPOINT ... 343
BP_HARDWARE_WATCHPOINT ... 344
BP_READ_WATCHPOINT ... 344
BP_WATCHPOINT ... 343
break ... 44
break ... task *taskno* (Ada) ... 198
break ... thread *threadno* ... 76
break, and Objective-C ... 184
break-range ... 271
breakpoint annotation ... 446
Breakpoint.__init__ ... 342
Breakpoint.commands ... 344
Breakpoint.condition ... 344
Breakpoint.delete ... 343
Breakpoint.enabled ... 343
Breakpoint.expression ... 344
Breakpoint.hit_count ... 344
Breakpoint.ignore_count ... 343
Breakpoint.is_valid ... 343
Breakpoint.location ... 344
Breakpoint.number ... 343
Breakpoint.silent ... 343
Breakpoint.stop ... 342
Breakpoint.task ... 343
Breakpoint.thread ... 343
Breakpoint.type ... 343

Breakpoint.visible 343
BreakpointEvent.breakpoint 325
BreakpointEvent.breakpoints 324
breakpoints-invalid annotation 445
bt (backtrace) 88

C

c (continue) 65
c (SingleKey TUI key) 359
C-L 359
C-x 1 358
C-x 2 358
C-x a 358
C-x A 358
C-x C-a 358
C-x o 358
C-x s 358
call 212
call-last-kbd-macro (C-x e) 477
capitalize-word (M-c) 474
catch 53
cd 30
cdir 98
character-search (C-]) 478
character-search-backward (M-C-]) 478
checkpoint 41
clear 57
clear, and Objective-C 184
clear-screen (C-l) 472
clone-inferior 33
collect (tracepoints) 155
Command.__init__ 326
Command.complete 327
Command.dont_repeat 326
Command.invoke 326
COMMAND_BREAKPOINTS 328
COMMAND_DATA 327
COMMAND_FILES 328
COMMAND_MAINTENANCE 328
COMMAND_NONE 327
COMMAND_OBSCURE 328
COMMAND_RUNNING 327
COMMAND_STACK 327
COMMAND_STATUS 328
COMMAND_SUPPORT 328
COMMAND_TRACEPOINTS 328
COMMAND_USER 328
commands 60
commands annotation 444
comment-begin 463
compare-sections 113
complete 22
complete (TAB) 476
COMPLETE_COMMAND 329
COMPLETE_FILENAME 328
COMPLETE_LOCATION 329
COMPLETE_NONE 328
COMPLETE_SYMBOL 329
completion-display-width 463
completion-ignore-case 463
completion-map-case 463
completion-prefix-display-length 463
completion-query-items 463
condition 59
continue 65
continue& 75
convert-meta 463
copy-backward-word () 475
copy-forward-word () 476
copy-region-as-kill () 475
core-file 216
Ctrl-o (operate-and-get-next) 19
cwd 98

D

d (delete) 57
d (SingleKey TUI key) 359
debug_chaos 266
define 298
delete 57
delete checkpoint *checkpoint-id* 41
delete display 114
delete mem 132
delete tracepoint 152
delete tvariable 154
delete-char (C-d) 474
delete-char-or-list () 477
delete-horizontal-space () 475
detach 32
detach (remote) 236
detach inferiors *infno* 34
digit-argument (*M-0*, *M-1*, ... *M--*) 476
dir 97
directory 97
dis (disable) 58
disable 58
disable display 114
disable mem 132
disable pretty-printer 124
disable tracepoint 152
disable type-printer 205
disable-completion 463
disassemble 100
disconnect 236
display 114
dll-symbols 256
do (down) 91
do-uppercase-version (M-a, M-b, M-*x*, ...) 477
document 298
dont-repeat 298
down 91
Down 358
down-silently 91

downcase-word (M-l) 474
dprintf 62
dprintf-style agent 62
dprintf-style call 62
dprintf-style gdb 62
dump 134
dump-functions () 478
dump-macros () 478
dump-variables () 478

E

e (edit) 95
echo 301
edit 95
editing-mode 464
else 301
emacs-editing-mode (C-e) 478
enable 58
enable display 114
enable mem 132
enable pretty-printer 124
enable tracepoint 152
enable type-printer 205
enable-keypad 464
enabled of type_printer 321
end (breakpoint commands) 60
end (if/else/while commands) 301
end (user-defined commands) 298
end-kbd-macro (C-x)) 477
end-of-history (M->) 473
end-of-line (C-e) 472
error annotation 445
error-begin annotation 445
eval 303
EventRegistry.connect 323
EventRegistry.disconnect 323
exceptionHandler 249
exchange-point-and-mark (C-x C-x) 478
exec-file 215
exited annotation 445
ExitedEvent 324
ExitedEvent.exit_code 324
expand-tilde 464
explore 103

F

f (frame) 90
f (SingleKey TUI key) 359
fg (resume foreground execution) 65
file 215
fin (finish) 67
find 139
finish 67
finish& 76
FinishBreakpoint.__init__ 344
FinishBreakpoint.out_of_scope 345
FinishBreakpoint.return_value 345
flush_i_cache 249
flushregs 498
fo (forward-search) 96
focus 360
forward-backward-delete-char () 474
forward-char (C-f) 472
forward-search 96
forward-search-history (C-s) 473
forward-word (M-f) 472
frame, command 88
frame, selecting 90
Frame.architecture 334
Frame.block 335
Frame.find_sal 336
Frame.function 336
Frame.is_valid 334
Frame.name 334
Frame.newer 336
Frame.older 336
Frame.pc 335
Frame.read_var 336
Frame.select 336
Frame.type 334
Frame.unwind_stop_reason 335
frames-invalid annotation 445
ftrace 151
Function 331
Function.__init__ 331
Function.invoke 331

G

gcore 135
gdb.Block 336
gdb.block_for_pc 336
gdb.BP_ACCESS_WATCHPOINT 344
gdb.BP_BREAKPOINT 343
gdb.BP_HARDWARE_WATCHPOINT 344
gdb.BP_READ_WATCHPOINT 344
gdb.BP_WATCHPOINT 343
gdb.Breakpoint 342
gdb.breakpoints 305
gdb.COMMAND_BREAKPOINTS 328
gdb.COMMAND_DATA 327
gdb.COMMAND_FILES 328
gdb.COMMAND_MAINTENANCE 328
gdb.COMMAND_NONE 327
gdb.COMMAND_OBSCURE 328
gdb.COMMAND_RUNNING 327
gdb.COMMAND_STACK 327
gdb.COMMAND_STATUS 328
gdb.COMMAND_SUPPORT 328
gdb.COMMAND_TRACEPOINTS 328
gdb.COMMAND_USER 328
gdb.COMPLETE_COMMAND 329
gdb.COMPLETE_FILENAME 328
gdb.COMPLETE_LOCATION 329

gdb.COMPLETE_NONE 328
gdb.COMPLETE_SYMBOL 329
gdb.current_objfile 333
gdb.current_progspace 332
gdb.decode_line 307
gdb.default_visualizer 318
gdb.error 308
gdb.execute 305
gdb.find_pc_line 305
gdb.FinishBreakpoint 344
gdb.flush 306
gdb.frame_stop_reason_string 334
gdb.Function 331
gdb.GdbError 308
gdb.history 305
gdb.Inferior 322
gdb.inferiors 322
gdb.InferiorThread 325
gdb.LazyString 345
gdb.lookup_global_symbol 338
gdb.lookup_symbol 337
gdb.lookup_type 313
gdb.MemoryError 308
gdb.newest_frame 334
gdb.Objfile 333
gdb.objfiles 333
gdb.PARAM_AUTO_BOOLEAN 330
gdb.PARAM_BOOLEAN 330
gdb.PARAM_ENUM 331
gdb.PARAM_FILENAME 331
gdb.PARAM_INTEGER 331
gdb.PARAM_OPTIONAL_FILENAME 331
gdb.PARAM_STRING 331
gdb.PARAM_STRING_NOESCAPE 331
gdb.PARAM_UINTEGER 331
gdb.PARAM_ZINTEGER 331
gdb.parameter 305
gdb.Parameter 329
gdb.parse_and_eval 305
gdb.post_event 306
gdb.Progspace 332
gdb.progspaces 332
gdb.prompt_hook 307
gdb.PYTHONDIR 304
gdb.search_memory 323
gdb.selected_frame 334
gdb.selected_inferior 322
gdb.selected_thread 325
gdb.solib_name 307
gdb.STDERR 306, 307
gdb.STDLOG 306, 307
gdb.STDOUT 306, 307
gdb.string_to_argv 327
gdb.Symbol 337
gdb.SYMBOL_FUNCTIONS_DOMAIN 339
gdb.SYMBOL_LABEL_DOMAIN 339
gdb.SYMBOL_LOC_ARG 340
gdb.SYMBOL_LOC_BLOCK 340
gdb.SYMBOL_LOC_COMPUTED 340
gdb.SYMBOL_LOC_CONST 339
gdb.SYMBOL_LOC_CONST_BYTES 340
gdb.SYMBOL_LOC_LOCAL 340
gdb.SYMBOL_LOC_OPTIMIZED_OUT 340
gdb.SYMBOL_LOC_REF_ARG 340
gdb.SYMBOL_LOC_REGISTER 340
gdb.SYMBOL_LOC_REGPARM_ADDR 340
gdb.SYMBOL_LOC_STATIC 340
gdb.SYMBOL_LOC_TYPEDEF 340
gdb.SYMBOL_LOC_UNDEF 339
gdb.SYMBOL_LOC_UNRESOLVED 340
gdb.SYMBOL_STRUCT_DOMAIN 339
gdb.SYMBOL_TYPES_DOMAIN 339
gdb.SYMBOL_UNDEF_DOMAIN 339
gdb.SYMBOL_VAR_DOMAIN 339
gdb.SYMBOL_VARIABLES_DOMAIN 339
gdb.Symtab 340
gdb.Symtab_and_line 340
gdb.target_charset 307
gdb.target_wide_charset 307
gdb.Type 313
gdb.TYPE_CODE_ARRAY 315
gdb.TYPE_CODE_BITSTRING 316
gdb.TYPE_CODE_BOOL 316
gdb.TYPE_CODE_CHAR 316
gdb.TYPE_CODE_COMPLEX 316
gdb.TYPE_CODE_DECFLOAT 316
gdb.TYPE_CODE_ENUM 315
gdb.TYPE_CODE_ERROR 316
gdb.TYPE_CODE_FLAGS 315
gdb.TYPE_CODE_FLT 316
gdb.TYPE_CODE_FUNC 316
gdb.TYPE_CODE_INT 316
gdb.TYPE_CODE_INTERNAL_FUNCTION 317
gdb.TYPE_CODE_MEMBERPTR 316
gdb.TYPE_CODE_METHOD 316
gdb.TYPE_CODE_METHODPTR 316
gdb.TYPE_CODE_NAMESPACE 316
gdb.TYPE_CODE_PTR 315
gdb.TYPE_CODE_RANGE 316
gdb.TYPE_CODE_REF 316
gdb.TYPE_CODE_SET 316
gdb.TYPE_CODE_STRING 316
gdb.TYPE_CODE_STRUCT 315
gdb.TYPE_CODE_TYPEDEF 316
gdb.TYPE_CODE_UNION 315
gdb.TYPE_CODE_VOID 316
gdb.WP_ACCESS 342
gdb.WP_READ 342
gdb.WP_WRITE 342
gdb.write 306
gdb_init_reader 449
gdbserver 237
generate-core-file 135
getDebugChar 249
gnu_debuglink_crc32 225

H

h (help) ... 21
handle ... 71
handle_exception ... 248
hbreak ... 45
help ... 21
help function ... 128
help target ... 232
help user-defined ... 298
history-preserve-point ... 464
history-search-backward () ... 473
history-search-forward () ... 473
history-size ... 464
hook ... 299
hookpost ... 299
horizontal-scroll-mode ... 464
htrace ... 270
hwatch ... 270

I

i (info) ... 23
if ... 301
ignore ... 60
INCLUDE_RDB ... 262
inferior *infno* ... 33
Inferior.is_valid ... 322
Inferior.num ... 322
Inferior.pid ... 322
Inferior.read_memory ... 322
Inferior.search_memory ... 323
Inferior.threads ... 322
Inferior.was_attached ... 322
Inferior.write_memory ... 323
InferiorThread.is_exited ... 326
InferiorThread.is_running ... 326
InferiorThread.is_stopped ... 326
InferiorThread.is_valid ... 325
InferiorThread.name ... 325
InferiorThread.num ... 325
InferiorThread.ptid ... 325
InferiorThread.switch ... 326
info ... 23
info address ... 202
info all-registers ... 128
info args ... 92
info auto-load ... 286
info auto-load gdb-scripts ... 289
info auto-load libthread-db ... 288
info auto-load local-gdbinit ... 288
info auto-load python-scripts ... 347
info auxv ... 130
info breakpoints ... 46
info checkpoints ... 41
info classes ... 206
info common ... 186
info copying ... 23
info dcache ... 138
info display ... 114
info dll ... 256
info dos ... 253
info extensions ... 175
info f (info frame) ... 91
info files ... 218
info float ... 130
info frame ... 91
info frame, show the source language ... 175
info functions ... 205
info handle ... 70
info inferiors ... 32
info io_registers, AVR ... 275
info line ... 99
info line, and Objective-C ... 184
info locals ... 92
info macro ... 145
info macros ... 145
info mem ... 132
info meminfo ... 253
info or1k spr ... 269
info os ... 130
info os files ... 131
info os modules ... 132
info os msg ... 131
info os processes ... 130
info os procgroups ... 131
info os semaphores ... 131
info os shm ... 131
info os sockets ... 131
info os threads ... 131
info pidlist ... 253
info pretty-printer ... 124
info probes ... 64
info proc ... 252
info program ... 43
info record ... 83
info registers ... 128
info scope ... 205
info selectors ... 206
info serial ... 255
info set ... 23
info share ... 220
info sharedlibrary ... 220
info signals ... 70
info skip ... 69
info source ... 205
info source, show the source language ... 175
info sources ... 205
info spu ... 278
info stack ... 88
info static-tracepoint-markers ... 157
info symbol ... 202
info target ... 218
info task *taskno* ... 197
info tasks ... 196
info terminal ... 30
info threads ... 36

info tp [n...] ... 156
info tracepoints [n...] ... 156
info tvariables ... 154
info type-printers ... 204
info types ... 204
info variables ... 205
info vector ... 130
info w32 ... 255
info warranty ... 23
info watchpoints [n...] ... 51
info win ... 359
init-if-undefined ... 126
input-meta ... 464
insert-comment (M-#) ... 478
insert-completions (M-*) ... 476
inspect ... 103
instantiate on type_printer ... 321
interpreter-exec ... 355
interrupt ... 76
isearch-terminators ... 464

J

j (jump) ... 210
jit-reader-load ... 449
jit-reader-unload ... 449
jump ... 210
jump, and Objective-C ... 184

K

KeyboardInterrupt ... 308
keymap ... 465
kill ... 32
kill inferiors *infno*... ... 34
kill-line (C-k) ... 475
kill-region () ... 475
kill-whole-line () ... 475
kill-word (M-d) ... 475
kvm ... 251

L

l (list) ... 93
layout ... 359
LazyString.address ... 345
LazyString.encoding ... 345
LazyString.length ... 345
LazyString.type ... 346
LazyString.value ... 345
Left ... 359
list ... 93
list, and Objective-C ... 184
load *filename* ... 233
loop_break ... 301
loop_continue ... 301

M

macro define ... 145
macro exp1 ... 145
macro expand ... 145
macro list ... 146
macro undef ... 146
maint agent ... 495
maint agent-eval ... 495
maint agent-printf ... 495
maint check-symtabs ... 496
maint cplus first_component ... 496
maint cplus namespace ... 496
maint demangle ... 496
maint deprecate ... 496
maint dump-me ... 496
maint info bfds ... 495
maint info breakpoints ... 495
maint info program-spaces ... 34
maint info psymtabs ... 206
maint info sections ... 218
maint info sol-threads ... 36
maint info symtabs ... 206
maint internal-error ... 496
maint internal-warning ... 496
maint packet ... 497
maint print architecture ... 497
maint print c-tdesc ... 497
maint print cooked-registers ... 498
maint print dummy-frames ... 497
maint print objfiles ... 498
maint print psymbols ... 206
maint print raw-registers ... 498
maint print reggroups ... 498
maint print register-groups ... 498
maint print registers ... 498
maint print remote-registers ... 498
maint print section-scripts ... 498
maint print statistics ... 498
maint print symbols ... 206
maint print target-stack ... 499
maint print type ... 499
maint print unwind, HPPA ... 278
maint set dwarf2 always-disassemble ... 499
maint set dwarf2 max-cache-age ... 499
maint set internal-error ... 497
maint set internal-warning ... 497
maint set profile ... 499
maint set show-all-tib ... 500
maint set show-debug-regs ... 500
maint show dwarf2 always-disassemble ... 499
maint show dwarf2 max-cache-age ... 499
maint show internal-error ... 497
maint show internal-warning ... 497
maint show profile ... 499
maint show show-all-tib ... 500
maint show show-debug-regs ... 500
maint space ... 500
maint time ... 500

maint translate-address 500
maint undeprecate 496
make 17
mark-modified-lines 465
mark-symlinked-directories 465
match-hidden-files 465
may-insert-breakpoints 78
may-insert-fast-tracepoints 78
may-insert-tracepoints 78
may-interrupt 78
may-write-memory 77
may-write-registers 77
mem 132
memset 249
menu-complete () 476
menu-complete-backward () 477
menu-complete-display-prefix 465
meta-flag 464
monitor 236

N

n (next) 66
n (SingleKey TUI key) 359
name of type_printer 321
NewObjFileEvent.new_objfile 325
next 66
next& 75
next-history (C-n) 473
nexti 68
nexti& 75
ni (nexti) 68
non-incremental-forward-search-history (M-n) 473
non-incremental-reverse-search-history (M-p) 473
nosharedlibrary 220

O

Objfile 333
Objfile.filename 333
Objfile.is_valid 333
Objfile.pretty_printers 333
Objfile.type_printers 333
observer 77
or1ksim 269
output 302
output-meta 465
overlay 169
overload-choice annotation 444
overwrite-mode () 475

P

page-completions 465
PARAM_AUTO_BOOLEAN 330
PARAM_BOOLEAN 330
PARAM_ENUM 331
PARAM_FILENAME 331
PARAM_INTEGER 331
PARAM_OPTIONAL_FILENAME 331
PARAM_STRING 331
PARAM_STRING_NOESCAPE 331
PARAM_UINTEGER 331
PARAM_ZINTEGER 331
Parameter 329
Parameter.__init__ 329
Parameter.get_set_string 330
Parameter.get_show_string 330
Parameter.set_doc 330
Parameter.show_doc 330
Parameter.value 330
passcount 153
path 29
PgDn 358
PgUp 358
pi 303
pmon, MIPS remote 269
po (print-object) 184
possible-completions (M-?) 476
post-commands annotation 444
post-overload-choice annotation 444
post-prompt annotation 444
post-prompt-for-continue annotation 444
post-query annotation 444
pre-commands annotation 444
pre-overload-choice annotation 444
pre-prompt annotation 444
pre-prompt-for-continue annotation 444
pre-query annotation 444
prefix-meta (ESC) 477
pretty_printer.children 317
pretty_printer.display_hint 317
pretty_printer.to_string 317
previous-history (C-p) 472
print 103
print-object 184
printf 302
proc-trace-entry 253
proc-trace-exit 253
proc-untrace-entry 253
proc-untrace-exit 253
Progspace 332
Progspace.filename 332
Progspace.pretty_printers 332
Progspace.type_printers 333
prompt annotation 444
prompt-for-continue annotation 444
ptype 203
putDebugChar 249
pwd 30
py 304
python 304
python-interactive 303

Q

q (quit) ... 17
q (SingleKey TUI key) ... 359
query annotation ... 444
quit [*expression*] ... 17
quit annotation ... 445
quoted-insert (C-q or C-v) ... 474

R

r (run) ... 26
r (SingleKey TUI key) ... 359
rbreak ... 45
rc (reverse-continue) ... 79
rdilogenable ... 265
rdilogfile ... 265
re-read-init-file (C-x C-r) ... 477
readnow ... 216
rec ... 81
rec btrace ... 81
rec del ... 83
rec full ... 81
rec function-call-history ... 84
rec instruction-history ... 83
rec s ... 82
recognize on type_recognizer ... 321
record ... 81
record btrace ... 81
record delete ... 83
record full ... 81
record function-call-history ... 84
record instruction-history ... 83
record restore ... 82
record save ... 82
record stop ... 82
redraw-current-line () ... 472
refresh ... 360
remote delete ... 237
remote get ... 237
remote put ... 237
remotetimeout ... 273
remove-inferiors ... 33
restart *checkpoint-id* ... 41
restore ... 134
RET (repeat last command) ... 19
return ... 211
reverse-continue ... 79
reverse-finish ... 80
reverse-next ... 80
reverse-nexti ... 80
reverse-search ... 96
reverse-search-history (C-r) ... 473
reverse-step ... 79
reverse-stepi ... 79
revert-all-at-newline ... 466
revert-line (M-r) ... 477
Right ... 359
rn (reverse-next) ... 80
rni (reverse-nexti) ... 80
rs (step) ... 79
rsi (reverse-stepi) ... 79
run ... 26
run& ... 75
rwatch ... 51

S

s (SingleKey TUI key) ... 359
s (step) ... 66
save breakpoints ... 63
save gdb-index ... 227
save tracepoints ... 164
save-tracepoints ... 164
sdireset ... 266
sdistatus ... 266
sds, a command ... 272
search ... 96
section ... 217
select-frame ... 88
self-insert (a, b, A, 1, !, ...) ... 474
set ... 23
set ada trust-PAD-over-XVS ... 200
set agent off ... 451
set agent on ... 451
set annotate ... 443
set architecture ... 231
set args ... 29
set arm ... 263
set auto-load gdb-scripts ... 289
set auto-load libthread-db ... 288
set auto-load local-gdbinit ... 288
set auto-load off ... 286
set auto-load python-scripts ... 347
set auto-load safe-path ... 289
set auto-load scripts-directory ... 347
set auto-solib-add ... 219
set backtrace ... 89
set basenames-may-differ ... 223
set board-address ... 266
set breakpoint always-inserted ... 49
set breakpoint auto-hw ... 48
set breakpoint condition-evaluation ... 49
set breakpoint pending ... 48
set can-use-hw-watchpoints ... 52
set case-sensitive ... 201
set charset ... 136
set check range ... 176
set check type ... 176
set circular-trace-buffer ... 159
set coerce-float-to-double ... 285
set com1base ... 255
set com1irq ... 255
set com2base ... 255
set com2irq ... 255
set com3base ... 255
set com3irq ... 255

set com4base ... 255
set com4irq ... 255
set complaints ... 291
set confirm ... 292
set cp-abi ... 285
set cygwin-exceptions ... 256
set data-directory ... 229
set dcache line-size ... 138
set dcache size ... 138
set debug ... 292
set debug aarch64 ... 276
set debug auto-load ... 291
set debug darwin ... 261
set debug entry-values ... 142
set debug hppa ... 278
set debug libthread-db ... 38
set debug mach-o ... 261
set debug mips ... 278
set debug monitor ... 233
set debug-file-directory ... 224
set debugevents ... 256
set debugexceptions ... 256
set debugexec ... 256
set debugmemory ... 256
set default-collect ... 156
set demangle-style ... 121
set detach-on-fork ... 39
set directories ... 98
set disable-randomization ... 28
set disassemble-next-line ... 101
set disassembly-flavor ... 101
set disconnected-dprintf ... 63
set disconnected-tracing ... 158
set displaced-stepping ... 495
set download-path ... 266
set editing ... 281
set endian ... 234
set environment ... 29
set exceptions, Hurd command ... 259
set exec-direction ... 80
set exec-done-display ... 292
set exec-wrapper ... 27
set extended-prompt ... 281
set extension-language ... 175
set follow-exec-mode ... 40
set follow-fork-mode ... 39
set gnutarget ... 232
set hash, for remote monitors ... 233
set height ... 283
set history expansion ... 283
set history filename ... 282
set history save ... 282
set history size ... 282
set host-charset ... 135
set inferior-tty ... 31
set input-radix ... 284
set interactive-mode ... 296
set language ... 174
set libthread-db-search-path ... 37
set listsize ... 93
set logging ... 18
set mach-exceptions ... 261
set max-user-call-depth ... 298
set mem inaccessible-by-default ... 134
set mips abi ... 277
set mips compression ... 277
set mips mask-address ... 277
set mipsfpu ... 268
set monitor-prompt, MIPS remote ... 269
set monitor-warnings, MIPS remote ... 269
set multiple-symbols ... 106
set new-console ... 256
set new-group ... 256
set non-stop ... 74
set opaque-type-resolution ... 206
set osabi ... 285
set output-radix ... 284
set overload-resolution ... 182
set pagination ... 284
set powerpc ... 272
set print ... 115
set print entry-values ... 118
set print frame-arguments ... 117
set print inferior-events ... 34
set print thread-events ... 37
set print type methods ... 201
set print type typedefs ... 201
set processor ... 231
set procfs-file ... 253
set procfs-trace ... 252
set prompt ... 281
set python print-stack ... 304
set radix ... 284
set range-stepping ... 68
set ravenscar task-switching off ... 199
set ravenscar task-switching on ... 199
set rdiheartbeat ... 265
set rdiromatzero ... 265
set record ... 84
set record full ... 82
set remote ... 242
set remote system-call-allowed ... 556
set remote-mips64-transfers-32bit-regs ... 278
set remotecache ... 138
set remoteflow ... 242
set retransmit-timeout ... 268
set schedule-multiple ... 73
set script-extension ... 297
set sdstimeout ... 272
set server-address ... 266
set sh calling-convention ... 275
set shell ... 256
set signal-thread ... 258
set signals, Hurd command ... 258
set sigs, Hurd command ... 258
set sigthread ... 258

set solib-absolute-prefix ... 221
set solib-search-path ... 222
set spu ... 279
set stack-cache ... 138
set step-mode ... 66
set stop-on-solib-events ... 220
set stopped, Hurd command ... 259
set struct-convention ... 276
set substitute-path ... 98
set syn-garbage-limit, MIPS remote ... 269
set sysroot ... 221
set target-async ... 75
set target-charset ... 135
set target-file-system-kind (unix|dos-based|auto) ... 222
set target-wide-charset ... 136
set task, Hurd commands ... 259
set tcp ... 244
set thread, Hurd command ... 260
set timeout ... 268
set trace-buffer-size ... 159
set trace-commands ... 292
set trace-notes ... 160
set trace-stop-notes ... 160
set trace-user ... 160
set trust-readonly-sections ... 219
set tui active-border-mode ... 361
set tui border-kind ... 361
set tui border-mode ... 361
set unwind-on-terminating-exception ... 213
set unwindonsignal ... 213
set variable ... 209
set verbose ... 291
set watchdog ... 501
set width ... 283
set write ... 213
set-mark (C-@) ... 477
set_debug_traps ... 248
share ... 220
sharedlibrary ... 220
shell ... 17
show ... 23
show ada trust-PAD-over-XVS ... 200
show agent ... 451
show annotate ... 443
show architecture ... 231
show args ... 29
show arm ... 263
show auto-load ... 286
show auto-load gdb-scripts ... 289
show auto-load libthread-db ... 288
show auto-load local-gdbinit ... 288
show auto-load python-scripts ... 347
show auto-load safe-path ... 289
show auto-load scripts-directory ... 348
show auto-solib-add ... 220
show backtrace ... 89
show basenames-may-differ ... 223
show board-address ... 266
show breakpoint always-inserted ... 49
show breakpoint auto-hw ... 48
show breakpoint condition-evaluation ... 49
show breakpoint pending ... 48
show can-use-hw-watchpoints ... 52
show case-sensitive ... 201
show charset ... 136
show check range ... 176
show check type ... 176
show circular-trace-buffer ... 159
show coerce-float-to-double ... 285
show com1base ... 255
show com1irq ... 255
show com2base ... 255
show com2irq ... 255
show com3base ... 255
show com3irq ... 255
show com4base ... 255
show com4irq ... 255
show commands ... 283
show complaints ... 291
show confirm ... 292
show convenience ... 126
show copying ... 23
show cp-abi ... 285
show cygwin-exceptions ... 256
show data-directory ... 229
show dcache line-size ... 139
show dcache size ... 139
show debug ... 292
show debug auto-load ... 291
show debug darwin ... 261
show debug entry-values ... 143
show debug libthread-db ... 38
show debug mach-o ... 261
show debug mips ... 278
show debug monitor ... 233
show debug-file-directory ... 224
show default-collect ... 156
show detach-on-fork ... 39
show directories ... 98
show disassemble-next-line ... 101
show disassembly-flavor ... 101
show disconnected-dprintf ... 63
show disconnected-tracing ... 159
show displaced-stepping ... 495
show download-path ... 266
show editing ... 282
show environment ... 29
show exceptions, Hurd command ... 259
show exec-done-display ... 292
show extended-prompt ... 281
show follow-fork-mode ... 39
show gnutarget ... 232
show hash, for remote monitors ... 233
show height ... 283
show history ... 283

show host-charset ... 136
show inferior-tty ... 31
show input-radix ... 284
show interactive-mode ... 296
show language ... 175
show libthread-db-search-path ... 38
show listsize ... 93
show logging ... 18
show mach-exceptions ... 261
show max-user-call-depth ... 298
show mem inaccessible-by-default ... 134
show mips abi ... 277
show mips compression ... 277
show mips mask-address ... 277
show mipsfpu ... 268
show monitor-prompt, MIPS remote ... 269
show monitor-warnings, MIPS remote ... 269
show multiple-symbols ... 107
show new-console ... 256
show new-group ... 256
show non-stop ... 74
show opaque-type-resolution ... 206
show osabi ... 285
show output-radix ... 284
show overload-resolution ... 182
show pagination ... 284
show paths ... 29
show print ... 115
show print inferior-events ... 34
show print thread-events ... 37
show print type methods ... 201
show print type typedefs ... 202
show processor ... 231
show procfs-file ... 253
show procfs-trace ... 252
show prompt ... 281
show radix ... 284
show range-stepping ... 68
show ravenscar task-switching ... 199
show rdiheartbeat ... 265
show rdiromatzero ... 265
show record ... 84
show record full ... 82
show remote ... 242
show remote system-call-allowed ... 556
show remote-mips64-transfers-32bit-regs ... 278
show remotecache ... 138
show remoteflow ... 242
show retransmit-timeout ... 268
show script-extension ... 297
show sdstimeout ... 272
show server-address ... 266
show sh calling-convention ... 275
show shell ... 257
show signal-thread ... 259
show signals, Hurd command ... 258
show sigs, Hurd command ... 258
show sigthread ... 259
show solib-search-path ... 222
show spu ... 279
show stack-cache ... 138
show stop-on-solib-events ... 220
show stopped, Hurd command ... 259
show struct-convention ... 276
show substitute-path ... 99
show syn-garbage-limit, MIPS remote ... 269
show sysroot ... 222
show target-async ... 75
show target-charset ... 136
show target-file-system-kind ... 222
show target-wide-charset ... 136
show task, Hurd commands ... 259
show tcp ... 244
show thread, Hurd command ... 260
show timeout ... 268
show trace-buffer-size ... 159
show trace-notes ... 160
show trace-stop-notes ... 160
show trace-user ... 160
show unwind-on-terminating-exception ... 213
show unwindonsignal ... 213
show user ... 298
show values ... 126
show verbose ... 291
show version ... 23
show warranty ... 23
show width ... 283
show write ... 214
show-all-if-ambiguous ... 466
show-all-if-unmodified ... 466
si (stepi) ... 68
signal ... 211
signal annotation ... 446
signal-name annotation ... 445
signal-name-end annotation ... 445
signal-string annotation ... 445
signal-string-end annotation ... 445
SignalEvent.stop_signal ... 324
signalled annotation ... 445
silent ... 61
sim ... 274
sim, a command ... 263
skip delete ... 70
skip disable ... 70
skip enable ... 70
skip file ... 69
skip function ... 69
skip-completed-text ... 466
skip-csi-sequence () ... 478
source ... 300
source annotation ... 446
spr ... 270
start ... 27
start-kbd-macro (C-x () ... 477
starting annotation ... 445

STDERR 306, 307
STDLOG 306, 307
STDOUT 306, 307
step 66
step& 75
stepi 68
stepi& 75
stop, a pseudo-command 299
stopping annotation 445
strace 151
symbol-file 215
Symbol.addr_class 338
Symbol.is_argument 338
Symbol.is_constant 338
Symbol.is_function 339
Symbol.is_valid 339
Symbol.is_variable 339
Symbol.line 338
Symbol.linkage_name 338
Symbol.name 338
Symbol.needs_frame 338
Symbol.print_name 338
Symbol.symtab 338
Symbol.type 338
Symbol.value 339
SYMBOL_FUNCTIONS_DOMAIN 339
SYMBOL_LABEL_DOMAIN 339
SYMBOL_LOC_ARG 340
SYMBOL_LOC_BLOCK 340
SYMBOL_LOC_COMPUTED 340
SYMBOL_LOC_CONST 339
SYMBOL_LOC_CONST_BYTES 340
SYMBOL_LOC_LOCAL 340
SYMBOL_LOC_OPTIMIZED_OUT 340
SYMBOL_LOC_REF_ARG 340
SYMBOL_LOC_REGISTER 340
SYMBOL_LOC_REGPARM_ADDR 340
SYMBOL_LOC_STATIC 340
SYMBOL_LOC_TYPEDEF 340
SYMBOL_LOC_UNDEF 339
SYMBOL_LOC_UNRESOLVED 340
SYMBOL_STRUCT_DOMAIN 339
SYMBOL_TYPES_DOMAIN 339
SYMBOL_UNDEF_DOMAIN 339
SYMBOL_VAR_DOMAIN 339
SYMBOL_VARIABLES_DOMAIN 339
Symtab.filename 341
Symtab.fullname 341
Symtab.global_block 341
Symtab.is_valid 341
Symtab.objfile 341
Symtab.static_block 341
Symtab_and_line.is_valid 341
Symtab_and_line.last 341
Symtab_and_line.line 341
Symtab_and_line.pc 341
Symtab_and_line.symtab 341
sysinfo 253

T

tab-insert (M-TAB) 474
tabset 360
target 232
target array 268
target dbug 266
target ddb *port* 268
target dink32 272
target jtag 269
target lsi *port* 268
target m32r 265
target m32rsdi 265
target mips *port* 267
target op50n 272
target pmon *port* 268
target ppcbug 272
target ppcbug1 272
target r3900 268
target rdi 263
target rdp 263
target record 81
target record-btrace 81
target record-full 81
target sds 272
target sim, with Z8000 274
target sparclite 274
target tfile 165
target vxworks 261
target w89k 272
task (Ada) 197
tbreak 44
tdump 163
teval (tracepoints) 156
tfile 165
tfind 161
thbreak 45
this, inside C++ member functions 180
thread apply 36
thread find 37
thread name 37
thread *threadno* 36
ThreadEvent.inferior_thread 324
tilde-expand (M-~) 477
tload, M32R 266
trace 150
transpose-chars (C-t) 474
transpose-words (M-t) 474
tsave 165
tstart [*notes*] 158
tstatus 158
tstop [*notes*] 158
tty 31
tui reg 360
tvariable 154
Type.array 314
Type.code 313
Type.const 314
Type.fields 313

Type.pointer ... 315
Type.range ... 315
Type.reference ... 315
Type.sizeof ... 313
Type.strip_typedefs ... 315
Type.tag ... 313
Type.target ... 315
Type.template_argument ... 315
Type.unqualified ... 314
Type.vector ... 314
Type.volatile ... 314
TYPE_CODE_ARRAY ... 315
TYPE_CODE_BITSTRING ... 316
TYPE_CODE_BOOL ... 316
TYPE_CODE_CHAR ... 316
TYPE_CODE_COMPLEX ... 316
TYPE_CODE_DECFLOAT ... 316
TYPE_CODE_ENUM ... 315
TYPE_CODE_ERROR ... 316
TYPE_CODE_FLAGS ... 315
TYPE_CODE_FLT ... 316
TYPE_CODE_FUNC ... 316
TYPE_CODE_INT ... 316
TYPE_CODE_INTERNAL_FUNCTION ... 317
TYPE_CODE_MEMBERPTR ... 316
TYPE_CODE_METHOD ... 316
TYPE_CODE_METHODPTR ... 316
TYPE_CODE_NAMESPACE ... 316
TYPE_CODE_PTR ... 315
TYPE_CODE_RANGE ... 316
TYPE_CODE_REF ... 316
TYPE_CODE_SET ... 316
TYPE_CODE_STRING ... 316
TYPE_CODE_STRUCT ... 315
TYPE_CODE_TYPEDEF ... 316
TYPE_CODE_UNION ... 315
TYPE_CODE_VOID ... 316

U

u (SingleKey TUI key) ... 359
u (until) ... 67
undisplay ... 114
undo (C-_ or C-x C-u) ... 477
universal-argument () ... 476
unix-filename-rubout () ... 475
unix-line-discard (C-u) ... 475
unix-word-rubout (C-w) ... 475
unset environment ... 30
unset substitute-path ... 99
until ... 67
until& ... 76
up ... 91
Up ... 358
up-silently ... 91
upcase-word (M-u) ... 474
update ... 360
upload, M32R ... 266
use_dbt_break ... 266
use_debug_dma ... 266
use_ib_break ... 266
use_mon_code ... 266

V

v (SingleKey TUI key) ... 359
Value.__init__ ... 310
Value.address ... 309
Value.cast ... 310
Value.dereference ... 310
Value.dynamic_cast ... 312
Value.dynamic_type ... 309
Value.fetch_lazy ... 313
Value.is_lazy ... 310
Value.is_optimized_out ... 309
Value.lazy_string ... 312
Value.referenced_value ... 311
Value.reinterpret_cast ... 312
Value.string ... 312
Value.type ... 309
vi-editing-mode (M-C-j) ... 478
visible-stats ... 466
vxworks-timeout ... 262

W

w (SingleKey TUI key) ... 359
watch ... 50
watchpoint annotation ... 446
whatis ... 202
where ... 88
while ... 301
while-stepping (tracepoints) ... 156
winheight ... 360
WP_ACCESS ... 342
WP_READ ... 342
WP_WRITE ... 342

X

x (examine memory) ... 111
x(examine), and info line ... 100

Y

yank (C-y) ... 476
yank-last-arg (M-. or M-_) ... 473
yank-nth-arg (M-C-y) ... 473
yank-pop (M-y) ... 476

The body of this manual is set in
cmr10 at 10.95pt,
with headings in **cmb10 at 10.95pt**
and examples in `cmtt10 at 10.95pt`.
cmti10 at 10.95pt,
cmb10 at 10.95pt, and
cmsl10 at 10.95pt
are used for emphasis.