



TOTALVIEW[®] FOR HPC USER GUIDE

Version 2016.06

Copyright © 2010-2016 by Rogue Wave Software, Inc. All rights reserved.

Copyright © 2007-2009 by TotalView Technologies, LLC

Copyright © 1998-2007 by Etnus LLC. All rights reserved.

Copyright © 1996-1998 by Dolphin Interconnect Solutions, Inc.

Copyright © 1993-1996 by BBN Systems and Technologies, a division of BBN Corporation.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise without the prior written permission of Rogue Wave Software, Inc. ("Rogue Wave").

Use, duplication, or disclosure by the Government is subject to restrictions as set forth in subparagraph (c)(1)(ii) of the Rights in Technical Data and Computer Software clause at DFARS 252.227-7013.

Rogue Wave has prepared this manual for the exclusive use of its customers, personnel, and licensees. The information in this manual is subject to change without notice, and should not be construed as a commitment by Rogue Wave. Rogue Wave assumes no responsibility for any errors that appear in this document.

TotalView and TotalView Technologies are registered trademarks of Rogue Wave Software, Inc. TVD is a trademark of Rogue Wave.

Rogue Wave uses a modified version of the Microline widget library. Under the terms of its license, you are entitled to use these modifications. The source code is available at <http://kb.roguewave.com/kb/>.

All other brand names are the trademarks of their respective holders.

ACKNOWLEDGMENTS

Use of the Documentation and implementation of any of its processes or techniques are the sole responsibility of the client, and Rogue Wave Software, Inc., assumes no responsibility and will not be liable for any errors, omissions, damage, or loss that might result from any use or misuse of the Documentation

ROGUE WAVE SOFTWARE, INC., MAKES NO REPRESENTATION ABOUT THE SUITABILITY OF THE DOCUMENTATION. THE DOCUMENTATION IS PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND. ROGUE WAVE SOFTWARE, INC., HEREBY DISCLAIMS ALL WARRANTIES AND CONDITIONS WITH REGARD TO THE DOCUMENTATION, WHETHER EXPRESS, IMPLIED, STATUTORY, OR OTHERWISE, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NONINFRINGEMENT. IN NO EVENT SHALL ROGUE WAVE SOFTWARE, INC., BE LIABLE, WHETHER IN CONTRACT, TORT, OR OTHERWISE, FOR ANY SPECIAL, CONSEQUENTIAL, INDIRECT, PUNITIVE, OR EXEMPLARY DAMAGES IN CONNECTION WITH THE USE OF THE DOCUMENTATION.

The Documentation is subject to change at any time without notice.

Rogue Wave Software, Inc.

Product Information: (303) 473-9118 (800) 487-3217

Fax: (303) 473-9137

Web: <http://www.roguewave.com>



Contents

About This Guide	1
Content Organization	1
Audience	2
Using the CLI	3
Resources	3
Part 1: Introduction to Debugging with TotalView	
Chapter 1 About TotalView	5
Sessions Manager	7
GUI and Command Line Interfaces	8
The GUI	8
The CLI	8
Stepping and Breakpoints	9
Data Display and Visualization	10
Data Display	10
Diving in a Variable Window	11
Viewing a Variable Value across Multiple Processes or Threads	13
Simplifying Array Display	13
Viewing a Variable's Changing Value	16
Setting Watchpoints	16
Data Visualization	16
The Array Visualizer	17
The Parallel Backtrace View	17
The Call Tree and Call Graph	18
The Message Queue Graph	20
C++ View	20
Tools for Multi-Threaded and Parallel Applications	22
Program Using Almost Any Execution Model	22
View Process and Thread State	22
Control Program Execution	23

	Using Groups	24
	Synchronizing Execution with Barrier Points	25
	Batch and Automated Debugging	26
	Remote Display	27
	Debugging on a Remote Host	27
	CUDA Debugger	28
	Memory Debugging	29
	Reverse Debugging	30
	What's Next	31
Chapter 2	Basic Debugging	32
	Program Load and Navigation	33
	Load the Program to Debug	33
	The Root and Process Windows	34
	Program Navigation	36
	Stepping and Executing	38
	Simple Stepping	38
	Canceling	40
	Setting Breakpoints (Action Points)	42
	Basic Breakpoints	42
	Evaluation Points	45
	Saving and Reloading Action Points	47
	Examining Data	49
	Viewing Built-in Data	49
	Viewing Variables in the Process Window	49
	Viewing Variables in an Expression List Window	50
	Viewing Compound Variables Using the Variable Window	51
	Basic Diving	51
	Nested Dives	53
	Rediving and Undiving	54
	Diving in a New Window	54
	Displaying an Element in an Array of Structures	55
	Visualizing Arrays	58
	Launching the Visualizer from an Eval Point	59
	Viewing Options	61
	Moving On	63
Chapter 3	Accessing TotalView Remotely	64
	About Remote Display	64
	Remote Display Supported Platforms	64

Remote Display Components	64
Installing the Client	66
Installing on Linux	66
Installing on Microsoft Windows	66
Installing on Apple Mac OS X Intel	67
Client Session Basics	69
Working on the Remote Host	71
Advanced Options	73
Naming Intermediate Hosts	75
Submitting a Job to a Batch Queuing System	76
Setting Up Your Systems and Security	77
Session Profile Management	78
Batch Scripts	80
tv_PBS.csh Script	80
tv_LoadLeveler.csh Script	81

Part 2: Debugging Tools and Tasks

Chapter 4	Starting TotalView	84
	Compiling Programs	85
	Using File Extensions	86
	Starting TotalView	87
	Starting TotalView	88
	Creating or Loading a Session	89
	Debugging a Program	89
	Debugging a Core File	90
	Debugging with a Replay Recording File	90
	Passing Arguments to the Program Being Debugged	90
	Debugging a Program Running on Another Computer	90
	Debugging an MPI Program	91
	Using gnu_debuglink Files	91
	Initializing TotalView	93
	Exiting from TotalView	95
Chapter 5	Loading and Managing Sessions	96
	Setting up Debugging Sessions	98
	Loading Programs from the Sessions Manager	98
	Starting a Debugging Session	98
	Debugging a New Program	99

Attaching to a Running Program	101
Debugging a Core File	106
Debugging with a Replay Recording File	107
Launching your Last Session	109
Loading Programs Using the CLI	109
Debugging Options and Environment Setup	111
Adding a Remote Host	111
Options: Reverse Debugging, Memory Debugging, and CUDA	113
Setting Environment Variables and Altering Standard I/O	115
Environment Variables	115
Standard I/O	116
Adding Notes to a Session	117
Managing Sessions	119
Editing or Starting New Sessions in a Sessions Window	121
Other Configuration Options	122
Handling Signals	122
Setting Search Paths	125
Setting Startup Parameters	127
Setting Preferences	128
Setting Preferences, Options, and X Resources	134
Chapter 6 Using and Customizing the GUI	138
Overview	138
Using Mouse Buttons	139
Using the Root Window	140
Controlling the Display of Processes and Threads	142
Default View	143
Changing the Display	144
Grouping by Status and Source Line	145
Grouping by All Properties	146
Using the Old Root Window	146
Suppressing the Root Window	147
Using the Process Window	148
Resizing and Positioning Windows	151
About Diving into Objects	152
Saving the Data in a Window	155
Searching and Navigating Program Elements	156
Searching for Text	156
Looking for Functions and Variables	157
Finding the Source Code for Functions	157
Resolving Ambiguous Names	158

	Finding the Source Code for Files	159
	Resetting the Stack Frame	160
	Viewing the Assembler Version of Your Code	161
	Editing Source Text	164
Chapter 7	Stepping through and Executing your Program	165
	Using Stepping Commands	166
	Stepping into Function Calls	167
	Stepping Over Function Calls	168
	Executing to a Selected Line	169
	Executing Out of a Function	170
	Continuing with a Specific Signal	171
	Killing (Deleting) Programs	172
	Restarting Programs	172
	Setting the Program Counter	173
Chapter 8	Setting Action Points	174
	About Action Points	175
	Print Statements vs. Action Points	177
	Setting Breakpoints and Barriers	179
	Setting Source-Level Breakpoints	179
	Choosing Source Lines	179
	Setting Breakpoints at Locations	182
	Ambiguous Functions and Pending Breakpoints	182
	Displaying and Controlling Action Points	184
	Disabling Action Points	185
	Deleting Action Points	185
	Enabling Action Points	185
	Suppressing Action Points	185
	Setting Breakpoints on Classes and Functions	186
	Setting Machine-Level Breakpoints	188
	Setting Breakpoints for Multiple Processes	189
	Setting Breakpoints When Using the fork()/execve() Functions	191
	Debugging Processes That Call the fork() Function	191
	Debugging Processes that Call the execve() Function	191
	Example: Multi-process Breakpoint	192
	Setting Barrier Points	193
	About Barrier Breakpoint States	193
	Setting a Barrier Breakpoint	194
	Creating a Satisfaction Set	195
	Hitting a Barrier Point	195

Releasing Processes from Barrier Points	196
Deleting a Barrier Point	196
Changing Settings and Disabling a Barrier Point	196
Defining Eval Points and Conditional Breakpoints	197
Setting Eval Points	198
Creating Conditional Breakpoint Examples	199
Patching Programs	200
Branching Around Code	200
Adding a Function Call	201
Correcting Code	201
About Interpreted and Compiled Expressions	202
About Interpreted Expressions	202
About Compiled Expressions	202
Allocating Patch Space for Compiled Expressions	203
Allocating Dynamic Patch Space	204
Allocating Static Patch Space	204
Using Watchpoints	206
Using Watchpoints on Different Architectures	206
Creating Watchpoints	208
Displaying Watchpoints	209
Watching Memory	210
Triggering Watchpoints	210
Using Multiple Watchpoints	211
Copying Previous Data Values	211
Using Conditional Watchpoints	211
Saving Action Points to a File	213
Chapter 9 Examining and Editing Data and Program Elements 214	
Changing How Data is Displayed	215
Displaying STL Variables	215
Changing Size and Precision	218
Displaying Variables	220
Displaying Program Variables	221
Controlling the Displayed Information	222
Seeing Value Changes	223
Seeing Structure Information	225
Displaying Variables in the Current Block	225
Viewing Variables in Different Scopes as Program Executes	226
Scoping Issues	227
Freezing Variable Window Data	227
Locking the Address	228
Browsing for Variables	230
Displaying Local Variables and Registers	232

Interpreting the Status and Control Registers	233
Dereferencing Variables Automatically	234
Examining Memory	235
Displaying Areas of Memory	236
Displaying Machine Instructions	237
Rebinding the Variable Window	238
Closing Variable Windows	239
Diving in Variable Windows	240
Displaying an Array of Structure's Elements	242
Changing What the Variable Window Displays	244
Viewing a List of Variables	246
Entering Variables and Expressions	246
Seeing Variable Value Changes in the Expression List Window	248
Entering Expressions into the Expression Column	249
Using the Expression List with Multi-process/Multi-threaded Programs	250
Reevaluating, Reopening, Rebinding, and Restarting	251
Seeing More Information	251
Sorting, Reordering, and Editing	252
Changing the Values of Variables	254
Changing a Variable's Data Type	256
Displaying C and C++ Data Types	256
Viewing Pointers to Arrays	258
Viewing Arrays	258
Viewing typedef Types	259
Viewing Structures	259
Viewing Unions	260
Casting Using the Built-In Types	261
Viewing Character Arrays (\$string Data Type)	263
Viewing Wide Character Arrays (\$wchar Data Types)	264
Viewing Areas of Memory (\$void Data Type)	265
Viewing Instructions (\$code Data Type)	265
Viewing Opaque Data	265
Type-Casting Examples	266
Displaying Declared Arrays	266
Displaying Allocated Arrays	266
Displaying the argv Array	266
Changing the Address of Variables	267
Displaying C++ Types	268
Viewing Classes	268
C++View	270
Displaying Fortran Types	271
Displaying Fortran Common Blocks	271

Displaying Fortran Module Data	273
Debugging Fortran 90 Modules	274
Viewing Fortran 90 User-Defined Types	275
Viewing Fortran 90 Deferred Shape Array Types	276
Viewing Fortran 90 Pointer Types	276
Displaying Fortran Parameters	277
Displaying Thread Objects	278
Scoping and Symbol Names	280
Qualifying Symbol Names	281

Chapter 10 **Examining Arrays** **283**

Examining and Analyzing Arrays	284
Displaying Array Slices	284
Using Slices and Strides	284
Using Slices in the Lookup Variable Command	287
Array Slices and Array Sections	287
Viewing Array Data	288
Expression Field	289
Type Field	289
Slice Definition	290
Update View Button	290
Data Format Selection Box	290
Filtering Array Data Overview	290
Filtering Array Data	291
Filtering by Comparison	291
Filtering for IEEE Values	292
Filtering a Range of Values	294
Creating Array Filter Expressions	295
Using Filter Comparisons	295
Sorting Array Data	296
Obtaining Array Statistics	297
Displaying a Variable in all Processes or Threads	300
Diving on a “Show Across” Pointer	301
Editing a “Show Across” Variable	301
Visualizing Array Data	302
Visualizing a “Show Across” Variable Window	302

Chapter 11 **Visualizing Programs and Data** **303**

Displaying Call Trees and Call Graphs	304
Parallel Backtrace View	307
Array Visualizer	309
Command Summary	309

How the Visualizer Works	310
Viewing Data Types in the Visualizer	311
Viewing Data	311
Visualizing Data Manually	312
Using the Visualizer	312
Using Dataset Window Commands	313
Using View Window Commands	314
Using the Graph Window	315
Displaying Graph Views	316
Using the Surface Window	317
Displaying Surface Views	318
Manipulating Surface Data	320
Visualizing Data Programmatically	322
Launching the Visualizer from the Command Line	323
Configuring TotalView to Launch the Visualizer	323
Setting the Visualizer Launch Command	325
Adapting a Third Party Visualizer	325

Chapter 12 **Evaluating Expressions** **327**

Why is There an Expression System?	328
Calling Functions: Problems and Issues	329
Expressions in Eval Points and the Evaluate Window	329
Using C++	331
Using Programming Language Elements	333
Using C and C++	333
Using Fortran	334
Fortran Statements	334
Fortran Intrinsic	335
Using the Evaluate Window	337
Writing Assembler Code	339
Using Built-in Variables and Statements	344
Using TotalView Variables	344
Using Built-In Statements	345

	Expression Evaluation with ReplayEngine	348
Chapter 13	About Groups, Processes, and Threads	349
	A Couple of Processes	350
	Threads	353
	Complicated Programming Models	355
	Types of Threads	357
	Organizing Chaos	360
	How TotalView Creates Groups	364
	Simplifying What You're Debugging	370
Chapter 14	Manipulating Processes and Threads	372
	Viewing Process and Thread States	374
	Seeing Attached Process States	375
	Seeing Unattached Process States	375
	Using the Toolbar to Select a Target	377
	Stopping Processes and Threads	378
	Using the Processes/Ranks and Threads Tabs	379
	The Processes Tab	379
	The Threads Tab	380
	Updating Process Information	382
	Holding and Releasing Processes and Threads	383
	Using Barrier Points	386
	Barrier Point Illustration	387
	Examining Groups	389
	Placing Processes in Groups	391
	Starting Processes and Threads	392
	Creating a Process Without Starting It	393
	Creating a Process by Single-Stepping	394
	Stepping and Setting Breakpoints	395
Chapter 15	Debugging Strategies for Parallel Applications	398
	General Parallel Debugging Tips	399
	Breakpoints, Stepping, and Program Execution	399
	Setting Breakpoint Behavior	399
	Synchronizing Processes	399
	Using Group Commands	399
	Stepping at Process Level	400
	Viewing Processes, Threads, and Variables	400

Identifying Process and Thread Execution	400
Viewing Variable Values	400
Restarting from within TotalView	401
Attaching to Processes Tips	401
MPI Debugging Tips and Tools	405
MPI Display Tools	405
MPI Rank Display	405
Displaying the Message Queue Graph Window	406
Displaying the Message Queue	408
MPICH Debugging Tips	411
IBM PE Debugging Tips	413

Part 3: Using the CLI

Chapter 16	Using the Command Line Interface (CLI)	415
	About the Tcl and the CLI	416
	About The CLI and TotalView	416
	Using the CLI Interface	417
	Starting the CLI	418
	Startup Example	419
	Starting Your Program	420
	About CLI Output	422
	‘more’ Processing	423
	Using Command Arguments	424
	Using Namespaces	425
	About the CLI Prompt	426
	Using Built-in and Group Aliases	427
	How Parallelism Affects Behavior	428
	Types of IDs	428
	Controlling Program Execution	430
	Advancing Program Execution	430
	Using Action Points	431

Chapter 17	Seeing the CLI at Work	432
	Setting the CLI EXECUTABLE_PATH Variable	433
	Initializing an Array Slice	434
	Printing an Array Slice	435
	Writing an Array Variable to a File	437
	Automatically Setting Breakpoints	438

Part 4: Advanced Tools and Customization

Chapter 18	Setting Up Remote Debugging Sessions	442
	About Remote Debugging	442
	Platform Issues when Remote Debugging	443
	Automatically Launching a Process on a Remote Server	445
	Troubleshooting Server Autolaunch	446
	Changing the Remote Shell Command	446
	Changing Arguments	447
	Autolaunching Sequence	447
	Starting the TotalView Server Manually	449
	TotalView Server Launch Options and Commands	452
	Server Launch Options	452
	Setting Single-Process Server Launch Options	452
	Setting Bulk Launch Window Options	453
	Customizing Server Launch Commands	455
	Setting the Single-Process Server Launch Command	455
	Setting the Bulk Server Launch Command	456
	Debugging Over a Serial Line	460
	Starting the TotalView Debugger Server	460
Chapter 19	Setting Up MPI Debugging Sessions	461
	Debugging MPI Programs	463
	Starting MPI Programs	463
	Starting MPI Programs Using File > Debug New Parallel Program	463
	The Parallel Program Session Dialog	465
	MPICH Applications	468
	Starting TotalView on an MPICH Job	468
	Attaching to an MPICH Job	470
	Using MPICH P4 procgroup Files	471
	MPICH2 Applications	472
	Downloading and Configuring MPICH2	472

Using SLURM	498
Debugging Cray XT Applications	499
Cray XT Catamount	499
Configuring Cray XT for TotalView	500
Using TotalView with your Cray XT System	501
Cray Linux Environment (CLE)	502
Support for Cray Abnormal Termination Processing (ATP)	502
Special Requirements for Using ReplayEngine	502
Debugging Global Arrays Applications	504
Debugging Shared Memory (SHMEM) Code	506
Debugging UPC Programs	507
Invoking TotalView	507
Viewing Shared Objects	507
Displaying Pointer to Shared Variables	509
Debugging CoArray Fortran (CAF) Programs	511
Invoking TotalView	511
Viewing CAF Programs	511
Using CLI with CAF	512

Chapter 21 **Group, Process, and Thread Control** **513**

Defining the GOI, POI, and TOI	514
Recap on Setting a Breakpoint	515
Stepping (Part I)	516
Understanding Group Widths	517
Understanding Process Width	517
Understanding Thread Width	517
Using Run To and duntil Commands	518
Setting Process and Thread Focus	520
Understanding Process/Thread Sets	520
Specifying Arenas	521
Specifying Processes and Threads	522
Defining the Thread of Interest (TOI)	522
About Process and Thread Widths	522
Specifier Examples	524
Setting Group Focus	526
Specifying Groups in P/T Sets	527
About Arena Specifier Combinations	528
‘All’ Does Not Always Mean ‘All’	531
Setting Groups	532
Using the g Specifier: An Extended Example	533
Merging Focuses	535

	Naming Incomplete Arenas	536
	Naming Lists with Inconsistent Widths	537
	Stepping (Part II): Examples	538
	Using P/T Set Operators	540
	Creating Custom Groups	542
Chapter 22	Scalability in HPC Computing Environments	544
	Overview	544
	Configuring TotalView for Scalability	546
	Process Window's Process Tab	546
	dlopen Options	547
	dlopen Event Filtering	547
	Handling dlopen Events in Parallel	548
	MRNet	549
	TotalView Infrastructure Models	549
	Using MRNet with TotalView	551
	General Use	551
	Using MRNet on Blue Gene	555
	Using MRNet on Cray Computers	560
Chapter 23	Checkpointing	562
Chapter 24	Fine-Tuning Shared Library Use	564
	Preloading Shared Libraries	565
	Controlling Which Symbols TotalView Reads	567
	Specifying Which Libraries are Read	568
	Reading Excluded Information	569
Part 5: Using the CUDA Debugger		
Chapter 25	About the TotalView CUDA Debugger	571
	TotalView CUDA Debugging Model	573
	Installing the CUDA SDK Tool Chain	574
	Backward Compatibility with CUDA Device Drivers	575
	Directive-Based Accelerator Programming Languages	576
Chapter 26	CUDA Debugging Tutorial	577
	Compiling for Debugging	577
	Compiling for Fermi	577

Compiling for Fermi and Tesla	578
Compiling for Kepler	578
Starting a TotalView CUDA Session	579
Loading the CUDA Kernel	580
Controlling Execution	583
Running to a Breakpoint in the GPU code	583
Viewing the Kernel's Grid Identifier	584
Single-Stepping GPU Code	584
Halting a Running Application	585
Displaying CUDA Program Elements	586
GPU Assembler Display	586
GPU Variable and Data Display	586
CUDA Built-In Runtime Variables	587
Type Casting	587
PTX Registers	590

	Enabling CUDA MemoryChecker Feature	592
	GPU Core Dump Support	593
	GPU Error Reporting	594
	Displaying Device Information	596
Chapter 27	CUDA Problems and Limitations	597
	Hangs or Initialization Failures	597
	CUDA and ReplayEngine	598
Chapter 28	Sample CUDA Program	599
 Part 6: Appendices		
Appendix A	Glossary	605
Appendix B	Licenses	623
	3rd-Party Licenses	623
	CUDA License Information	623
Appendix C	Resources	627
	TotalView Family Differences	627
	TotalView Documentation	628
	Conventions	630
	Contacting Us	630
	 Index	 631



About This Guide

Content Organization

This guide describes how to use the TotalView® for HPC debugger, a source- and machine-level debugger for multi-process, multi-threaded programs. It is assumed that you are familiar with programming languages, a UNIX or Linux operating system, and the processor architecture of the system on which you are running TotalView and your program.

This user guide combines information for running the TotalView debugger either from within a Graphic User Interface (GUI), or the Command Line Interface (CLI), run within an xterm-like window for typing commands.

The information here emphasizes the GUI interface, as it is easier to use. Understanding the GUI will also help you understand the CLI.

Although TotalView doesn't change much from platform to platform, differences between platforms are mentioned.

The information in this guide is organized into these parts:

- [Part I, "Introduction to Debugging with TotalView"](#) contains an overview of TotalView features and an introduction to debugging with TotalView.
- [Part II, "Debugging Tools and Tasks"](#) describes the function and use of TotalView's primary set of debugging tools, such as stepping ([Chapter 7](#)), setting breakpoints ([Chapter 8](#)) and examining data including arrays ([Chapter 9](#) and [Chapter 10](#)).

This part also includes detail on TotalView's process/thread model ([Chapter 13](#) and working with multi-process, multi-threaded programs ([Chapter 14](#)).

- [Part III, “Using the CLI”](#) discusses the basics of using the Command Line Interface (CLI) for debugging. CLI commands are not documented in this book but in the *TotalView for HPC Reference Guide*.
- [Part IV, “Advanced Tools and Customization”](#) provides additional information required for setting up various MPI and other parallel programming environments, including high performance computing environments such as MPICH, OpenMP, UPC, and CAF. [Chapter 18](#) discusses how to get the TotalView Debugger Server (**tvdsvr**) running and how to reconfigure the way that TotalView launches the **tvdsvr**. [Chapter 21](#) builds on previous process/thread discussions to provide more detailed configuration information and ways to work in multi-process, multi-threaded environments.

In most cases, TotalView defaults work fine and you won't need much of this information.

- [Part V, “Using the CUDA Debugger”](#) describes the CUDA debugger, including a sample application.

Audience

Many of you are sophisticated programmers with knowledge of programming and its methodologies, and almost all of you have used other debuggers and have developed your own techniques for debugging the programs that you write.

We know you are an expert in your area, whether it be threading, high-performance computing, or client/server interactions. So, rather than telling you about what you're doing, this book tells you about TotalView.

TotalView is a rather easy-to-use product. Nonetheless, we can't tell you how to use TotalView to solve your problems because your programs are unique and complex, and we can't anticipate what you want to do. So, what you'll find in this book is a discussion of the kinds of operations you can perform. This book, however, is not just a description of dialog boxes and what you should click on or type. Instead, it tells you how to control your program, see a variable's value, and perform other debugging actions.

Detailed information about dialog boxes and their data fields is in the context-sensitive Help available directly from the GUI. In addition, an HTML version of this information is shipped with the documentation and is available on our Web site. If you have purchased TotalView, you can also post this HTML documentation on your intranet.

Using the CLI

To use the Command Line Interface (CLI), you need to be familiar with and have experience debugging programs with the TotalView GUI. CLI commands are embedded within a Tcl interpreter, so you get better results if you are also familiar with Tcl. If you don't know Tcl, you can still use the CLI, but you lose the ability to program actions that Tcl provides; for example, CLI commands operate on a set of processes and threads. By using Tcl commands, you can save this set and apply this saved set to other commands.

The following books are excellent sources of Tcl information:

- Ousterhout, John K. *Tcl and the Tk Toolkit*. Reading, Mass.: Addison Wesley, 1997.
- Welch, Brent B. *Practical Programming in Tcl & Tk*. Upper Saddle River, N.J.: Prentice Hall PTR, 1999.

There is also a rich set of resources available on the Web.

The fastest way to gain an appreciation of the actions performed by CLI commands is to scan “CLI Command Summary” of the *TotalView for HPC Reference Guide*, which contains an overview of CLI commands.

Resources

For information on

- TotalView family differences, which details the differences among TotalView Enterprise, TotalView Team, and TotalView Individual
- a complete list of TotalView documentation
- conventions used in the documentation
- contact information

please see [Appendix C](#).



Introduction to Debugging with TotalView

This part of the *TotalView for HPC User Guide* introduces TotalView's basic features and walks through a basic debugging session. Also included here is how to use the Remote Display Client, which allows you to connect to TotalView remotely.

Chapter 1, "About TotalView," on page 5

Introduces some of TotalView's primary features.

Chapter 2, "Basic Debugging," on page 32

Presents a basic debugging session with TotalView, illustrating tasks such as setting action points and viewing data.

Chapter 3, "Accessing TotalView Remotely," on page 64

Discusses how to start and interact with TotalView when it is executing on another computer.



Chapter 1

About TotalView

TotalView® for HPC is a powerful tool for debugging, analyzing, and tuning the performance of complex serial, multi-process, multi-threaded, and network-distributed programs. It supports a broad range of platforms, environments, and languages.

TotalView is designed to handle most types of High Performance Computing (HPC) parallel applications, and can be used to debug programs, running processes, or core files.

This chapter introduces TotalView's primary components and features, including:

- **Sessions Manager** for managing and loading debugging sessions, "[Sessions Manager](#)" on page 7
- **Graphical User Interface** with powerful data visualization capabilities, "[The GUI](#)" on page 8
- **Command Line Interface (CLI)** for scripting and batch environments, "[The CLI](#)" on page 8
- **Stepping commands and specialized breakpoints** that provide fine-grained control, "[Stepping and Breakpoints](#)" on page 9
- **Examining complex data sets**, "[Data Display and Visualization](#)" on page 10
- **Controlling threads and processes**, "[Tools for Multi-Threaded and Parallel Applications](#)" on page 22
- **Automatic batch debugging**, "[Batch and Automated Debugging](#)" on page 26
- **Running TotalView remotely**, "[Remote Display](#)" on page 27
- **Debugging CUDA code** running on the host Linux-x86_64 and the NVIDIA® GPU, "[CUDA Debugger](#)" on page 28
- **Debugging remote programs**, "[Debugging on a Remote Host](#)" on page 27

- **Memory debugging capabilities** integrated into the debugger, "[Memory Debugging](#)" on page 29
- **Recording and replaying running programs**, "[Reverse Debugging](#)" on page 30

Sessions Manager

The Sessions Manager is a GUI interface to manage your debugging sessions. Use the manager to load a new program, to attach to a program, or to debug a core file. The manager keeps track of your debugging sessions, enabling you to save, edit or delete any previous session. You can also duplicate a session and then edit its configuration to test programs in a variety of ways.

RELATED TOPICS

Managing debugging sessions [“Managing Sessions”](#) on page 119

Loading programs into TotalView [“Loading Programs from the Sessions Manager”](#) on page 98
using the Session Manager

GUI and Command Line Interfaces

TotalView provides both an easy-to-learn graphical user interface (GUI) and a Command Line Interface (CLI). The CLI and GUI are well integrated, so you can use them both together, launching the CLI from the GUI and invoking CLI commands that display data in the GUI. Or you can use either separately without the other. However, because of the GUI's powerful data visualization capabilities and ease of use, we recommend using it (along with the CLI if you wish) for most tasks.

The GUI

The GUI is an easy and quick way to access most of TotalView's features, allowing you to *dive* on almost any object for more information. You can dive on variables, functions, breakpoints, or processes. Data is graphically displayed so you can easily analyze problems in array data, memory data, your call tree/graph, or a message queue graph.

RELATED TOPICS

GUI Basics and Customizations [“Using and Customizing the GUI” on page 138](#)

The CLI

The Command Line Interface, or CLI, provides an extensive set of commands to enter into a command window. These commands are embedded in a version of the Tcl command interpreter. You can enter any Tcl statements from any version of Tcl into a CLI window, and you can also make use of TotalView-specific debugging commands. These additional commands are native to this version of Tcl, so you can also use Tcl to manipulate your programs. The result is that you can use the CLI to create your own commands or perform any kind of repetitive operation. For example, the following code shows how to set a breakpoint at line 1038 using the CLI:

```
dbreak 1038
```

When you combine Tcl and TotalView, you can simplify your job. For example, the following code sets a group of breakpoints:

```
foreach i {1038 1043 1045} {  
    dbreak $i  
}
```

RELATED TOPICS

Using the CLI [Part III, “Using the CLI,” on page 414](#)

CLI commands and reference [Chapter 3 of the *TotalView for HPC Reference Guide*](#)

Stepping and Breakpoints

In TotalView, breakpoints are just a type of *action point*, and there are four types:

- A *breakpoint* stops execution of processes and threads that reach it.
- An *eval point* executes a code fragment when it is reached.
- A *barrier point* synchronizes a set of threads or processes at a location (“[Synchronizing Execution with Barrier Points](#)” on page 25).
- A *watchpoint* monitors a location in memory and stops execution when it changes (“[Setting Watchpoints](#)” on page 16).

You can set action points in your program by selecting the boxed line numbers in the Source Code pane of a Process window. A boxed line number indicates that the line generates executable code. A **STOP** icon appears at the line number to indicate that a breakpoint is set on the line. Selecting the **STOP** icon clears the breakpoint.

When a program reaches a breakpoint, it stops. You can resume or otherwise control program execution in any of the following ways:

- Use the single-step commands described in “[Using Stepping Commands](#)” on page 166.
- Use the set program counter command to resume program execution at a specific source line, machine instruction, or absolute hexadecimal value. See “[Setting the Program Counter](#)” on page 173.
- Set breakpoints at lines you choose, and let your program execute to that breakpoint. See “[Setting Breakpoints and Barriers](#)” on page 179.
- Set conditional breakpoints that cause a program to stop after it evaluates a condition that you define, for example, “stop when a value is less than eight.” See “[Setting Eval Points](#)” on page 198.

RELATED TOPICS

Detailed information on action points [Chapter 8, “Setting Action Points,”](#) on page 174

Stepping commands [“Stepping through and Executing your Program”](#) on page 165

Data Display and Visualization

TotalView provides comprehensive and flexible tools for developers to explore large and complex data sets. The TotalView data window supports browsing through complex structures and arrays. Powerful slicing and filtering helps developers manage arrays of thousands or even millions of elements. Data watchpoints provide answers to questions about how data is changing. Built-in graphical visualization displays a quick view of complex numerical data. Type transformations, especially C++ View, help you display data in a meaningful way.

This section includes:

- “Data Display” on page 10
- “Data Visualization” on page 16
- “C++ View” on page 20

RELATED TOPICS

Viewing and editing data	Chapter 9, “Examining and Editing Data and Program Elements,” on page 214
Data Visualization	Chapter 11, “Visualizing Programs and Data,” on page 303

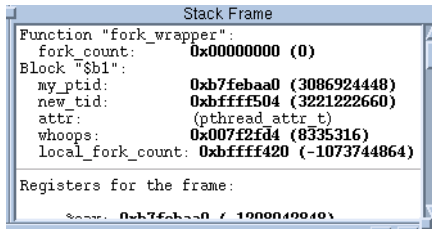
Data Display

All variables in your current routine are displayed in the Process Window's Stack Frame Pane in its upper right corner, [Figure 1](#). If a variable's value is simple, it is visible here. If the value is not simple, *dive* on the variable to get more information.

NOTE >> You can dive on almost any object in TotalView to display more information about that object. To dive, position the cursor over the item and click the middle mouse button or double-click the left mouse button.

Some values in the Stack Frame Pane are **bold**, meaning that you can click on the value and edit it.

Figure 1 – Stack Frame Pane of the Process Window



This section includes:

- [“Diving in a Variable Window”](#) on page 11
- [“Viewing a Variable Value across Multiple Processes or Threads”](#) on page 13
- [“Simplifying Array Display”](#) on page 13
- [“Viewing a Variable’s Changing Value”](#) on page 16
- [“Setting Watchpoints”](#) on page 16

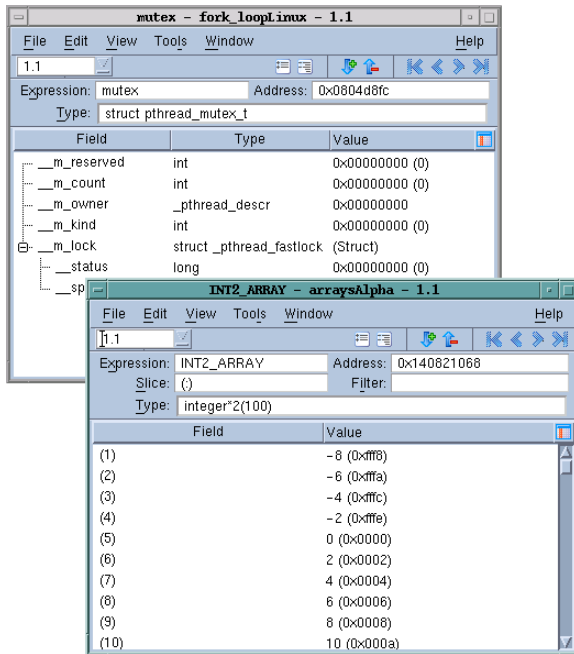
RELATED TOPICS

Diving in general	“About Diving into Objects” on page 152
Displaying non-scalar variables	“Displaying Variables” on page 220
Editing variables	“Changing the Values of Variables” on page 254 and “Changing a Variable’s Data Type” on page 256

Diving in a Variable Window

Figure 2 shows two Variable Windows, one created by diving on a structure and the second by diving on an array.

Figure 2 – Diving on a Structure and an Array



If the displayed data is not scalar, you can redive on it for more information. When you dive in a Variable Window, TotalView replaces the window's contents with the new information, or you can use the **View > Dive Thread in New Window** command to open a separate window.

For pointers, diving on the variable dereferences the pointer and displays the data pointed to. In this way, you can follow linked lists.

Buttons in the upper right corner () support undives and redives. For example, if you're following a pointer chain, click the center-left arrow to go back to where you just were. Click the center-right arrow to move forward.

RELATED TOPICS

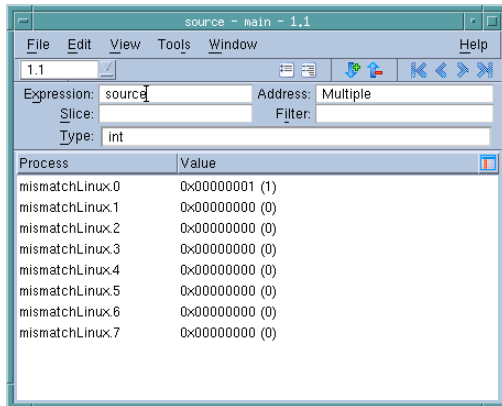
Diving in variable windows [“Diving in Variable Windows”](#) on page 240

Duplicating variable windows The **Window > Duplicate** command, in the in-product Help

Viewing a Variable Value across Multiple Processes or Threads

You can simultaneously see the value of a variable in each process or thread using the **View > Show Across > Thread** or **View > Show Across > Process** commands, Figure 3.

Figure 3 – Viewing Across Processes



You can export data created by the **Show Across** command to the Array Visualizer (see “[The Array Visualizer](#)” on page 17).

RELATED TOPICS

The **View > Show Across...** command

“[Displaying a Variable in all Processes or Threads](#)” on page 300

Exporting a **Show Across** view to the Visualizer

“[Visualizing a “Show Across” Variable Window](#)” on page 302

Simplifying Array Display

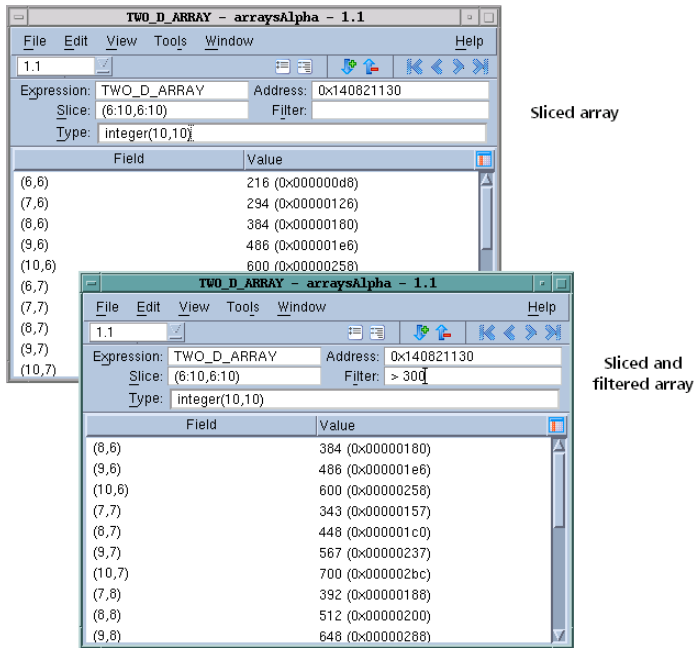
Because arrays frequently have large amounts of data, TotalView provides a variety of ways to simplify their display, including *slicing* and *filtering*, and a special viewer, the Array Viewer.

Slicing and Filtering

The top Variable Window of [Figure 4](#) shows a basic slice operation that displays array elements at positions named by the slice. In this case, TotalView is displaying elements 6 through 10 in each of the array’s two dimensions.

The other Variable Window combines a filter with a slice to display data according to some criteria. Here, the filter shows only elements with a value greater than 300.

Figure 4 – Slicing and Filtering Arrays



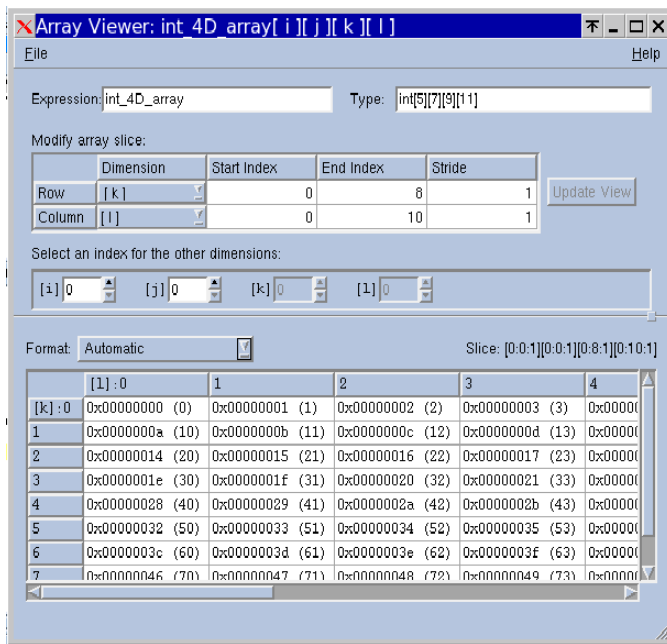
RELATED TOPICS

Arrays in general	Chapter 10, "Examining Arrays," on page 283
Filtering in arrays	"Filtering Array Data Overview" on page 290
Array slices	"Displaying Array Slices" on page 284

The Array Viewer

Use the Array Viewer (from the Variable Window's **Tools > Array Viewer** command) for another graphical view of data in a multi-dimensional array, [Figure 5](#). Think of this as viewing a “plane” of two-dimensional data in your array.

Figure 5 – Array Viewer



The Array Viewer initially displays a slice of data based on values entered in the Variable Window. You can change the displayed data by modifying the Expression, Type, or Slice controls.

You can also see the shape of the data using the Visualizer, introduced in this chapter in [“The Array Visualizer”](#) on page 17.

RELATED TOPICS

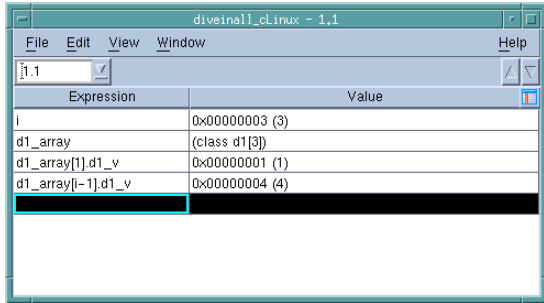
The Array Viewer

[“Viewing Array Data”](#) on page 288

Viewing a Variable's Changing Value

Variable Windows let you critically examine many aspects of your data. In many cases, however, you may be primarily interested in the variable's value. For this, use the Expression List Window, [Figure 6](#), to display the values of many variables at the same time.

Figure 6 – Tools > Expression List Window



This is particularly useful for viewing variable data about scalar variables in your program.

RELATED TOPICS

Lists of variables in the Expression List Window

[“Viewing a List of Variables”](#) on page 246

TotalView's comprehensive expression system

[“Evaluating Expressions”](#) on page 327

Setting Watchpoints

The *watchpoint* — another type of action point — is yet another way to look at data. A TotalView watchpoint can stop execution when a variable's data changes, no matter the cause. That is, you could change data from within 30 different statements, triggering the watchpoint to stop execution after each of these 30 statements make a change. Or, if data is being overwritten, you could set a watchpoint at that location in memory and then wait until TotalView stops execution because of an overwrite.

If you associate an expression with a watchpoint (by selecting the Conditional button in the Watchpoint Properties dialog box to enter an expression), TotalView evaluates the expression after the watchpoint triggers.

RELATED TOPICS

About watchpoints in general

[“Using Watchpoints”](#) on page 206

The **Tools > Create Watchpoint** command

Tools > Create Watchpoint in the in-product Help

Data Visualization

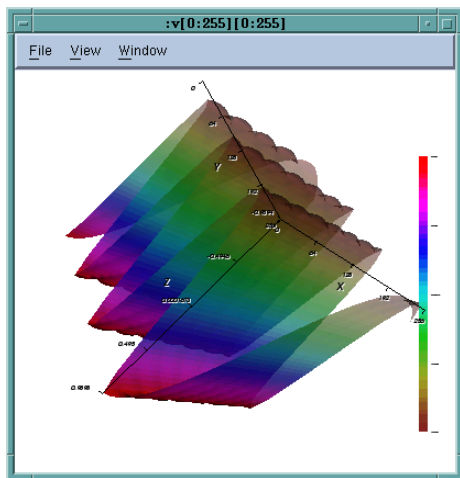
TotalView provides a set of tools to visualize your program activity, including its arrays and MPI message data. These include:

- “The Array Visualizer” on page 17
- “The Parallel Backtrace View” on page 17
- “The Call Tree and Call Graph” on page 18
- “The Message Queue Graph” on page 20

The Array Visualizer

The Variable Window’s **Tools > Visualize** command shows a graphical representation of a multi-dimensional dataset. For instance, [Figure 7](#) shows a sine wave in the Visualizer.

Figure 7 – Visualizing an Array



This helps you to quickly see outliers or other issues with your data.

RELATED TOPICS

The Visualizer

“Visualizing Programs and Data” on page 303

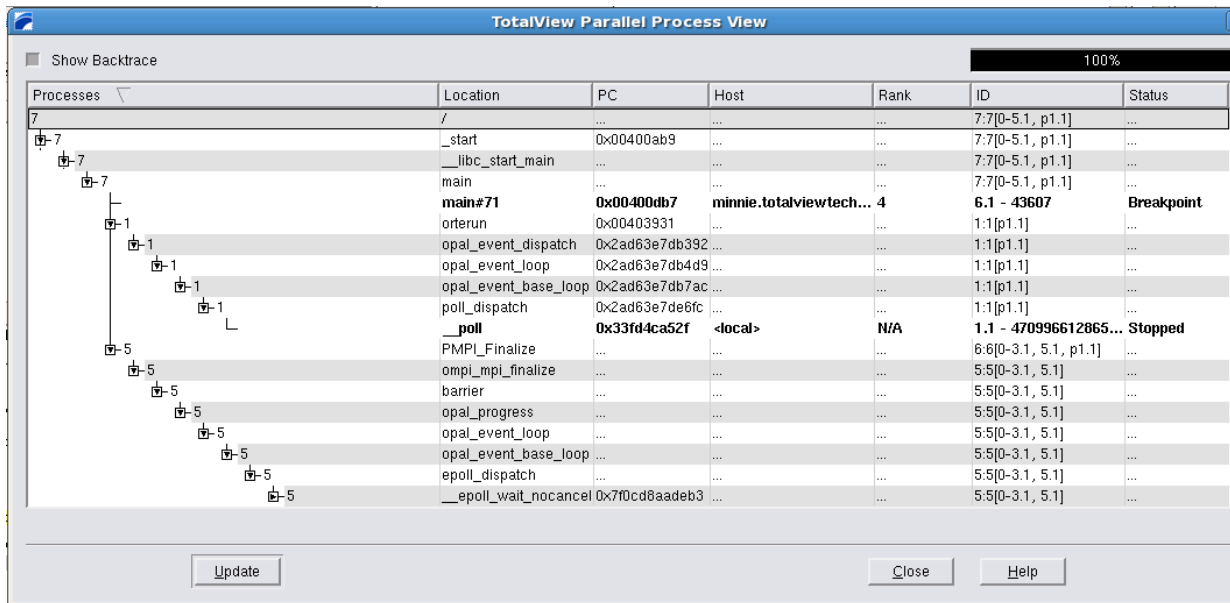
Using the **Tools > Visualize** and the **Tools > Visualize Distribution** commands

The Parallel Backtrace View

The Parallel Backtrace View displays the state of every process and thread in a parallel job, allowing you to view thousands of processes at once, and helping you to identify stray processes.

Access the Parallel Backtrace View from the Tools menu of the Variable Window.

Figure 8 – Parallel Backtrace View



This view groups threads by common stack backtrace frames in a text-based tree. Expand or collapse elements to drill down and get more information.

RELATED TOPICS

The Parallel Backtrace View

[“Parallel Backtrace View”](#) on page 307

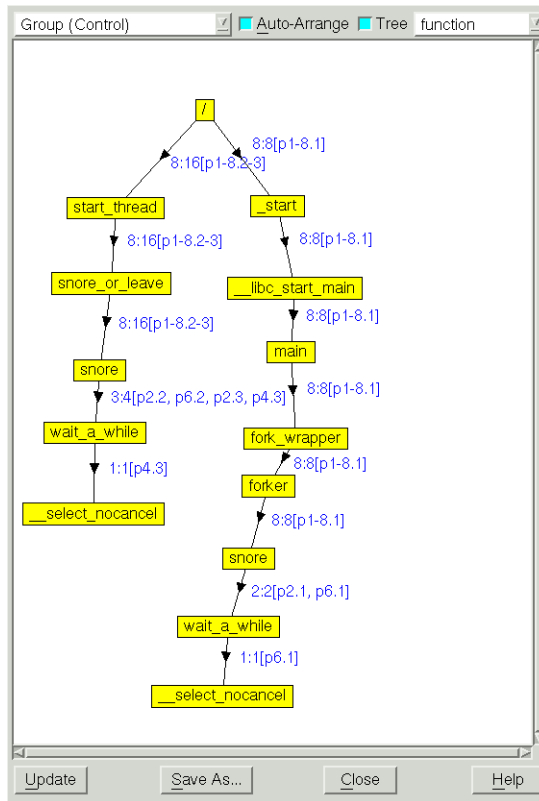
Using the **Tools > Parallel Backtrace View** command

Tools > Parallel Backtrace View in the in-product Help

The Call Tree and Call Graph

The Call Tree or Call Graph, accessible from the Process Window using the command **Tools > Call Graph**, provides a quick view of application state and is especially helpful for locating outliers and bottlenecks.

Figure 9 – Tools > Call Graph Dialog Box



By default, the Call Tree or Call Graph displays the Call Tree representing the backtrace of all the selected processes and threads.

For multi-process or multi-threaded programs, a compressed process/thread list (**ptlist**) next to the arrows indicates which threads have a routine on their call stack. You can dive on a routine in the call tree/graph to create a group called **call_graph** that contains all the threads that have the routine you dived on in their call stack.

RELATED TOPICS

The Call Tree or Call Graph in more detail ["Displaying Call Trees and Call Graphs"](#) on page 304

Using the CLI's **dwhere -group_by** option to control and reduce the backtraces [dwhere -group_by](#) in the *TotalView for HPC Reference Guide*

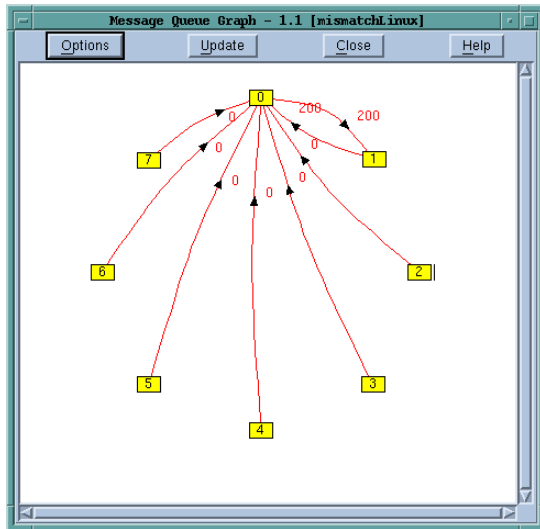
About the **ptlist** ["Compressed List Syntax \(ptlist\)"](#) in the *TotalView for HPC Reference Guide*

Using the **Tools > Call Graph** command [Tools > Call Graph](#) in the in-product Help

The Message Queue Graph

For MPI programs, use the Process Window's Message Queue Graph (**Tools > Message Queue Graph**) to display your program's message queue state.

Figure 10 – A Message Queue Graph



The graph's Options window (available by clicking on the Options button, above) provides a variety of useful tools, such as Cycle Detection to generate reports about cycles in your messages, a helpful way to see when messages are blocking or causing deadlocks. Also useful is its filtering capability, which helps you identify pending send and receive messages, as well as unexpected messages.

RELATED TOPICS

The Message Queue Graph

[“Displaying the Message Queue Graph Window”](#) on page 406

Using the **Tools > Message Queue Graph** command

Tools > Message Queue Graph in the in-product Help

C++ View

Using C++ View, you can format program data in a more useful or meaningful form than its concrete representation displayed in a running program. This allows you to inspect, aggregate, and check the validity of complex data, especially data that uses abstractions such as structures, classes, and templates.

RELATED TOPICS

[More on C++ View](#)

[Creating Type Transformations" in the
TotalView for HPC Reference Guide](#)

Tools for Multi-Threaded and Parallel Applications

TotalView is designed to debug multi-process, multi-threaded programs, with a rich feature set to support fine-grained control over individual or multiple threads and processes. This level of control makes it possible to quickly resolve problems like deadlocks or race conditions in a complex program that spawns thousands of processes and threads across a broad network of servers.

When your program creates processes and threads, TotalView can automatically bring them under its control, whether they are local or remote. If the processes are already running, TotalView can acquire them as well, avoiding the need to run multiple debuggers.

TotalView places a server on each remote processor as it is launched that then communicates with the main TotalView process. This debugging architecture gives you a central location from which you can manage and examine all aspects of your program.

This section introduces some of TotalView's primary tools for working with complex parallel applications, and includes:

- [“Program Using Almost Any Execution Model”](#) on page 22
- [“View Process and Thread State”](#) on page 22
- [“Control Program Execution”](#) on page 23

Program Using Almost Any Execution Model

TotalView supports the popular parallel execution models MPI and MPICH, OpenMP, ORNL, SGI shared memory (shmem), Global Arrays, UPC, and CAF.

RELATED TOPICS

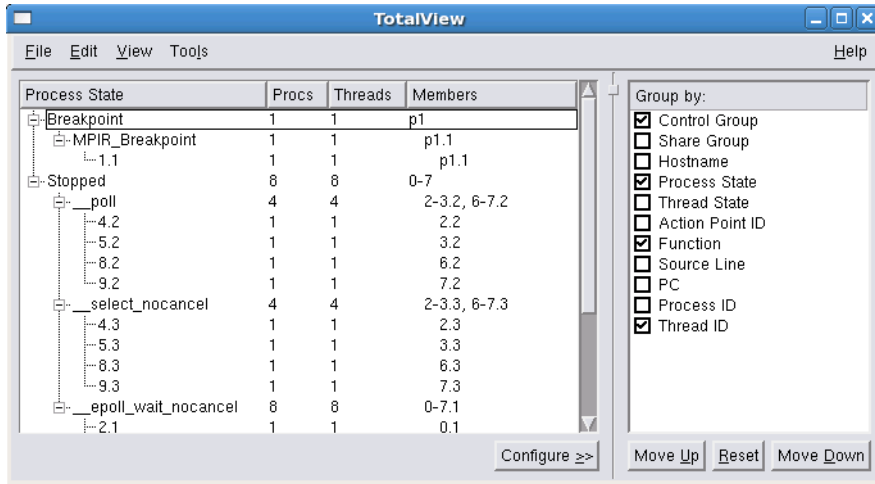
MPI debugging sessions	“Setting Up MPI Debugging Sessions” on page 461
Other parallel environments (not MPI)	“Setting Up Parallel Debugging Sessions” on page 492

View Process and Thread State

You can quickly view process and thread state in both the Root Window and the Process Window. (You can also view the state of *all* processes and threads in a parallel job using the [“The Parallel Backtrace View”](#) on page 17.)

The Root Window contains an overview of all processes and threads being debugged, along with their process state (i.e. stopped, running, at breakpoint, etc.). You can dive on a process or a thread listed in the Root Window to quickly see detailed information.

Figure 11 – The Root Window



RELATED TOPICS

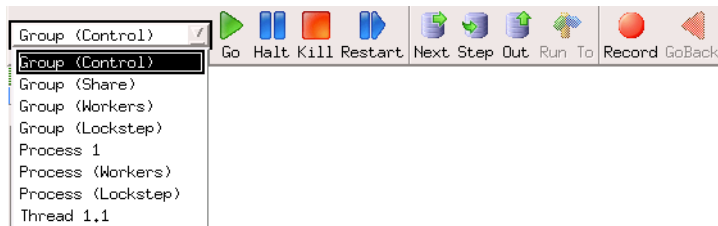
- More on process and thread state [“Viewing Process and Thread States” on page 374](#)
- The Root Window [“Using the Root Window” on page 140](#)
- The Process Window [“Using the Process Window” on page 148](#)

Control Program Execution

Commands controlling execution operate on the current focus, or target -- either an individual thread or process, or a group of threads and processes. You can individually stop, start, step, and examine any thread or process, or perform these actions on a group.

Select the target of your action from the toolbar’s pulldown menu, [Figure 12](#).

Figure 12 – Selecting a Target from the Toolbar Pulldown



You can also synchronize execution across threads or processes using a *barrier point*, which holds any threads or processes in a group until each reaches a particular point.

RELATED TOPICS

Selecting a target (also called focus) [“Using the Toolbar to Select a Target”](#) on page 377

Setting process and thread focus using the CLI [“Setting Process and Thread Focus”](#) on page 520

Setting group focus [“Setting Group Focus”](#) on page 526

Finely controlling focus [“Defining the GOI, POI, and TOI”](#) on page 514

Introduction to barrier points [“Synchronizing Execution with Barrier Points”](#) on page 25

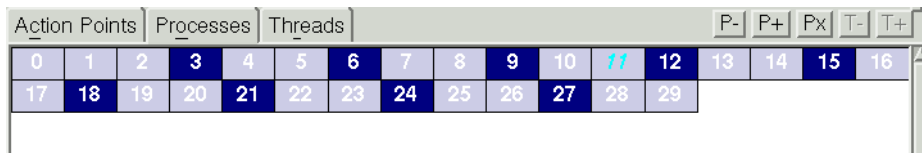
Using Groups

TotalView automatically organizes your processes and threads into groups, allowing you to view, execute and control any individual thread, process, or group of threads and processes. TotalView defines built-in groups, and you can define your own custom groups that help support full, asynchronous debugging control over your program.

For example, you can:

- Single step one or a small set of processes rather than all of them
- Use **Group > Custom Group** to create named groups
- Use **Run To** or breakpoints to control large groups of processes
- Use *Watchpoints* to watch for variable changes

For instance, here is the Processes Tab after a group containing 10 processes (in dark blue below) is selected in the Toolbar’s Group pulldown list. This identifies the processes that will be acted on when you select a command such as **Go** or **Step**.



RELATED TOPICS

Groups in TotalView [“Organizing Chaos”](#) on page 360

How TotalView predefines groups [“How TotalView Creates Groups”](#) on page 364

Introduction to setting watchpoints [“Setting Watchpoints”](#) on page 16

Creating custom groups [“Creating Custom Groups”](#) on page 542

Synchronizing Execution with Barrier Points

You can synchronize execution of threads and processes either manually using a *hold* command, or automatically by setting an action point called a *barrier point*. These two tools can be used together for fine-grained execution control. For instance, if a process or thread is held at a barrier point you can manually release it and then run it without first waiting for all other processes or threads in the group to reach that barrier.

When a process or a thread is *held*, it ignores any command to resume executing. For example, assume that you place a hold on a process in a **control group** that contains three processes. If you select **Group > Go**, two of the three processes resume executing. The held process ignores the **Go** command.

RELATED TOPICS

Setting barrier points	“Setting Breakpoints and Barriers” on page 179 and
Using barrier points in a multi-threaded, multi-process program	“Using Barrier Points” on page 386
Using the CLI to set barrier points	“Using Action Points” on page 431
Strategies for using barrier points	“Simplifying What You’re Debugging” on page 370 and “Breakpoints, Stepping, and Program Execution” on page 399

Batch and Automated Debugging

You can set up unattended batch debugging sessions using TotalView's powerful scripting tool **tvscript**. First, define a series of events that may occur within the target program. **tvscript** loads the program under its control, sets breakpoints as necessary, and runs the program. At each program stop, **tvscript** logs the data for your review when the job has completed.

A script file can contain CLI and Tcl commands (Tcl is the basis for TotalView's CLI).

Here, for example, is how **tvscript** is invoked on a program:

```
tvscript \  
-create_actionpoint "method1=>display_backtrace -show_arguments" \  
-create_actionpoint "method2#37=>display_backtrace -show_locals -level 1" \  
-display_specifiers "nowshow_pid,noshow_tid" \  
-maxruntime "00:00:30" \  
  filterapp -a 20
```

You can also execute MPI programs using **tvscript**. Here is a small example:

```
tvscript -mpi "Open MP" -tasks 4 \  
-create_actionpoint \  
  "hello.c#14=>display_backtrace" \  
  ~/tests/MPI_hello
```

While batch debugging of large-scale MPI applications through **tvscript** has long been a powerful tool, **tvscript** has recently been enhanced and fully certified to handle 1024 process jobs, and 2048 threads per process, or more than two million running operations.

RELATED TOPICS

About **tvscript** and batch scripting, including Batch Scripting and Using the CLI" in *Debugging memory debugging* *Memory Problems with MemoryScope*

tvscript syntax and command line options Batch Debugging Using tvscript" in the *TotalView for HPC Reference Guide*

Remote Display

Using the Remote Display Client, you can easily set up and operate a TotalView debug session that is running on another system. A licensed copy of TotalView must be installed on the remote machine, but you do not need an additional license to run the Client.

The Client also provides for submission of jobs to batch queuing systems PBS Pro and Load Leveler.

RELATED TOPICS

Using the Remote Display Client [“Accessing TotalView Remotely”](#) on page 64

Debugging on a Remote Host

Using the TotalView Server, you can debug programs located on remote machines. Debugging a remote process is similar to debugging a native process, although performance depends on the load on the remote host and network latency. TotalView runs and accesses the process **tvdsvr** on the remote machine.

RELATED TOPICS

The TotalView Server [“Setting Up Remote Debugging Sessions”](#) on page 442

The **tvdsvr** process: [“The tvdsvr Command and Its Options”](#) in the *TotalView for HPC Reference Guide*

CUDA Debugger

The TotalView CUDA debugger is an integrated debugging tool capable of simultaneously debugging CUDA code that is running on the host Linux-x86_64 and the NVIDIA® GPU. CUDA support is an extension to the standard version of Linux-x86_64 TotalView, and is capable of debugging 64-bit CUDA programs on Linux-x86_64. Debugging 32-bit CUDA programs is currently not supported.

Supported major features:

- Debug a CUDA application running directly on GPU hardware
- Set breakpoints, pause execution, and single step in GPU code
- View GPU variables in PTX registers, and in local, parameter, global, or shared memory
- Access runtime variables, such as threadIdx, blockIdx, blockDim, etc.
- Debug multiple GPU devices per process
- Support for the CUDA MemoryChecker
- Debug remote, distributed and clustered systems
- All Linux-x86_64 host debugging features are supported, except ReplayEngine

RELATED TOPICS

The CUDA debugger	“Using the CUDA Debugger” on page 570
The CLI dcuda command	dcuda in the <i>TotalView for HPC Reference Guide</i>

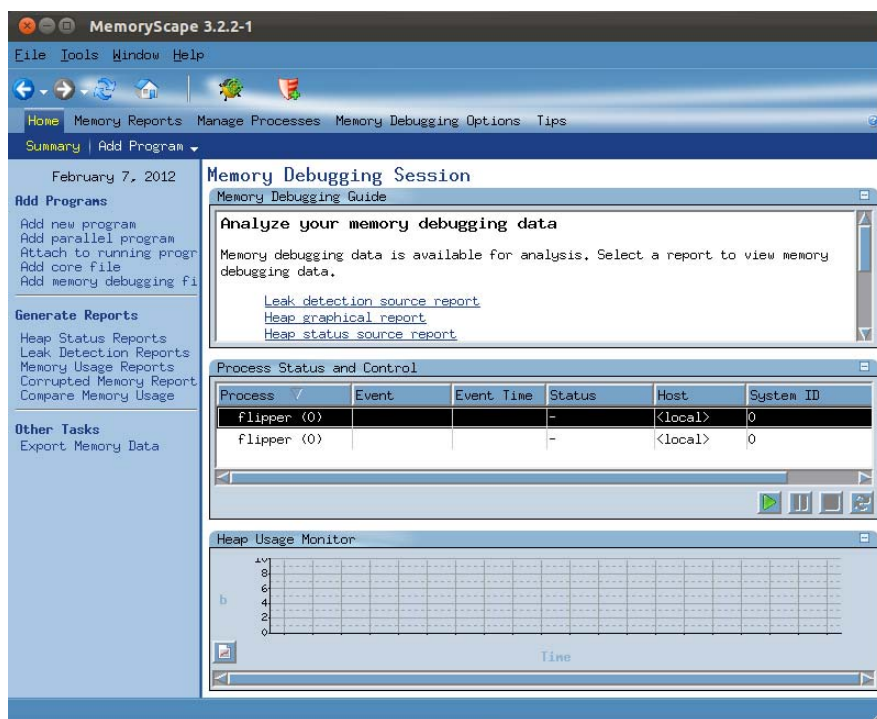
Memory Debugging

TotalView has a fully integrated version of the MemoryScope product for debugging memory issues. MemoryScope is also available as a standalone product.

MemoryScope can monitor how your program uses **malloc()** and **free()** and related functions such as **calloc()** and **realloc()**. For example, the C++ **new** operator is almost always built on top of the **malloc()** function. If it is, MemoryScope can track it.

You must enable memory debugging *before* you start running your program. Once you have loaded a program to debug in TotalView, select **Debug > Open MemoryScope** to launch the primary MemoryScope window.

Figure 13 – MemoryScope home window



RELATED TOPICS

MemoryScope has its own user guide *Debugging Memory Problems with MemoryScope*.

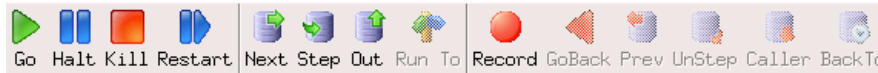
Reverse Debugging

ReplayEngine records all your program's activities as it executes within TotalView. After recording information, you can move forward and backward by function, line, or instruction. You can examine data and state in the past, as if it were a live process.

Using ReplayEngine eliminates the cycle of starting and restarting so common in debugging and greatly helps in finding hard-to-reproduce bugs.

NOTE >> ReplayEngine is a separately licensed product for linux-86 and linux-x86-64.

When enabled, ReplayEngine commands are added to the toolbar (at right):



RELATED TOPICS

Reverse debugging is discussed in a [Reverse Debugging with ReplayEngine](#) separate user guide

What's Next

This chapter has presented TotalView's primary features and tools, but a single chapter cannot provide a complete picture of everything you can do with TotalView. See the rest of this user guide and other books in the TotalView documentation for more about TotalView.

If you are a new TotalView user, we recommend reading *Getting Started with TotalView Products*, which provides basic information on TotalView's most commonly used tools.

You may also wish to work through the introductory tutorial in "[Basic Debugging](#)" on page 32.



Chapter 2

Basic Debugging

This chapter illustrates some basic debugging tasks and is based on the shipped program, **wave_extended**, located in the directory `installdir/toolworks/totalview.version/platform/examples`. This is a simple program that creates an array and then increments its values to simulate a wave form which can then be viewed using the Visualizer. The program requires user input to provide the number of times to increment.

The first steps when debugging programs with TotalView are similar to those using other debuggers:

- Use the **-g** option to compile the program. (Compiling is not discussed here. Please see [“Compiling Programs”](#) on page 85.)
- Start the program under TotalView control.
- Start the debugging process, including setting breakpoints and examining your program’s data.

The chapter introduces some of TotalView’s primary tools, as follows:

- [“Program Load and Navigation”](#) on page 33
- [“Stepping and Executing”](#) on page 38
- [“Setting Breakpoints \(Action Points\)”](#) on page 42
- [“Examining Data”](#) on page 49
- [“Visualizing Arrays”](#) on page 58

Program Load and Navigation

This section discusses how to load a program and looks at the two primary TotalView windows, the Root and Process windows. It also illustrates some of TotalView's navigation tools.

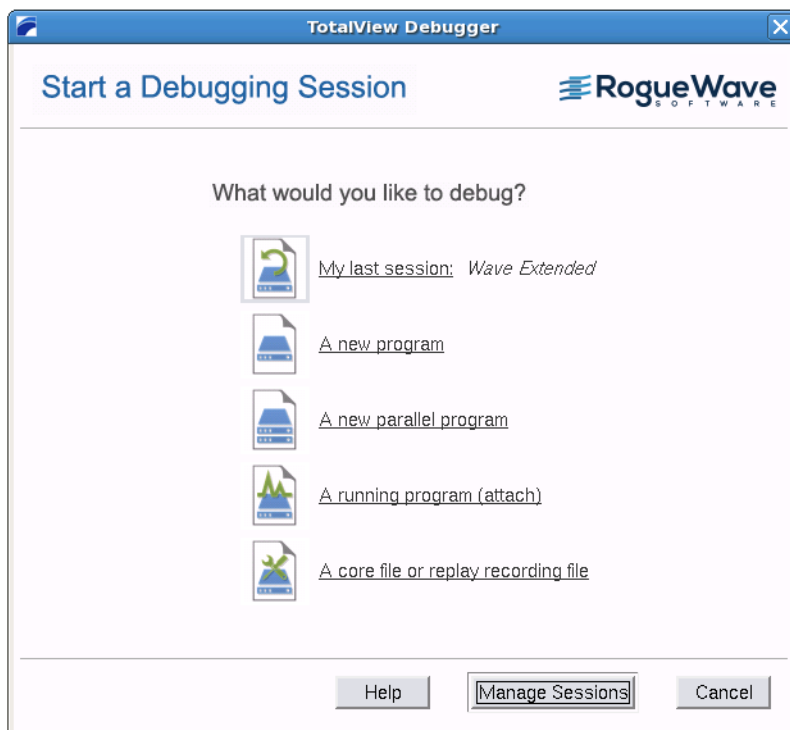
Load the Program to Debug

NOTE >> Before starting TotalView, you must add TotalView to your PATH variable. For information on installing or configuring TotalView, see the *TotalView for HPC Installation Guide*.

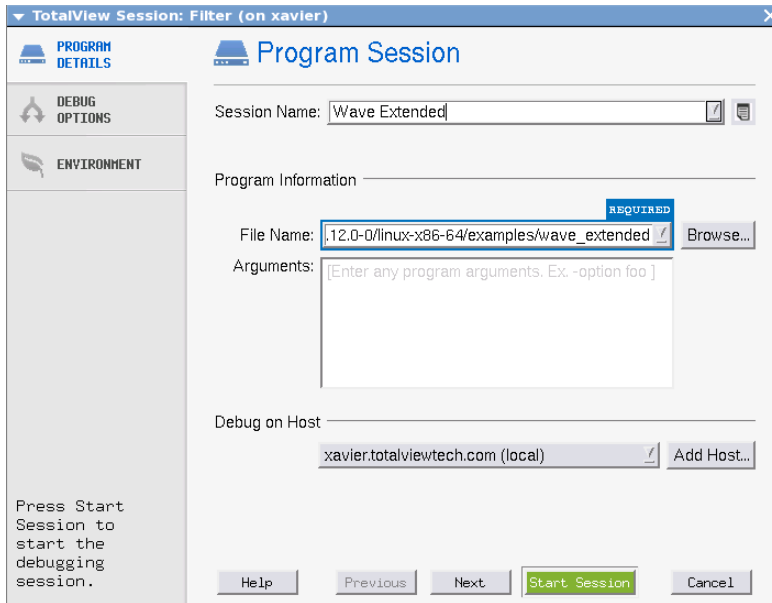
1. Start TotalView.

`totalview`

The Start a Debugging Session dialog launches.



2. Select **A new program** to launch the Program Session dialog.



3. Provide a name for the session in **Session Name** field. This can be any string.
4. In the **File Name** field, browse to and select the **wave_extended** program, located in the directory *install-dir/toolworks/totalview.version/platform/examples*. Leave all other fields and options as is. Click **Start Session** to load the program into TotalView.

Note that this is the same as entering the program name as an argument when starting TotalView:

```
totalview wave_extended
```

(Note that this invocation assumes that your **examples** directory is known to TotalView or that you are invoking TotalView from within the **examples** directory.)

RELATED TOPICS

Compiling programs for debugging [“Compiling Programs”](#) on page 85

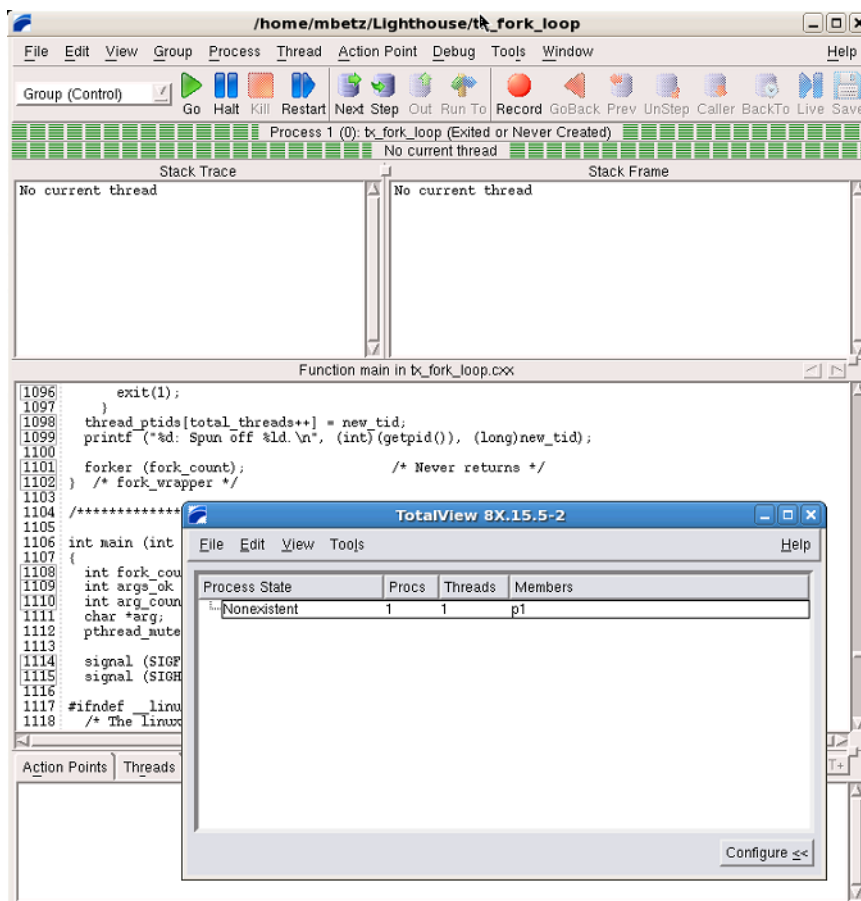
Various ways to start TotalView [“Starting TotalView”](#) on page 87

Loading programs [“Loading Programs from the Sessions Manager”](#) on page 98

The Root and Process Windows

At startup, TotalView launches its two primary windows, the Root Window and the Process Window. With these two windows, you can navigate through the various elements of your program.

Figure 14 – The Root and Process Windows



The Root Window

The Root Window (the smaller window above) lists all processes and threads under TotalView control. You can use the Configure pane, displayed by clicking the button on the bottom right, to specify the specific information you want to view.

Since the program has been created but not yet executed, there is just a single process and thread listed.

The Process Window

The Process Window displays a wide range of information about the state of a process and its individual threads.

- The Stack Trace pane displays the call stack with any active threads.
- The Stack Frame pane displays information on the current thread's variables.
- The Source Pane displays source code for the **main()** function. Note that the pane's header reports its focus as being in **main()**:

- Two tabs are visible at the bottom, Action Points, which displays any set action points, and Threads, which lists all active threads in the process. The Processes/Ranks tab, if enabled, displays processes within the current control group. The Processes/Ranks tab is disabled by default.

RELATED TOPICS

The Root Window	“Using the Root Window” on page 140
The Process Window	“Using the Process Window” on page 148
Processes/Ranks tab	“Using the Processes/Ranks and Threads Tabs” on page 379

Program Navigation

From the Root and Process Windows, you can navigate anywhere in your program. Some examples:

1. Dive on a function


- From the Process Window, in **main()**, “dive” on the function **load_matrix()** by double-clicking on it. (Click on the text, not on the line number, which would instead add an Action Point.)

NOTE >> *Diving* simply means clicking on an object to launch a window with detailed information. Diving is integral to using TotalView and provides instant access to detailed data by drilling down into the object, routine, process, thread, etc.

```

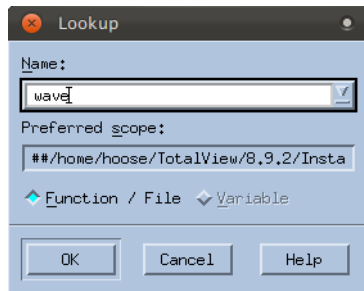
100 int main (int argc, char **argv)
101 {
102     struct wave_value_t values[XSIZE][YSIZE];
103
104     load_matrix(values);
105
106     printf("\nProgram is complete.\n");
107

```

The focus in the Source Pane shifts to this function. You can change the focus back to **main()** using the *dive stack* icons () at the top right. If you click the left arrow, the focus returns to **main()** and the right arrow becomes enabled, allowing you to dive, undo a dive, and then redive.

2. Look up a function

- From the View menu, select **Lookup Function**, then enter **wave**:

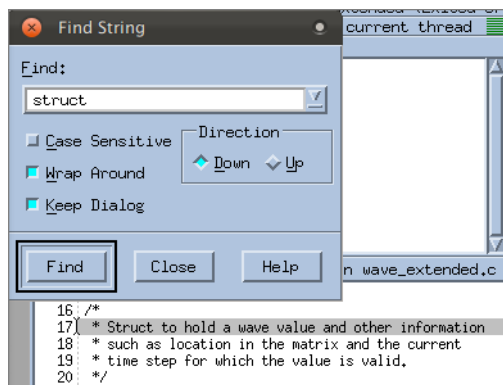


The focus shifts to the function **wave()**. This function happens to be in the same file, **wave_extended.c**, but finding, diving, and other navigation tools operate on any file in a project.

3. Find any program element

- From the Edit menu, select **Find**.

You can enter any search term, and TotalView returns results from anywhere in your program, including from assembler code if it is visible. For instance, a search on “struct” returns several instances:



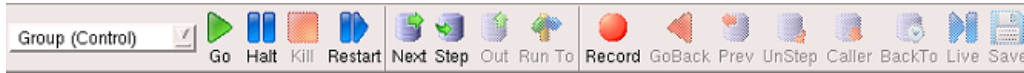
RELATED TOPICS

- | | |
|--------------------------|---|
| Diving on objects | “About Diving into Objects” on page 152 |
| Finding program elements | “Searching and Navigating Program Elements” on page 156 |
| The Lookup Function | “Looking for Functions and Variables” on page 157 |

Stepping and Executing

The Process Window's toolbar features buttons that control stepping and execution.

Figure 15 – Toolbar



The following sections explore how these work using the **wave_extended** example.

NOTE >> These procedures on stepping and execution can be performed independently of the other tasks in this chapter, but you must first load the program, as described in “[Load the Program to Debug](#)” on page 33.

Simple Stepping

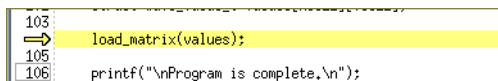
Here, we'll use the commands **Step**, **Run To**, and **Next**, and then note process and thread status.

1. Step

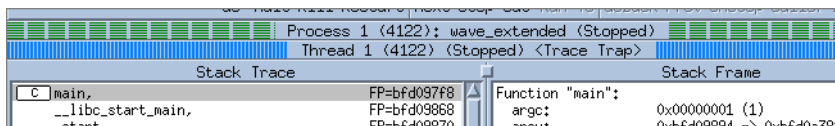
- Select **Step**. TotalView stops the program just before the first executable statement, the method **load_matrix()**.

All stepping functions are under the Process, Thread, and Group menus. So for the above, you could also select **Process > Step**, or just press the keyboard shortcut **s** — keyboard shortcuts are all listed under the above menus, and can considerably speed debugging tasks.

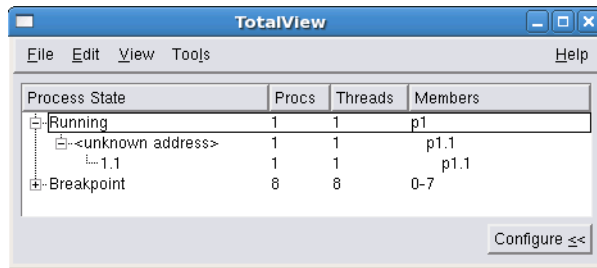
Note the yellow arrow that shows the current location of the Program Counter, or **PC**, in the selected stack frame.



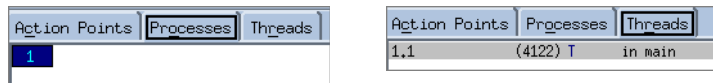
The process and thread status are displayed in the status bars above the Stack Trace and Stack Frame panes:



The Root Window also displays process/thread status. The Process State column displays the state of the thread:



You can also see that a single Process and Thread have been launched in the Process Window's Thread tab at the bottom of the interface. (1.1 indicates one process and one thread.) If enabled, you can also see information about the process in the Processes tab.



The process is blue, meaning that it is stopped. If it were running, it would be green. A single thread has been spawned, which reports that it is in **main()**.

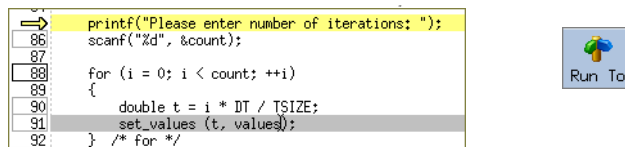
- Select **Step** again to *step into* the function. (**Next** would *step over*, or execute the function, as described in [Step 3](#).)

TotalView goes into the **load_matrix()** function.

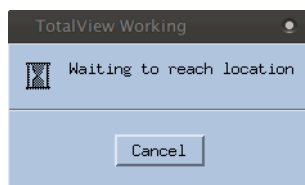
The Source Pane header reports that the program is in **load_matrix()**, and the PC is at **printf()**.

2. Run To

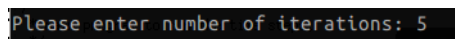
- Select the **set_values()** function at line 91, then click **Run To** in the toolbar.



The program attempts to run to the selected line. Note that the PC does not change, and TotalView launches a popup:



Because the method **set_values()** is called after **scanf()**, the program is waiting for user input. From the shell that launched TotalView, enter **5** at the prompt "Please enter number of iterations", then hit Return. (You can enter a different number, but a higher value will require you to wait over more iterations during later discussions.)

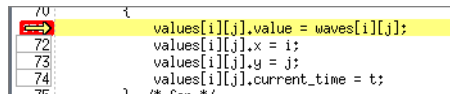


The PC stops at `set_values()`.

3. Next

- Select **Next**. The program executes the for loop the number of times you input in the previous step, and then completes the program by printing “Program is complete.” to the console. (If you had instead selected **Step**, the program would have gone *into* the `set_values()` function.)

The **Next** command simply executes any executable code at the location of the PC. If that is a function, it fully executes the function. If the PC is instead at a location within a function, it executes that line and then moves the PC to the next line. For instance, below the PC is setting a variable value. In this case, **Next** executes line 71, and then moves the PC to line 72.



```
70:         values[i][j].value = waves[i][j];
71:         values[i][j].x = i;
72:         values[i][j].y = j;
73:         values[i][j].current_time = t;
```

(Note that the array building the wave is not visible, as there is no program output. To examine or visualize data, including array data, we’ll use the Variable Window and the Visualizer, discussed in “Examining Data” on page 49 and “Visualizing Arrays” on page 58.)

To just run the program, select **Go**. This may be useful if you entered a larger number into the console, so you can avoid iterating through the for loop numerous times.

RELATED TOPICS

Detailed information on stepping	“Stepping through and Executing your Program” on page 165
Stepping instructions	“Using Stepping Commands” on page 166

Canceling

First, make sure the program has exited, by selecting **Kill**.

1. Execute until user input is required

- Select **Next** twice. The “Waiting to reach location” dialog launches.

2. Cancel the operation

- Rather than providing input, in the dialog, select **Cancel**.

The Stack Trace Pane reports that the process is currently within a system call. The Source Pane displays assembler code, and its header identifies the library you’re in, rather than the source file. This is because no debug information is present for system calls, and TotalView always focuses on the stack frame where your PC is, even if it was not built with debug information.

```

Function __kernel_vsyscall in @syscall_library@-32
0xb77c2415:      0xcd  int    #128
0xb77c2416:      0x80
0xb77c2417:      0x90  nop
0xb77c2418:      0x90  nop
0xb77c2419:      0x8d  leal  0(%esi),%esi
0xb77c241a:      0xb4  movb  #38,%ah
0xb77c241b:      0x26  addb  %al,%eax
0xb77c241c:      0x00  addb  %al,%eax
0xb77c241d:      0x00  addb  %al,%eax
0xb77c241e:      0x00  addb  %al,%eax
0xb77c241f:      0x00  addb  %cl,%ch
__kernel_vsyscall:
0xb77c2421:      0x80  int    #128
=> 0xb77c2422:      0xc3  ret

```

In the Stack Trace Pane, **main** is preceded by C, meaning that TotalView has debug information for that frame, and the language is C.

```

Process 1 (25932): wave_extended
Thread 1 (25932) (Stopped) <Stop>
Stack Trace
__kernel_vsyscall, FP=bfd86710
read, FP=bfd86718
_IO_file_underflow, FP=bfd86744
_IO_default_uflow, FP=bfd86754
__uflow, FP=bfd8676c
_IO_vfscanf, FP=bfd869b0
__isoc99_scanf, FP=bfd869d8
load_matrix, FP=bfd86a08
main, FP=bf06a28
__libc_start_main, FP=bf06aa8

```

To execute out of the assembler code so you're back in your code, use the **Out** command.

- Select **Out** several times until the program returns to your code and resumes execution. When the dialog “Waiting to reach location” launches, enter a number into the console, click **Next**, and let the program complete.

RELATED TOPICS

Viewing assembler code [“Viewing the Assembler Version of Your Code”](#) on page 161 and “View > Assembler > By Address” in the in-product Help

Setting Breakpoints (Action Points)

In TotalView, a breakpoint is just one type of “**action point**” of which there are four types:

- **Breakpoint** - stops execution of the processes or threads that reach it.
- **Evaluation Point** - executes a code fragment when it is reached. Enables you to set “conditional breakpoints” and perform conditional execution.
- **Process Barrier Point** - holds each process when it reaches the barrier point until all processes in the group have reached the barrier point. Primarily for MPI programs.
- **Watchpoint** - monitors a location in memory and either stops execution or evaluates an expression when the value stored in memory is modified.

This section uses the **wave_extended** example to set a basic breakpoint as well as an evaluation point, called an “eval point.”

NOTE >> These procedures on working with action points can be performed independently of the other sections in this chapter (which starts at “[Basic Debugging](#)” on page 32), but you must first load the program as described in “[Load the Program to Debug](#)” on page 33.

RELATED TOPICS

Action points overview	“About Action Points” on page 175
Process barrier point	“Setting Breakpoints and Barriers” on page 179
Watchpoint	“Using Watchpoints” on page 206
Action Points Tab in the Process Window	Action Points Tab” in the in-product Help

Basic Breakpoints

1. Set a breakpoint

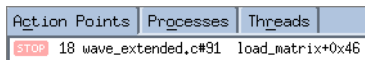
- Click a line number. for instance, select line 91, the call to **set_values()**. TotalView displays a **STOP** sign, both in the Source Pane at line 91 and in the Action Points tab where all action points in a program are listed.

NOTE >> A breakpoint can be set if the line number is boxed in the Source Pane:

```
87:
88: for (i = 0; i < count; ++i)
89: {
90:     double t = i * DT / TSIZE;
91:     set_values (t, values);
92: } /* for */
93: } /* load_matrix */
94:
```

2. Delete/disable/enable a breakpoint

- To delete the breakpoint, click the **Stop** icon in the Source Pane, and then re-add it by clicking again. You can also select it in the Action Points tab, right-click for a context menu, and select **Delete**.
- To disable a breakpoint, click its icon in the Action Points tab. The icon dims to show it is disabled:



Click it again to re-enable it. Again, you can also disable or re-enable a breakpoint using the context menu.

3. Run the program

- Click the **Go** button in the toolbar.
All panes in the Process Window report that the thread is running, or that it must be stopped for frame display. At this point, the program is waiting for user input.
- Enter a number into the console, then click **Go** again.

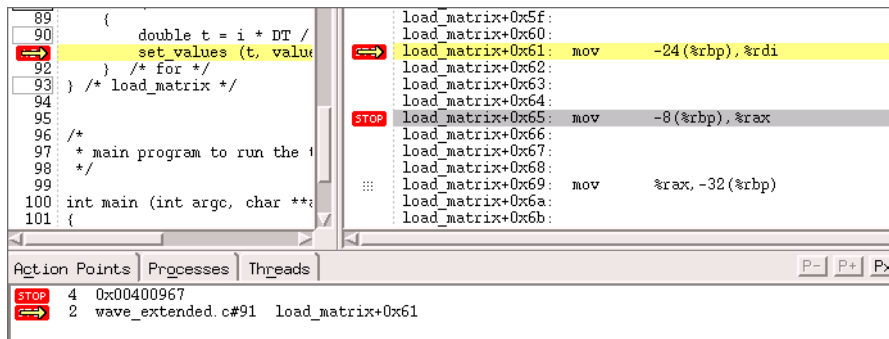
The program halts execution at the breakpoint.

4. Set a breakpoint in assembler code

You can also set a breakpoint in assembler code to view specific memory allocation.

- Select **View > Source As > Both** to view both source and assembler code.
- Set a breakpoint in some assembler code, such as the instruction immediately following the existing breakpoint.

The Source Pane and Action Points tab display two breakpoints, one in source code and one in assembler code.

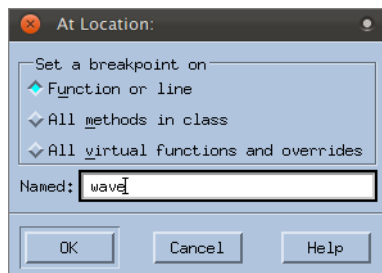


5. Set a breakpoint at a particular location

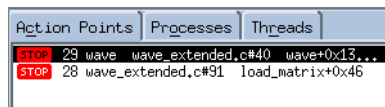
In a complex program, it may be easier to set a breakpoint using the **At Location** dialog, which allows you to specify where you want the breakpoint without having to first find the source line in the Source Pane. Using this dialog, you can set breakpoints on all methods of a class or all virtual functions, a useful tool for C++ programs.

NOTE >> This dialog acts like a toggle, meaning that it *sets* a breakpoint if none exists at the specified location, or *deletes* an existing breakpoint at that location.

- Select **Action Point> At Location** and then enter **wave** to set a breakpoint at the function **wave()**.



The breakpoint is set and added to the Action Points tab. If a breakpoint already exists at that location, this action toggles the setting to *delete* the breakpoint.



RELATED TOPICS

Action points properties	“About Action Points” on page 175 and “Action Point Properties” in the in-product Help.
Enabling/disabling action points	“Displaying and Controlling Action Points” on page 184
Suppressing action points	“Suppressing Action Points” on page 185
Breakpoints in assembler code	“Setting Machine-Level Breakpoints” on page 188

Evaluation Points

You can define an action point identified with a code fragment to be executed. This is called an *eval point*. This allows you to test potential fixes for your program, set the values of your program's variables, or stop a process based on some condition. You can also send data to the Visualizer to produce an animated display of changes to your program's data, discussed in [“Visualizing Arrays”](#) on page 58.

At each eval point, the code in the eval point is executed *before* the code on that line. One common use of an eval point is to include a **goto** statement that transfers control to a line number in your program, so you can test program patches.

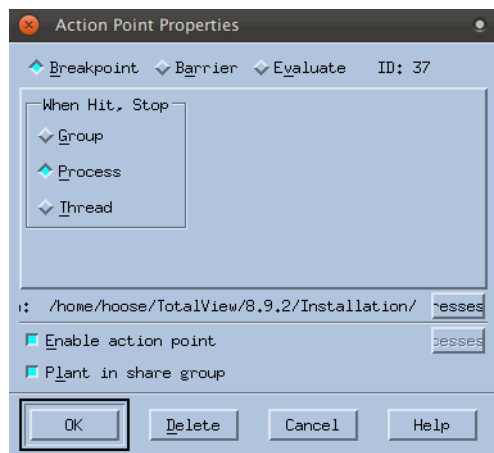
1. Delete any breakpoints

Before setting an eval point, delete all other breakpoints you have set while working through this chapter.

- Select **Action Points > Delete All**.

2. Set an eval point

- Set a breakpoint on line 85 at the **printf()** function.
- Open the **Action Point Properties** dialog by right-clicking on the **Stop** icon and selecting Properties.

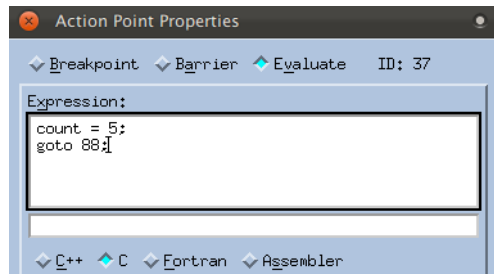


The **Action Point Properties** dialog box sets and controls an action point. Using this dialog, you can also change an action point's type to breakpoint, barrier point, or eval point, and define the behavior of threads and processes when execution reaches this action point.

3. Add an expression

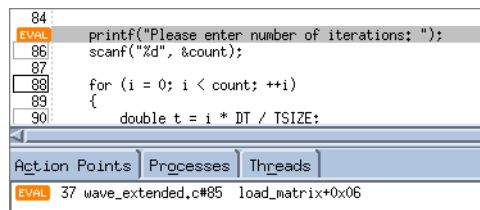
- Select the **Evaluate** button, to display an Expression box. In the box, enter:

```
count = 5;  
goto 88;
```



- Click **OK** to close the dialog. This code will be executed before the **printf()** statement, and then will jump to line 88 where the for loop begins. This sets the count to **5** and avoids having to enter user input. (Code entered here is specific to TotalView debugging only, and is not persisted to your actual source code.)

Note that the **Stop** icon becomes an **Eval** icon, both in the Source Pane and in the Action Points tab:



4. Execute the program to observe eval point behavior

- Click **Go**. If no other breakpoints were planted in your code, the program simply executes and prints "Program is complete."

RELATED TOPICS

Evaluation points in general	"Defining Eval Points and Conditional Breakpoints" on page 197
Writing expressions in eval points	"Expressions in Eval Points and the Evaluate Window" on page 329
Action Point Properties dialog box	"About Action Points" on page 175 and "Action Point Properties" in the in-product Help.

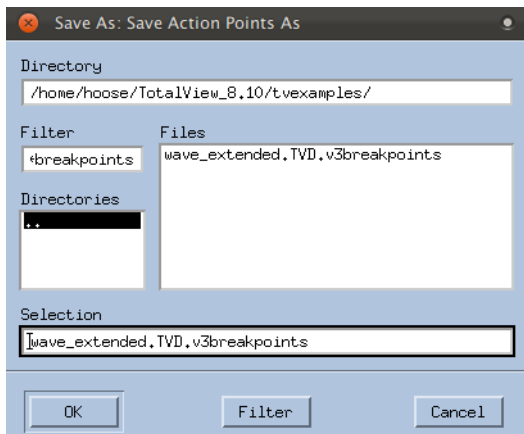
Saving and Reloading Action Points

You can save a set of action points to load into your program at a later time.

1. Save Action Points

- Select **Action Point > Save All** to save your action points to a file in the same directory as your program. When you save action points, TotalView creates a file named *program_name.TVD.v3breakpoints*, where *program_name* is the name of your program. No dialog launches, but a file is created titled **wave_extended.TVD.v3breakpoints**.
- Select **Action Point > Save As**, if you wish to name the file yourself and select a directory for its location.

A dialog launches where you can enter a custom name and browse to a location.



2. Load Saved Action Points

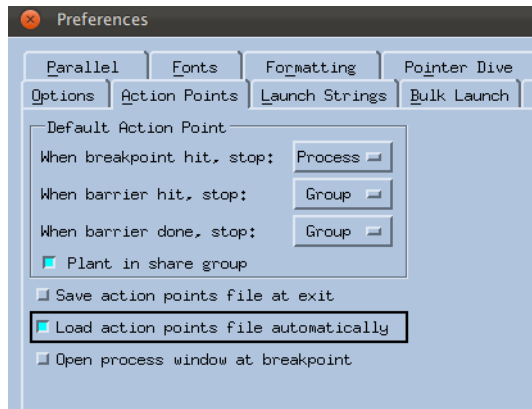
You can either explicitly load saved action points into a program when it is launched, or you can define a preference to load them automatically.

To manually load saved action points:

- After loading your program into TotalView, select **Action Point > Load All** to load these saved actions points into your program.

To automatically load saved action points:

- Select **File > Preferences** to launch the Preferences window, and then select the **Action Points** tab.
- Click the **Load Action Points File Automatically** button, then click OK.



If you close and then reload the program, your actions points are automatically loaded as well.

(Several other options exist to customize action points behavior. These are not discussed here. Please see the Related Topics table below.)

RELATED TOPICS

The CLI command dbreak	“dbreak” in the TotalView for HPC Reference Guide
The Action Point Properties dialog box	“About Action Points” on page 175 and “Action Point Properties” in the in-product Help.
The Action Point > At Location command	“Setting Breakpoints at Locations” on page 182
Setting Action Points preferences	“Setting Preferences” on page 128 and “Action Points Page” in the in-product Help

Examining Data

Examining data is, of course, a primary focus of any debugging process. TotalView provides multiple tools to examine, display, and edit data.

This section discusses viewing built-in data in the Process Window and Expression List Window, and then using the Variable Window to look at compound data.

NOTE >> These procedures on examining data can be performed independently of the tasks in other sections in this chapter, but you must first load the program (“[Load the Program to Debug](#)” on page 33). In addition, the discussion assumes an existing eval point has been set as described in “[Evaluation Points](#)” on page 45.

Viewing Built-in Data

For primitive, built-in types, you can quickly view data values from within the Process Window and can also add them to another window, the Expression List Window.

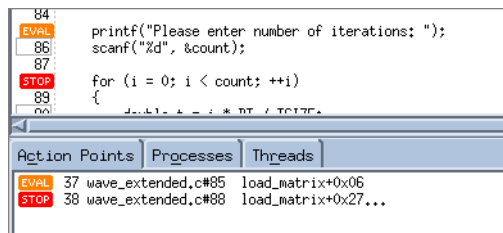
Viewing Variables in the Process Window

First, we'll add a breakpoint so the program will stop execution and we can view data.

1. Set a breakpoint

- Add a breakpoint at line 88, the beginning of the for loop in the **load_matrix()** function.

At this point, you should have two action points: the breakpoint just added, and the eval point added in the section “[Evaluation Points](#)” on page 45.



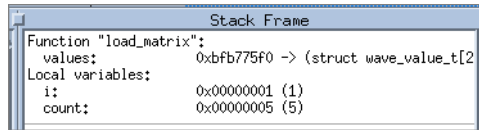
- Click **Go**. The program should stop on the breakpoint you just added.

Now let's view some data.

2. View variables in the Stack Frame pane

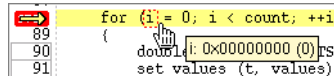
The Stack Frame pane lists function parameters, local variables, and registers. Scalar values are displayed directly, while aggregate types are identified with just type information.

In the Stack Frame pane, note the value of the local variables **i** and **count**: **i** is **1**, and **count** is **5**.



3. View variables in a tool tip

- In the Source Pane, hover over the variable **i** to view a tool tip that displays its value:

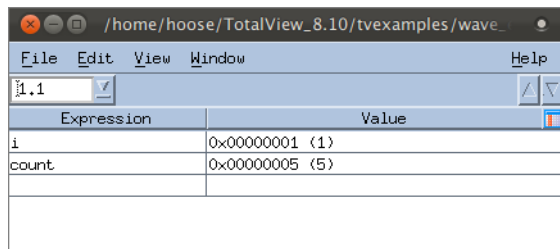


Viewing Variables in an Expression List Window

The Expression List window is a powerful tool that can list any variable in your program, along with its current or previous value and other information. This helps you to monitor variables as your program executes. For scalar variables, this is a particularly easy, compact way to view changing values.

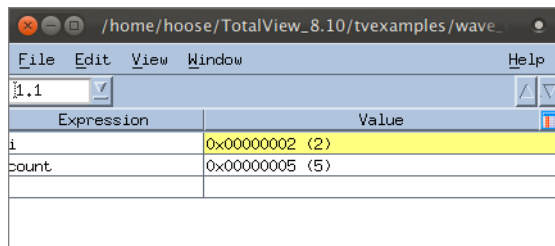
1. Create an Expression List

- In the Stack Frame pane, right-click on the variable **i**, and select **Add to Expression List**. Then do the same for the variable **count**. The Expression List Window launches, displaying these two variables and their values.



2. View the updated values

- Click **Go**. When the breakpoint is hit, the value of **i** increments to **2**, and this changed value is highlighted in yellow in the Expression List window:



- If you continue to hit **Go**, you can view the value of **i** increment to **5** before the program completes.

3. Add additional columns to see more data

- Right-click on the column header and select **Type** and **Last Value**. These two columns are added to the table:

Expression	Type	Last Value	Value
i	int	0x00000001 (1)	0x00000002 (2)
count	int		0x00000005 (5)

RELATED TOPICS

Viewing variables in the Process Window

[“Displaying Variables”](#) on page 220

Viewing variables in the Expression List Window

[“Viewing a List of Variables”](#) on page 246

Viewing Compound Variables Using the Variable Window

For nonscalar variables, such as structures, classes, arrays, common blocks, or data types, you can dive on the variable to get more detail. This launches the Variable Window.

(For an overview on diving, see [“About Diving into Objects”](#) on page 152.)

This section includes:

- [“Basic Diving”](#) on page 51
- [“Nested Dives”](#) on page 53
- [“Rediving and Undiving”](#) on page 54
- [“Diving in a New Window”](#) on page 54
- [“Displaying an Element in an Array of Structures”](#) on page 55

Basic Diving

First, delete any breakpoints you had entered previously except the eval point set in [“Evaluation Points”](#) on page 45. (Retaining this eval point simply allows the program to run without user input.)

1. Set a breakpoint

- Add a breakpoint at line 77, at the completion of the `set_values()` method.

```

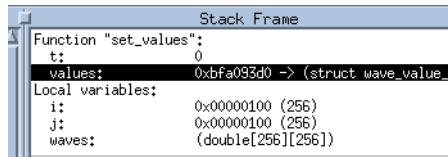
73         values[i][j].y = j;
74         values[i][j].current_time = t;
75     } /* for */
76 } /* for */
77 } /* set_values */
78

```

- Click **Go**. The program runs until the breakpoint.

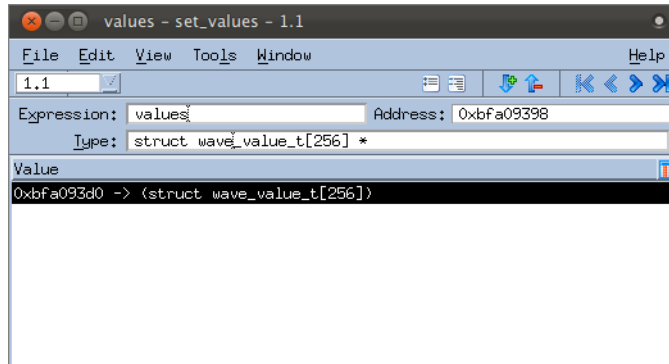
2. Dive on a variable

- Dive on the variable **values** in the Stack Frame pane (by double-clicking on **values** or by right-clicking and selecting **Dive**).



The **values** variable is a struct of type **wave_value_t**, created to hold a copy of the variables that create the wave, as well as other data.

The Variable Window launches.



Elements of a Variable Window

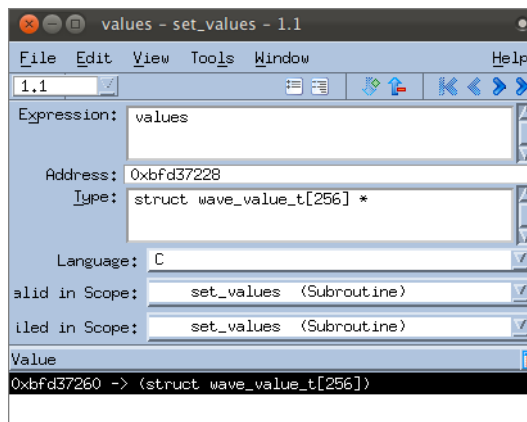
The basic elements of the Variable Window include:

- A set of toolbar icons that provide navigation and customizations:

Thread ID (1.1) icon to identify the current thread (in a single-threaded program, this is always 1.1, meaning process 1, thread 1).

Collapse/expand () icons to expand or collapse the contents of a compound type in nested windows.

Up/down () icons to control the level of information about your data. If you select the up arrow, more information about your data is displayed.



Redive/Undive buttons, discussed in “[Rediving and Undiving](#)” on page 54.

- The editable fields **Expression**, **Address**, and **Type**. You can add an expression or change the address and type for your variable here. Then select **Edit > Reset Defaults** when you are finished. (This is beyond the scope of this chapter. See the Related Topics table for more information.)

RELATED TOPICS

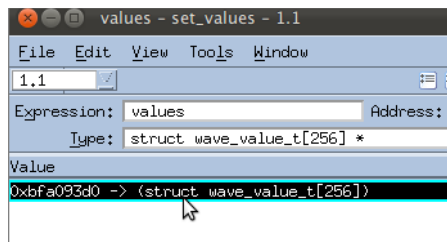
Diving on objects	“About Diving into Objects” on page 152 and
The View > Dive command	View > Dive” in the Process Window in the in-product Help
More on the Variable Window	“Diving in Variable Windows” on page 240
Editing data in the Variable Window	“Changing What the Variable Window Displays” on page 244

Nested Dives

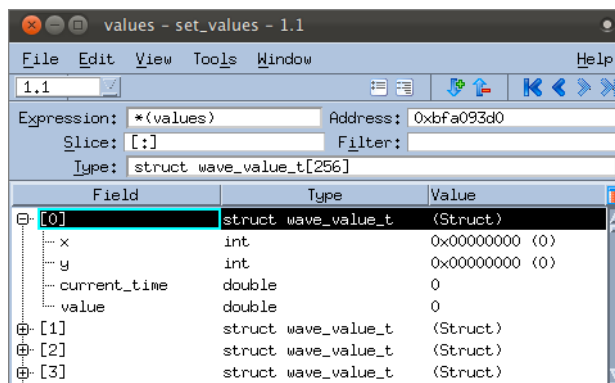
Since **values** is a compound type, you can dive again to get more detail about its components. This is called a *nested dive*.

1. Dive on an array

- Dive on the array **wave_value_t** in the Value column, by double-clicking it:

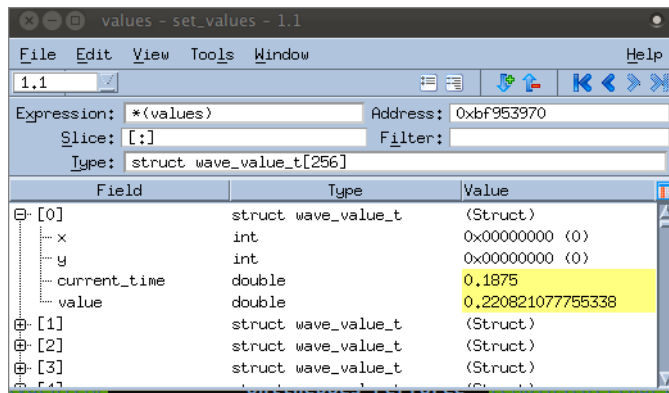


This replaces the existing display with the array's contents. Note the **+**(plus) sign on the left side of the Field column. For nonscalar types, you can click the plus sign to see the type's components:



2. Run the program and observe changing variable values

- Click **Go** so that the program runs and again stops at the breakpoint. Note that the variables **current_time** and **value** have both changed:

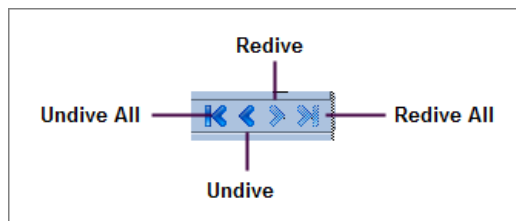


RELATED TOPICS

More on nested dives [“Diving in Variable Windows” on page 240](#)

Rediving and Undiving

Note the arrow icons on the top right of the Variable Window. These are the **Undive/Redive** and **Undive all/Redive all** buttons. Using these buttons, you can navigate up and down into your dive.



Click the Undive button, for instance, to return to the previous window.

Diving in a New Window

If you wish to have more than one dive level visible at the same time rather than having a dive replace the existing window's data, you can create a duplicate window.

1. Undive

- Click the **Undive** arrow to return to the initial Variable Window.

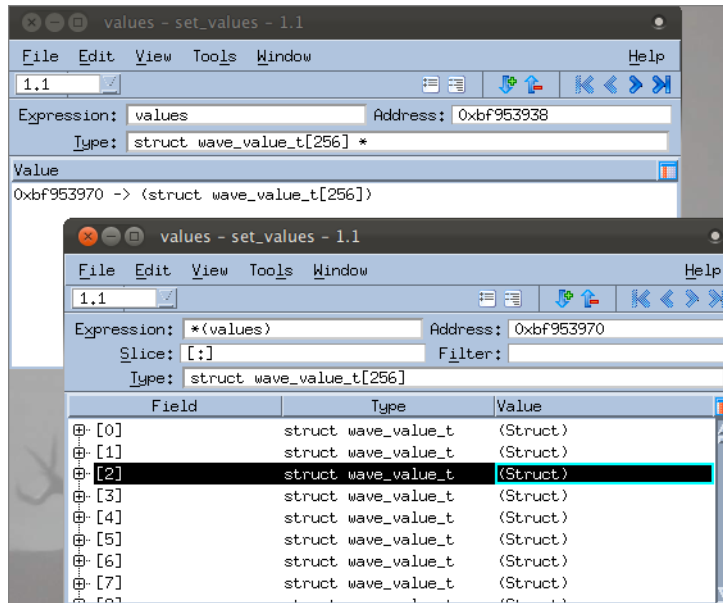
2. Launch a new window

- Right-click on the array and select **Dive in New Window**. Another window launches. Now, you can see both the original window and the new, nested dive.

3. Duplicate a window

Alternatively you can create a duplicate of a window.

- Select the command **Window > Duplicate** to duplicate the active Variable Window and then dive to the desired level in a new window.



Displaying an Element in an Array of Structures

You can display an element in an array of structures as if it were a simple array using the **View > Dive In All** command.

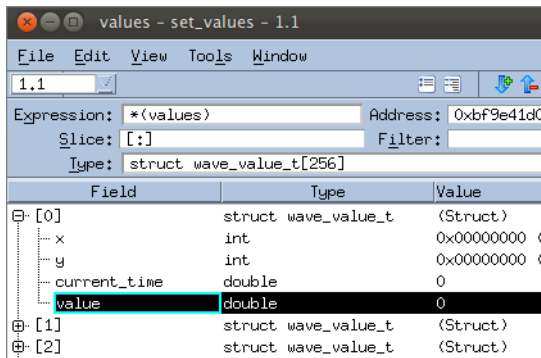
Consider our **values** struct defined like this:

```
struct wave_value_t
{
    int x;
    int y;
    double current_time;
    double value;
};
```

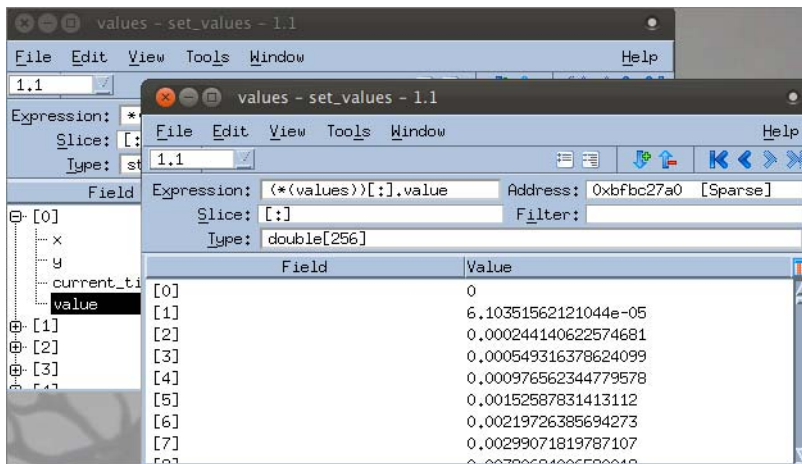
We can select an element within that structure and view it as an array, allowing us to easily see the values of any individual element as they change throughout program execution.

1. Dive in All on a variable

- In the nested Variable Window, select the double **value**.



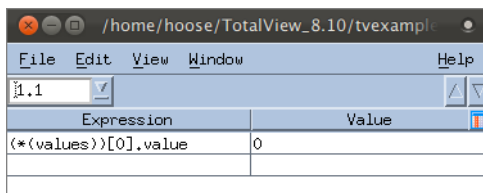
- Right-click and select **Dive In All**. TotalView displays all of the **value** elements of the **values** array as if they were a single array.



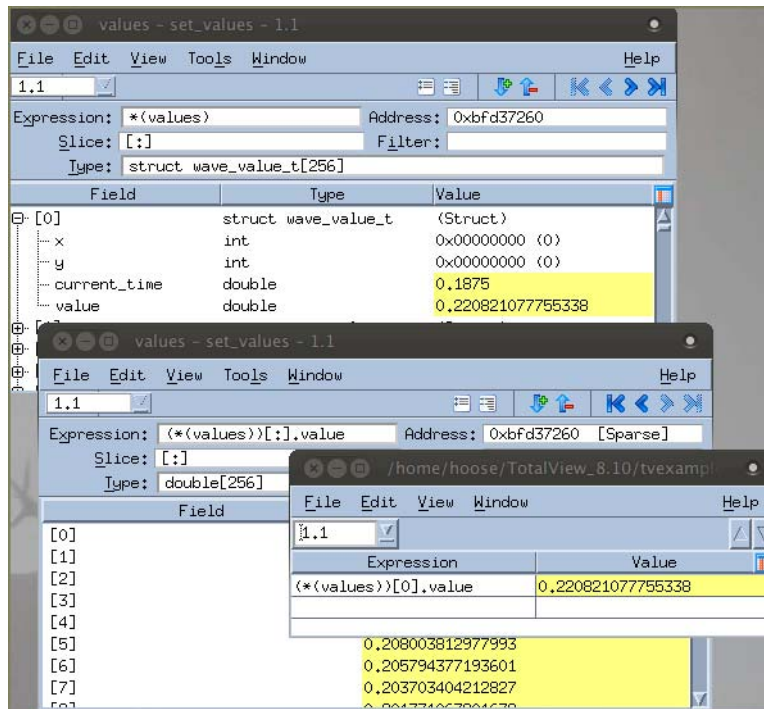
2. Add the value to the Expression List

Remember that you can also view the scalar type value in an Expression List window.

- In the window just launched, right-click again on **value** and select **Add to Expression List**. The Expression List window launches listing **value**:



3. Click **Go** to run your program. You can now view your variable values changing in three windows:



RELATED TOPICS

Displaying an array of any element [“Displaying an Array of Structure’s Elements”](#) on page 242

More on the **View > Dive in All** command [View > Dive in All](#) in the in-product Help

Visualizing Arrays

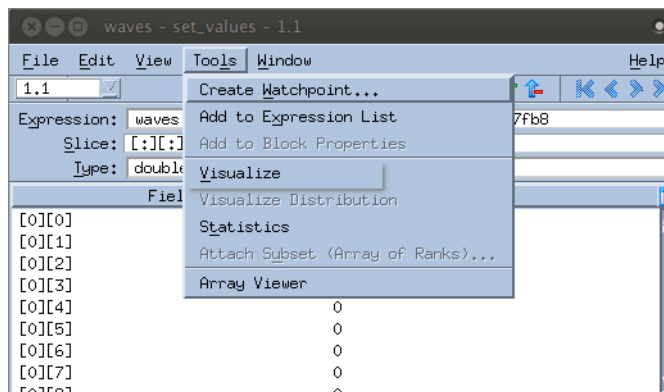
The Visualizer is a special tool to graphically visualize array data. This is a powerful and easy way to view your program's data during debugging and is useful in discovering anomalies in data value range, numerical spikes, and NaNs.

NOTE >> These procedures on visualizing arrays can be performed independently of the other tasks discussed in this chapter, but you must first load the program (“Load the Program to Debug” on page 33). In addition, the discussion assumes an existing eval point has been set, as described in “Evaluation Points” on page 45.

You can launch the Visualizer either directly from the GUI or from within an eval point.

From the GUI

Select an array in a Variable Window, and then select **Tools > Visualizer**.



From within an eval point

Invoke the Visualizer using the **\$visualize** command, with this syntax:

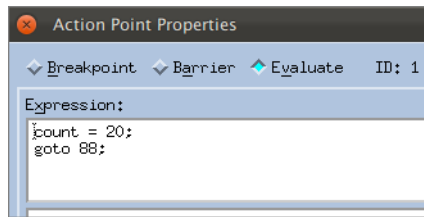
```
$visualize ( array [, slice_string ] )
```

Launching from an eval point also provides the ability to stop program execution if desired.

This discussion uses the **\$visualize** command in an eval point to launch the Visualizer to view the **waves** array. This array increments the value of **XSIZE** and **YSIZE** to create a visual wave.

Set Up

- Delete any breakpoints previously set except the eval point set at line 85 to suppress user input (“Evaluation Points” on page 45).
- Edit that eval point to provide a higher count, for instance, **20**. This will allow a more interesting wave to build as the values are incremented. (Right-click on its Eval icon, select Properties, and then edit the **count** value:

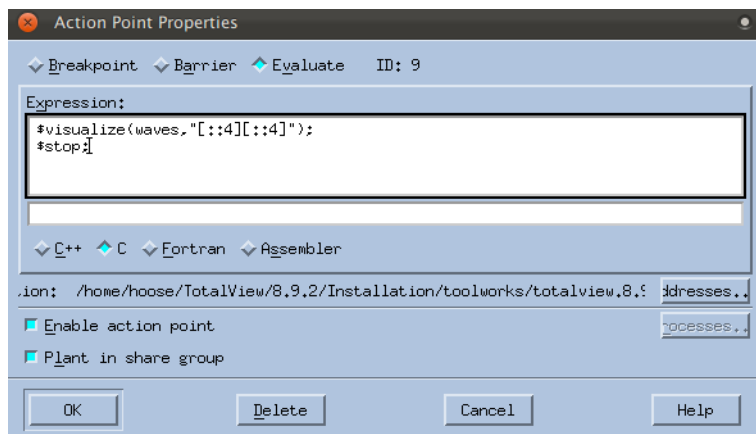


Launching the Visualizer from an Eval Point

1. Add an eval point

- Click on line 63 at the function **wave()** to add a breakpoint, as the comments suggest.
- Right-click on the breakpoint icon and select Properties to launch the **Action Point Properties** dialog.
- Click the **Evaluate** button to open the Expression field. Enter the following code:

```
$visualize(waves, "[::4][::4]");
$stop;
```

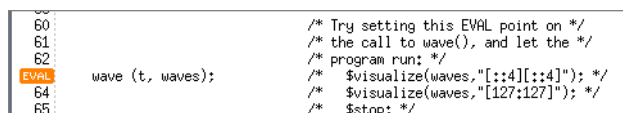


When the eval point is hit, this code will launch a single Visualizer window that will display every fourth element in the major dimension (the X axis), and then program execution will stop. To display the entire array, you could just write:

```
$visualize(waves); // entire array
```

(Note that the code comments suggest launching two Visualizer windows. For purposes of this discussion, we'll add just one.)

- Click **OK**. The Eval Point icon appears:



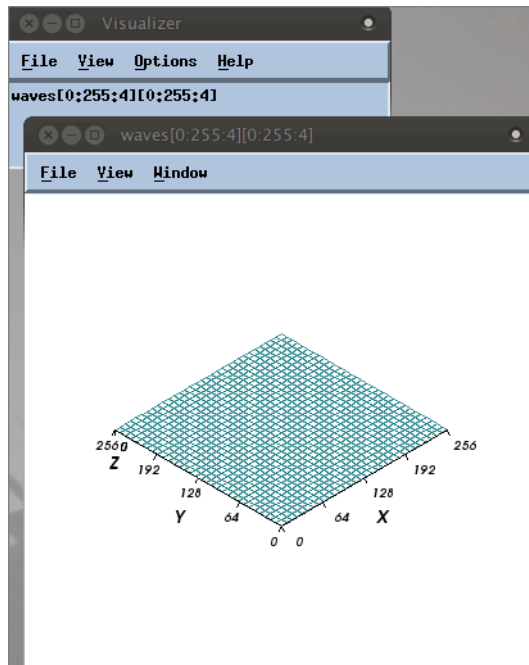
2. Run the program and view the data

At this point, the program should have no regular breakpoints and two eval points:

Action	Points	Processes	Threads
EVAL	9	wave_extended.c#63	set_values+0x1b
EVAL	1	wave_extended.c#85	load_matrix+0x06

- Click **Go**.

The program runs to the eval point at **wave()** and then stops. The Visualizer launches, reflecting the array's initial values:

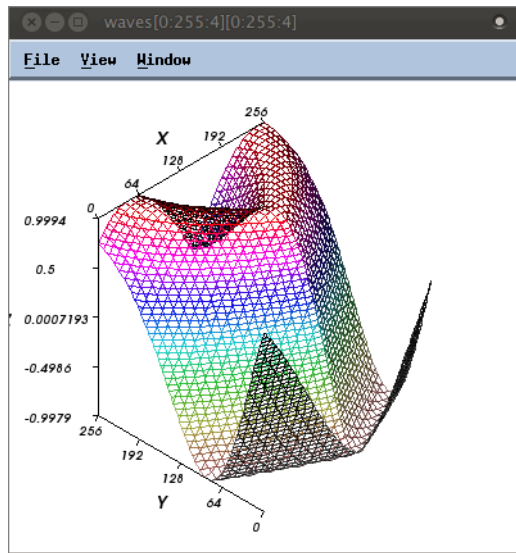


Above are the Visualizer's two windows: the top window is the Dataset window listing all datasets available to visualize (only one dataset has been loaded into the Visualizer at this point); the bottom is the View window where the graphical display appears.

3. Complete the program

- Click **Go** several more times (the program will complete once you have clicked **Go** as many times as the value for the variable **count** in the eval point).

You can watch the wave build, for example:



4. Run the program without stopping execution

An eval point does not have to stop execution. To let the program run without interruption, just remove the **\$stop** command from the Expression field in the **Action Point Properties** dialog, then click **Go**.

RELATED TOPICS

The Array Visualizer ["Array Visualizer"](#) on page 309

More ways to use view arrays ["Examining Arrays"](#) on page 283

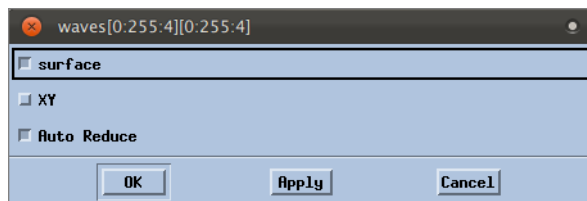
Viewing Options

The Visualizer shows either a Graph view (2-D plot) or Surface view (3-D plot) of your data. (If the array is one-dimensional, only the Graph view is available. The Graph view is not discussed here.)

By default, it shows a Surface view for most two-dimensional data, and that is what it shows for the **waves** array.

The Surface view displays two-dimensional datasets as a surface in two or three dimensions. The dataset's array indices map to the first two dimensions (X and Y axes) of the display, and the values map to the height (Z axis).

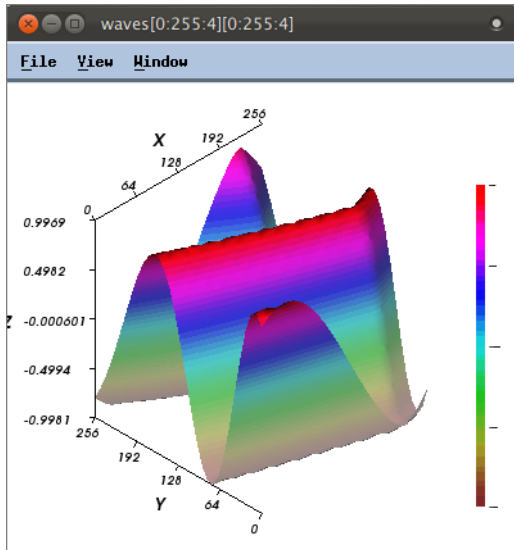
You can further refine the Surface view using the View window's options. Select **File > Options** from the View window to launch the Options dialog.



Possible options are:

- **surface:** Displays the array as a three-dimensional surface (the default is to display it as a grid).
- **XY:** Reorients the view's XY axes. The Z axis is perpendicular to the display.
- **Auto Reduce:** Speeds visualization by averaging neighboring elements in the original dataset.

For example, click **surface**, then click OK. The view changes from a grid to a 3-D:



The Visualizer has many more options with various other viewing modes and tools. See the Related Topics below for references to further discussions.

This completes this tutorial on basic debugging.

RELATED TOPICS

More on the Visualizer	“Array Visualizer” on page 309
Visualizer options	“Using the Graph Window” on page 315 and “Using the Surface Window” on page 317
The Array Viewer (another way of looking at arrays)	“Viewing Array Data” on page 288
Displaying slices of arrays	“Displaying Array Slices” on page 284
Filtering array data	“Filtering Array Data Overview” on page 290

Moving On

- For an overview on TotalView's features, see [“About TotalView”](#) on page 5.
- To learn about parallel debugging tasks, see [“Manipulating Processes and Threads”](#) on page 372.
- For detailed information on TotalView's debugging tools and features, see [“Debugging Tools and Tasks”](#) on page 82.



Chapter 3

Accessing TotalView Remotely

About Remote Display

Using the TotalView Remote Display client, you can start and then view TotalView as it executes on another system, so that TotalView need not be installed on your local machine.

Remote Display Supported Platforms

Remote Display is currently bundled into all TotalView releases.

Supported platforms include:

- Linux x86 and Linux x86-64
- Microsoft Windows
- Apple Mac OS X Intel

No license is needed to run the Client, but TotalView running on any supported operating system must be a licensed version of TotalView 8.6 or greater.

Remote Display Components

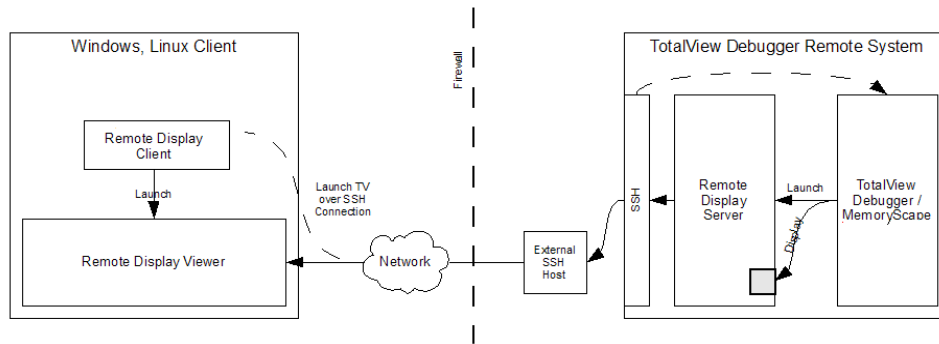
TotalView Remote Display has three components:

- The Client is a window running on a Remote Display supported platform (See [“Remote Display Supported Platforms”](#) on page 64).

- The Server is invisible, managing the movement of information between the Viewer, the remote host, and the Client. The Server can run on all systems that TotalView supports. For example, you can run the Client on a Windows system and set up a Viewer environment on an IBM RS/6000 machine.
- The Viewer is a window that appears on the Client system. All interactions between this window and the system running TotalView are handled by the Server.

Figure 16 shows how these components interact.

Figure 16 – Remote Display Components



In this figure, the two large boxes represent the computer upon which you execute the Client and the remote system upon which TotalView runs. Notice where the Client, Viewer, and Server are located. The small box labeled External SSH Host is the gateway machine inside your network. The Client may be either inside or outside your firewall. This figure also shows that the Server is created by TotalView or MemoryScope as it is contained within these programs and is created after the Client sends a message to TotalView or MemoryScope.

TotalView and the X Window system must be installed on the remote server machine containing the rgb and font files in order for the remote display server to start correctly. The bastion nodes (if any) between the remote client machine and remote server machine do not require TotalView or X Window file access.

Installing the Client

Before installing the Client, TotalView must already be installed.

The files used to install the client are in these locations:

- Remote Display Client files for each supported platform are in the **remote_display** subdirectory in your TotalView installation directory.
- Clients may also be downloaded from our Web site at <http://www.roguewave.com/products-services/totalview/features/remote-display-client>.

Because Remote Display is built into TotalView, you do not need to have a separate license for it. Remote Display works with your product's license. If you have received an evaluation license, you can use Remote Display on another system.

Installing on Linux

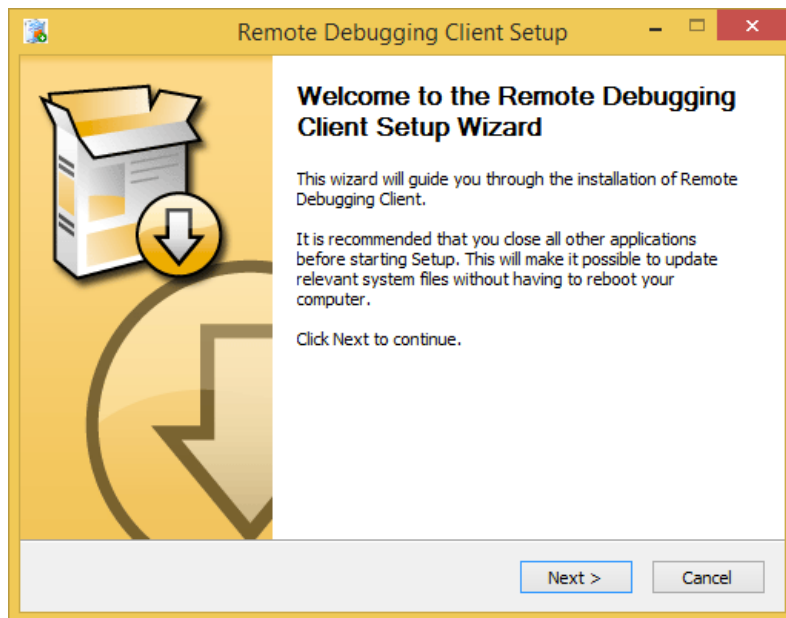
The installation procedure for the Client is straight-forward. The **remote_display** directory contains two tar files used on a Linux x86 or a Linux 86-64 system.

1. Place a tar file within your **toolworks** installation directory if it is not already there. You can install the Client on as many Linux x86 and Linux x86-64 systems as you need, as the Client is unlicensed. This means TotalView can be run from any Client, and more than one person can be running Clients simultaneously. The only licensing requirement is that you have a license for the platform upon which TotalView will run. Of course, the number of users who can run TotalView simultaneously is specified in that product's license.
2. Type **tar xvf name_of_remote_display_file.tar**. This creates and populates a **remote_display/bin** directory.
3. Add the **remote_display** directory to your PATH environment variable. If you place this directory in your PATH, typing **remote_display_client.sh** invokes the Client.

Installing on Microsoft Windows

Before installing the Client, TotalView must already be installed on your Linux or UNIX system. The Client file, contained in your **remote_display** directory, is named **TVT_RDC_Installer.release_number.exe**. To use the installer:

1. Either copy the **exe** file to your Windows system or place it in a location that is directly accessible from your Windows machine.
2. Double-click on the installer **exe** file to launch the client setup dialog.

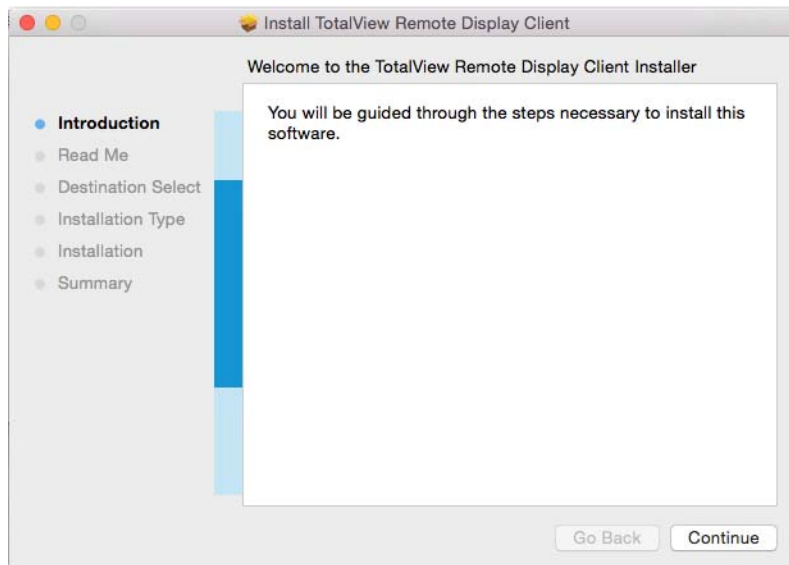


3. Click the **Next** button and follow the instructions on the displayed screen. As with many Windows applications, you are asked if the installer should create an entry in the start menu and place an icon on your desktop.

Installing on Apple Mac OS X Intel

Before you install the Client, you must have installed TotalView or MemoryScape. The Client file, contained in your **remote_display** directory, is named **TVT_RDC_Installer.<release_number>.dmg**. To use the installer:

1. Either copy the **dmg** file to your Mac OS X system or place it in a location that is directly accessible from your Mac machine.
2. Double-click on the installer **dmg** file and then the TotalViewRemoteDisplayClient.pkg icon to launch the set up dialog.



3. Click the Continue button and follow the instructions on the displayed screen.

Client Session Basics

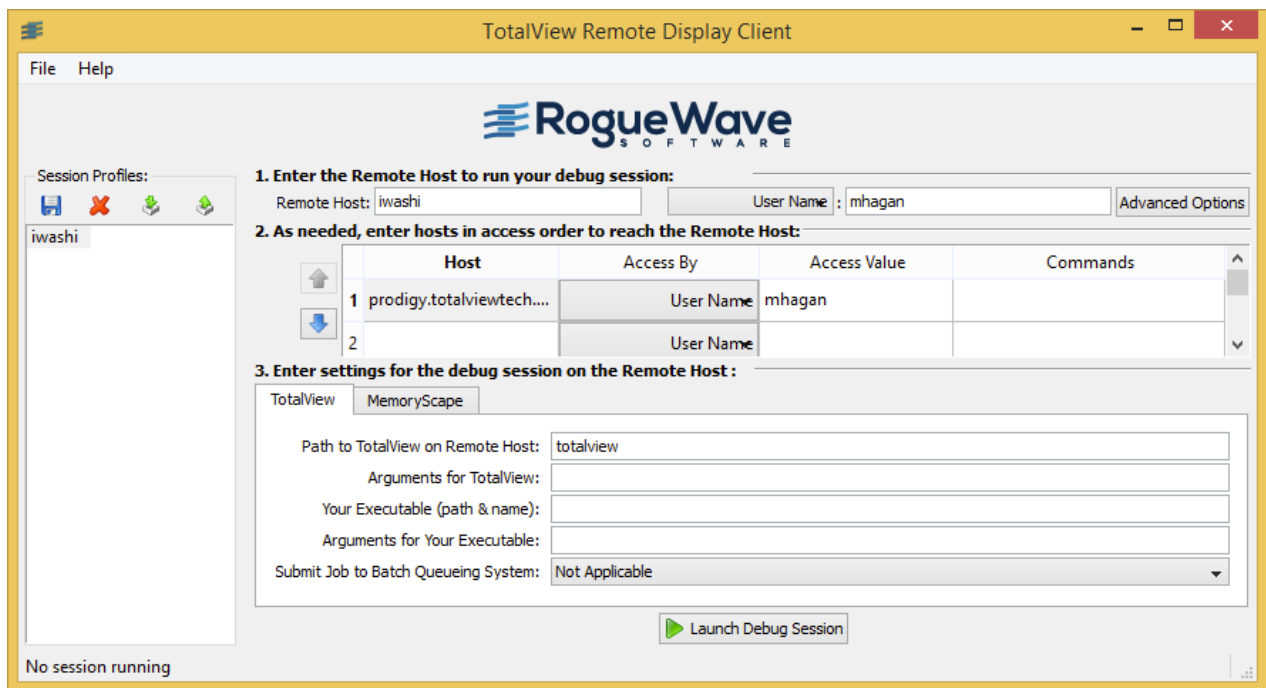
The TotalView Remote Display Client is simple to use. Just enter the required information, and the Client does the rest.

On Linux, invoke the Client with the following:

```
remote_display_client.sh
```

On Windows, either click the desktop icon or use the TVT Remote Display item in the start menu to launch the remote display dialog.

Figure 17 – Remote Display Client Window



The Client window displays similarly on Linux or Windows.

Here are the basic steps:

1. Enter the Remote Host

- **Remote Host:** The name of the machine upon which TotalView will execute. While the Client can execute only on specified systems (see [Remote Display Supported Platforms](#)), the remote system can be any system upon which you are licensed to run TotalView.
- **User Name** dropdown: Your user name, a public key file, or other **ssh** options.

2. (Optional) As needed, enter hosts in access order...(depending on your network).

If the Client system cannot directly access the remote host, specify the path. For more information, see [“Naming Intermediate Hosts”](#) on page 75.

3. Enter settings for the debug session on the Remote Host

Settings required to start TotalView on the remote host. (The TotalView and MemoryScape tabs are identical.)

- **Path to TotalView on the Remote Host:** The directory on the remote host in which TotalView resides, using either an absolute or relative path. “Relative” means relative to your home directory.
- **(Optional) Your Executable:** Either a complete or relative pathname to the program being debugged. If you leave this empty, TotalView begins executing as if you had just typed **totalview** on the remote host.
- **Other options:**
You can add any command-line options for TotalView or your program.
TotalView options are described in the *“TotalView Debugger Command Syntax”* chapter of the *TotalView for HPC Reference Guide*.
For arguments to your program, enter them in the same way as you would using the **-a** command-line option.

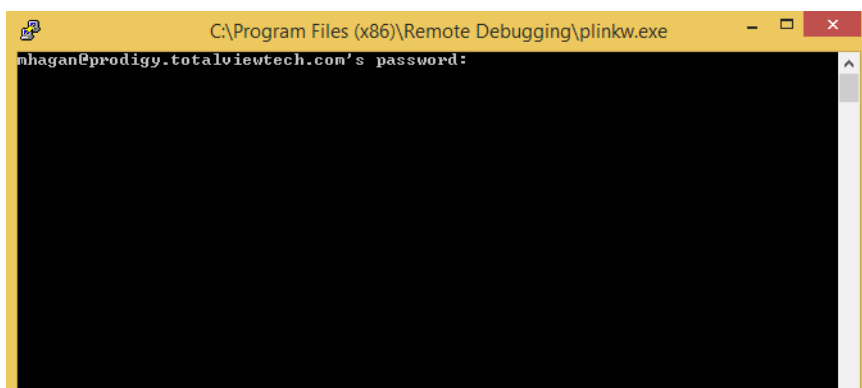
Additional options include:

- **Advanced Options:** Press the Advanced Options button to customize client/server interaction and server execution, [“Advanced Options”](#) on page 73.
- **Submit job to batch queueing system:** You can submit jobs to the PBS Pro and LoadLeveler batch queueing systems, [“Submitting a Job to a Batch Queueing System”](#) on page 76.

Launching the Remote Session

Next, press the **Launch Debug Session** button, which launches a password dialog box.

Figure 18 – Asking for Password



Depending on how you have connected, you may be prompted twice for your password: first when Remote Display is searching ports on a remote system and another when accessing the remote host. You can often simplify logging in by using a public key file.

After entering the remote host password, a window opens on the local Client system containing TotalView as well as an xterm running on the remote host where you can enter operating system and other commands. If you do not add an executable name, TotalView displays its **File > New Debugging Session** dialog box. If you do enter a name, TotalView displays its **Process > Startup Parameters** dialog box.

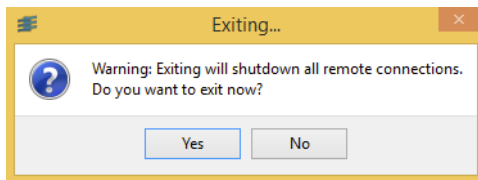
Closing the Remote Session

To close the session:

- From the Client, terminate the Viewer and Server by pressing the **End Debug Session** button. (The **Launch Debug Session** button changes to this button after you launch the session.)
- Click **Close** on the Viewer's window to remove the Viewer Window. This does not end the debugging session, so then select the Client's **End Debug Session** button. Using these two steps to end the session may be useful when many windows are running on your desktop, and the Viewer has obscured the Client.

Closing all Remote Sessions and the Client

To close all remote connections and shut down the Client window, select **File > Exit**.



Working on the Remote Host

After launching a remote session, the Client starts the Remote Display Server on the remote host where it creates a virtual window. The Server then sends the virtual window to the Viewer window running on your system. The Viewer is just another window running on the Client's system. You can interact with the Viewer window in the same way you interact with any window that runs directly on your system.

Behind the scenes, your interactions are sent to the Server, and the Server interacts with the virtual window running on the remote host. Changes made by this interaction are sent to the Viewer on your system. Performance depends on the load on the remote host and network latency.

If you are running the Client on a Windows system, these are the icons available:

Figure 19 – Remote Display Client commands on Windows



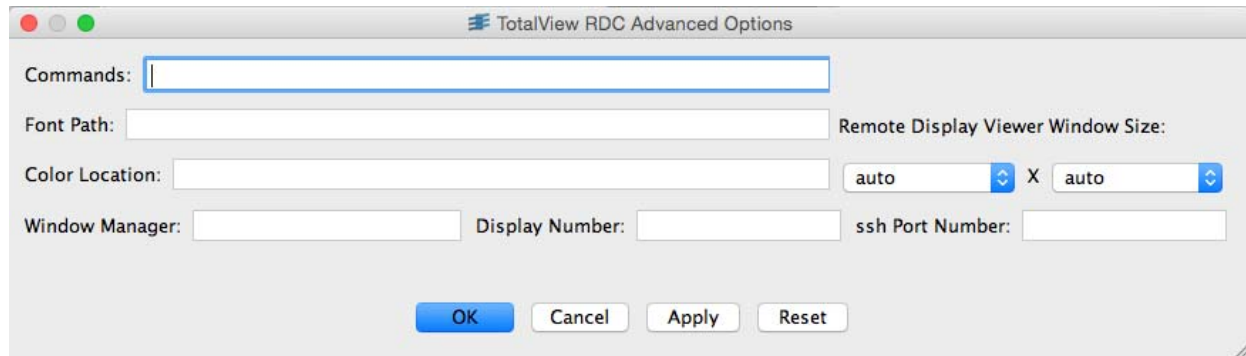
From left to right, the commands associated with these icons are:

- Connection options
- Connection information
- Full Screen - this does not change the size of the Viewer window
- Request screen refresh
- Send Ctrl-Alt-Del
- Send Ctrl-Esc
- Send Ctrl key press and release
- Send Alt key press and release
- Disconnect

Advanced Options

The Advanced Options window in [Figure 20](#) is used to customize Remote Display Client and Server interaction and to direct the Server and Remote Display Viewer execution.

Figure 20 – Advanced Options Window



Options are:

- **Commands:** Enter commands to execute before TotalView begins. For example, you can set an environment variable or change a directory location.
- **Font Path:** Specify the remote host's font path, needed by the Remote Display Server. Remote Display checks the obvious places for the font path, but on some architectures, the paths are not obvious.
- **Remote Display Viewer Window:** The default size of the Remote Display Viewer is dynamically computed, taking into account the size of the device on which the Remote Display Client is running. You can override this by selecting a custom size, which will be saved with the profile.
- **Color Location:** Specify the location of the **rgb.txt** file needed by the Remote Display Server. Remote Display checks the obvious places for the location, but on some architectures, its location is not obvious. Providing the correct location may improve the startup time.
- **Window Manager:** Specify the name of the window manager. The path of the window manager you provide must be named in your **PATH** environment variable. The Server looks for (in order) the following window managers on the remote host: **icewm**, **fvwm**, **twm**, and **mwm**. Specifying a window manager may improve the startup time.
- **Display Number:** Specify a display number for Remote Display to use when the Client and Server connect. The Remote Display Client determines a free display number when connecting to the Server, requiring two password entries in some instances. Specifying the display number overrides the Remote Display Client determining a free number, and collisions may occur.

- **ssh Port Number:** On most systems, **ssh** uses port 22 when connecting, but in rare instances another port is used. This field allows you to override the default.

The buttons at the bottom are:

- **Cancel:** Closes the window without saving changes.
- **Apply:** Saves the changes with the profile, leaving the window open.
- **OK:** Closes the window and saves the changes with the profile.
- **Reset:** Reverts back to the previously saved values.

Naming Intermediate Hosts


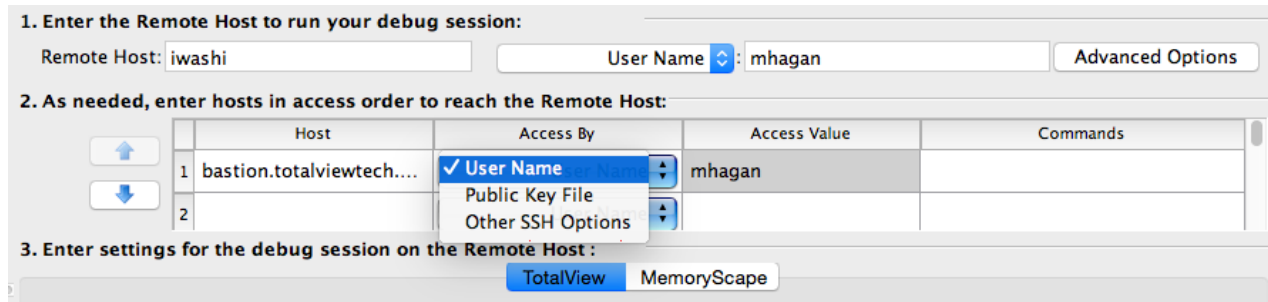
If the Client system does not have direct access to the remote host, you must specify the path, or paths, along with how you will access the host. You can enter multiple hosts; the order in which you enter them determines the order Remote Display uses to reach your remote host. Use the arrow buttons on the left () to change the order.

Figure 21 – Access By Options



The screenshot shows a configuration window with three main sections:

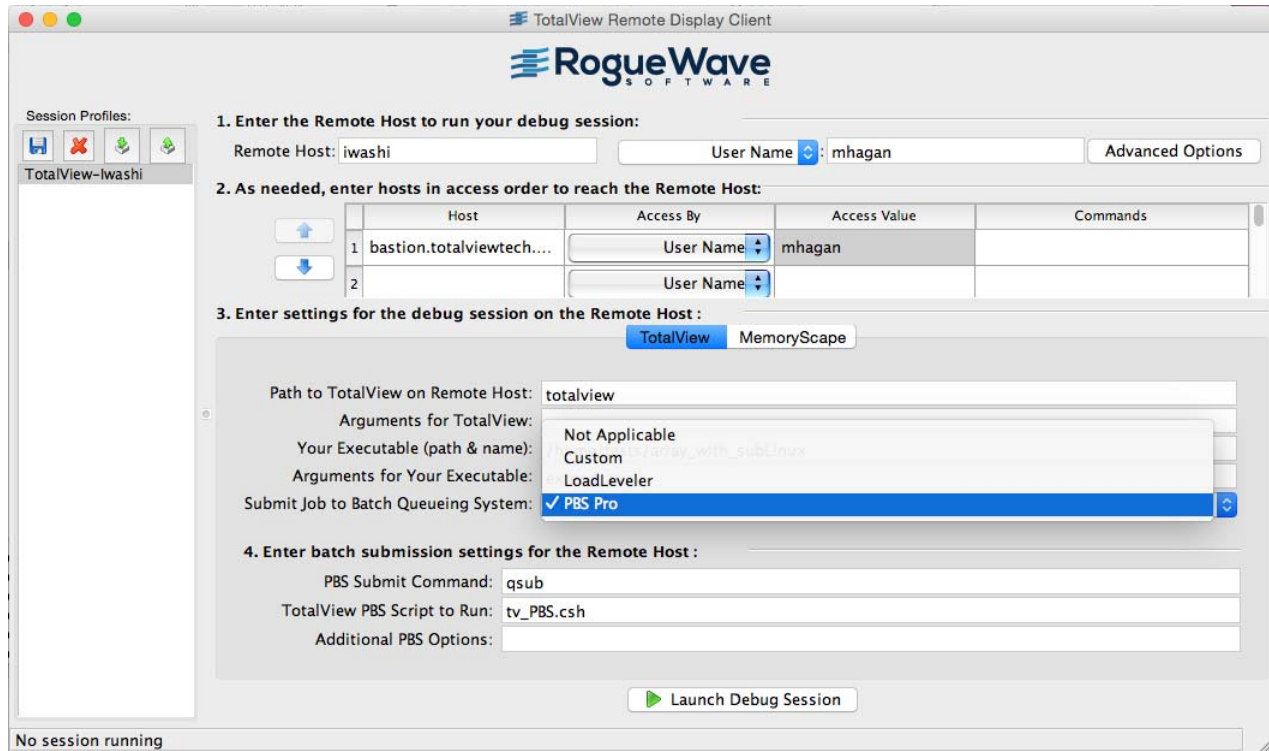
- 1. Enter the Remote Host to run your debug session:** Includes fields for "Remote Host" (iwashi), "User Name" (mhagan), and an "Advanced Options" button.
- 2. As needed, enter hosts in access order to reach the Remote Host:** A table with columns: Host, Access By, Access Value, and Commands. Row 1 contains "bastion.totalviewtech..." in the Host column, "User Name" in the Access By column, and "mhagan" in the Access Value column. A dropdown menu is open over the "Access By" column, showing "User Name" (selected), "Public Key File", and "Other SSH Options".
- 3. Enter settings for the debug session on the Remote Host:** Includes buttons for "TotalView" and "MemoryScape".

- **Host:** The route the Client should take to access the remote host. For instance, this can be a network path or an IP address. If your network has a gateway machine, you would name it here in addition to other systems in the path to the remote host.
- **Access By/Access Value:** The most common access method is by a user name, the default. If this is incorrect for your environment, use the dropdown menu to select the correct method:
 - **User Name**, i.e. the name you enter into a shell command such as ssh to log in to the host machine. Enter this in the **Access Value** field.
 - **Public Key File**, the file that contains access information, entered into the **Access Value** field.
 - **Other SSH Options**, the ssh arguments needed to access the intermediate host. These are the same arguments you normally add to the ssh command.
- **Commands:** Commands (in a comma-separated list) to execute when connected to the remote host, before connecting to the next host.

Submitting a Job to a Batch Queuing System

TotalView Remote Display can submit jobs to the PBS Pro and LoadLeveler batch queuing systems.

Figure 22 – Remote Display Window: Showing Batch Options



1. Select a batch system from the **Submit job to Batch Queuing System** dropdown list, either **PBS Pro** or **LoadLeveler**.

The default values are **qsub** for PBS Pro and **lsubmit** for LoadLeveler.

The **Script to Run** field is populated with the default scripts for either system: **tv_PBS.csh** for PBS Pro and **tv_LoadLeveler.csh** for LoadLeveler. These scripts were installed with TotalView, but can of course be changed if your system requires it. For more information, see “[Batch Scripts](#)” on page 80.

2. (Optional) Select additional PBS or LoadLeveler options in the **Additional Options** field.
Any other required command-line options to either PBS or LoadLeveler. Options entered override those in the batch script.

3. Launch by pressing the **Launch Debug Session** button.

Behind the scenes, a job is submitted that will launch the Server and the Viewer when it reaches the head of the batch queue.

Setting Up Your Systems and Security

In order to maintain a secure environment, Remote Display uses SSH. The Remote Display Server, which runs on the remote host, allows only RFB (Remote Frame Buffer) connections from and to the remote host. No incoming access to the Server is allowed, and the Server can connect back to the Viewer only over an established SSH connection. In addition, only one Viewer connection is allowed to the Server.

As Remote Display connects to systems, a password is required. If you are allowed to use keyless ssh, you can simplify the connection process. Check with your system administrator to confirm that this kind of connection is allowed and the ssh documentation for how to generate and store key information.

Requirements for the Client to connect to the remote host:

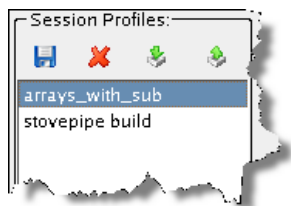
- If you use an LM_LICENSE_FILE environment variable to identify where your license is located, ensure that this variable is read in on the remote host. This is performed automatically if the variable's definition is contained within one of the files read by the shell when Remote Display logs in.
- ssh must be available on all non-Windows systems being accessed.
- X Windows must be available on the remote system.

Session Profile Management

The Client saves your information into a profile based on the name entered in the remote host area. You can restore these settings by clicking on the profile's name in the Session Profiles area.

Figure 23 shows two saved profiles.


Figure 23 – Session Profiles

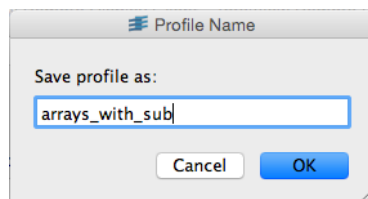


When you select a profile, the Client populates the right window with that profile's values.

If you edit the data in a text field, the Client automatically updates the profile information. If this is not what you want, click the **Create** icon to display a dialog box into which you can enter a new session profile name. The Client writes this existing data into a new profile instead of saving it to the original profile.


Saving a Profile

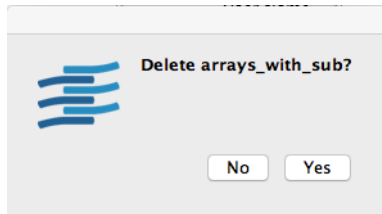
To save a profile, click the save button () or select **File > Profile > Save**, then provide a profile name in the Profile Name popup.




This command saves the profile information currently displayed in the Client window to a name you provide, placing it in the **Session Profiles** area. You do not need to save changes to the current profile as the Client automatically saves them.


Deleting a Profile

To delete a profile, click the delete button () or select **File > Profile > Delete**. This command deletes the currently selected profile and requires a confirmation.



Sharing Profiles

To import a profile, click the import button () or select **File > Profile > Import**, and then browse to the profile to import. After you import a file, it remains in your Client profile until you delete it.

To export a profile, click the export button () or select **File > Profile > Export**, browse to a directory where you want to export it, and then name the profile.

Batch Scripts

The actions that occur when you select PBS Pro or LoadLeveler within the **Submit job to Batch Queueing System** are defined in two files: **tv_PBS.csh** and **tv_LoadLever.csh**. If the actions defined in these scripts are not correct for your environment, you can either change one of these scripts or add a new script, which is the recommended procedure.

Place the script you create into *installation_dir/totalview_version/batch*. For example, you could place a new script file called **Run_Large.csh** into the *installation_dir/toolworks/totalview.8.6.0/batch* directory.

tv_PBS.csh Script

Here are the contents of the **tv_PBS.csh** script file:

```
#!/bin/csh -f
#
# Script to submit using PBS
#
# These are passed to batch scheduler::
#
# account to be charged
##PBS -A VEN012
#
# pass users environment to the job
##PBS -V
#
# name of the job
#PBS -N TotalView
#
# input and output are combined to standard
##PBS -o PBSPro_out.txt
##PBS -e PBSPro_err.txt
#
##PBS -l feature=xt3
#
#PBS -l walltime=1:00:00,nodes=2:ppn=1
#
#
# Do not remove the following:
TV_COMMAND
exit
#
# end of execution script
#
```

You can uncomment or change any line and add commands to this script. The only lines you cannot change are:

```
TV_COMMAND
exit
```

tv_LoadLeveler.csh Script

Here are the contents of the **tv_Loadleveler.csh** script file:

```
#!/bin/csh -f
# @ job_type = bluegene
#@ output = tv.out.%(jobid).%(stepid)
#@ error = tv.job.err.%(jobid).%(stepid)
#@ queue
TV_COMMAND
```

You can uncomment or change any line and add commands to this script. The only line you cannot change is:

```
TV_COMMAND
```

Debugging Tools and Tasks

This part introduces basic tools and features for debugging your programs using TotalView, including:

Chapter 4, “Starting TotalView”

If you just enter `totalview` in a shell, the Sessions Manager launches where you can configure your debugging session. But you can also bypass the manager and launch TotalView directly. This chapter details the multiple options you have for starting TotalView.

Chapter 5, “Loading and Managing Sessions”

You can set up a debugging session in several ways, depending on your platform. This chapter discusses common setup scenarios and configurations.

Chapter 6, “Using and Customizing the GUI”

The TotalView GUI provides an extensive set of tools for viewing, navigating, and customization. This chapter discusses features specific to TotalView’s interface.

Chapter 7, “Stepping through and Executing your Program”

TotalView provides a wide set of tools for stepping through your program, using either the Process and Group menus, toolbar commands, or the CLI.

Chapter 8, “Setting Action Points”

Action points control how your programs execute and what happens when your program reaches statements that you define as important. Action points also let you monitor changes to a variable’s value.

Chapter 9, “Examining and Editing Data and Program Elements”

This chapter discusses how to examine the value stored in a variable.

Chapter 10, “Examining Arrays”

Displaying information in arrays presents special problems. This chapter tells how TotalView solves these problems.

Chapter 11, “Visualizing Programs and Data”

Some TotalView commands and tools are only useful if you’re using the GUI. Here you will find information on the Call Graph and Visualizer.

Chapter 12, “Evaluating Expressions”

Many TotalView operations such as displaying variables are actually operating upon expressions. Here’s where you’ll find details of what TotalView does. This information is not just for advanced users.

Chapter 13, “About Groups, Processes, and Threads”

This chapter is the first of a three-chapter look at the TotalView process/thread model and how to manipulate threads and processes while debugging your multi-threaded applications. This chapter contains concept information on threads and processes in general. [Chapter 14, “Manipulating Processes and Threads”](#) describes TotalView’s hands-on tools for organizing and viewing thread and process activity and data, while [Chapter 21, “Group, Process, and Thread Control”](#) includes advanced configuration and customization, useful for finely controlling execution in very complex applications.

Chapter 14, “Manipulating Processes and Threads”

The second (of three) chapter focusing on threads and processes, with an emphasis on hands-on tasks and tools to control the view, execution, and focus of a single or group of threads and processes.

Chapter 15, “Debugging Strategies for Parallel Applications”

Because debugging parallel applications can be so complex, this chapter offers a few strategies that can help streamline the task.



Chapter 4

Starting TotalView

Before starting TotalView and loading a program to debug, first compile your program for debugging.

When you are ready to start debugging, you have many options for starting TotalView. This chapter discusses:

- [“Compiling Programs”](#) on page 85
- [“Starting TotalView”](#) on page 87
- [“Exiting from TotalView”](#) on page 95

Compiling Programs

The first step in getting a program ready for debugging is to add your compiler's **-g** debugging command-line option. This option tells your compiler to generate symbol table debugging information; for example:

```
cc -g -o executable source_program
```

You can also debug programs that you did not compile using the **-g** option, or programs for which you do not have source code. For more information, see

The following table presents some general considerations. "Compilers and Platforms" in the *TotalView for HPC Reference Guide* contains additional considerations.

Compiler Option or Library	What It Does	When to Use It
Debugging symbols option (usually -g)	Generates debugging information in the symbol table.	Before debugging <i>any</i> program with TotalView.
Optimization option (usually -O)	Rearranges code to optimize your program's execution. Some compilers won't let you use the -O option and the -g option at the same time. Even if your compiler lets you use the -O option, don't use it when debugging your program, since strange results often occur.	After you finish debugging your program.
multi-process programming library (usually dbfork)	Uses special versions of the fork() and execve() system calls. In some cases, you need to use the -lpthread option. For more information about dbfork, see "Linking with the dbfork Library" contained in the "Compilers and Platforms" Chapter of the <i>TotalView for HPC Reference Guide</i> .	Before debugging a multi-process program that explicitly calls fork() or execve() . See "Debugging Processes That Call the fork() Function" on page 191 and "Debugging Processes that Call the execve() Function" on page 191.

RELATED TOPICS

Compilers and platforms	"Compilers and Platforms" in the <i>TotalView for HPC Platforms Guide</i>
The dbfork library	"Linking with the dbfork Library" in the <i>TotalView for HPC Platforms Guide</i>
Assembler code	"Viewing the Assembler Version of Your Code" on page 161

Using File Extensions

When opening a file, TotalView uses the file's extension to determine the programming language used. If you are using an unusual extension, you can manually associate your extension with a programming language by setting the **TV::suffixes** variable in a startup file. For more information, see the “*TotalView Variables*” chapter in the *TotalView for HPC Reference Guide*.

Note that your installation may have its own guidelines for compiling programs.

Starting TotalView

TotalView can debug programs that run in many different computing environments using many different parallel processing modes and systems. This section looks at few of the ways you can start TotalView. See the “*TotalView Command Syntax*” chapter in the *TotalView for HPC Reference Guide* for more detailed information.

NOTE >> Starting TotalView with no arguments (just entering `totalview` in your shell) launches the Sessions Manager’s Start a Debugging Session dialog, “[Starting a Debugging Session](#)” on page 98.

In most cases, the command for starting TotalView looks like the following:

```
totalview [ executable [ core-files | recording-file ] ] [ options ]
```

where *executable* is the name of the executable file to debug, *core-files* is the name of one or more core files to examine, and *recording-file* is the name of a ReplayEngine recording to load.

```
CLI: totalviewcli [ executable [ core-files | recording-file ] ] [ options ]
```

Your environment may require you to start TotalView in another way. For example, if you are debugging an MPI program, you must invoke TotalView on `mpirun`. For details, see “[Setting Up Parallel Debugging Sessions](#)” on page 492.

Note that you can use the GUI and the CLI at the same time. Use the **Tools > Command Line** command to display the CLI’s window.

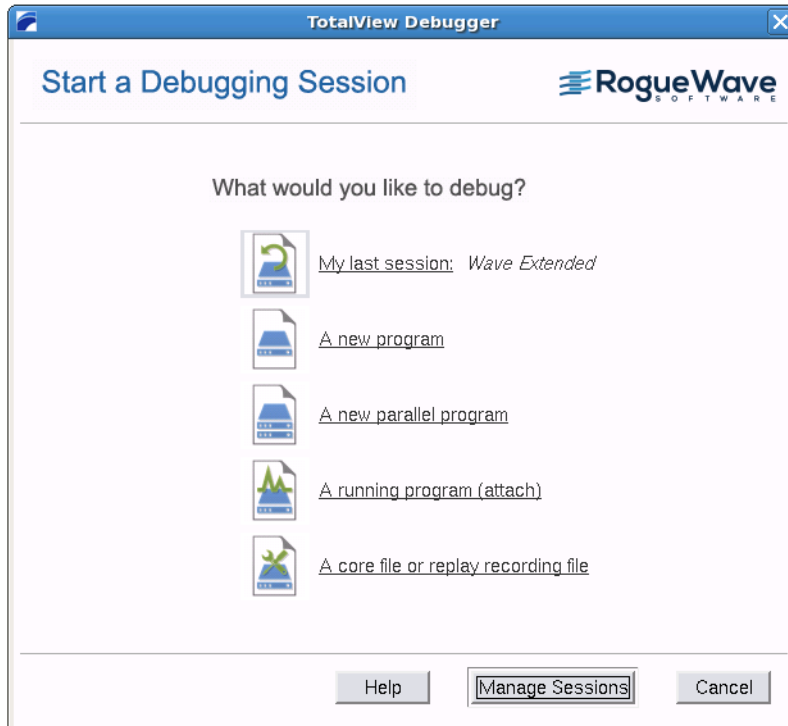
NOTE >> Your installation may have its own procedures and guidelines for running TotalView.

The following examples show different ways that you might begin debugging a program:

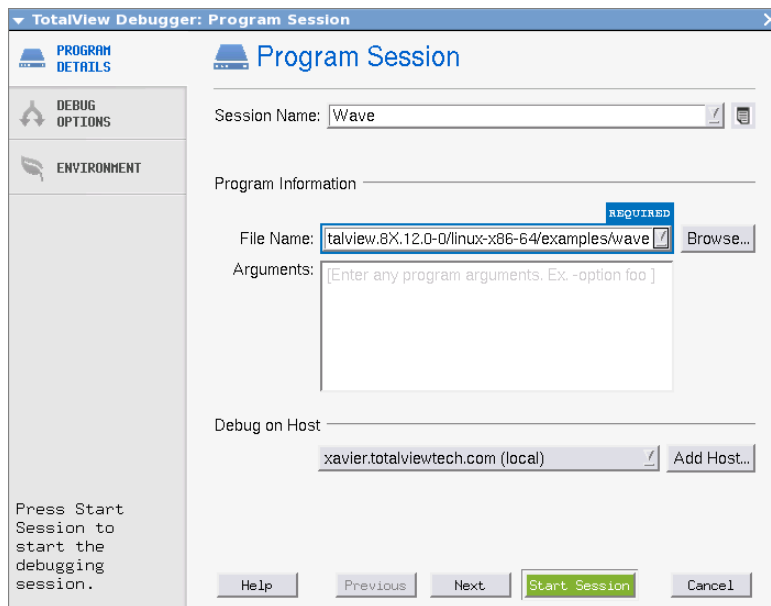
Starting TotalView

totalview

Starts TotalView without loading a program or core file. Instead, TotalView launches the Sessions Manager's Start a Debugging Session dialog where you can choose the type of session you plan to debug.



When you select your type of session, the relevant dialog launches. For instance, if you select A new program, the Program Session dialog launches.



Notice the **Debug Options** tab in the sidebar. Selecting this launches a dialog that enables reverse debugging with ReplayEngine and memory debugging with MemoryScape.

On the CLI, enter:

```
CLI: totalviewcli
      dload executable
```

Starting on Mac OS X

If you installed TotalView on a Macintosh using the application bundle, you can click on the TotalView icon. If you've installed the **.dmg** version, you can start TotalView from an **xterm** by typing:

```
installdir/TotalView.app/totalview
```

where *installdir* is where TotalView is installed.

If TotalView was installed on your system without **procmod** permission, you will not be able to debug programs. If TotalView detects this problem, it displays a dialog box with information on how to fix it.

Creating or Loading a Session

```
totalview -load_session session_name
```

Creates a process based on the session values. Sessions that attach to an existing process cannot be loaded this way; use the **-pid** command line option instead

```
CLI: totalviewcli
      dsession -load session_name
```

Debugging a Program

```
totalview executable
```

Starts TotalView and loads the *executable* program.

```
CLI: totalviewcli executable
```

If you installed TotalView on a Macintosh using the application bundle, you can drag your program's executable to the TotalView icon on your desktop.

If you type an executable name, TotalView remembers that name and many of its arguments.

Debugging a Core File

totalview executable corefiles

Starts TotalView and loads the *executable* program and one or more associated *core-files*.

```
CLI: dattach -c core-files -e executable
```

The *core-files* argument represents one or more core files associated with this executable. You can use wild cards in the core file names.

Debugging with a Replay Recording File

totalview executable recording-file

Starts TotalView and loads the *executable* program and an associated *recording-file*. The recording file was saved in a previous debugging session that used the Replay feature, and restores the state of that debugging session, including all Replay information.

```
CLI: dattach -c recording-file -e executable
```

Passing Arguments to the Program Being Debugged

totalview executable -a args

Starts TotalView and passes all the arguments following the **-a** option to the *executable* program. When using the **-a** option, it must be the last TotalView option on the command line.

```
CLI: totalviewcli executable -a args
```

If you don't use the **-a** option and you want to add arguments after TotalView loads your program, add them either using either the **File > Debug New Program** dialog box or use the **Process > Startup** command.

```
CLI: dset ARGS_DEFAULT {value}
```

Debugging a Program Running on Another Computer

totalview executable -remote hostname_or_address[:port]

Starts TotalView on your local host and the **tvdsvr** command (which implements and controls debugging on remote machines) on a remote host. After TotalView begins executing, it loads the program specified by *executable* for remote debugging. You can specify a host name or a TCP/IP address. If you need to, you can also enter the TCP/IP port number.

```
CLI: totalviewcli executable  
-r hostname_or_address[:port]
```

If TotalView fails to automatically load a remote executable, you may need to disable **auto-launching** for this connection and manually start the **tvdsvr**. (*Autolaunching* is the process of automatically launching **tvdsvr** processes.) To disable autolaunching, add the *hostname:port-number* suffix to the name entered in the **Debug on Host** field of the **File > Debug New Program** dialog box. As always, the *portnumber* is the TCP/IP port number on which TotalView server is communicating with TotalView. See “Starting the TotalView Server Manually” on page 449 for more information.

NOTE >> TotalView Individual does not allow remote debugging.

Debugging an MPI Program

totalview

Method 1: In many cases, you can start an MPI program in much the same way as you would start any other program. However, you need to select **A New Parallel program** from the **Start a Debugging Session** dialog box, and enter the MPI version and other information on the parallel program to debug.

mpirun -np count -tv executable

Method 2: The MPI **mpirun** command starts the TotalView executable pointed to by the **TOTALVIEW** environment variable. TotalView then starts your program. This program runs using **count** processes.

Using gnu_debuglink Files

totalview executable

If you have prepared a **gnu_debuglink** file, TotalView can access this information. For more information, see “Using gnu_debuglink Files” within the *Compilers and Platforms* chapter of the *TotalView for HPC Reference Guide*.

RELATED TOPICS

Debugging parallel programs such as MPI, UPC, or CAF, including invoking TotalView on **mpirun**

Chapter 20, “Setting Up Parallel Debugging Sessions,” on page 492

RELATED TOPICS

Remote debugging	Chapter 18, “Setting Up Remote Debugging Sessions,” on page 442, and “TotalView Debugger Server (tvdsvr) Command Syntax” in the <i>TotalView for HPC Reference Guide</i> .
The <code>totalview</code> command	“TotalView Command Syntax” in the <i>TotalView for HPC Reference Guide</i>

Initializing TotalView

When TotalView begins executing, it reads initialization and startup information from a number of files. The two most common are initialization files that you create and preference files that TotalView creates.

NOTE >> It is sometimes desirable to bypass defaults that have been set in either a global or a private initialization file. To bypass the default execution of startup scripts, you can specify `-no_startup_scripts` on the TotalView startup command line.

An *initialization file* stores CLI functions, set variables, and execute actions that TotalView interprets when it begins executing. This file, which you must name **tvdrc**, resides in the **.totalview** subdirectory contained in your home directory. TotalView creates this directory for you the first time it executes.

TotalView can read more than one initialization file. You can place these files in your installation directory, the **.totalview** subdirectory, the directory in which you invoke TotalView, or the directory in which the program resides. If an initialization file is present in one or all of these places, TotalView reads and executes each. Only the initialization file in your **.totalview** directory has the name **tvdrc**. The other initialization files have the name **.tvdrc**. That is, a dot precedes the file name.

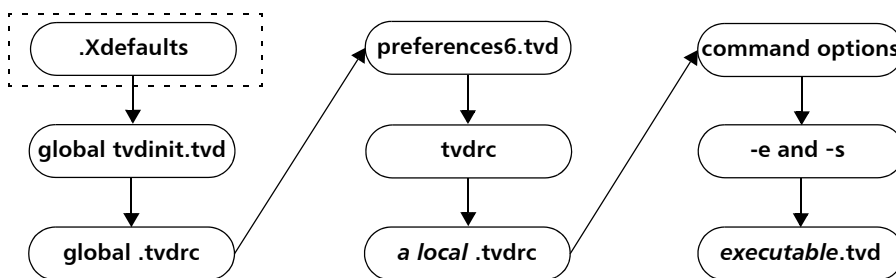
NOTE >> Before Version 6.0, you placed your personal **.tvdrc** file in your home directory. If you do not move this file to the **.totalview** directory, TotalView will still find it. However, if you also have a **tvdrc** file in the **.totalview** directory, TotalView ignores the **.tvdrc** file in your home directory.

TotalView automatically writes your *preferences file* to your **.totalview** subdirectory. Its name is **preferences6.tvd**. Do not modify this file as TotalView overwrites it when it saves your preferences.

If you add the **-s filename** option to either the **totalview** or **totalviewcli** shell command, TotalView executes the CLI commands contained in *filename*. This startup file executes after a **tvdrc** file executes. The **-s** option lets you, for example, initialize the debugging state of your program, run the program you're debugging until it reaches some point where you're ready to begin debugging, and even create a shell command that starts the CLI.

Figure 24 shows the order in which TotalView executes initialization and startup files.

Figure 24 – Startup and Initialization Sequence



The **.Xdefaults** file, which is actually read by the server when you start X Windows, is only used by the GUI. The CLI ignores it.

The **tvdinit.tvd** file resides in the TotalView **lib** directory. It contains startup macros that TotalView requires. Do not edit this file. Instead, if you want to globally set a variable or define or run a CLI macro, create a file named **.tvdrc** and place it in the TotalView **lib** directory.

As part of the initialization process, TotalView exports three environment variables into your environment: **LM_LICENSE_FILE**, **TVROOT**, and either **SHLIB_PATH** or **LD_LIBRARY_PATH**.

If you have saved an action point file to the same subdirectory as your program, TotalView automatically reads the information in this file when it loads your program.

You can also invoke scripts by naming them in the **TV::process_load_callbacks** list. For information on using this variable, see the "Variables" chapter of the *TotalView for HPC Reference Guide*.

If you are debugging multi-process programs that run on more than one computer, TotalView caches library information in the **.totalview** subdirectory. If you want to move this cache to another location, set **TV::library_cache_directory** to this location. TotalView can share the files in this cache directory among users.

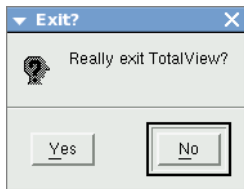
RELATED TOPICS

The TV::process_load_callbacks variable	"TotalView Variables" in the <i>TotalView for HPC Reference Guide</i>
Saving action points	"Saving Action Points to a File" on page 213

Exiting from TotalView

To exit from TotalView, select **File > Exit**. You can select this command in the Root, Process, and Variable Windows. After selecting this command, TotalView displays the dialog box shown in [Figure 25](#).

Figure 25 – File > Exit Dialog Box



Select **Yes** to exit. As TotalView exits, it kills all programs and processes that it started. However, programs and processes that TotalView did not start continue to execute.

NOTE >> If you have a CLI window open, TotalView also closes this window. Similarly, if you type **exit** in the CLI, the CLI closes GUI windows. If you type **exit** in the CLI and you have a GUI window open, TotalView still displays this dialog box.

CLI: exit

Note that if both the CLI and the GUI are open, and you want to exit only from the CLI, type Ctrl+D.



Chapter 5

Loading and Managing Sessions

This chapter discusses how to set up a TotalView session, based on some of the most-used setup commands and procedures.

There are two primary ways to load programs into TotalView for debugging: the GUI via the Sessions Manager ([Loading Programs from the Sessions Manager](#)) or the CLI ([Loading Programs Using the CLI](#)) using its various commands. Both support all debugging session types.

For information on setting up remote debugging, see [“Setting Up Remote Debugging Sessions”](#) on page 442.

For information on setting up parallel debugging sessions, see [“Setting Up MPI Debugging Sessions”](#) on page 461 and [“Setting Up Parallel Debugging Sessions”](#) on page 492.

This chapter contains the following sections (not necessarily in this order):

Setting up Debugging Sessions

- [“Loading Programs from the Sessions Manager”](#) on page 98
 - [“Starting a Debugging Session”](#) on page 98
 - [“Debugging a New Program”](#) on page 99
 - [“Attaching to a Running Program”](#) on page 101
 - [“Debugging a Core File”](#) on page 106
 - [“Debugging with a Replay Recording File”](#) on page 107
 - [“Launching your Last Session”](#) on page 109
- [“Loading Programs Using the CLI”](#) on page 109

NOTE >> Setting up parallel debugging sessions is not discussed in this chapter. Rather, see [Chapter 19](#).

Additional Session Setup Options

- [“Adding a Remote Host”](#) on page 111
- [“Options: Reverse Debugging, Memory Debugging, and CUDA”](#) on page 113
- [“Setting Environment Variables and Altering Standard I/O”](#) on page 115

Managing Debug Sessions

- [“Managing Sessions”](#) on page 119

Other Configuration Options

- [“Handling Signals”](#) on page 122
- [“Setting Search Paths”](#) on page 125
- [“Setting Startup Parameters”](#) on page 127
- [“Setting Preferences”](#) on page 128

Setting up Debugging Sessions

The easiest way to set up a new debugging session is to use the Sessions Manager, which provides an easy-to-use interface for configuring sessions and loading programs into TotalView. Alternatively, you can use the CLI.

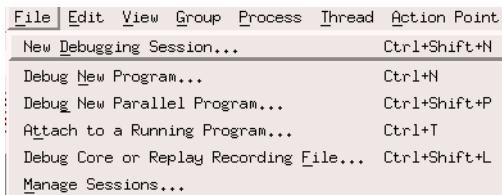
“Loading Programs from the Sessions Manager” on page 98

“Loading Programs Using the CLI” on page 109

Loading Programs from the Sessions Manager

TotalView can debug programs on local and remote hosts, and programs that you access over networks and serial lines. The **File** menu of both the Root and Process windows contains a series of debug options to load local and remote programs, core files, and processes that are already running.

Figure 26 – Debugging options from the File Menu



Each of these debug options launches the Sessions Manager where you can configure a new debug session or launch a previous session.

From this menu, you can also select **Manage Sessions** to edit or delete previously saved debug sessions.

NOTE >> Your license limits the number of programs you can load. For example, TotalView Individual limits you to 16 processes or threads.

Starting a Debugging Session

Access the main page of the Sessions Manager either directly from your shell by just entering `totalview`

or by selecting **File > New Debugging Session** in the Root and Process windows.

Figure 27 – Start a Debugging Session dialog box



The Start a Debugging Session dialog of the Sessions Manager can configure various types of debugging sessions, depending on your selection. These are:

- “[Debugging a New Program](#)” on page 99
- Debugging a parallel application in “[Starting MPI Programs Using File > Debug New Parallel Program](#)” on page 463
- “[Attaching to a Running Program](#)” on page 101
- “[Debugging a Core File](#)” on page 106
- “[Debugging with a Replay Recording File](#)” on page 107
- “[Launching your Last Session](#)” on page 109

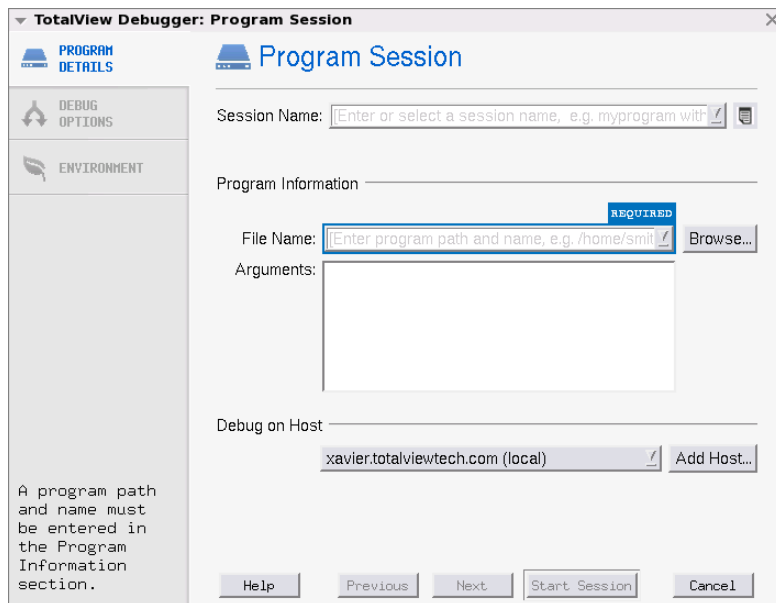
Debugging a New Program

To configure a new debugging session, either:

- Select **A new program** to launch the Program Session dialog, or
- Select **File > Debug New Program** from the Root or Process windows, if TotalView is already running.

The Program Session dialog launches.

Figure 28 – Program Session dialog



1. Enter a session name in the **Session Name** text box.

NOTE >> Note that any previously entered sessions of the same type are available from the Session Name dropdown box. Once selected, you can change any session properties and start your debug session. See [“Editing or Starting New Sessions in a Sessions Window”](#) on page 121.


2. Enter the name of your program in the **File Name** box or press **Browse** to browse to and select the file. You can enter a full or relative path name. If you have previously entered programs here, they will appear in a drop-down list.

If you enter a file name, TotalView searches for it in the list of directories named using the **File > Search Path** command or listed in your **PATH** environment variable.

CLI: dset EXECUTABLE_PATH

3. (Optional) Add any custom configurations or options:
 - **Remote debugging:** Select or add a remote host, if the program is to be executed on a remote computer. See [“Adding a Remote Host”](#) on page 111.
 - **Program arguments:** Enter any program arguments into the Arguments field.

Because you are loading the program from within TotalView, you will not have entered the command-line arguments that the program needs. For detail, see **Program Arguments** in the In-Product Help.

- **Debugging Options:** See “[Options: Reverse Debugging, Memory Debugging, and CUDA](#)” on page 113.
- **Environment variables or standard I/O:** See “[Setting Environment Variables and Altering Standard I/O](#)” on page 115
- **Notes:** You can add any notes to the session by selecting the Note icon (). See “[Adding Notes to a Session](#)” on page 117.

4. Click **Start Session**. The Start Session button is enabled once all required information is entered.

Attaching to a Running Program

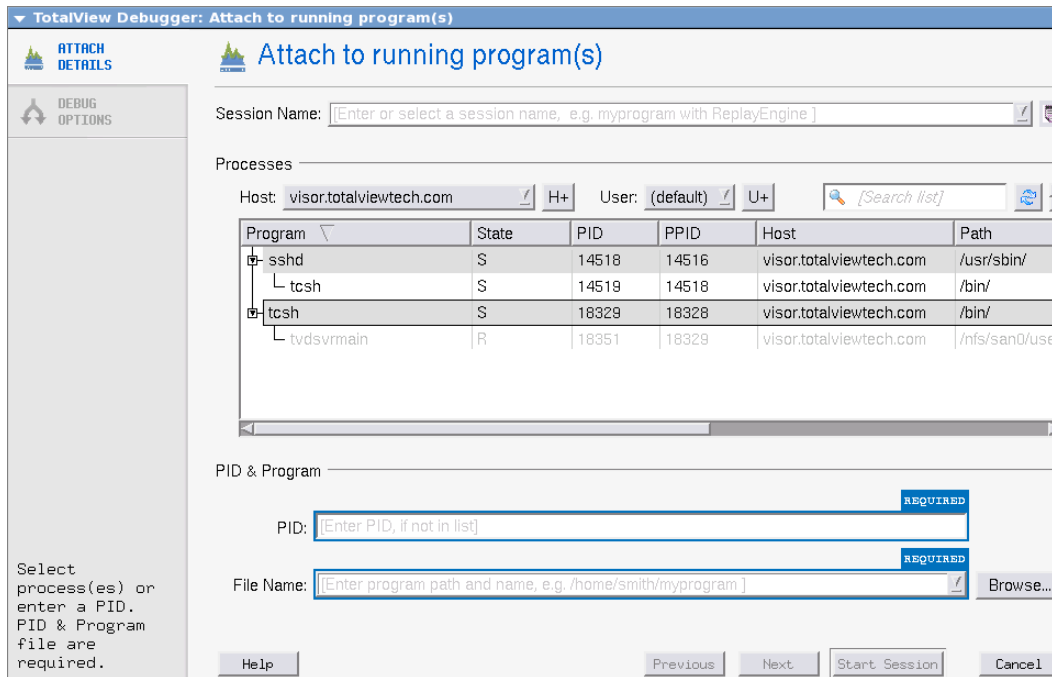
If a program you’re testing is hung or looping (or misbehaving in some other way), you can attach to it while it is running. You can attach to single and multi-process programs, and these programs can be running remotely.

To open the Attach window, select either

- **A running program (attach)** on the Start a Debugging Session dialog, or
- **File > Attach to a Running Program** from the Root or Process window if TotalView is already running.

A list of processes running on the selected host displays in the **Attach to running program(s)** dialog.

Figure 29 – Attaching to an existing process



In the displayed list, processes to which TotalView is already attached are shown in gray text, while the processes displayed in black text are not currently running under TotalView control.

1. Enter a name for this session in the **Session Name** field.

NOTE >> Any previously entered sessions of the same type are available from the Session Name dropdown box. Once selected, you can change any session properties and start your debug session. See [“Editing or Starting New Sessions in a Sessions Window”](#) on page 121.

2. Click on the program’s name under the Program column, and press **Start Session**.


CLI: `dattach executable pid`

While you must link programs that use **fork()** and **execve()** with the TotalView dbfork library so that TotalView can automatically attach to them when your program creates them, programs that you attach to need not be linked with this library.

NOTE >> You cannot attach to processes running on another host if you are using TotalView Individual.

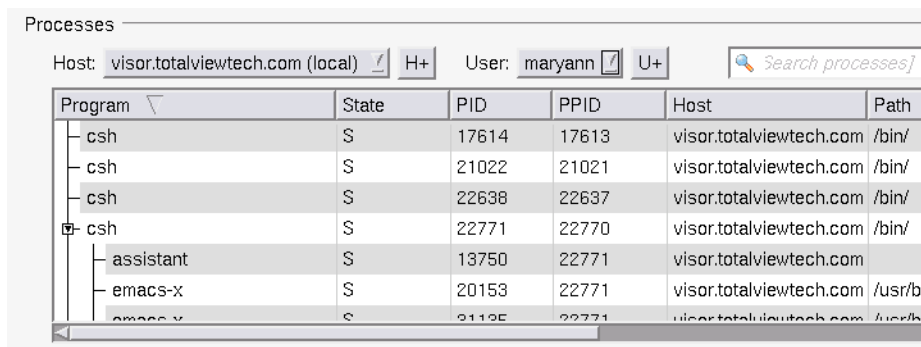
Adding a New User

You can enter a user name to see the processes owned by that user. If you wish to attach to a process owned by someone else, you need the proper permissions.

1. Click the  icon to launch the **Add username** dialog.
2. Enter a known username, then click OK.



If the username is not recognized, the system returns an error; otherwise, the user is added to the User drop-down and selected as the current user.

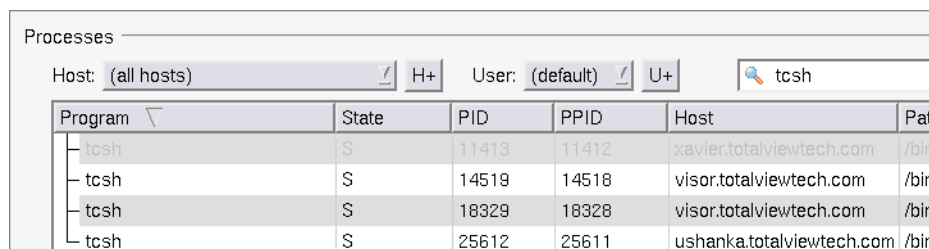


The selected user's processes are displayed. Attach to another user's processes just by clicking the process and selecting **Start Session**.

If you do not have permissions to attach to the process, an error is returned.

Searching for Processes

You can search for any process using the search box ( *Search processes* ). If found, the process will display in the Processes pane.



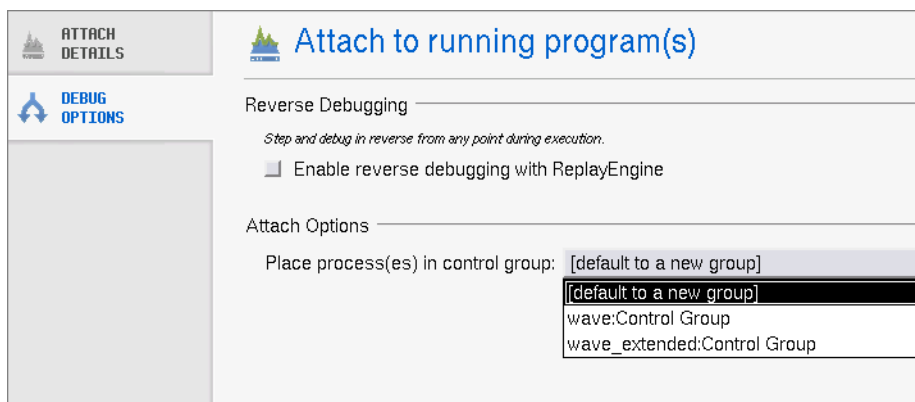
RELATED TOPICS

Attached process states	"Seeing Attached Process States" on page 375
Starting TotalView	"Starting TotalView" on page 87
Using the Root Window	"Using the Root Window" on page 140
File > Attach to a Running Program	Process > Detach in the in-product Help

Attach Options

On the **Debug Options** tab, two options exist:

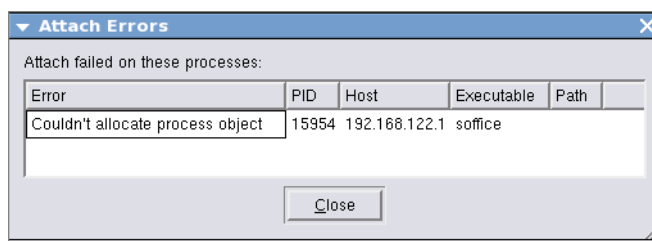
- Enabling ReplayEngine, which is an option available to all other debugging sessions (See ["Options: Reverse Debugging, Memory Debugging, and CUDA"](#) on page 113)
- Placing the processes to which you are attaching into a control group under the **Attach Options** area.



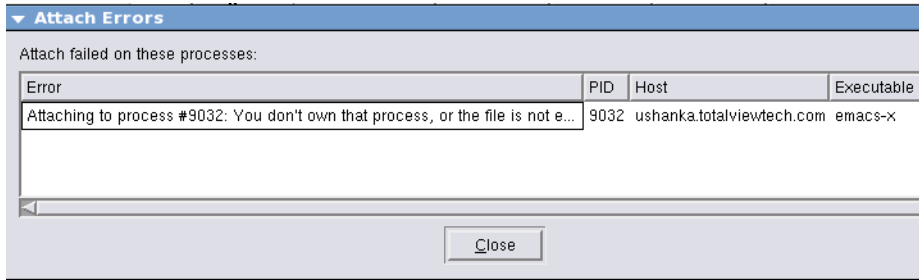
If you have selected a group in previous TotalView sessions and the group exists in the dropdown, it is selected for you. Otherwise, the default is to create a new group to contain all processes attached to in this session.

Attaching Errors

If TotalView returns an error while attempting to attach to a process, it is usually because you do not have permission to attach to that process. For example, the process could not be allocated:



Or you don't own the process:



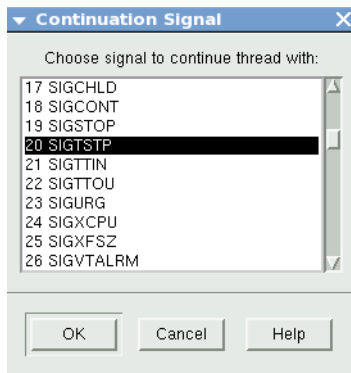
Detaching from Processes

You can either detach from a group of processes or detach from one process.

Use the **Group > Detach** command to remove attached processes within a control group. As TotalView executes this command, it eliminates all of the state information related to these processes. If TotalView didn't start a process, it continues executing in its normal run-time environment.

To detach from processes that TotalView did not create:

1. (Optional) After opening a Process Window on the process, select the **Thread > Continuation Signal** command to display the following dialog box.



The examples at the end of TV::thread discussion show setting a signal.

Choose the signal that TotalView sends to the process when it detaches from the process. For example, to detach from a process and leave it stopped, set the continuation signal to **SIGSTOP**.

2. Select **OK**.
3. Select the **Process > Detach** command.

CLI: ddetach

When you detach from a process, TotalView removes all breakpoints that you have set in it.

RELATED TOPICS

The Process > Detach command in detail	Process > Detach in the in-product Help
The CLI ddetach command	ddetach in the <i>TotalView for HPC Reference Guide</i>
The continuation signal	Thread > Continuation Signal in the in-product Help

Debugging a Core File

If a process encounters a serious error and dumps a core file, you can load the file to examine it.

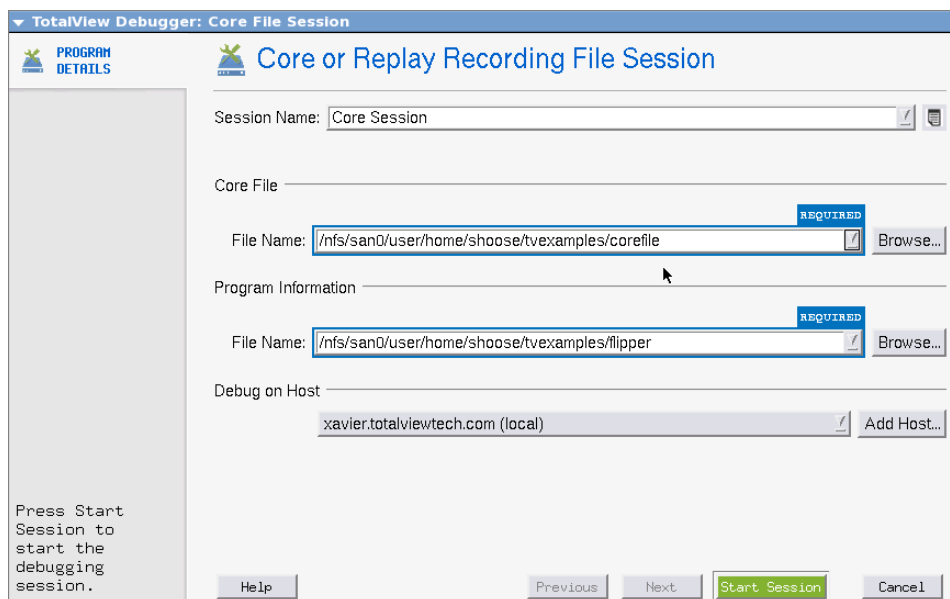
To debug a core file, select either

- **A core file or replay recording file** on the Start a Debugging Session dialog, or
- **File > Debug Core or Replay Recording** from the Root or Process window if TotalView is already running.

The “Core or Replay Recording File Session” dialog launches. Enter a name for the session and the program and core file’s name.

NOTE >> Any previously entered sessions of the same type are available from the Session Name drop-down box. Once selected, you can change any session properties and start your debug session. See “[Editing or Starting New Sessions in a Sessions Window](#)” on page 121.

Figure 30 – Open a Core File



If the program and core file reside on another system, enter that system's name in the Debug on Host area (see [“Adding a Remote Host”](#) on page 111 for details).

If your operating system can create multi-threaded core files (and most can), TotalView can examine the thread in which the problem occurred. It can also show you information about other threads in your program.

When TotalView launches, the Process Window displays the core file, with the Stack Trace, Stack Frame, and Source Panes showing the state of the process when it dumped core. The title bar of the Process Window names the signal that caused the core dump. The right arrow in the line number area of the Source Pane indicates the value of the program counter (PC) when the process encountered the error.

You can examine the state of all variables at the time the error occurred. See [“Examining and Editing Data and Program Elements”](#) on page 214.

If you start a process while you're examining a core file, TotalView stops using the core file and switches to this new process.

RELATED TOPICS

Debugging a Core File

The **File > Debug Core File** dialog in the in-product Help

The CLI **dattach** command's **-c core-files** option

dattach in the *TotalView for HPC Reference Guide*

Debugging with a Replay Recording File

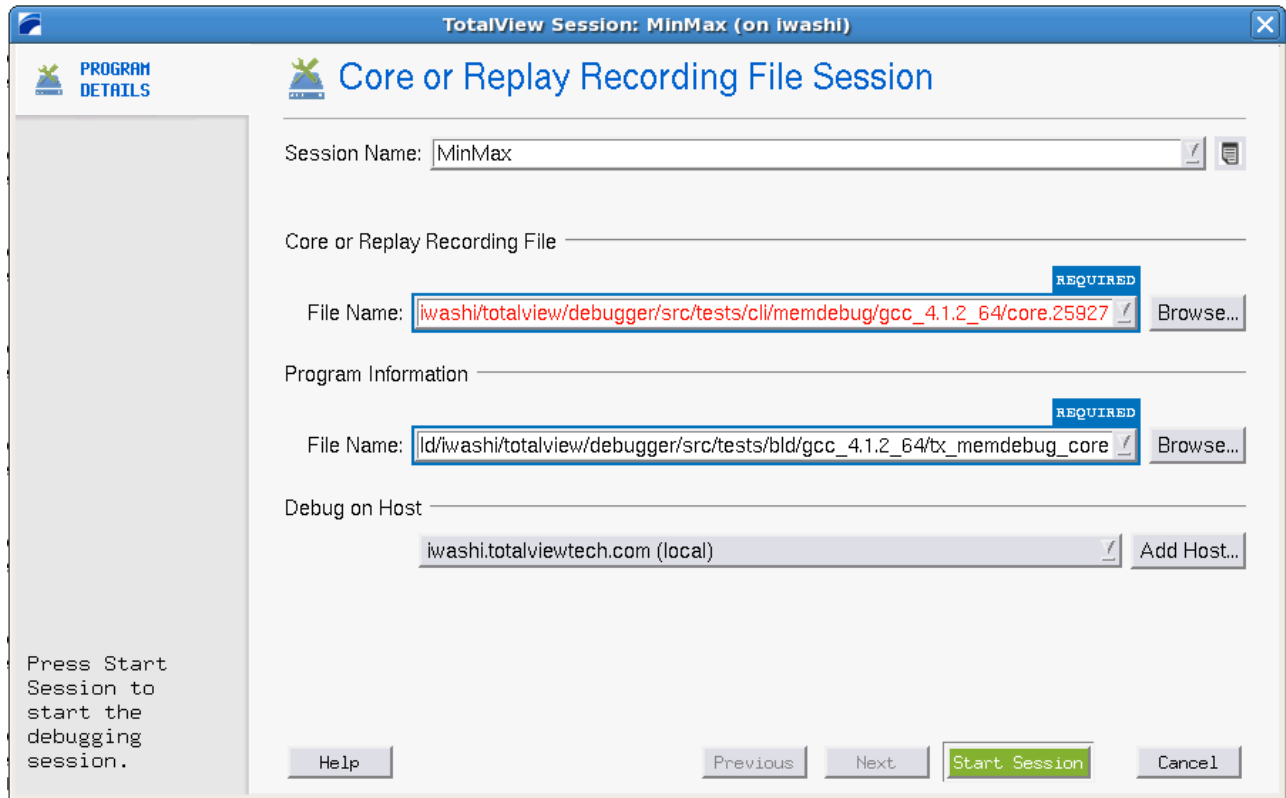
Previously saved Replay recording files can be loaded to further debug applications. These recording files contain the state of a previous debugging session, including all Replay information.

To debug with a replay recording file, select either

- A **core file or replay recording file** on the **Start a Debugging Session** dialog, *or*
- **File > Debug Core or Replay Recording File** from the Root or Process window if TotalView is already running.

The **Core or Replay Recording File Session** dialog launches. Enter a name for the session, the program, and replay recording file's name.

Figure 31 – Open a Replay Recording File



If the program and replay recording file reside on another system, enter that system's name in the **Debug on Host** area (see “[Adding a Remote Host](#)” on page 111 for details).

When TotalView launches, the Process Window displays the replay recording file, with the Stack Trace, Stack Frame, and Source Panes showing the state of the process when the replay session was saved. The title bar of the Process Window displays “Recording File”. The right arrow in the line number area of the Source Pane indicates the value of the program counter (PC) when the process was saved.

You can examine the state of all variables at the time the replay recording file was saved. See [Chapter 9, “Examining and Editing Data and Program Elements,”](#) on page 214.

RELATED TOPICS

Debugging with a Replay recording file

The **File > Debug Core or Replay Recording File** dialog in the in-product Help

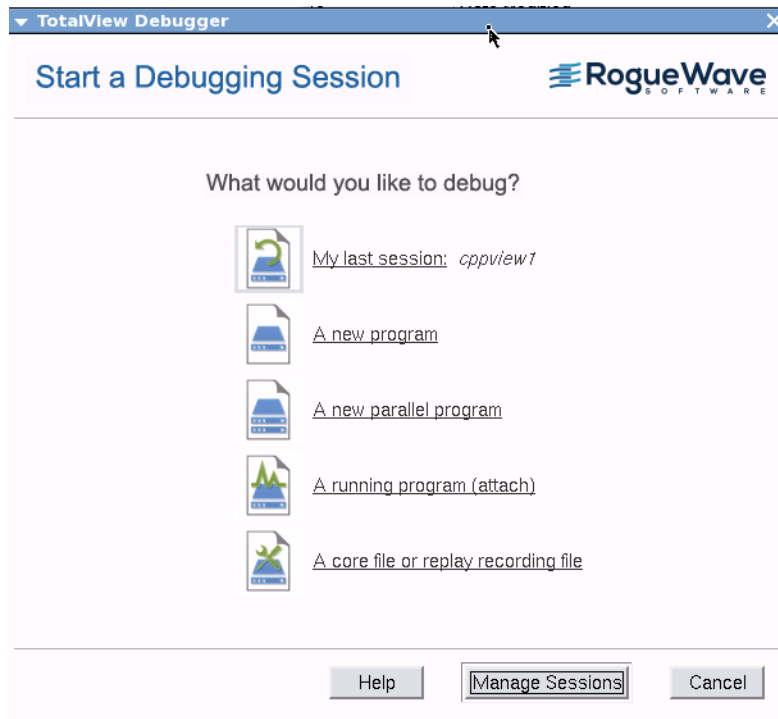
The CLI **dattach** command's **-c recording-file** option

dattach in the *TotalView for HPC Reference Guide*

Launching your Last Session

The initial window of the Sessions Manager displays your most recent session so you can quickly continue a debugging session where you left off.

Figure 32 – Start a Debugging Session



If you click on **My last session**, TotalView immediately launches based on your last session's settings, and displays the Process Window.

If you do wish to edit any properties of your last session, just select the **Manage Sessions** button to instead launch the Manage Debugging Sessions page.

Loading Programs Using the CLI

When using the CLI, you can load programs in a number of ways. Here are a few examples.

Load a session **dsession -load** *session_name*

If the preference "Show the Startup Parameters dialog on startup" is selected, this command launches the Sessions Manager so you can edit session properties; otherwise, it loads the session directly into Totalview and launches the Process and Root windows.

Start a new process **dload -e** *executable*

Open a core file

```
dattach -c core-files -e executable
```

If TotalView is not yet running, you can also provide the core file as a startup argument, like so:

```
totalview executable core-files [ options ]
```

Open a replay recording session file

```
dattach -c recording-file -e executable
```

If TotalView is not yet running, you can also provide the replay recording session file as a startup argument, like so:

```
totalview executable recording-file [ options ]
```

Load a program using its process ID

```
dattach executable pid
```

Load a program on a remote computer

```
dload executable -r hostname
```

You can type the computer's name (for example, **gandalf.roguewave.com**) or an IP address.

Load a poe program

```
dload -mpi POE -np 2 -nodes \  
-starter_args "hfile=~/my_hosts"
```

RELATED TOPICS

CLI commands	"CLI Commands" in the <i>TotalView for HPC Reference Guide</i>
Using the CLI	"Using the CLI" on page 414

Debugging Options and Environment Setup

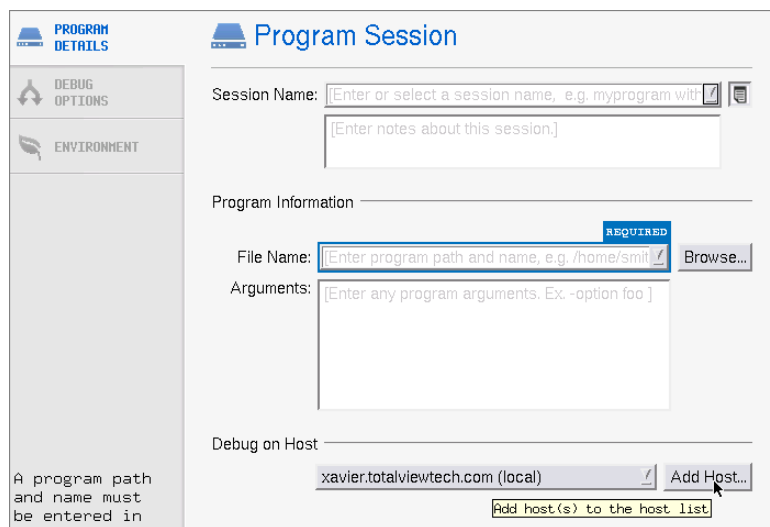
A debugging session can be customized in a variety of ways. This section discusses

- “Adding a Remote Host” on page 111
- “Options: Reverse Debugging, Memory Debugging, and CUDA” on page 113
- “Setting Environment Variables and Altering Standard I/O” on page 115
- “Adding Notes to a Session” on page 117

Adding a Remote Host

To debug a program running on a remote computer, enter the computer name in the Debug on Host area, or select it from the dropdown if already entered.

Figure 33 – Debug on Host area



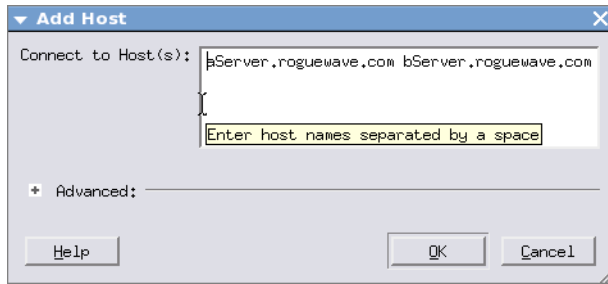
The screenshot shows the 'Program Session' dialog box with the following sections:

- PROGRAM DETAILS** (top left)
- DEBUG OPTIONS** (middle left)
- ENVIRONMENT** (bottom left)
- Session Name:** [Enter or select a session name, e.g. myprogram with] [icon] [icon]
[Enter notes about this session.]
- Program Information**
 - File Name:** [REQUIRED] [Enter program path and name, e.g. /home/smi] [Browse...]
 - Arguments:** [Enter any program arguments. Ex. -option foo]
- Debug on Host**
 - [xavier.totalviewtech.com (local)] [Add Host...]
 - [Add host(s) to the host list]

A note at the bottom left states: "A program path and name must be entered in..."

To enter a new host, select the **Add host** button and enter its name or IP address in the displayed dialog box.

Figure 34 – Add Host dialog



You can add multiple hosts separated by a space. Alternatively, add the IP address. For example:

`server1 server2 server3`

or

`10.5.6.123 10.5.7.124`

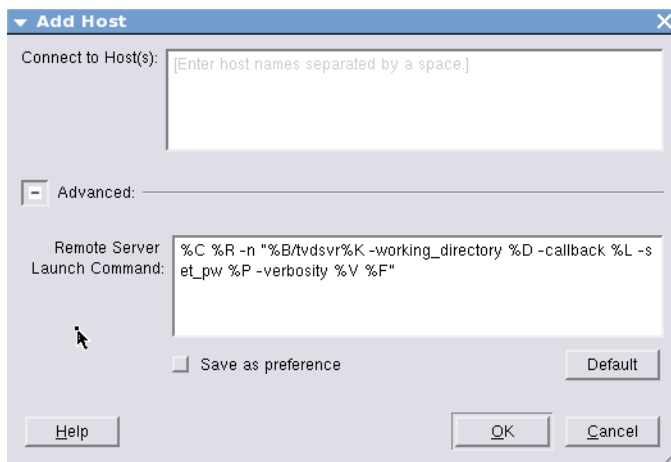
If TotalView cannot connect to the host, it displays an error dialog.

Figure 35 – Add Host Failure popup



To modify the launch string or to view the default string TotalView will use to launch the remote debug session, select the **Advanced** button (Advanced) to open the **Remote Server Launch Command** field.

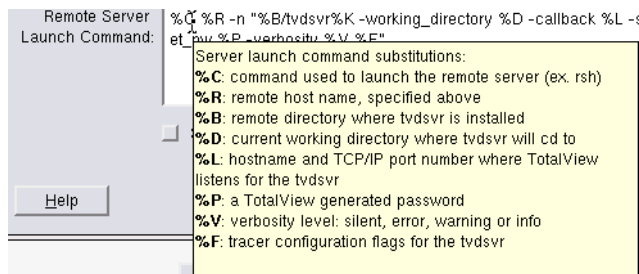
Figure 36 – Remote server launch command



You can edit this string and then click **Save as preference** to have TotalView save it to your preferences. Once saved, you can view or edit it at **File > Preferences > Launch Strings** tab.

Note that if you hover your cursor inside the text field, a popup displays the substitutions used in the launch string.

Figure 37 – Remote server launch command substitutions



If TotalView supports your program’s parallel process runtime library (for example, MPI, UPC, or CAF), it automatically connects to remote hosts. For more information, see [Chapter 20, “Setting Up Parallel Debugging Sessions,”](#) on page 492.

RELATED TOPICS

Editing the server launch command	“Customizing Server Launch Commands” on page 455
TotalView command line options	“Command-Line Options” in the <i>TotalView for HPC Reference Guide</i>
The tvdsr command	“The TotalView Debugger Server Command Syntax” in the <i>TotalView for HPC Reference Guide</i>
Remote debugging	“Setting Up Remote Debugging Sessions” on page 442

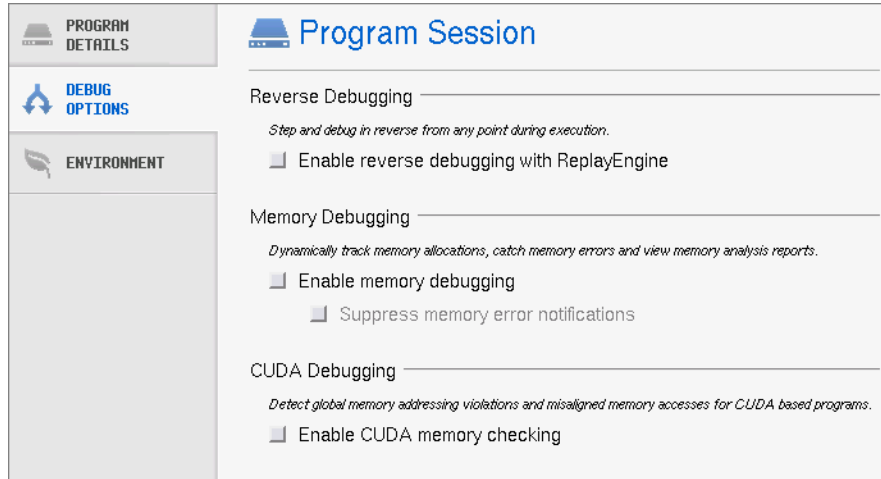
Options: Reverse Debugging, Memory Debugging, and CUDA

You can choose to enable various additional debugging features for a given session. Select the **Debug Options** tab to launch options.

Depending on the type of debug session, different options are available:

- The **New Program** and **New Parallel Program** windows offer reverse debugging, memory debugging, and CUDA debugging options:

Figure 38 – Debug Options for Reverse, Memory or CUDA debugging



- **Reverse Debugging.** Record all program state while running and then roll back your program to any point.

The **Enable ReplayEngine** check box is visible only on Linux-x86 and Linux-86-64 platforms. If you do not have a license for ReplayEngine, enabling the check box has no effect, and TotalView displays an error message when your program begins executing. Selecting this check box tells TotalView that it should instrument your code so that you can move back to previously executed lines.

- **Memory Debugging.** Track dynamic memory allocations. Catch common errors, leaks, and show reports.

Enabling memory debugging here is the same as enabling it within MemoryScope or using the Process Window's **Debug> Enable Memory Debugging** command.

The **Enable memory debugging** and **Suppress memory error notifications** check boxes perform the same functions as the **Enable memory debugging** and **On memory event, halt execution** checkboxes do within the Advanced Options on MemoryScope's Memory Debugging Options page. This is the equivalent of the basic Low setting.

- **CUDA Debugging.** Detect global memory addressing violations and misaligned memory accesses for CUDA-based programs.

- The **Attach to a Running Program** window supports only ReplayEngine and a special Attach option. For more information, see [“Attaching to a Running Program”](#) on page 101.

RELATED TOPICS

Reverse Debugging	“Understanding ReplayEngine” in the ReplayEngine User Guide
Memory Debugging	More on MemoryScope in <i>Debugging Memory Problems with MemoryScope</i>

RELATED TOPICS

CUDA Debugging

Part V, "Using the CUDA Debugger," on page 570

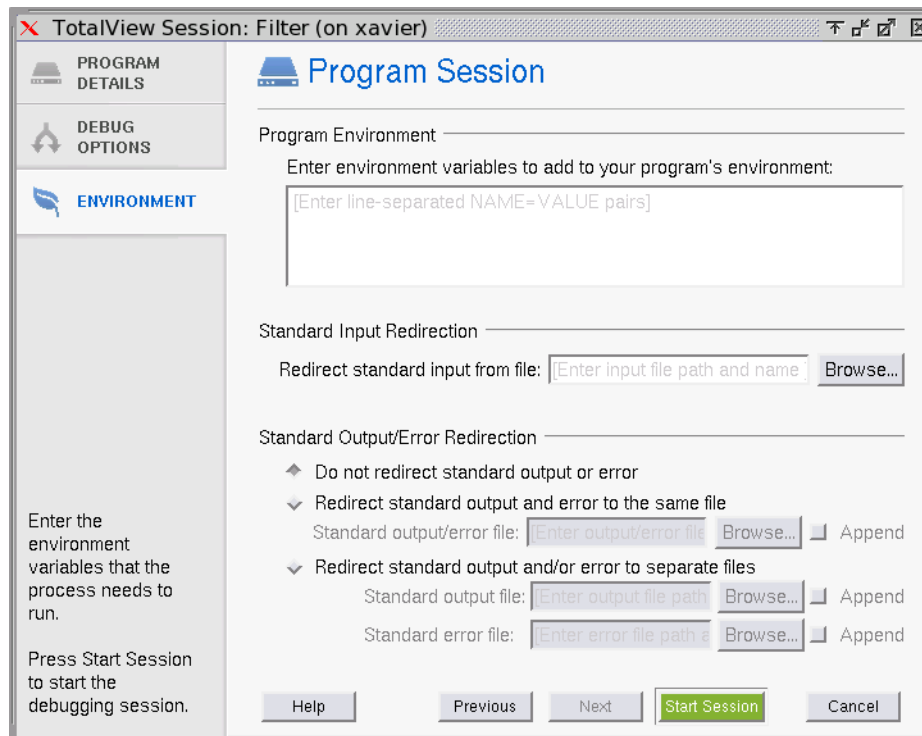
Attach options

"Attach Options" on page 104

Setting Environment Variables and Altering Standard I/O

When loading the program from within TotalView, you can add any necessary environment variables or alter standard I/O using the **Environment** tab.

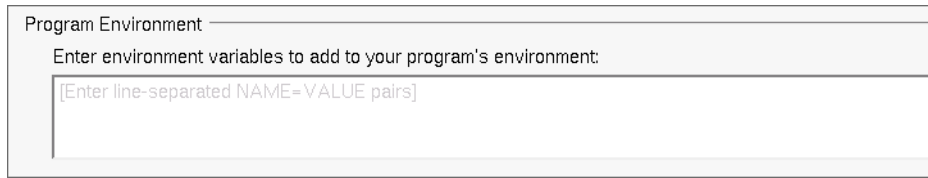
Figure 39 – Setting Environment Variables and Altering Standard I/O



Environment Variables

Enter environment variables in the field in the Program Environment area.

Figure 40 – Setting environment variables



Either separate each argument with a space, or place each one on a separate line. If an argument contains spaces, enclose the entire argument in double-quotation marks.

At startup, TotalView reads in your environment variables to ensure that your program has access to them when the program begins executing. Use the Program Environment area to add additional environment variables or to override values of existing variables.

NOTE >> TotalView does not display the variables that were passed to it when you started your debugging session. Instead, this field displays only the variables you added using this command.

The format for specifying an environment variable is *name=value*. For example, the following definition creates an environment variable named **DISPLAY** whose value is **enterprise:0.0**:

```
DISPLAY=enterprise:0.0
```

You can also enter this information using the Process Window's **Process > Startup Parameters** command.

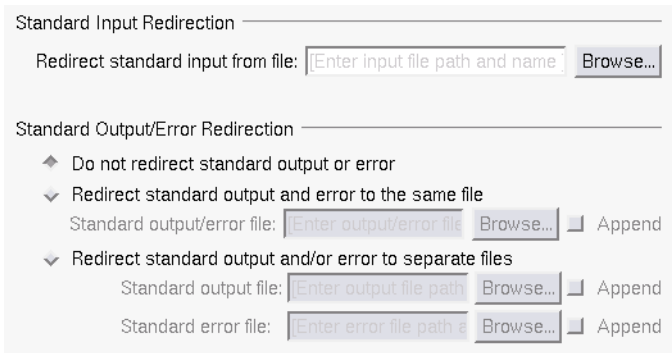
RELATED TOPICS

Environment options in the **File > "Environment Variables"** in the in-product Help **Debug New Program** dialog

Standard I/O

Use the controls in the Input Processing and Standard and Error Output Processing to alter standard input, output, and error. In all cases, name the file to which TotalView will write or from which TotalView will read information. Other controls append output to an existing file if one exists instead of overwriting it or merge standard out and standard error to the same stream.

Figure 41 – Resetting Standard I/O



You can also enter this information using the Process Window's **Process > Startup Parameters** command.

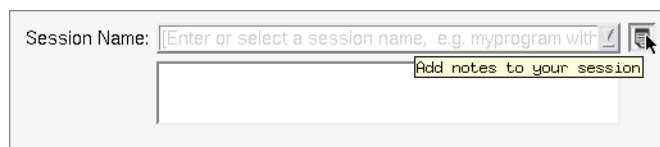
RELATED TOPICS

The standard I/O in the **File > Debug New Program** dialog "Standard I/O" in the in-product Help

Adding Notes to a Session

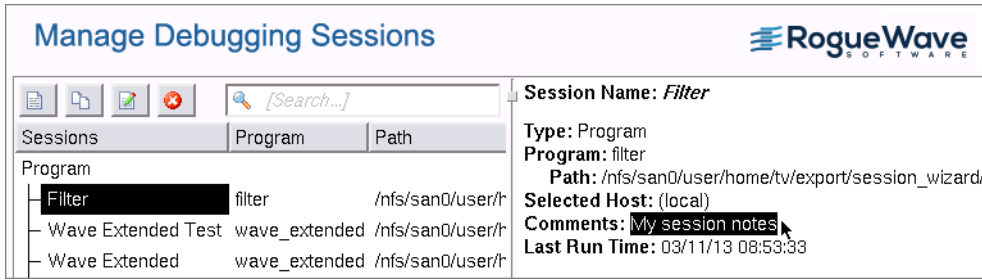
On any of the Sessions Manager dialogs for configuring debugging sessions, you can add a note by selecting the **Note** icon (📝). This opens a simple text field where you can enter your note.


Figure 42 – Adding a note to a session



Once added, your note is saved and viewable in the Manage Sessions dialog under Comments.

Figure 43 – Viewing notes saved in a session



To edit your note, or any other option for this session, click the **Edit** button () to launch the relevant session window.

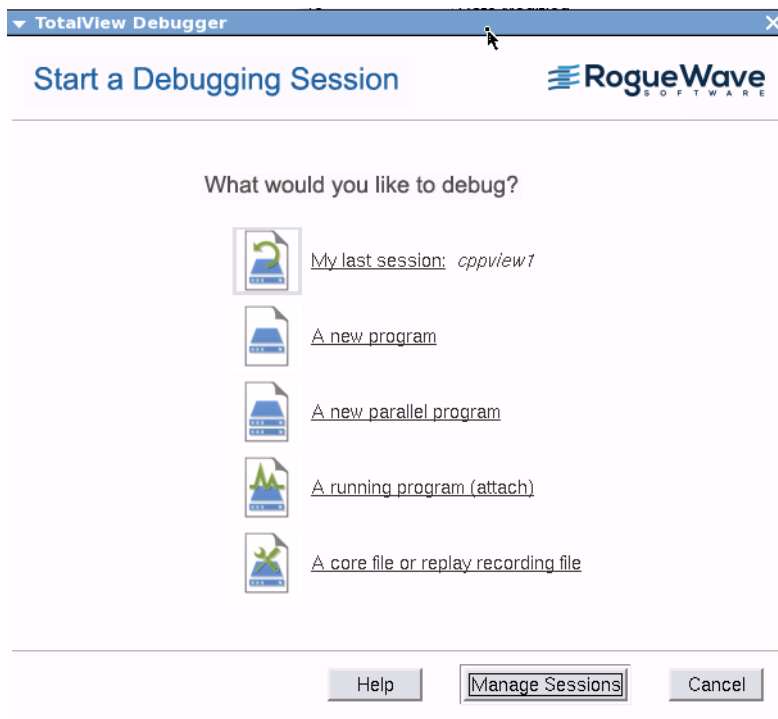
Managing Sessions

TotalView saves the settings for each of your previously-entered debugging sessions, available in the Manage Debugging Sessions window of the Sessions Manager. Here, you can edit, duplicate or delete sessions as well as start a session and create new sessions.

NOTE >> You can also edit and create new sessions from any Sessions Window. See “[Editing or Starting New Sessions in a Sessions Window](#)” on page 121

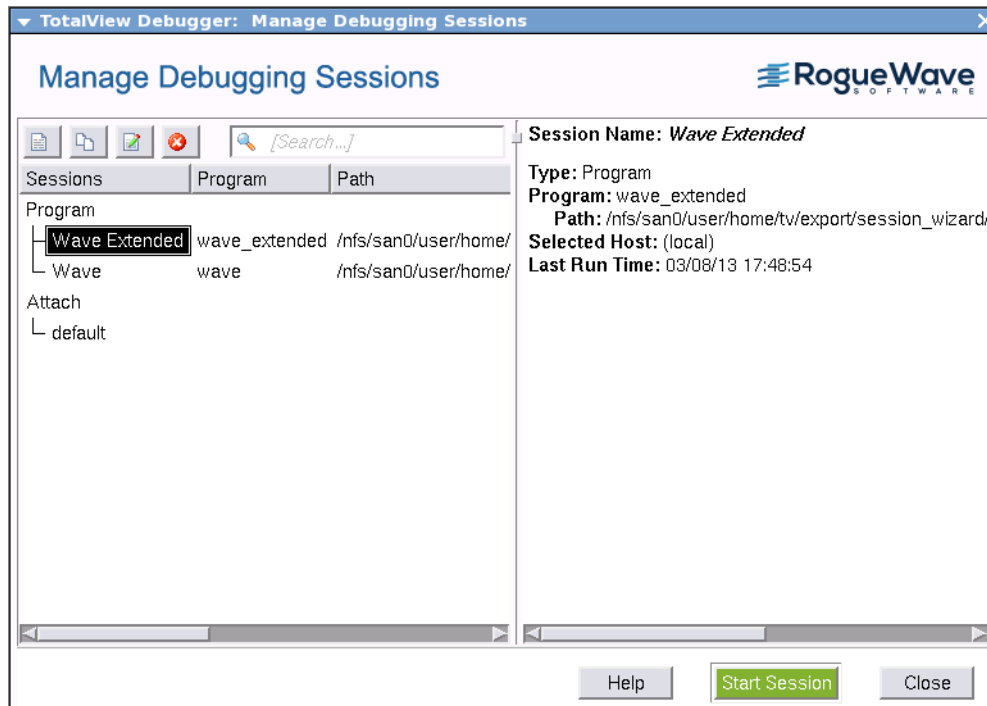
Access the Manage Debugging Sessions window, either from the **Start a Debugging Session** window of the Sessions Manager or from **File -> Manage Sessions** if TotalView is already running.


Figure 44 – Accessing the Manage Sessions page







The Manage Debugging Sessions window launches. The left pane lists all sessions you have created. When you select a session in the left pane, the right pane displays data about that session.

Figure 45 – Manage Debugging Sessions main page



If you have many sessions, you can search by keyword in the search box ( |). When found, TotalView immediately launches the session.

You can edit, delete and duplicate sessions using the icons in the left toolbar.

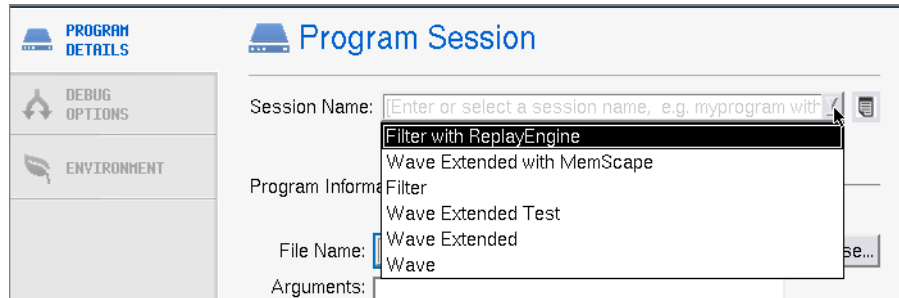
Icon	Action
	Creates a new debugging session, launching the Start a Debugging Session window of the Sessions Manager.
	Duplicates a session, naming it "<Session Name> Copy". You can rename and then edit this session.
	Edits a session, launching the appropriate window to change the session's configuration, either New Program, Parallel Program, Running Program or Core File.
	Deletes the session.

Editing or Starting New Sessions in a Sessions Window

In addition to editing a session using the Manage Debugging Sessions Window (“[Managing Sessions](#)” on page 119), you can also edit or even create a new session directly from any sessions window.

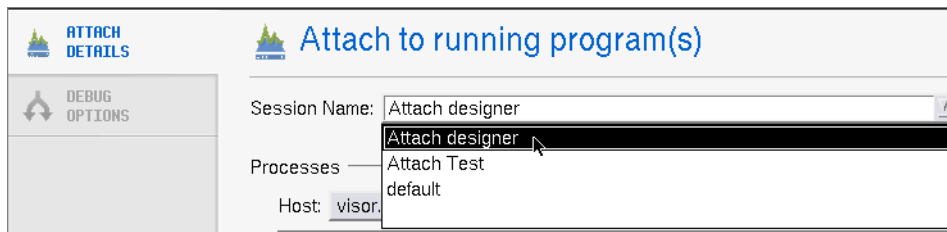
The **Session Name** field on each sessions window contains a dropdown that lists all previously created sessions of that type. For instance, from the Program Session window, you can access any session created in another Program Session:

Figure 46 – Sessions Name dropdown of a Program Session window



Similarly, the Attach to a running program dialog displays any previous attach sessions:

Figure 47 – Sessions Name dropdown of an Attach Session window



If you select a previous session, you can edit any field’s values, even the Session Name to create an entirely new session. Then just click **Start Session** to launch that new debugging session.

Other Configuration Options

Handling Signals

If your program contains a signal handler routine, you may need to adjust the way TotalView handles signals. The following table shows how TotalView handles UNIX signals by default:

Signals Passed Back to Your Program		Signals Treated as Errors	
SIGHUP	SIGIO	SIGILL	SIGPIPE
SIGINT	SIGIO	SIGTRAP	SIGTERM
SIGQUIT	SIGPROF	SIGIOT	SIGTSTP
SIGKILL	SIGWINCH	SIGEMT	SIGTTIN
SIGALRM	SIGLOST	SIGFPE	SIGTTOU
SIGURG	SIGUSR1	SIGBUS	SIGXCPU
SIGCONT	SIGUSR2	SIGSEGV	SIGXFSZ
SIGCHLD		SIGSYS	

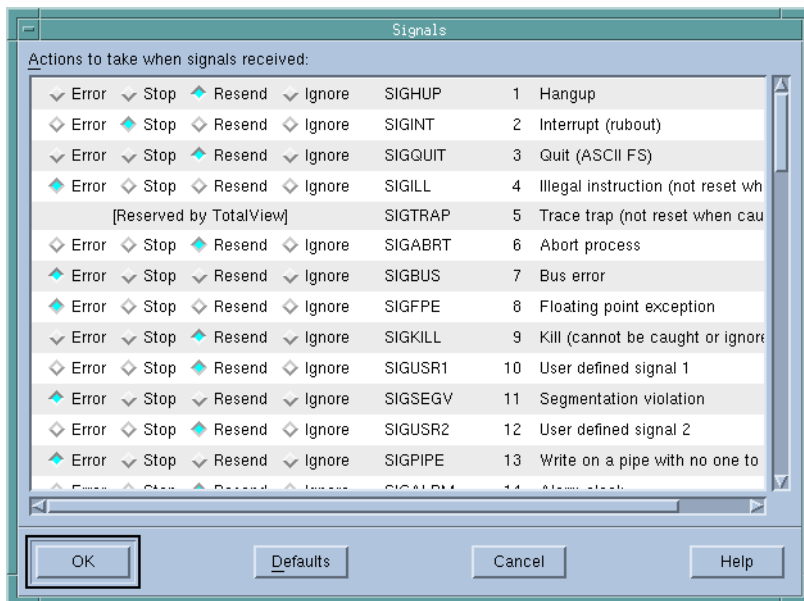
NOTE >> TotalView uses the **SIGTRAP** and **SIGSTOP** signals internally. If a process receives either of these signals, TotalView neither stops the process with an error nor passes the signal back to your program. You cannot alter the way TotalView uses these signals.

On some systems, hardware registers affect how TotalView and your program handle signals such as **SIGFPE**. For more information, see [“Interpreting the Status and Control Registers”](#) on page 233 and the “Architectures” chapter in the *TotalView for HPC Reference Guide*.

NOTE >> On an SGI computer, setting the **TRAP_FPE** environment variable to any value indicates that your program traps underflow errors. If you set this variable, however, you also need to use the controls in the **File > Signals** Dialog Box to indicate what TotalView should do with **SIGFPE** errors. (In most cases, you set **SIGFPE** to **Resend**.)

You can change the signal handling mode using the **File > Signals** command, [Figure 48](#).

Figure 48 – File > Signals Dialog Box



CLI: `dset TV::signal_handling_mode`

The signal names and numbers that TotalView displays are platform-specific. That is, what you see in this box depends on the computer and operating system in which your program is executing.

You can change the default way in which TotalView handles a signal by setting the **TV::signal_handling_mode** variable in a **.tvdrc** startup file. For more information, see “Command-Line Options” in the *TotalView for HPC Reference Guide*.

When your program receives a signal, TotalView stops all related processes. If you don’t want this behavior, clear the **Stop control group on error signal** check box on the Options Page of the **File > Preferences** Dialog Box.

CLI: `dset TV::warn_step_throw`

When your program encounters an error signal, TotalView opens or raises the Process Window. Clearing the **Open process window on error signal** check box, also found on the Options Page in the **File > Preferences** Dialog Box, tells TotalView not to open or raise windows.

CLI: `dset TV::GUI::pop_on_error`

If processes in a multi-process program encounter an error, TotalView only opens a Process Window for the first process that encounters an error. (If it did it for all of them, TotalView would quickly fill up your screen with Process Windows.)

If you select the **Open process window at breakpoint** check box on the **File > Preferences** Action Points Page, TotalView opens or raises the Process Window when your program reaches a breakpoint.

CLI: dset TV::GUI::pop_at_breakpoint

Make your changes by selecting one of the radio buttons described in the following table.

Button	Description
Error	Stops the process, places it in the <i>error</i> state, and displays an error in the title bar of the Process Window. If you have also selected the Stop control group on error signal check box, TotalView also stops all related processes. Select this button for severe error conditions, such as SIGSEGV and SIGBUS .
Stop	Stops the process and places it in the <i>stopped</i> state. Select this button if you want TotalView to handle this signal as it would a SIGSTOP signal.
Resend	Sends the signal back to the process. This setting lets you test your program's signal handling routines. TotalView sets the SIGKILL and SIGHUP signals to Resend since most programs have handlers to handle program termination.
Ignore	Discards the signal and continues the process. The process does not know that something raised a signal.

NOTE >> Do not use *Ignore* for fatal signals such as **SIGSEGV** and **SIGBUS**. If you do, TotalView can get caught in a signal/resignal loop with your program; the signal immediately reoccurs because the failing instruction repeatedly re-executes.

RELATED TOPICS

Thread continuation signal command **Thread > Continuation Signal** in the in-product Help

The **TV::signal_handling_mode** variable in a **.tvdrc** startup file "*Command-Line Options*" in the *TotalView for HPC Reference Guide*

TotalView preferences The **File > Preferences** dialog in the in-product Help and "*Setting Preferences*" on page 128

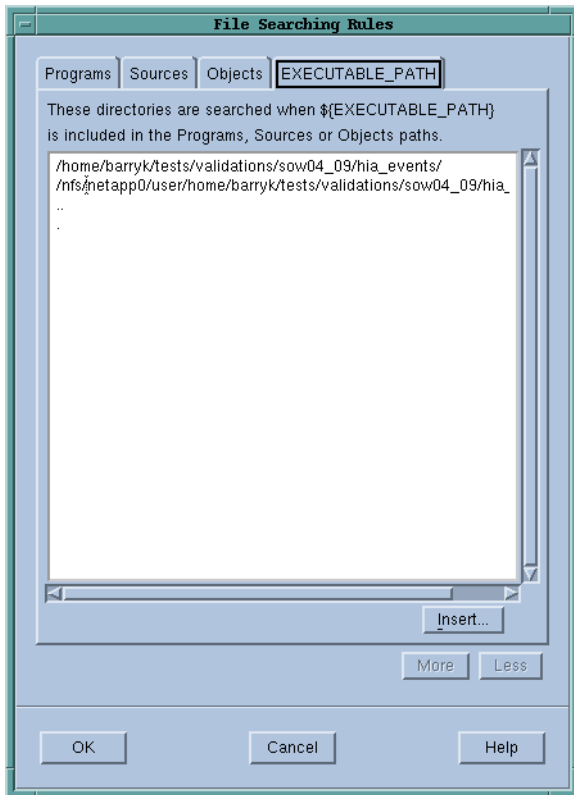
Setting Search Paths

If your source code, executable, and object files reside in different directories, set search paths for these directories with the **File > Search Path** command. You do not need to use this command if these directories are already named in your environment's **PATH** variable.

CLI: dset EXECUTABLE_PATH

These search paths apply to *all* processes that you're debugging.

Figure 49 – File > Search Path Dialog Box



TotalView searches the following directories in order:

4. The current working directory (.) and the directories you specify with the **File > Search Path** command, in the exact order entered.
5. The directory name hint. This is the directory that is within the debugging information generated by your compiler.
6. If you entered a full path name for the executable when you started TotalView, TotalView searches this directory.

7. If your executable is a symbolic link, TotalView looks in the directory in which your executable actually resides for the new file.

Since you can have multiple levels of symbolic links, TotalView continues following links until it finds the actual file. After it finds the current executable, it looks in its directory for your file. If the file isn't there, TotalView backs up the chain of links until either it finds the file or determines that the file can't be found.

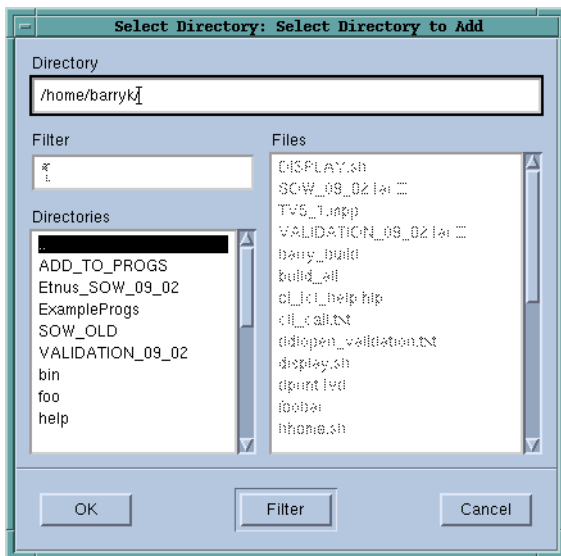
8. The directories specified in your **PATH** environment variable.
9. The **src** directory within your TotalView installation directory.

The simplest way to enter a search path is select the **EXECUTABLE_PATH** tab, then type an entry or press **Insert** and use the displayed dialog box to find the directory.

When you enter directories into this dialog box, you must enter them in the order you want them searched, and you must enter each on its own line. You can enter directories in the following ways:

- Type path names directly.
- Cut and paste directory information.
- Click the **Insert** button to display the **Select Directory** dialog box that lets you browse through the file system, interactively selecting directories, as shown in [Figure 50](#).

Figure 50 – Select Directory Dialog Box



The current working directory (.) in the **File > Search Path** Dialog Box is the first directory listed in the window. TotalView interprets relative path names as being *relative* to the current working directory.

If you remove the current working directory from this list, TotalView reinserts it at the top of the list.

After you change this list of directories, TotalView again searches for the source file of the routine being displayed in the Process Window.

You can also specify search directories using the **EXECUTABLE_PATH** environment variable.

TotalView search path is not usually passed to other processes. For example, it does not affect the **PATH** of a starter process such as **poe**. Suppose that "." is in your TotalView path, but it is not in your **PATH** environment variable. In addition, the executable named **prog_name** is listed in your **PWD** environment variable. In this case, the following command works:

```
totalview prog_name
```

However, the following command does not:

```
totalview poe -a prog_name
```

You will find a complete description of how to use this dialog box in the help.

RELATED TOPICS

Starting TotalView

["Starting TotalView" on page 87](#)

The **EXECUTABLE_PATH** environment variable

The **EXECUTABLE_PATH** variable in "TotalView Variables" in the *TotalView for HPC Reference Guide*

Setting Startup Parameters

After you load a program, you may want to change a program's command-line arguments and environment variables or change the way standard input, output, and error behave. Do this using the **Process > Startup Parameters** command. The displayed dialog box is nearly identical to that displayed when you use the **File > Debug New Program** command, differing only in that it has an **Apply** button to save your entered parameters, rather than a **Start Session** button.

For information on other options you can edit here, see ["Options: Reverse Debugging, Memory Debugging, and CUDA"](#) on page 113 and ["Setting Environment Variables and Altering Standard I/O"](#) on page 115.

If you are using the CLI, you can set default command line arguments by setting the **ARGS_DEFAULT** variable.

Also, the **drun** and **drrun** commands let you reset stdin, stdout, and stderr.

RELATED TOPICS

The **ARGS_DEFAULT** variable

"TotalView Variables" in the *TotalView for HPC Reference Guide* and ["dset ARGS_DEFAULT {value}" on page 90](#)

The **drun** command

drun in the *TotalView for HPC Reference Guide*

The **drrun** command

drrun in the *TotalView for HPC Reference Guide* and ["Restarting Programs" on page 172](#)

Setting Preferences

The **File > Preferences** command tailors many TotalView behaviors. This section contains an overview of these preferences. See **File > Preferences** in the in-product Help for more information.

Some settings, such as the prefixes and suffixes examined before loading dynamic libraries, can differ between operating systems. If they can differ, TotalView can store a unique value for each. TotalView does this transparently, which means that you only see an operating system's values when you are running TotalView on that operating system. For example, if you set a server launch string on an SGI computer, it does not affect the value stored for other systems. Generally, this occurs for server launch strings and dynamic library paths.

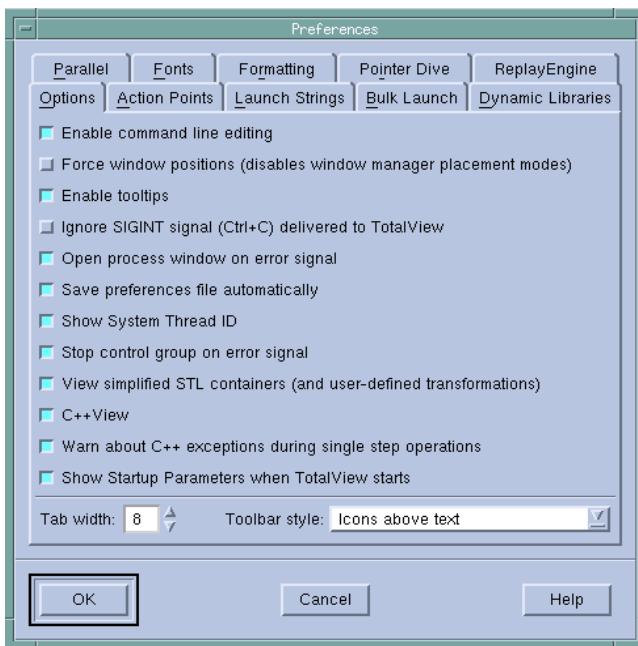
Every preference has a variable that you can set using the CLI. These variables are described in the "Variables" chapter of the *TotalView for HPC Reference Guide*.

The rest of this section is an overview of these preferences.

Options

This page contains check boxes that are either general in nature or that influence different parts of the system.

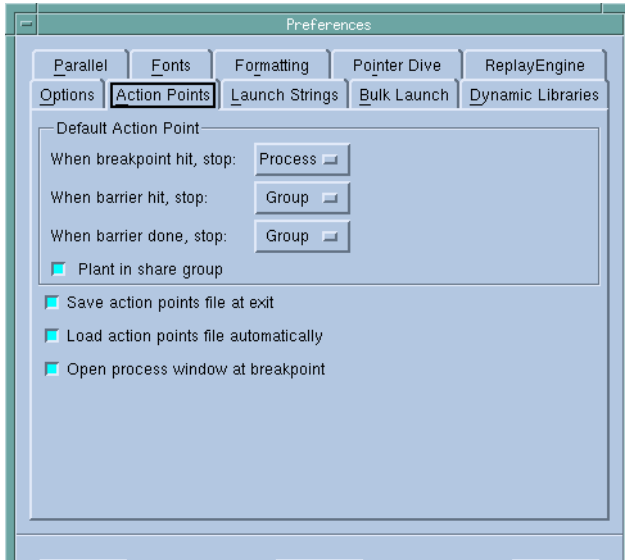
Figure 51 – File > Preferences Dialog Box: Options Page



Action Points

The commands on this page indicate whether TotalView should stop anything else when it encounters an **action point**, the scope of the action point, automatic saving and loading of action points, and if TotalView should open a Process Window for the process encountering a **breakpoint**.

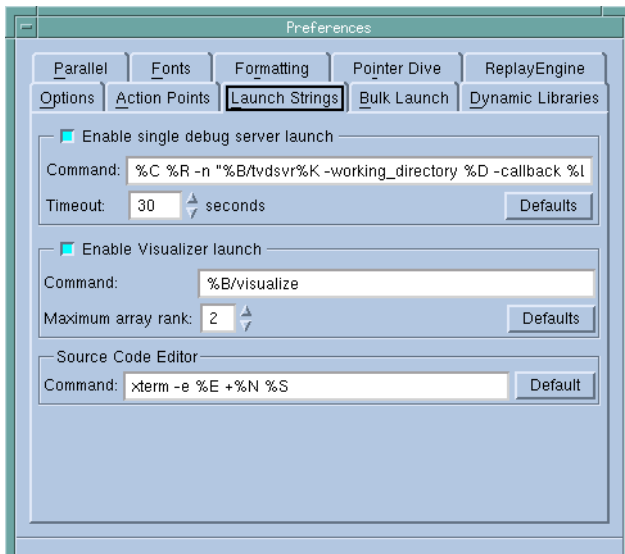
Figure 52 – File > Preferences Dialog Box: Action Points Page



Launch Strings

This page sets the launch string that TotalView uses when it launches the **tvdsvr** remote debugging server, the Visualizer, and a source code editor. The initial values are the defaults

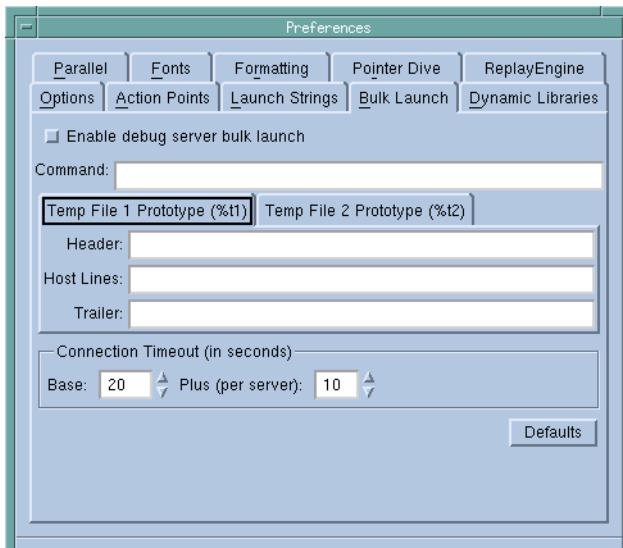
Figure 53 – File > Preferences Dialog Box: Launch Strings Page



Bulk Launch

This page configures the TotalView bulk launch system which launches groups of processes simultaneously.

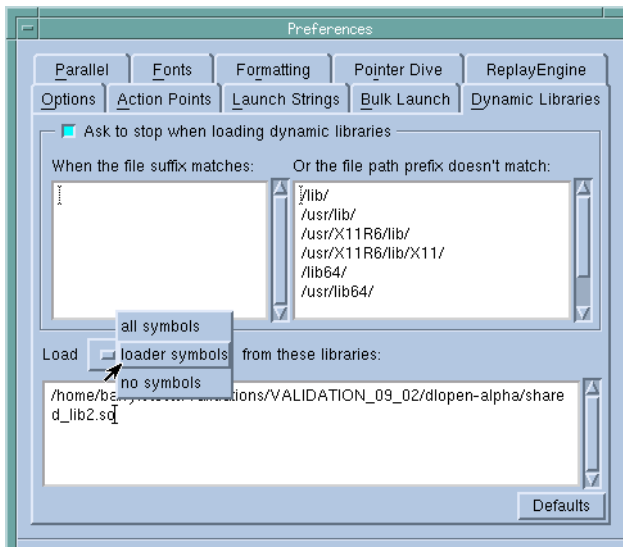
Figure 54 – File > Preferences Dialog Box: Bulk Launch Page



Dynamic Libraries

When debugging large programs, you can sometimes increase performance by loading and processing debugging symbols. This page controls which symbols are added to TotalView when it loads a dynamic library, and how many of a library's symbols are read in.

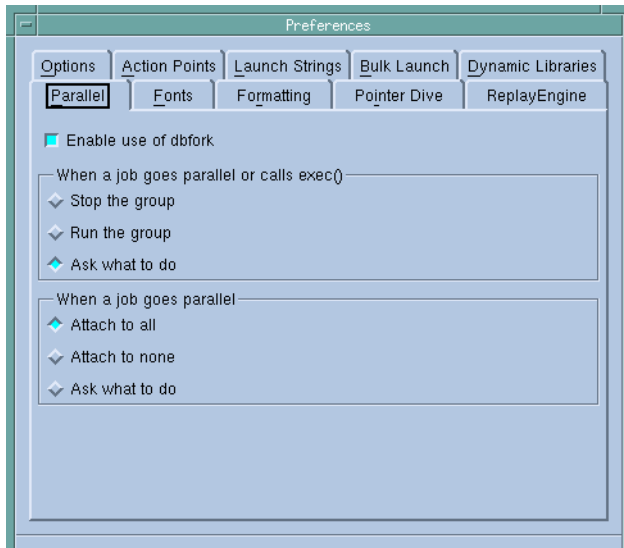
Figure 55 – File > Preferences Dialog Box: Dynamic Libraries Page



Parallel

The options on this page control whether TotalView stops or continues executing when a process creates a thread or goes parallel. By stopping your program, you can set breakpoints and examine code before execution begins.

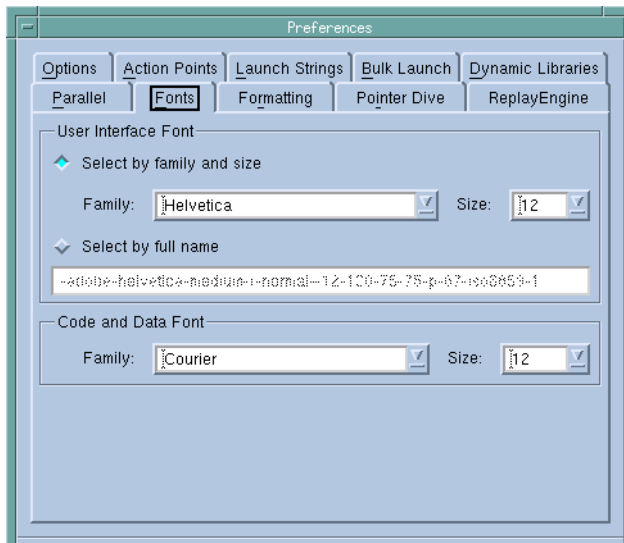
Figure 56 – File > Preferences Dialog Box: Parallel Page



Fonts

This page specifies the fonts used in the user interface and how code is displayed.

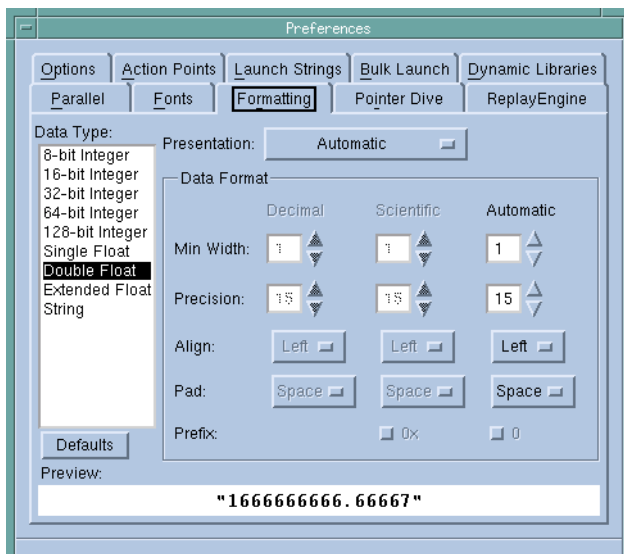
Figure 57 – File > Preferences Dialog Box: Fonts Page



Formatting

This page controls how TotalView displays your program's variables.

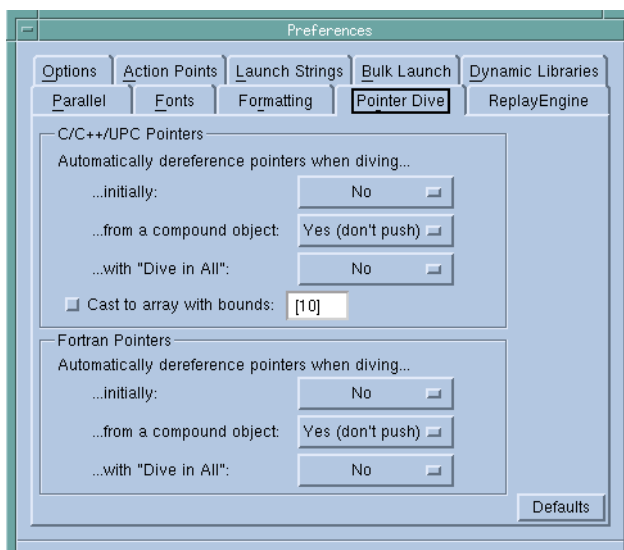
Figure 58 – File > Preferences Dialog Box: Formatting Page



Pointer Dive

The options on this page control how TotalView dereferences pointers and casts pointers to arrays.

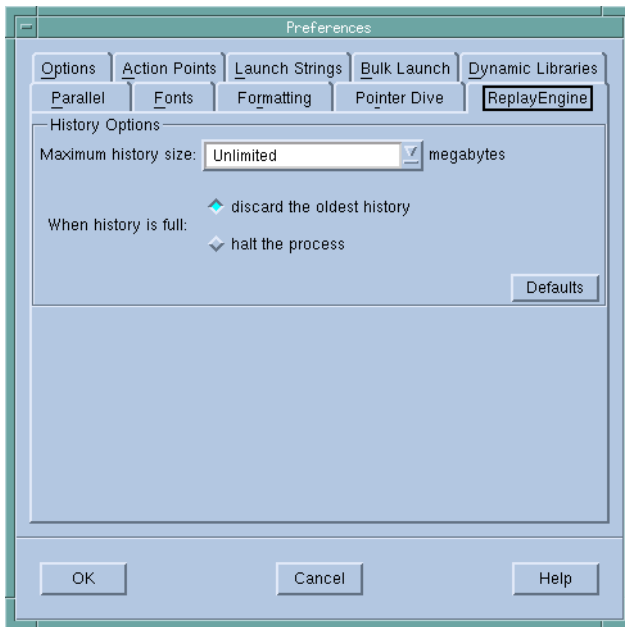
Figure 59 – File > Preferences Dialog Box: Pointer Dive Page



ReplayEngine

This page controls how ReplayEngine handles recorded history.

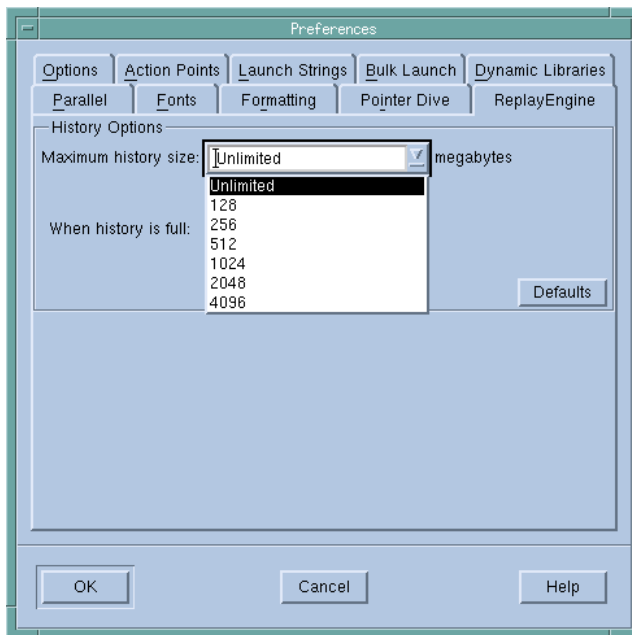
Figure 60 – File > Preferences Dialog Box: ReplayEngine



The **Maximum history size** option sets the size in megabytes for ReplayEngine's history buffer. The default value, Unlimited, means ReplayEngine will use as much memory as is available to save recorded history. You can enter a new value into the text field or select from a drop-down list, as seen in [Figure 61](#).

The second option on the ReplayEngine preference page defines the tool's behavior when the history buffer is full. By default, the oldest history will be discarded so that recording can continue. You can change that so that the recording process will simply stop when the buffer is full.

Figure 61 – File > Preferences Dialog Box: ReplayEngine History Option



Setting Preferences, Options, and X Resources

In most cases, preferences are the best way to set many features and characteristics. In some cases, you need more control. When these situations occur, you can the preferences and other TotalView attributes using variables and command-line options.

Older versions of TotalView did not have a preference system. Instead, you needed to set values in your **.Xdefaults** file or using a command-line option. For example, setting **totalview*autoLoadBreakpoints** to true automatically loads an executable's breakpoint file when it loads an executable. Because you can also set this option as a preference and set it using the CLI **dset** command, this X resource has been *deprecated*.

NOTE >> Deprecated means that while the feature still exists in the current release, there's no guarantee that it will continue to work at a later time. We have deprecated all "totalview" X default options. TotalView still fully supports Visualizer resources. Information on these Visualizer settings is in the document **TotalView XResources.pdf**, downloadable from the Rogue Wave website at <http://www.roguewave.com/help-support/documentation/totalview>.

Similarly, documentation for earlier releases told you how to use a command-line option to tell TotalView to automatically load breakpoints, and there were two different command-line options to perform this action. While these methods still work, they are also deprecated.

In some cases, you might set a state for one session or you might override one of your preferences. (A *preference* indicates a behavior that you want to occur in all of your TotalView sessions.) This is the function of the command-line options described in *"TotalView Command Syntax"* in the *TotalView for HPC Reference Guide*.

For example, you can use the **-bg** command-line option to set the background color for debugger windows in the session just being invoked. TotalView does not remember changes to its default behavior that you make using command-line options. You have to set them again when you start a new session.

RELATED TOPICS

Setting preferences in TotalView ["Setting Preferences"](#) on page 128

TotalView variables ["TotalView Variables"](#) in the *TotalView for HPC Reference Guide*



Chapter 6

Using and Customizing the GUI

Overview

This chapter contains information about using the TotalView GUI, including:

- [“Using Mouse Buttons”](#) on page 139
- [“Using the Root Window”](#) on page 140
- [“Using the Process Window”](#) on page 148
- [“Resizing and Positioning Windows”](#) on page 151
- [“About Diving into Objects”](#) on page 152
- [“Saving the Data in a Window”](#) on page 155
- [“Searching and Navigating Program Elements”](#) on page 156
- [“Viewing the Assembler Version of Your Code”](#) on page 161
- [“Editing Source Text”](#) on page 164

Using Mouse Buttons



The buttons on your three-button mouse work like this:

Button	Action	Purpose	How to Use It
Left	Select	Selects or edits object. Scrolls in windows and panes.	Move the cursor over the object and click.
Middle	Paste	Writes information previously copied or cut into the clipboard.	Move the cursor to the insertion point and click. Not all windows support pasting.
	Dive	Displays more information or replaces window contents.	Move the cursor over an object, then click.
Right	Context menu	Displays a menu with commonly used commands.	Move the cursor over an object and click. Most windows and panes have context menus; dialog boxes do not have context menus.

In most cases, a single-click selects an object while a double-click dives on the object. However, if the field is editable, TotalView enters edit mode, so you can alter the selected item's value.

In some areas, such as the Stack Trace Pane, selecting a line performs an action. In this pane, TotalView dives on the selected routine. (In this case, *diving* means that TotalView finds the selected routine and shows it in the Source Pane.)

In the line number area of the Source Pane, a left mouse click sets a **breakpoint** at that line, displaying a  icon instead of a line number.

Selecting the  icon a second time deletes the breakpoint. If you change any of the breakpoint's properties or if you've created an eval point (indicated by an  icon), selecting the icon disables it. For more information on breakpoints and eval points, see [Chapter 8, "Setting Action Points,"](#) on page 174.

Using the Root Window

The Root Window appears when you start TotalView.

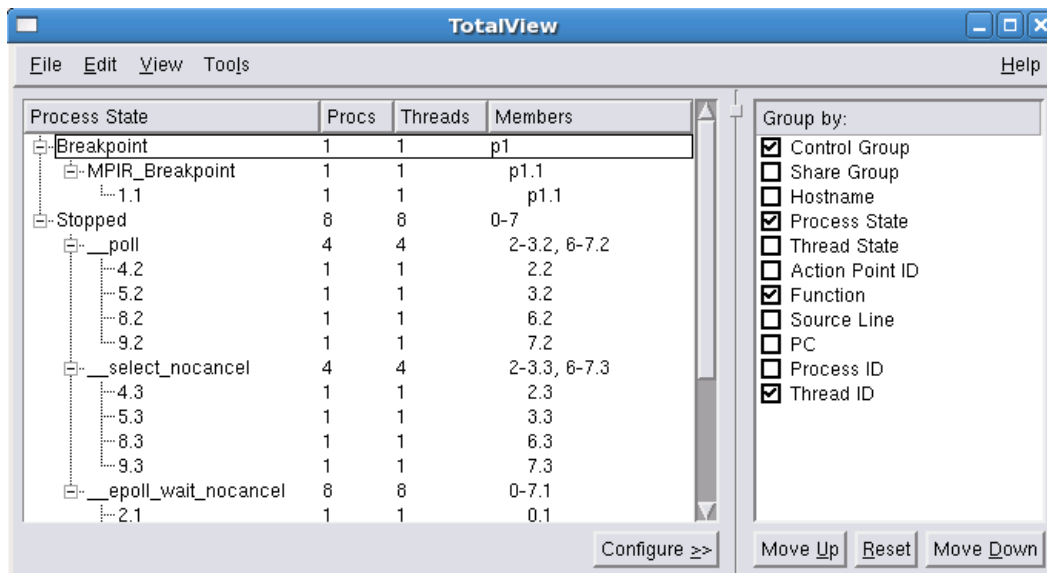
- If you type a program name immediately after the **totalview** command, TotalView also opens a Process Window with the program's source code.
- If you do not enter a program name when starting TotalView, TotalView displays its **File > New Debugging Session** dialog box. Use this dialog box to select the type of debug session you wish to configure.

As of TotalView 8.15.0, the Root Window displays a list of aggregated processes and threads — instead of displaying one line per each process or thread, it groups them by common properties that you can configure. This provides a considerable performance boost when scaling to thousands — or more — threads or processes.

NOTE >> You can choose to display the Root Window from versions prior to TotalView 8.15.0, discussed in [Using the Old Root Window](#). The old Root Window, however, does not perform as well for high-scale programs. See [Chapter 22, "Scalability in HPC Computing Environments,"](#) on page 544.

Figure 62 shows the Root Window for an executing multi-threaded multi-process program.

Figure 62 – Root Window



The Root Window groups threads and processes under common properties. The initial default view groups the display by control group, process state, function, and thread ID. You can regroup and reduce the display in a number of ways, based on either process or thread properties, as described in [Table 1](#).

Table 1: Thread and Process Properties

Process	Property Level	Description
Control Group	Process	Control group of the processes in your job. Processes in the same job are placed in the same control group by default. If there is only one control group in the debug session, this property is omitted from the display.
Share Group	Process	Share group of the processes within a control group. Processes that are running the same main executable are placed in the same share group by default.
Hostname	Process	The hostname or IP address of where the process is running.
Process State	Process	The process execution state, e.g., Nonexistent, Running, Stopped, Breakpoint, Watchpoint, etc. The process execution state derives from the execution state of the threads it contains.
Thread State	Thread	The thread execution state, e.g., Running, Stopped, Breakpoint, Watchpoint, etc.
Action Point ID	Thread	The action point (breakpoint or watchpoint) ID of the location of the stopped thread. Displays "ap(<i>ID</i>)", where <i>ID</i> is the action point ID or "none" if the thread is not stopped at an action point.
Function	Thread	The function name of the location of the stopped thread. Displays the function name or "<unknown address>" if the thread is running or the function name is not known.
Source Line	Thread	The function name of the location of the stopped thread. Displays the source file name and line number or "<unknown line>" if the thread is running or the source line is not known.
PC	Thread	The PC of the location of the stopped thread. Displays the program counter value or "<unknown address>" if the thread is running.
Process ID	Process	The debugger process ID (<i>dpid</i>) of the process. Displays <i>dpid</i> .
Thread ID	Thread	The <i>dpid</i> and debugger thread ID (<i>dtid</i>) of the thread. Displays <i>dpid dtid</i> .

The various properties here are either process or thread-level, which determines the kind of **ptlist** displayed in the Members column: the members of process-level properties are processes, and the members of thread-level properties are threads.

You can also use the CLI's **dstatus** command's `-group_by` switch for additional reduction options.

RELATED TOPICS

The CLI's **dstatus** command's `-group_by` switch **dstatus** in the *Reference Guide*

Controlling the Display of Processes and Threads

The Root Window's layout enables you to modify the grouping parameters while viewing the results.

Figure 63 – Root Window and Process/Thread Display

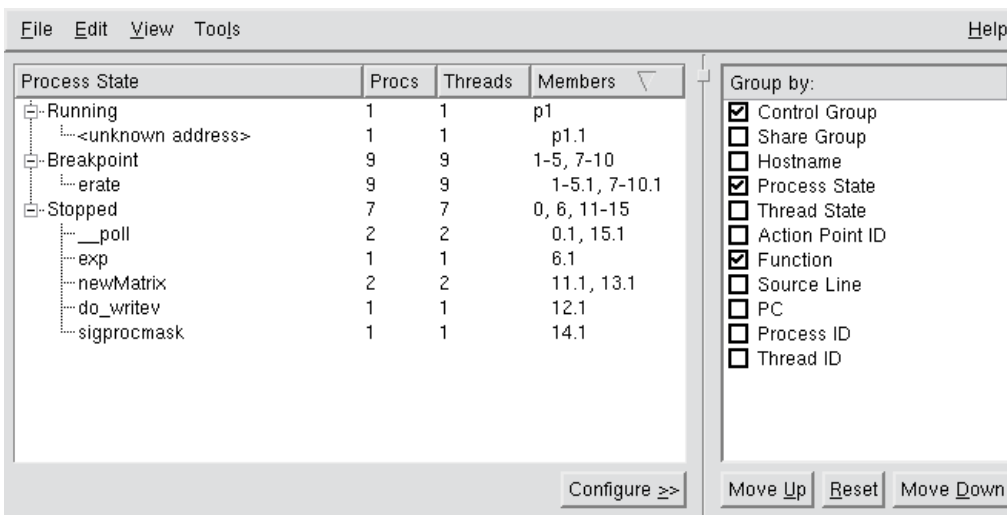


Figure 63 illustrates a 17-process MPI job comprised of a single MPI starter process, e.g., `mpirun` (**p1**), and 16 MPI processes (0-15). At the highest level, processes are grouped by **Process State**, then by **Function**. The individual groupings are then sorted in ascending order (**Member**) by the debugger's process ID.

- **Configure:** Show or hide the configuration panel on the right using the **Configure** button or the **View > Show Configure Panel** menu item.
- **Move Up and Move Down:** By default, the properties are displayed in a hierarchical manner, such that the property at the top of the Configuration Panel forms the highest level grouping, the next property forms the second level of grouping subordinate to the first, and so on. Use **Move Up** and **Move Down** to control where to display a property in the hierarchy.
- **Reset:** The selected groupings and their relative order are automatically saved across TotalView sessions. To revert to the default order, press **Reset**.
- **Nested Attributes:** Instead of the default hierarchical display, the properties can "flattened" into a single line in which each property is separated by a colon, using the **View > Nested Attribute** menu item. This menu item toggles between the hierarchical and flat display modes.

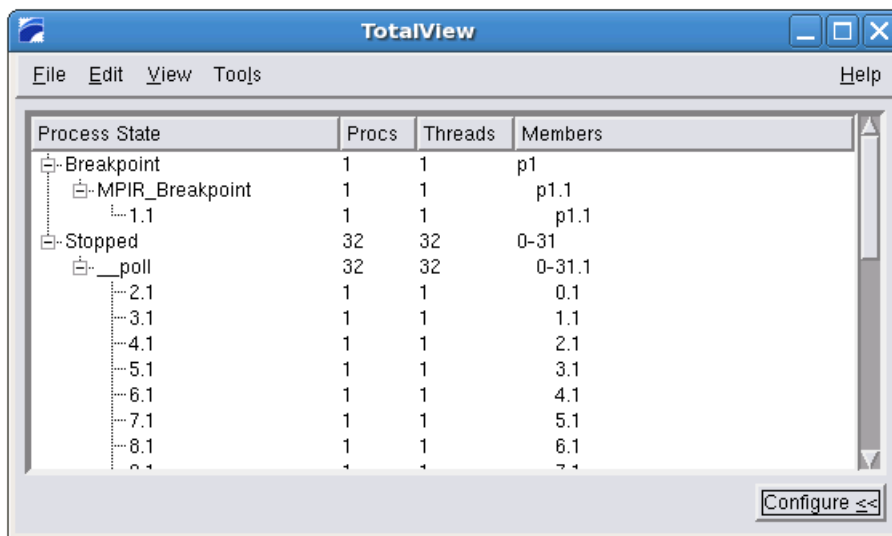
- **Show MPI Rank:** By default, TotalView shows the rank in MPI_COMM_WORLD of MPI processes in the compressed **ptlist** in the Members column. Non-MPI processes are shown using the "**pdpid**" where *dpid* is the debugger process ID of the process. Use the **View > Show MPI Rank** menu item to toggle between displaying MPI processes using the MPI rank or "**pdpid**" notation.
- **Expand/Collapse All:** Minimize or fully expand the entire tree with **View > Expand All** and **View > Collapse All**.
- **Copy/Select All:** To copy data to an external program, use the clipboard: Select one or more rows using your computer's keyboard shortcuts, or select **Edit > Select All**, and copy to the clipboard using **Edit > Copy**.

Default View

By default, the Root Window displays Control Group, Process State, Function and Thread ID in a hierarchical or "nested" manner.

Figure 64 shows a 32-process, 32-thread MPI job, each process containing one thread, which is a single-threaded MPI starter process (e.g., mpiexec).

Figure 64 – Root Window: Default View



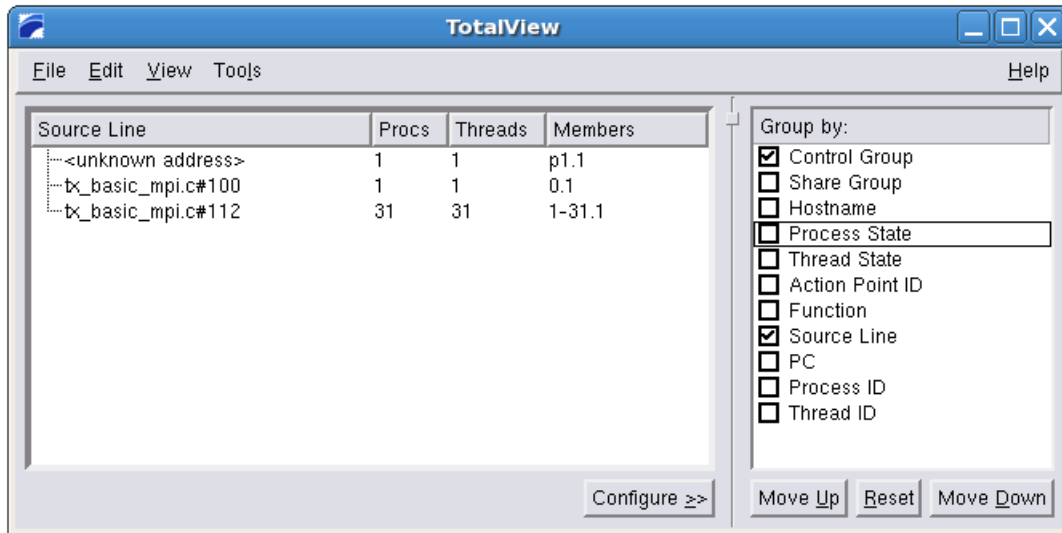
Since there is only one control group in the debug session, the control group has been omitted, and the Process state becomes the top-level property, in this case displaying two process states:

- The first grouping lists the MPI starter process in **Breakpoint** process state, stopped in function **MPIR_Breakpoint**, and one thread with thread ID **1.1**. The **Procs** column shows the number of processes, and the Threads column shows the number of threads displayed in the **Members** column. The Members column shows the *dpid* the process and *dpid.dtid* of the threads, displayed as a compressed process/thread list **ptlist**.
- The grouping defined by "Stopped" displays all processes in a **Stopped** process state, of which there are 32, the MPI job size. The membership shows **0-31**, which means MPI ranks 0 to 31, inclusive.

Changing the Display

To change the view, select the **Configure <<** button and select or deselect properties. [Figure 65](#) shows a configuration where just the Source Line property is selected.

Figure 65 – Root Window: Configure Pane, Group by Source Line



In this example, we've de-selected Process State, Function, and Thread ID and selected Source Line in order to group by Source Line instead.

Because Source Line is a thread property, the Members column now displays only threads. Here are the three lines:

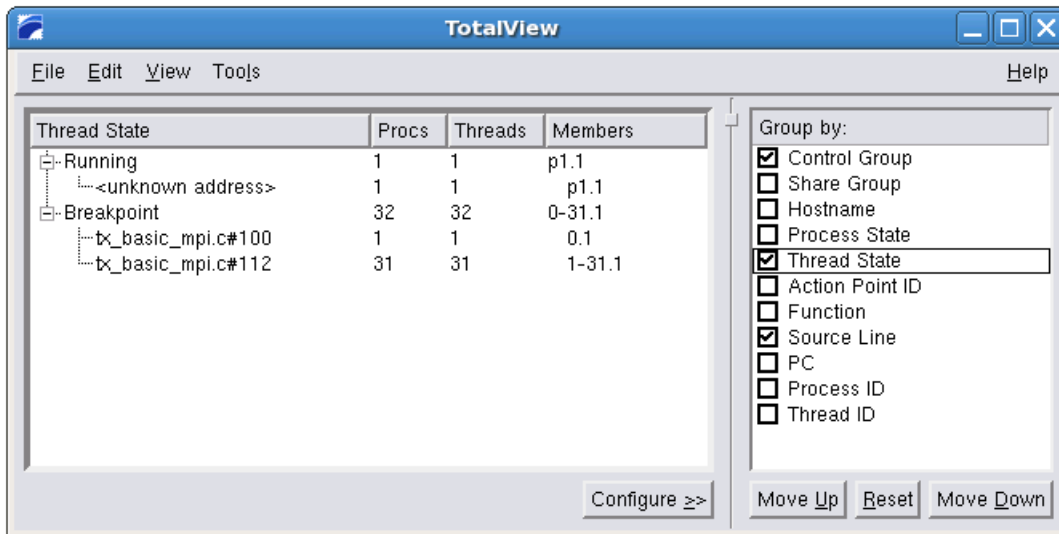
- Line 1 is the **mpirun** process used to launch the **tx_basic_mpi mpi** program.
- Line 2 displays all the threads at Line 100 in the source file **tx_basic_mpi.c**. The membership is 0.1, which means thread (dtid) 1 in MPI rank 0.
- Line 3 are all the threads that are at line 112 inside that same file, representing the remaining 30 threads.

Note that even though the Control Group is selected, it has no grouping effect most of the time and is relevant only for debugging multiple jobs at once (which is uncommon), in which case the window would display a separate top-level control-group grouping for each job.

Grouping by Status and Source Line

If you select the Thread State, leaving Source Line also selected, you can group by both properties, as in Figure 66.

Figure 66 – Root Window: Grouped by Status *and* Source Line



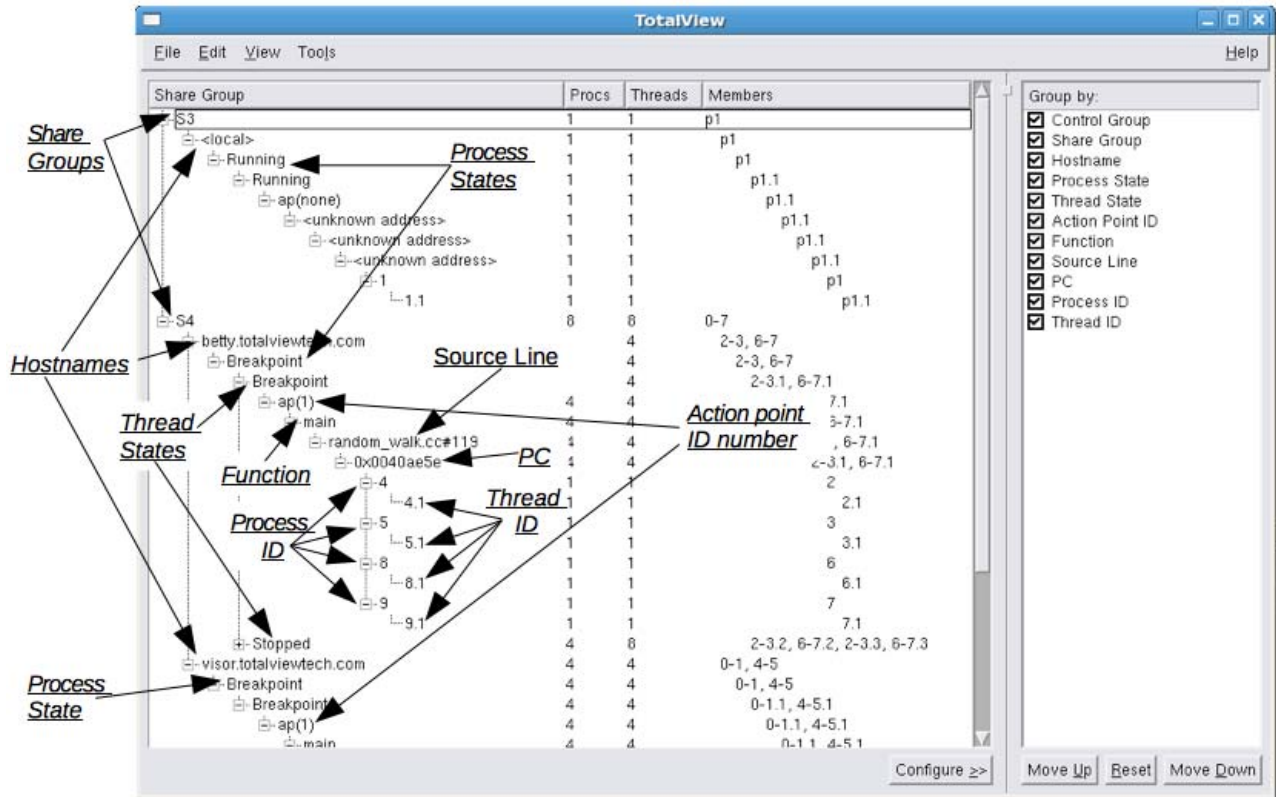
Again, there are two groupings in the list: the first is the **mpirun** process. Note that the second grouping is now multi-line:

- The first line of the second grouping displays a single thread, showing both that its status is at **Breakpoint** and that it is at line 100 in **tx_basic_mpi.c**.
- The second line displays 31 threads, all at a different **Breakpoint** at line 112 in **tx_basic_mpi.c**.

Grouping by All Properties

For illustration purposes, [Figure 67](#) shows the Root Window configured to group by all properties in their default order. This figure also describes each of the groupings in this window.

Figure 67 – Root Window Showing Two Host Computers



When you dive on a line in this window, its source is displayed in a Process Window.

RELATED TOPICS

The **dattach** command The **dattach** command in the *TotalView for HPC Reference Guide*

Displaying manager threads The **View > Display Manager Threads** command in the in-product Help

Displaying exited threads The **View > Display Exited Threads** command in the in-product Help

Using the Old Root Window

If debugger scalability is not a concern and you prefer the Root Window prior to version TotalView 8.15, you can reinstate it. Note, however, that the old Root Window is deprecated and may not be supported in future versions.

To start TotalView using the old Root Window, pass TotalView the **-oldroot** command option:

```
totalview -oldroot
```

To always use the old Root Window by default, set the state variable `-TV::GUI::old_root_window` to **true** for use when initializing TotalView:

```
dset TV::GUI::old_root_window true
```

RELATED TOPICS

Using the Root Window from previous TotalView versions — The **oldroot** command line option in the *TotalView for HPC Reference Guide*

Suppressing the Root Window

To suppress opening the Root Window entirely when TotalView starts — whether the current or old Root Window — use the **--norootwin** option:

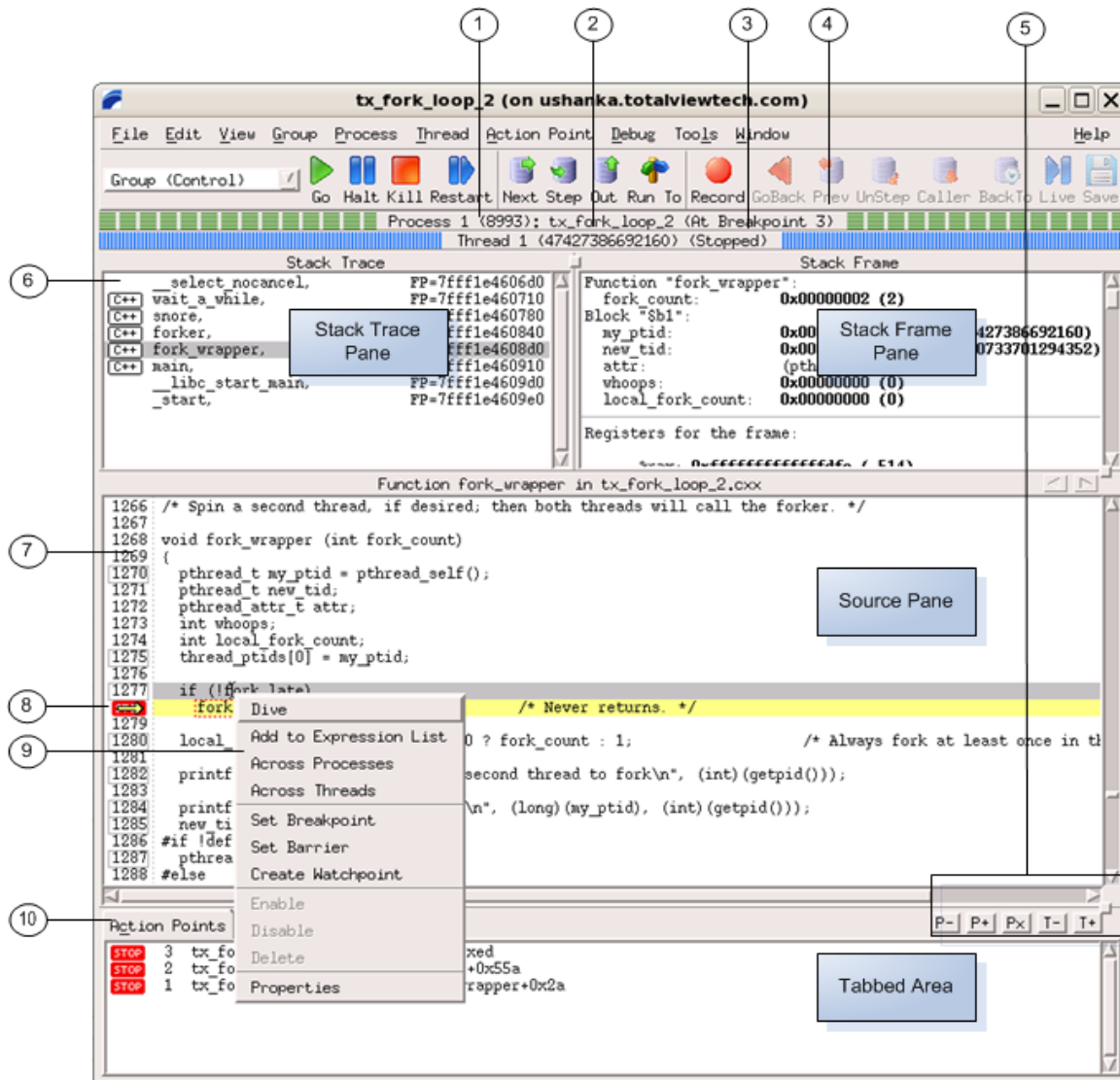
```
totalview -norootwin
```

Note that you can open the Root Window at any time from the Process Window using the **Window > Root** menu item. The Root Window can also be closed at any time without quitting TotalView, if another window is open in the same debugging session.

Using the Process Window

The *Process Window* contains various panes that display the code for the process or thread that you're debugging, as well as other related information. The large scrolling list in the middle is the Source Pane. (The contents of these panes are discussed later in this section.)

Figure 68 – A Process Window



1. Process ID (PID)
2. Thread ID (TID)
3. Thread status
4. Process status
5. Process/thread switching
6. Language of routine
7. Line number area
8. Current program counter
9. Context menu
10. Action Points tab displayed

As you examine the Process Window, notice the following:

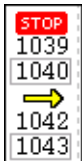
- The thread ID shown in the Root Window and in the process's Threads Tab with the Tabs Pane is the logical thread ID (TID) assigned by TotalView and the system-assigned thread ID (SYSTID). On systems where the TID and SYSTID values are the same, TotalView displays only the TID value.

In other windows, TotalView uses the *pid.tid* value to identify a process's threads.

The Threads Tab shows the threads that currently exist in a process. When you select a different thread in this list, TotalView updates the Stack Trace, Stack Frame, and Source Panes to show the information for that thread. When you dive on a different thread in the thread list, TotalView finds or opens a new window that displays information for that thread.

- The Stack Trace Pane shows the **call stack** of routines that the selected thread is executing. You can move up and down the **call stack** by clicking on the routine's name (stack **frame**). When you select a different stack frame, TotalView updates the Stack Frame and Source Panes with the information about the routine you just selected.
- The Stack Frame Pane displays all a routine's parameters, its local variables, and the registers for the selected stack frame.
- The information displayed in the Stack Trace and Stack Frame Panes reflects the state of a process when it was last stopped. Consequently, the information is not up-to-date while a thread is running.
- The left margin of the *Source Pane* displays line numbers and **action point** icons. You can place a **breakpoint** at any line whose line number is contained within a box indicating that this is executable code.

When you place a breakpoint on a line, TotalView places a **STOP** icon over the line number. An arrow over the line number shows the current location of the program counter (PC) in the selected stack frame.



Each thread has its own unique program counter (PC). When you stop a multi-process or multi-threaded program, the routine displayed in the Stack Trace Pane for a thread depends on the thread's PC. Because threads execute asynchronously, threads are stopped at different places. (When your thread hits a breakpoint, the default is to stop all the other threads in the process as well.)

- The tabbed area at the bottom contains a set of tabs whose information you can hide or display as needed. In addition, the **P+**, **P-**, **Px**, **T+**, and **T-** buttons within this area allow you to change the Process Window's context by moving to another process or thread.

The *Action Points Tab* with the Tabs Pane shows the list of breakpoints, eval points, and watchpoints for the process.

The *Threads Tab* shows each thread and information about the thread. Selecting a process switches the context to that thread.

The *Processes/Ranks tab*, if present, displays a grid of all of your program's processes. The grid's elements show process status and indicate the selected group. Selecting a process switches the context to the first thread in that process.

The Processes/Ranks Tab was displayed by default in previous versions of TotalView, but now it is off by default. This is because it can significantly affect performance, particularly for large, massively parallel applications. The tab can be turned back on with the command line switch **-processgrid** and/or by setting **TV::GUI::process_grid_wanted** to **true** in the `.tvdrp` file. If you enable this tab in the `.tvdrp` file, you can disable it for a particular session with the **-noprocessgrid** command line switch.

RELATED TOPICS

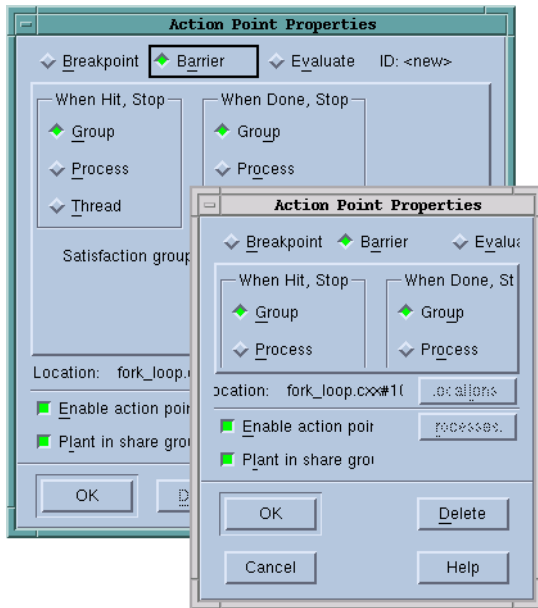
More on using the Process Window The **"Process Window"** in the in-product Help

More on the Processes/Ranks tab The topic **Using the Processes/Ranks and Threads Tabs** in this user guide.

Resizing and Positioning Windows

You can resize most TotalView windows and dialog boxes. While TotalView tries to do the right thing, you can push things to the point where shrinking doesn't work very well. [Figure 69](#) shows a before-and-after look in which a dialog box was made too small.

Figure 69 – Resizing (and Its Consequences)



Many programmers like to have their windows always appear in the same position in each session. The following two commands can help:

- **Window > Memorize:** Tells TotalView to remember the position of the current window. The next time you bring up this window, it'll be in this position.
- **Window > Memorize All:** Tells TotalView to remember the positions of most windows. The next time you bring up any of the windows displayed when you used this command, it will be in the same position.

Most modern window managers such as KDE or Gnome do an excellent job managing window position. If you are using an older window manager such as **twm** or **mwm**, you may want to select the **Force window positions (disables window manager placement modes)** check box option located on the **Options** Page of the **File > Preferences** Dialog Box. This tells TotalView to manage a window's position and size. If it isn't selected, TotalView only manages a window's size.

About Diving into Objects

Diving is integral to the TotalView GUI and provides a quick and easy way to get more information about variables, processes, threads, functions, and other program elements.

To dive on an element, just click your middle mouse button on it to launch another window with more information.

NOTE >> In some cases, single-clicking performs a dive. For example, single-clicking on a function name in the Stack Trace Pane dives into the function. In other cases, double-clicking does the same thing.

Diving on processes and threads in the Root Window is the quickest way to launch a Process Window with more information. Diving on variables in the Process Window launches a Variable Window.

In the Process Window's Source Pane, if a global variable or function can be dived on, a red dotted box appears when your cursor hovers over it, [Figure 70](#).

Figure 70 – Diving on an object in the Source Pane

```
457  /* Setup and parse the command line */
458  init_globals();
459  opal_cmd_line_create(&cmd_line, cmd_line_init);
460  mca_base_cmd_line_setup(&cmd_line);
461  if (ORTE_SUCCESS != (rc = opal_cmd_line_init(cmd_line_init, (opal_cmd_line_init_t){79},
462                                             argc, argv))) {
```

NOTE >> If you prefer that the cursor remain an arrow when hovering over an element you can dive on, specify the option `-nohand_cursor` when starting TotalView, or set this permanently in `.tvdr` as `"TV::GUI::hand_cursor_enabled {false}"`.

The following table describes typical diving operations:

Items you dive on:	Information Displayed:
Process or thread	When you dive on a thread in the Root Window, TotalView finds or opens a Process Window for that process. If it doesn't find a matching window, TotalView replaces the contents of an existing window and shows you the selected process.
Variable	The variable displays in a Variable Window.
Expression List Variable	Same as diving on a variable in the Source Pane: the variable displays in a Variable Window.

Items you dive on:	Information Displayed:
Routine in the Stack Trace Pane	The stack frame and source code for the routine appear in a Process Window.
Array element, structure element, or referenced memory area	The contents of the element or memory area replace the contents that were in the Variable Window. This is known as a <i>nested</i> dive.
Pointer	TotalView dereferences the pointer and shows the result in a separate Variable Window. Given the nature of pointers, you may need to cast the result into the logical data type.
Subroutine	The source code for the routine replaces the current contents of the Source Pane. When this occurs, TotalView places a right angle bracket (>) in the process's title. Every time it dives, it adds another angle bracket, Figure 71 .
	A routine must be compiled with source-line information (usually, with the -g option) for you to dive into it and see source code. If the subroutine wasn't compiled with this information, TotalView displays the routine's assembler code.
Variable Window	TotalView replaces the contents of the Variable Window with information about the variable or element.
Expression List Window	TotalView displays information about the variable in a separate Variable Window.

Figure 71 – Nested Dive

Function >>>pthread_mutex_lock

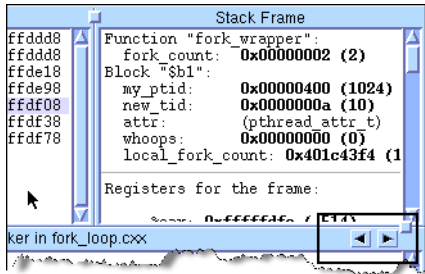
NOTE >> Diving on a struct or class member that is out of scope does not work.

TotalView tries to reuse windows. For example, if you dive on a variable and that variable is already displayed in a window, TotalView pops the window to the top of the display. If you want the information to appear in a separate window, use the **View > Dive in New Window** command.

NOTE >> Diving on a process or a thread might not create a new window if TotalView determines that it can reuse a Process Window. If you really want to see information in two windows, use the **Process Window Window > Duplicate** command.

When you dive into functions in the Process Window, or when you are chasing pointers or following structure elements in the Variable Window, you can move back and forth between your selections by using the *forward* and *backward* buttons. The boxed area of the following figure shows the location of these two controls.

Figure 72 – Backward and Forward Buttons



For additional information about displaying variable contents, see [“Diving in Variable Windows”](#) on page 240.

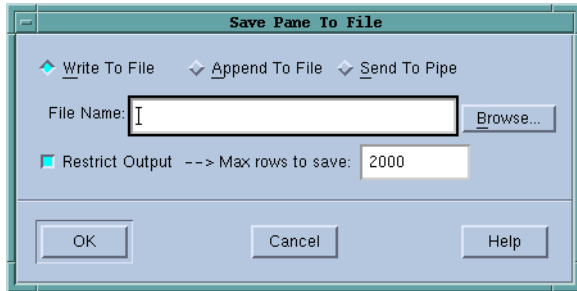
You can also use the following additional windowing commands:

- **Window > Duplicate:** (Variable and Expression List Windows) Creates a duplicate copy of the current Variable Window.
- **File > Close:** Closes an open window.
- **File > Close Relatives:** Closes windows that are related to the current window. The current window isn't closed.
- **File > Close Similar:** Closes the current window and all windows similar to it.

Saving the Data in a Window

You can write an ASCII equivalent to most pages and panes by using the **File > Save Pane** command. This command can also pipe data to UNIX shell commands.

Figure 73 – File > Save Pane Dialog Box



If the window or pane contains a lot of data, use the **Restrict Output** option to limit the information TotalView writes or sends. For example, you might not want to write a 100 x 100 x 10,000 array to disk. If this option is checked (the default), TotalView sends only the number of lines indicated in the **Max rows to save** box.

When piping information, TotalView sends the entered information to **/bin/sh**. This means that you can enter a series of shell commands. For example, the following is a command that ignores the top five lines of output, compares the current ASCII text to an existing file, and writes the differences to another file:

```
| tail +5 | diff - file > file.diff
```

Searching and Navigating Program Elements

TotalView provides several ways for you to navigate and find information in your source file.

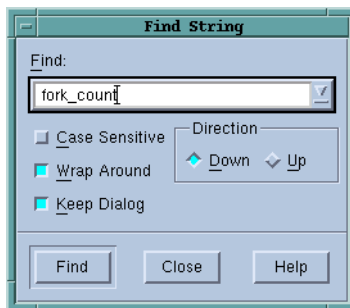
Topics in this section are:

- “Searching for Text” on page 156
- “Looking for Functions and Variables” on page 157
- “Finding the Source Code for Functions” on page 157
- “Finding the Source Code for Files” on page 159
- “Resetting the Stack Frame” on page 160

Searching for Text

You can search for text strings in most windows using the **Edit > Find** command, which launches the find dialog box.

Figure 74 – Edit > Find Dialog Box



Controls in this dialog box let you:

- Perform case-sensitive searches.
- Wrap searches back to the beginning of the file.
- Keep the dialog box displayed.
- Search down or up.

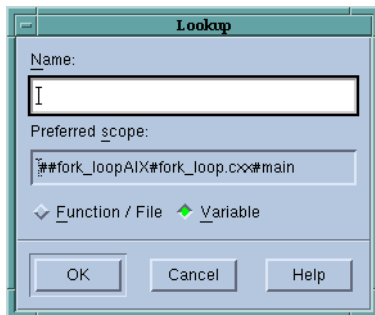
After you have found a string, you can find another instance of it by using the **Edit > Find Again** command.

If you searched for the same string previously, you can select it from the pulldown list on the right side of the **Find** text box.

Looking for Functions and Variables

Having TotalView locate a variable or a function is usually easier than scrolling through your sources to look for it. Do this with the **View > Lookup Function** and **View > Lookup Variable** commands. Here is the dialog set to look

Figure 75 – View > Lookup Variable Dialog Box

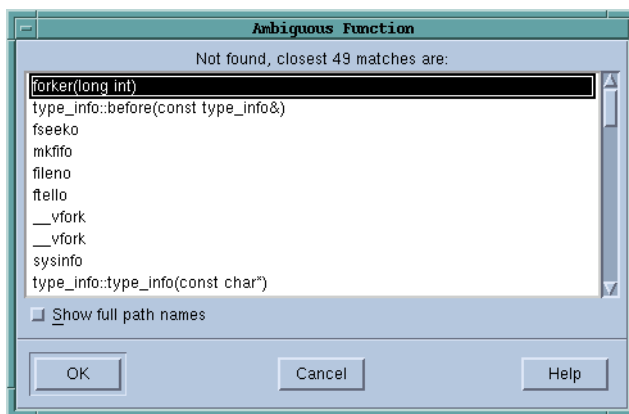


CLI: `dprint variable`

for variables:

If TotalView doesn't find the name and it can find something similar, it displays a dialog box that contains the names of functions that might match.

Figure 76 – Ambiguous Function Dialog Box



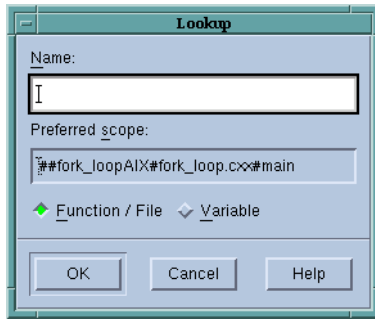
If the one you want is listed, click on its name and then choose **OK** to display it in the Source Pane.

Finding the Source Code for Functions

Use the **File > Open Source** command to search for a function's declaration.

CLI: `dlist function-name`

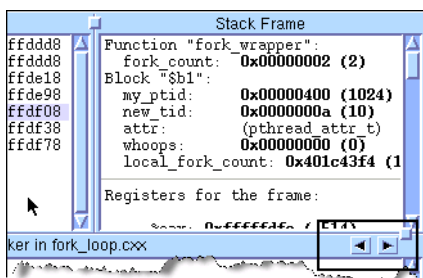
Figure 77 – View > Lookup Function Dialog Box



After locating your function, TotalView displays it in the Source Pane. If you didn't compile the function using the `-g` command-line option, TotalView displays disassembled machine code.

When you want to return to the previous contents of the Source Pane, use the Backward button located in the upper-right corner of the Source Pane and just below the Stack Frame Pane. In [Figure 78](#), a rectangle surrounds this button.

Figure 78 – Undive/Dive Controls



You can also use the **View > Reset** command to discard the dive stack so that the Source Pane is displaying the PC it displayed when you last stopped execution.

Another method of locating a function's source code is to dive into a source statement in the Source Pane that shows the function being called. After diving, you see the source.

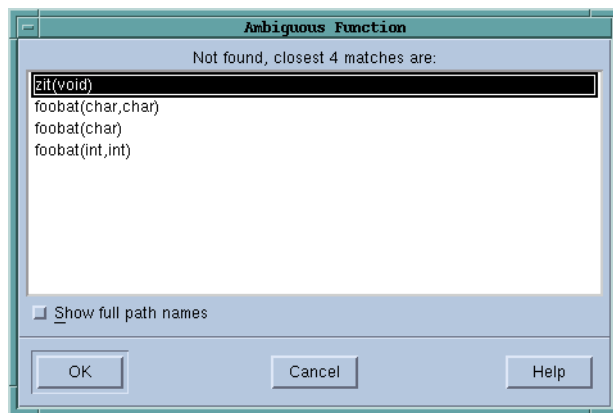
Resolving Ambiguous Names

Sometimes the function name you specify is ambiguous. For example, you might have specified the name of:

- A static function, and your program contains different versions of it.
- A member function in a C++ program, and multiple classes have a member function with that name.
- An overloaded function or a template function.

The following figure shows the dialog box that TotalView displays when it encounters an ambiguous function name. You can resolve the ambiguity by clicking the function name.

Figure 79 – Ambiguous Function Dialog Box



If the name being displayed isn't enough to identify which name you need to select, select the **Show full path names** check box to display additional information.

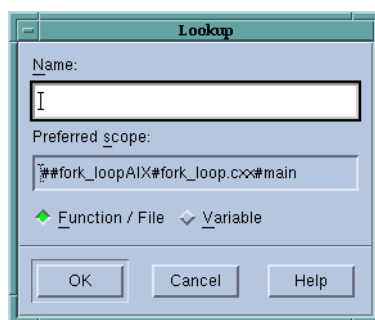
RELATED TOPICS

Using C++ in TotalView “Using C++” on page 331

Finding the Source Code for Files

You can display a file's source code by selecting the **View > Lookup Function** command and entering the file name in the dialog box shown in Figure 80

Figure 80 – View > Lookup Function Dialog Box



If a header file contains source lines that produce executable code, you can display the file's code by typing the file name here.

Resetting the Stack Frame

After moving around your source code to look at what's happening in different places, you can return to the executing line of code for the current stack [frame](#) by selecting the **View > Reset** command. This command places the PC arrow on the screen.

This command is also useful when you want to undo the effect of scrolling, or when you move to different locations using, for example, the **View > Lookup Function** command.

If the program hasn't started running, the **View > Reset** command displays the first executable line in your main program. This is useful when you are looking at your source code and want to get back to the first statement that your program executes.

Viewing the Assembler Version of Your Code

You can display your program in source or assembler using these commands:

Source code (Default)

Select the **View > Source As > Source** command.

Assembler code

Select the **View > Source As > Assembler** command.

Both Source and assembler

Select the **View > Source As > Both** command.

The Source Pane divides into two parts. The left pane contains the program's source code and the right contains the assembler version. You can set breakpoints in either of these panes. Setting an **action point** at the first instruction after a source statement is the same as setting it at that source statement.

The following commands display your assembler code by using symbolic or absolute addresses:

Command	Display
View > Assembler > By Address	Absolute addresses for locations and references (default)
View > Assembler > Symbolically	Symbolic addresses (function names and offsets) for locations and references

NOTE >> You can also display assembler instructions in a Variable Window. For more information, see [“Displaying Machine Instructions”](#) on page 237.

The following three figures illustrate the different ways TotalView can display assembler code. In [Figure 81](#), the second column (the one to the right of the line numbers) shows the absolute address location. The fourth column shows references using absolute addresses.

Figure 81 – Address Only (Absolute Addresses)

```
Function forker in fork_loop.cxx
0x0804a4f7: 0x0c
0x0804a4f8: 0x6a push $0
0x0804a4f9: 0x00
0x0804a4fa: 0xe8 call snore(void*)
0x0804a4fb: 0x35
0x0804a4fc: 0xf3
0x0804a4fd: 0xff
0x0804a4fe: 0xff
0x0804a4ff: 0x83 addl $16, %esp
0x0804a500: 0xc4
0x0804a501: 0x10
0x0804a502: 0xc9 leave
0x0804a503: 0xc3 ret
1026 0x0804a503: 0xc3 ret
1032 forker_wrapper(int): 0x55 pushl %ebp
0x0804a505: 0x89 movl %esp, %ebp
0x0804a506: 0xe5
0x0804a507: 0x83 subl $88, %esp
0x0804a508: 0xec
0x0804a509: 0x58
1033 0x0804a50a: 0xe8 call pthread_self@0GLIBC_2.0
0x0804a50b: 0x29
0x0804a50c: 0xe8
0x0804a50d: 0xff
```

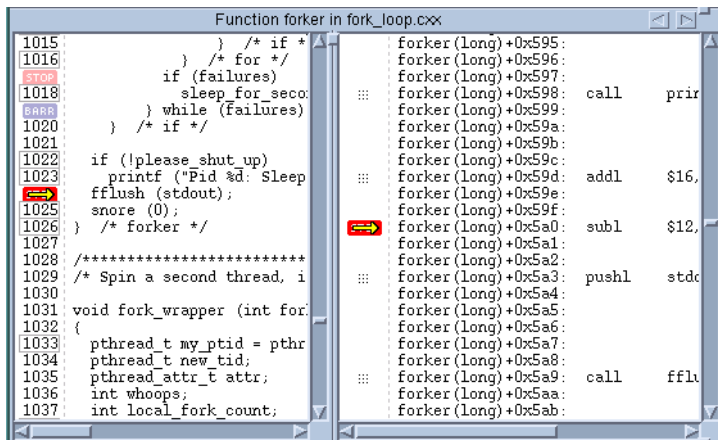
Figure 82 displays information symbolically. The second column shows locations using functions and offsets.

Figure 82 – Assembly Only (Symbolic Addresses)

```
Function forker in fork_loop.cxx
0x0c
forker (long)+0x5b3: 0x6a push $0
forker (long)+0x5b4: 0x00
forker (long)+0x5b5: 0xe8 call snore(void*)
forker (long)+0x5b6: 0x35
forker (long)+0x5b7: 0xf3
forker (long)+0x5b8: 0xff
forker (long)+0x5b9: 0xff
forker (long)+0x5ba: 0xff
forker (long)+0x5bb: 0x83 addl $16, %esp
forker (long)+0x5bc: 0xc4
forker (long)+0x5bd: 0x10
1026 forker (long)+0x5be: 0xc9 leave
0x0804a503: 0xc3 ret
1032 forker_wrapper(int): 0x55 pushl %ebp
forker_wrapper(int)+0x01: 0x89 movl %esp, %ebp
forker_wrapper(int)+0x02: 0xe5
forker_wrapper(int)+0x03: 0x83 subl $88, %esp
forker_wrapper(int)+0x04: 0xec
forker_wrapper(int)+0x05: 0x58
1033 forker_wrapper(int)+0x06: 0xe8 call pthread_self@0GLIBC_2.0
forker_wrapper(int)+0x07: 0x29
forker_wrapper(int)+0x08: 0xe8
forker_wrapper(int)+0x09: 0xff
```

Figure 83 displays the split Source Pane, with the program's source code on the left and assembler version on the right. In this example, the assembler is shown symbolically (by selecting **View > Assembler > Symbolically**).

Figure 83 – Both Source and Assembler (Symbolic Addresses)



NOTE >> When TotalView displays instructions, the arguments are almost always in the following order: “source,destination”. On Linux-x86 and Linux x86-64 platforms, this can be confusing as the order indicated in AMD and Intel technical literature indicates that the order is usually “destination,source”. The order in which TotalView displays this information conforms to the GNU assembler. This ordering is usually an issue only when you are examining a core dump.

RELATED TOPICS

- Machine instructions [“Displaying Machine Instructions” on page 237](#)
- Memory with an unknown data type [“Viewing Areas of Memory \(\\$void Data Type\)” on page 265](#)
- Viewing the contents of a location as machine instruction [“Viewing Instructions \(\\$code Data Type\)” on page 265](#)

Editing Source Text

Use the **File > Edit Source** command to examine the current routine in a text editor. TotalView uses an *editor launch string* to determine how to start your editor. TotalView expands this string into a command that TotalView sends to the **sh** shell.

The default editor is **vi**. However, TotalView uses the editor named in an **EDITOR** environment variable, or the editor you name in the Source Code Editor field of the **File > Preferences** Launch Strings Page. The online Help for this page contains information on setting this preference.



Chapter 7

Stepping through and Executing your Program

This chapter discusses stepping and program execution, including these sections:

- “Using Stepping Commands” on page 166
- “Executing to a Selected Line” on page 169
- “Executing Out of a Function” on page 170
- “Continuing with a Specific Signal” on page 171
- “Killing (Deleting) Programs” on page 172
- “Restarting Programs” on page 172
- “Setting the Program Counter” on page 173

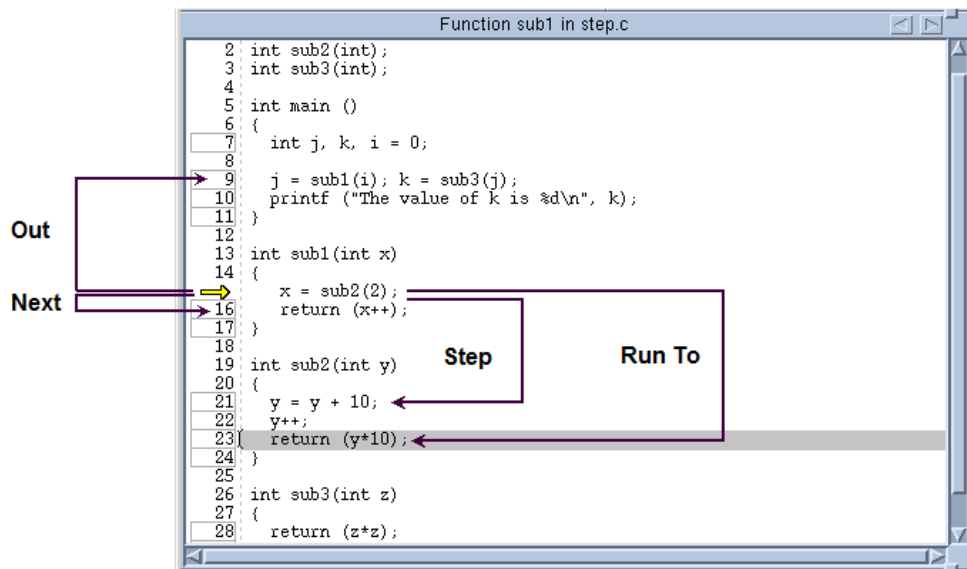
Using Stepping Commands

While different programs have different requirements, the most common stepping mode is to set group focus to **Control** and the target to **Process** or **Group**. You can now select stepping commands from the **Process** or **Group** menus or use commands in the toolbar.

```
CLI: dfocus g
      dfocus p
```

Figure 84 illustrates stepping commands.

Figure 84 – Stepping Illustrated



The arrow indicates that the PC is at line 15. The four stepping commands do the following:

- **Next** executes line 15. After stepping, the PC is at line 16.
- **Step** moves into the **sub2()** function. The PC is at line 21.
- **Run To** executes all lines until the PC reaches the selected line, which is line 23.
- **Out** executes all statements within **sub1()** and exits from the function. The PC is at line 9. If you now execute a Step command, TotalView steps into **sub3()**.

Remember the following things about single-stepping commands:

- To cancel a single-step command, select **Group > Halt** or **Process > Halt**.

```
CLI: dhalt
```

- If your program reaches a breakpoint while stepping over a function, TotalView cancels the operation and your program stops at the breakpoint.
- If you enter a source-line stepping command and the primary thread is executing in a function that has no source-line information, TotalView performs an assembler-level stepping command.
- When TotalView steps through your code, it steps one line at a time. This means that if you have more than one statement on a line, a step instruction executes all of the instructions on that line.

RELATED TOPICS

The **dfocus** command

The `dfocus` command in "CLI Commands" in the TotalView for HPC Reference Guide

Detailed discussion on stepping

"[Stepping \(Part I\)](#)" on page 516, with examples in "[Stepping \(Part II\): Examples](#)" on page 538

Stepping into Function Calls

The stepping commands execute one line in your program. If you are using the CLI, you can use a numeric argument that indicates how many source lines TotalView steps. For example, here's the CLI instruction for stepping three lines:

```
dstep 3
```

If the source line or instruction contains a function call, TotalView steps into it. If TotalView can't find the source code and the function was compiled with **-g**, it displays the function's machine instructions.

You might not realize that your program is calling a function. For example, if you overloaded an operator, you'll step into the code that defines the overloaded operator.

NOTE >> If the function being stepped into wasn't compiled with the **-g** command-line option, TotalView always steps over the function.

The GUI has eight **Step** commands and eight **Step Instruction** commands. These commands are located on the **Group**, **Process**, and **Thread** pulldowns. The difference between them is the focus.

```
CLI: dfocus ... dstep
      dfocus ... dstepi
```

RELATED TOPICS

The dstep command	dstep in "CLI Commands" in the TotalView for HPC Reference Guide
The dstepi command	dstepi in "CLI Commands" in the TotalView for HPC Reference Guide

Stepping Over Function Calls

When you step over a function, TotalView stops execution when the primary thread returns from the function and reaches the source line or instruction after the function call.

The GUI has eight **Next** commands that execute a single source line while stepping over functions, and eight **Next Instruction** commands that execute a single machine instruction while stepping over functions. These commands are on the **Group**, **Process**, and **Thread** menus.

```
CLI: dfocus ... dnext  
      dfocus ... dnexti
```

If the PC is in assembler code—this can happen, for example, if you halt your program while it's executing in a library—a **Next** operation executes the next instruction. If you want to execute out of the assembler code so you're back in your code, select the **Out** command. You might need to select **Out** a couple of times until you're back to where you want to be.

RELATED TOPICS

The dnext command	dnext in "CLI Commands" in the TotalView for HPC Reference Guide
The dnexti command	dnexti in "CLI Commands" in the TotalView for HPC Reference Guide

Executing to a Selected Line

If you don't need to stop execution every time execution reaches a specific line, you can tell TotalView to run your program to a selected line or machine instruction. After selecting the line on which you want the program to stop, invoke one of the eight **Run To** commands defined within the GUI. These commands are on the **Group**, **Process**, and **Thread** menus.

CLI: `dfocus ... duntil`

Executing to a selected line is discussed in greater depth in [Chapter 21, "Group, Process, and Thread Control,"](#) on page 513.

If your program reaches a breakpoint while running to a selected line, TotalView stops at that breakpoint.

If your program calls recursive functions, you can select a nested stack [frame](#) in the Stack Trace Pane. When you do this, TotalView determines where to stop execution by looking at the following:

- The frame pointer (FP) of the selected stack frame.
- The selected source line or instruction.

CLI: `dup` and `ddown`

RELATED TOPICS

Detailed discussion on stepping ["Stepping and Setting Breakpoints"](#) on page 395 and setting breakpoints

The duntil command	duntil in "CLI Commands" in the TotalView for HPC Reference Guide
The dup command	dup in "CLI Commands" in the TotalView for HPC Reference Guide
The ddown command	ddown in "CLI Commands" in the TotalView for HPC Reference Guide

Executing Out of a Function

You can step your program out of a function by using the **Out** commands. The eight **Out** commands in the GUI are located on the **Group**, **Process**, and **Thread** menus.

CLI: `dfocus ... dout`

If the source line that is the *goal* of the **Out** operation has more than one statement, TotalView will stop execution just after the routine from which it just emerged. For example, suppose that the following is your source line:

```
routine1; routine2;
```

Suppose you step into **routine1**, then use an **Out** command. While the PC arrow in the Source Pane still points to this same source line, the actual PC is just after **routine1**. This means that if you use a step command, you will step into **routine2**.

The PC arrow does not move when the source line only has one statement on it. The internal PC does, of course, change.

You can also return out of several functions at once, by selecting the routine in the Stack Trace Pane that you want to go to, and then selecting an **Out** command.

If your program calls recursive functions, you can select a nested stack frame in the Stack Trace Pane to indicate which instance you are running out of.

RELATED TOPICS

The **dout** command

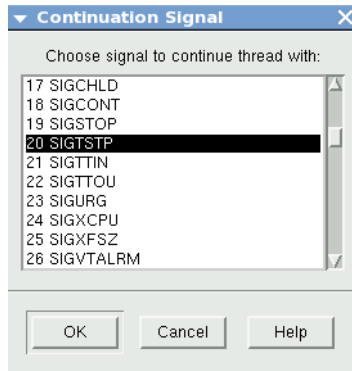
dout in "CLI Commands" in the TotalView for HPC Reference Guide

Continuing with a Specific Signal

Letting your program continue after sending it a signal is useful when your program contains a signal handler. To set this up:

1. Select the Process Window's **Thread > Continuation Signal** command.

Figure 85 – Thread > Continuation Signal Dialog Box



2. Select the signal to be sent to the thread and then select **OK**.

The continuation signal is set for the thread contained in the current Process Window. If the operating system can deliver multi-threaded signals, you can set a separate continuation signal for each thread. If it can't, this command clears continuation signals set for other threads in the process.

3. Continue execution of your program with commands such as **Process > Go, Step, Next, or Detach**.

TotalView continues the threads and sends the specified signals to your process.

NOTE >> To clear the continuation signal, select **signal 0** from this dialog box.

You can change the way TotalView handles a signal by setting the **TV::signal_handling_mode** variable in a **.tvdr**c startup file. For more information, see Chapter 4 of the *"TotalView for HPC Reference Guide."*

RELATED TOPICS

The **TV::signal_handling_mode** command

The **TV::signal_handling_mode** variable in "TotalView Variables" in the TotalView for HPC Reference Guide

Default settings for signals and how to change them

["Handling Signals"](#) on page 122

Killing (Deleting) Programs

To kill (or delete) all the processes in a **control group**, use the **Group > Kill** command. The next time you start the program, for example, by using the **Process > Go** command, TotalView creates and starts a fresh master process.

```
CLI: dfocus g dkill
```

Restarting Programs

You can use the **Group > Restart** command to restart a program that is running or one that is stopped but hasn't exited.

```
CLI: drerun
```

If the process is part of a multi-process program, TotalView deletes all related processes, restarts the master process, and runs the newly created program.

The **Group > Restart** command is equivalent to the **Group > Kill** command followed by the **Process > Go** command.

Setting the Program Counter

TotalView lets you resume execution at a different statement than the one at which it stopped execution by resetting the value of the program counter (PC). For example, you might want to skip over some code, execute some code again after changing certain variables, or restart a thread that is in an error state.

Setting the PC can be crucial when you want to restart a thread that is in an error state. Although the PC symbol in the line number area points to the source statement that caused the error, the PC actually points to the failed machine instruction in the source statement. You need to explicitly reset the PC to the correct instruction. (You can verify the actual location of the PC before and after resetting it by displaying it in the Stack Frame Pane, or displaying both source and assembler code in the Source Pane.)

In TotalView, you can set the PC of a stopped thread to a selected source line or a selected instruction. When you set the PC to a selected line, the PC points to the memory location where the statement begins. For most situations, setting the PC to a selected line of source code is all you need to do.

To set the PC to a selected line:

1. If you need to set the PC to a location somewhere in a line of source code, select the **View > Source As > Both** command.

TotalView responds by displaying assembler code.

2. Select the source line or instruction in the Source Pane.

TotalView highlights the line.

3. Select the **Thread > Set PC** command.

TotalView asks for confirmation, resets the PC, and moves the PC symbol to the selected line.

When you select a line and ask TotalView to set the PC to that line, TotalView attempts to force the thread to continue execution at that statement in the currently selected stack **frame**. If the currently selected stack frame is not the top stack frame, TotalView asks if it can unwind the stack:

`This frame is buried. Should we attempt to unwind the stack?`

If you select **Yes**, TotalView discards deeper stack frames (that is, all stack frames that are more deeply nested than the selected stack frame) and resets the machine registers to their values for the selected frame. If you select **No**, TotalView sets the PC to the selected line, but it leaves the stack and registers in their current state. Since you can't assume that the stack and registers have the right values, selecting **No** is almost always the wrong thing to do.



Chapter 8

Setting Action Points

In TotalView, breakpoints are called "action points." TotalView has four kinds of action points:

- A *breakpoint* stops execution of processes and threads that reach it.
- A *barrier point* synchronizes a set of threads or processes at a location.
- An *eval point* executes a code fragment when it is reached.
- A *watchpoint* monitors a location in memory and stops execution when it changes.

This chapter contains the following sections:

- ["About Action Points"](#) on page 175
- ["Setting Breakpoints and Barriers"](#) on page 179
- ["Defining Eval Points and Conditional Breakpoints"](#) on page 197
- ["Using Watchpoints"](#) on page 206
- ["Saving Action Points to a File"](#) on page 213

About Action Points

Action points specify an action to perform when a thread or process reaches a source line or machine instruction in your program. TotalView provides four types of action points:

- **Breakpoints**

When a thread encounters a breakpoint, it stops at the breakpoint. Other threads in the process also stop. You can indicate that you want other related processes to stop, as well. Breakpoints are the simplest kind of action point.

- **Barrier points**

Barrier points are similar to simple breakpoints, differing in that you use them to synchronize a group of processes or threads. A barrier point holds each thread or process that reaches it until all threads or processes reach it. Barrier points work together with the TotalView hold-and-release feature. TotalView supports thread barrier and process barrier points.

- **Eval points**

An eval point is a breakpoint that has a code fragment associated with it. When a thread or process encounters an eval point, it executes this code. You can use eval points in a variety of ways, including conditional breakpoints, thread-specific breakpoints, countdown breakpoints, and patching code fragments into and out of your program.

- **Watchpoints**

A watchpoint tells TotalView to either stop the thread so that you can interact with your program (unconditional watchpoint), or evaluate an expression (conditional watchpoint).

The different kinds of action points that you can use are shown in [Figure 86](#) on page 176.

Action Point Properties

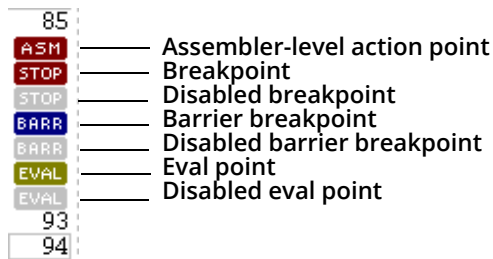
All action points share the following common properties.

- You can independently enable or disable action points. A disabled action isn't deleted; however, when your program reaches a disabled action point, TotalView ignores it.
- You can share action points across multiple processes or set them in individual processes.
- Action points apply to the process. In a multi-threaded process, the action point applies to all of the threads associated with the process.
- TotalView assigns unique ID numbers to each action point. These IDs appear in several places, including the Root Window, the Action Points Tab of the Process Window, and the **Action Point > Properties** Dialog Box.

Action Point Status Display

In the Process Window, each action point is identified by a symbol:

Figure 86 – Action Point Symbols



The **ASM** icon is displayed when you create a breakpoint on an assembler statement.

CLI: `dactions --` shows information about action points

All action points display as “@” when you use the `dlist` command to display your source code. Use the `dactions` command to see what type of action point is set.

When your program halts because it encountered an action point, TotalView reports status in several locations. In the Root Window, the Process State is displayed with Breakpoint as well as the letters **ap** followed by a number if the Action Point ID checkbox is enabled in the Configure pane. This is the same number as in the Action Points tab within the Process Window. In the Process Window, the status lines above the Source Pane also let you know that the thread is at a breakpoint. Finally, TotalView places a yellow arrow over the action point’s icon in the Action Point tab. For example:

Figure 87 – Action Points Tab

Action Points	Processes	Threads
STOP	3	tx_fork_loop.cxx#567 wait_a_while+0x21...
EVAL	1	tx_fork_loop.cxx#681 snore+0xd3
STOP	2	tx_fork_loop.cxx#683 snore+0xe9
STOP	4	tx_fork_loop.cxx#1066 fork_wrapper+0x20
STOP	5	tx_fork_loop.cxx#1074 fork_wrapper+0x7a

For templated code, an ellipsis (...) is displayed after the address, indicating that additional addresses are associated with the breakpoint.

Manipulating Action Points

When working with action points, you can use your mouse to quickly manipulate breakpoints. In the line number area of the Source Pane, a left mouse click sets a **breakpoint** at that line, displaying a **STOP** icon instead of a line number.

Selecting the **STOP** icon a second time deletes the breakpoint. If you change any of the breakpoint's properties or if you've created an eval point (indicated by an **EVAL** icon), selecting the icon disables it.

RELATED TOPICS

Modifying action point properties The **Action Point > Properties** dialog box in the in-product Help
Using action points with the CLI "Using Action Points" on page 431

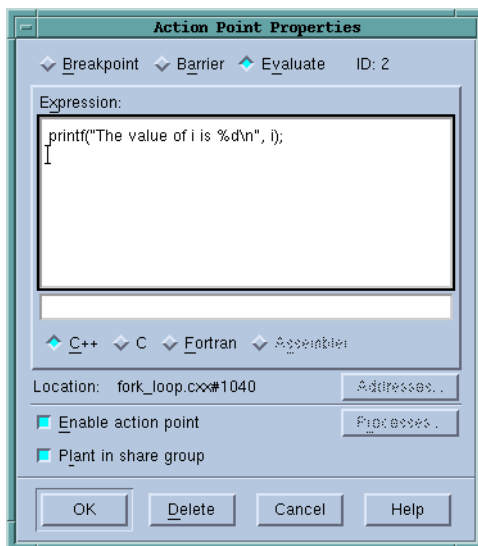
Print Statements vs. Action Points

Print statements are common in debugging, in which you insert **printf()** or **PRINT** statements in your code and then inspect the output. However, using print statements requires that you recompile your program; further, the output may be difficult to navigate as it is likely to be out of order when running multi-process, multi-threaded programs.

You can still use **printf()** statements if you wish — but more effectively and without recompiling your program. Simply add a breakpoint that prints information, using the **Action Point Properties**, dialog, [Figure 88](#), which adds any code you want to a breakpoint.

NOTE >> In this book, the term "breakpoint" is often used interchangeably with the broader TotalView-specific term "action point."

Figure 88 – Action Point Properties Dialog Box

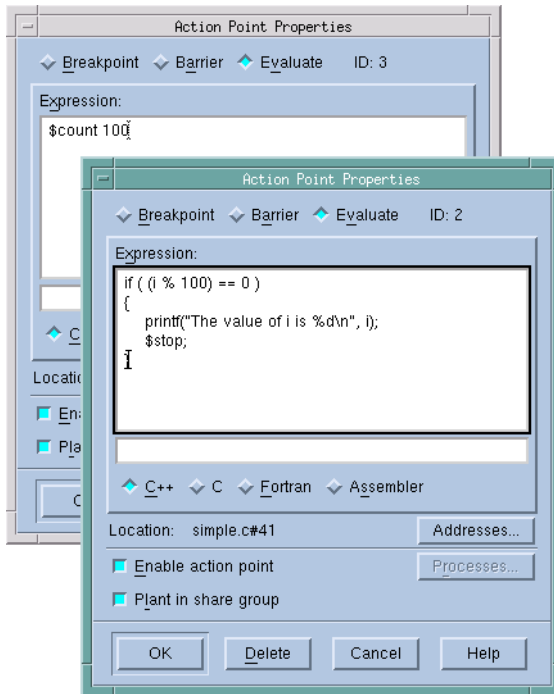


A breakpoint with associated code is an **eval point**. When your program reaches an eval point, TotalView executes the code. For instance, in the above case, TotalView prints the value of **i**.

Eval points do exactly what you tell them to do. Note that, in [Figure 88](#), TotalView allows your program to continue to execute because you didn't tell it to stop. In other words, you don't have to stop program execution just to observe print statement output.

[Figure 89](#) shows two eval points that do stop execution.

Figure 89 – Setting Conditions



The eval point in the foreground uses programming language statements and a built-in debugger function to stop a loop every 100 iterations. It also prints the value of `i`. In contrast, the eval point in the background just stops the program every 100 times a statement is executed.

These are just a few ways that action points can define print statements. More examples can be seen throughout this chapter.

Setting Breakpoints and Barriers

TotalView has several options for setting breakpoints, including:

- Source-level breakpoints
- Breakpoints that are shared among all processes in multi-process programs
- Assembler-level breakpoints

You can also control whether TotalView stops all processes in the **control group** when a single member reaches a breakpoint.

Topics in this section are:

- [“Setting Source-Level Breakpoints”](#) on page 179
- [“Setting Breakpoints at Locations”](#) on page 182
- [“Displaying and Controlling Action Points”](#) on page 184
- [“Setting Machine-Level Breakpoints”](#) on page 188
- [“Setting Breakpoints for Multiple Processes”](#) on page 189
- [“Setting Breakpoints When Using the fork\(\)/execve\(\) Functions”](#) on page 191
- [“Setting Barrier Points”](#) on page 193

Setting Source-Level Breakpoints

Typically, you set and clear breakpoints before you start a process. To set a source-level breakpoint, select a boxed line number in the Process Window. (A boxed line number indicates that the line is associated with executable code.) A **STOP** icon lets you know that a breakpoint is set immediately before the source statement.

CLI: @ next to the line number denotes a breakpoint

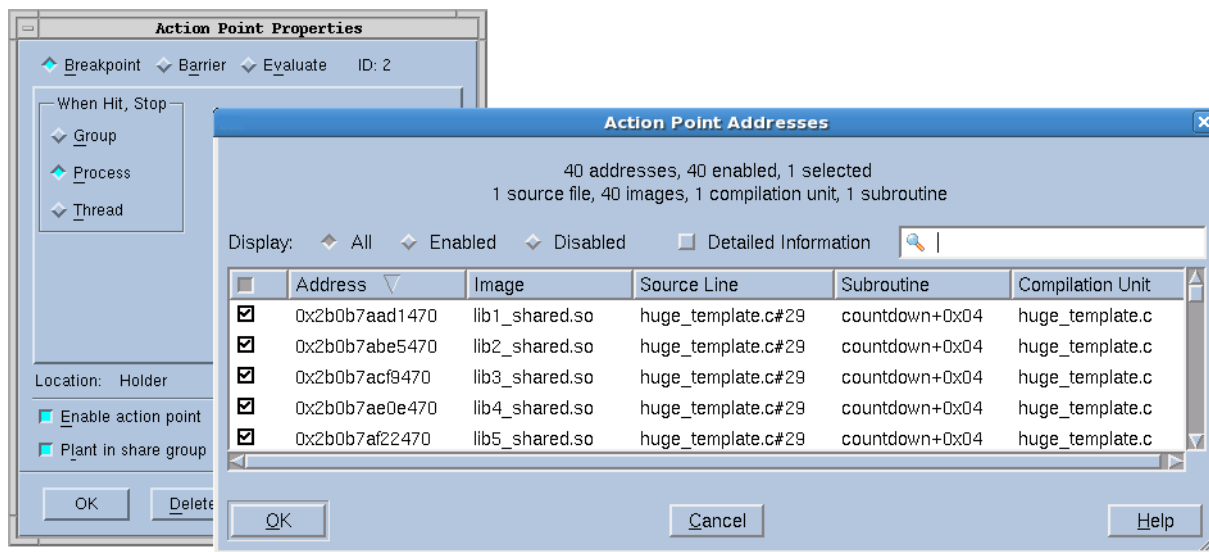
You can also set a breakpoint while a process is running by selecting a boxed line number in the Process Window.

CLI: `dbreak --` to set a breakpoint whenever the CLI displays a prompt

Choosing Source Lines

If you're using C++ templates, TotalView sets a breakpoint in all instantiations of that template. If this isn't what you want, clear the button and then select the **Addresses** button in the Action Point Properties Dialog Box. You can now clear locations where the action point shouldn't be set.

Figure 90 – Action Point and Addresses Dialog Boxes



Initially, addresses are either enabled or disabled, but you can change their state by clicking the checkbox in the first column. The checkbox in the columns bar enables or disables all the addresses. This dialog supports selecting multiple separate items (Ctrl-Click) or a range of items (Shift-Click or click and drag). Once the desired subset is selected, right-click one of the selected items and choose Enable Selection or Disable Selection from the context menu.

Filtering

In massively parallel programs, the number of addresses can become very large, so the Addresses dialog has several mechanisms to help you manage the data. The search box filters the currently displayed data based on one or more space-separated strings or phrases (enclosed in quotes). Remember that data not currently displayed is not included in the filtering. It may be helpful to click the Detailed Information checkbox, which displays much more complete information, giving you more possibilities for filtering.

Sorting

Clicking on the column labels performs a sort based on the data in that column. Each click toggles between ascending and descending order. If entry values in a column are the same, the values of the column to the right of the sorted column are examined and sorted based on those values. If the values are the same, the next column is examined and so on, until different values are found. The Addresses dialog uses a stable sort, i.e. if all the entries are the same in the selected column and in the columns to the right, the list is not modified.

Displaying and rearranging columns

Finally, right-clicking in the columns bar presents a context menu for displaying or hiding columns. All are initially displayed except Image. You can reorder the columns by selecting a column label and dragging it to a new location.

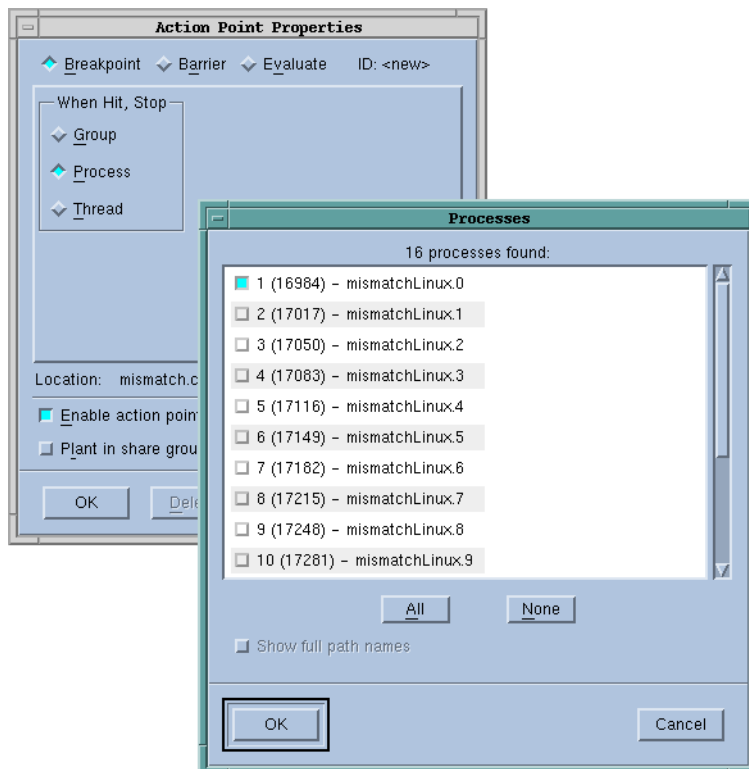
Keyboard Shortcuts

To provide easy access to the buttons at the bottom of the Addresses dialog, the following mnemonic keys have been assigned.

Button	Keyboard Sequence
OK	Alt-o
Cancel	Alt-c
Help	Alt-h

Similarly, in a multi-process program, you might not want to set the breakpoint in all processes. If this is the case, select the **Process** button.

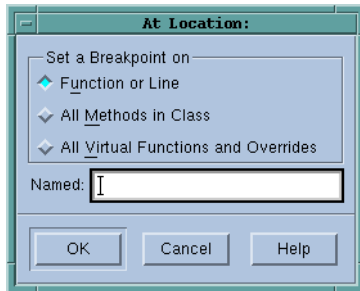
Figure 91 – Setting Breakpoints on Multiple Similar Addresses and on Processes



Setting Breakpoints at Locations

You can set or delete a breakpoint at a specific function or source-line number without having to first find the function or source line in the Source Pane. Do this by entering a line number or function name in the **Action Point > At Location** Dialog Box.

Figure 92 – Action Point > At Location Dialog Box



When you're done, TotalView sets a breakpoint at the location. If you enter a function name, TotalView sets the breakpoint at the function's first executable line. In either case, if a breakpoint already exists at a location, TotalView deletes it.

CLI: `dbreak` sets a breakpoint
`ddelete` deletes a breakpoint

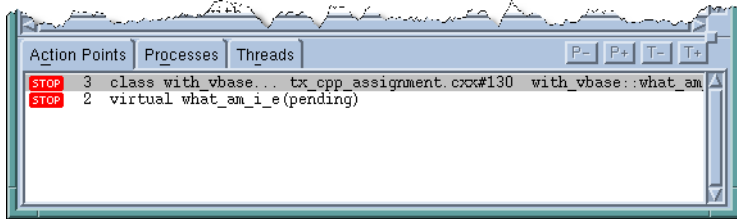
For detailed information about the kinds of information you can enter in this dialog box, see **`dbreak`** in the *TotalView for HPC Reference Guide*.

Ambiguous Functions and Pending Breakpoints

If you type a function name that TotalView has no information about into the **Action Point > At Location** dialog box, it assumes that you have either mistyped the function name or that the library containing the function has not yet been loaded into memory.

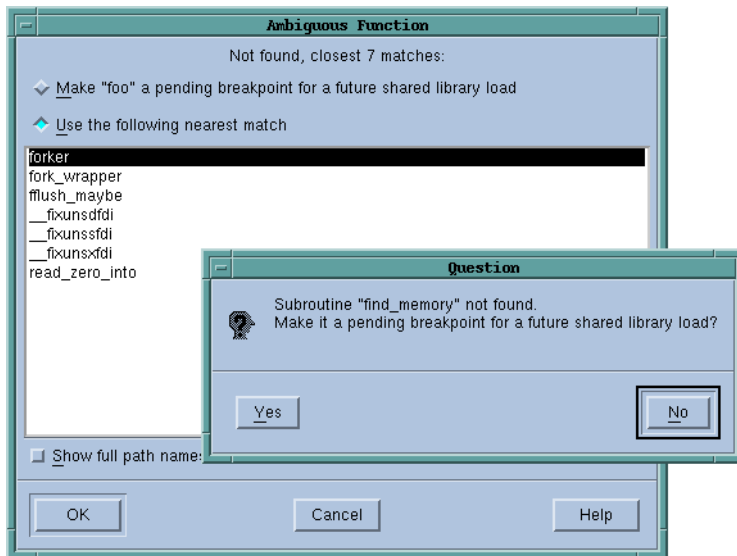
If TotalView cannot find a location to set a breakpoint (or a barrier point), you can tell it to set it anyway because it could exist in a shared library or it could be loaded later. These kind of breakpoints are called *pending breakpoints*. When libraries are loaded, TotalView checks for the function's name. If the name is found, it sets the breakpoint. If it isn't in a newly loaded library, TotalView just keeps on waiting for it to be loaded. You'll see information in the Action Points tab that tells you that the breakpoint is pending.

Figure 93 – Pending Breakpoints



If the name you type is similar to the name of an existing function, TotalView displays its **Ambiguous Function** dialog box that lets you select which of these existing functions it should set a breakpoint on. If, however, the function will be loaded into memory later, you can set a pending breakpoint.

Figure 94 – Ambiguous Function Dialog Box



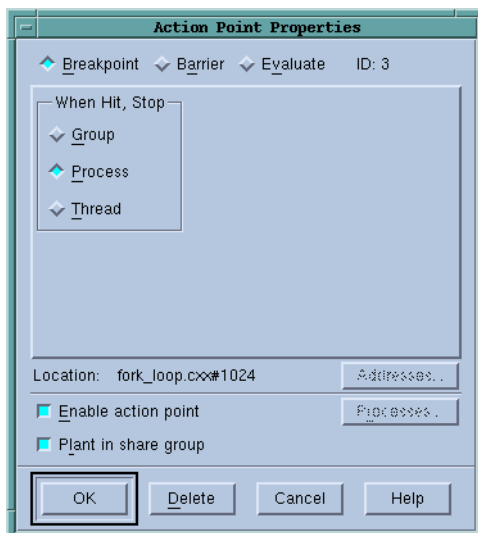
If the name you entered was not similar to any existing function, TotalView just asks if it should set a pending breakpoint. This question box is also shown in [Figure 94](#).

NOTE >> TotalView can only place one action point on an address. Because the breakpoints you specify are actually expressions, the locations to which these expressions evaluate can overlap or even be the same. Sometimes, and this most often occurs with pending breakpoints in dynamically loaded libraries, TotalView cannot tell when action points overlap. If they do, TotalView only enables one of the action points and disables all others that evaluate to the same address. The actionpoint that TotalView enables is the one with the lowest actionpoint ID.

Displaying and Controlling Action Points

The **Action Point > Properties** Dialog Box sets and controls an action point. Controls in this dialog box also let you change an action point's type to breakpoint, barrier point, or eval point. You can also define what happens to other threads and processes when execution reaches this action point.

Figure 95 – Action Point > Properties Dialog Box



The following sections explain how you can control action points by using the Process Window and the **Action Point > Properties** Dialog Box.

```
CLI: dset SHARE_ACTION_POINT
      dset STOP_ALL
      ddisable action-point
```

Disabling Action Points

TotalView can retain an action point's definition and ignore it while your program is executing. That is, disabling an action point deactivates it without removing it.

```
CLI: ddisable action-point
```

You can disable an action point by:

- Clearing **Enable action point** in the **Action Point > Properties** Dialog Box.
- Selecting the **STOP** or **BARR** symbol in the Action Points Tab.
- Using the context (right-click) menu.
- Clicking on the **Action Points > Disable** command.

Deleting Action Points

You can permanently remove an action point by selecting the **STOP** or **BARR** symbol or selecting the **Delete** button in the **Action Point > Properties** Dialog Box.

To delete all breakpoints and barrier points, use the **Action Point > Delete All** command.

```
CLI: ddelete
```

If you make a significant change to the action point, TotalView disables it rather than deleting it when you click the symbol.

Enabling Action Points

You can activate a previously disabled action point by selecting a dimmed **STOP**, **BARR**, or **EVAL** symbol in the Source or Action Points tab, or by selecting **Enable action point** in the **Action Point > Properties** Dialog Box.

```
CLI: denable
```

Suppressing Action Points

You can tell TotalView to ignore action points by using the **Action Point > Suppress All** command.

```
CLI: ddisable -a
```

The command **ddisable -a** is the closest CLI command to the GUI **Suppress All** feature. However, **ddisable -a** does not actually put TotalView into suppressed action point mode and you can still set and manipulate action points. Be aware that the **ddisable -a** command in the CLI operates only on the current focus. See the *TotalView for HPC Reference Guide* for more discussion.

When you suppress action points, you disable them. After you suppress an action point, TotalView changes the symbol it uses within the Source Pane's line number area. In all cases, the icon's color is lighter. Selecting **Suppress All** in the Action Point menu places TotalView in a suppressed action point mode such that no action points are enabled in any process within the entire debugging session. While in this mode, you are unable to create new action points or enable any that are currently disabled.

You can make previously suppressed action points active and allow the creation of new ones by again selecting the **Action Point > Suppress All** command, which functions as a toggle.

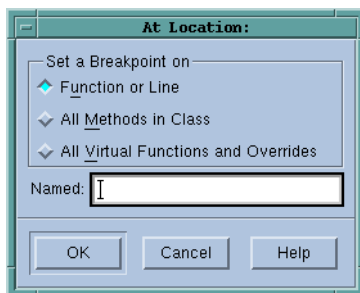
CLI: denable -a

The command **denable -a** is the closest CLI command to turning off **Suppress All** from within the GUI. However, the **denable -a** feature in the CLI operates only on the current focus. See the *TotalView for HPC Reference Guide* for more discussion.

Setting Breakpoints on Classes and Functions

The **Action Point > At Location** dialog box lets you set breakpoints on all functions within a class or on a virtual function. The **All Methods in Class** and **All Virtual Functions and Overrides** check boxes tell TotalView that it should set multiple breakpoints. Each place that TotalView sets a breakpoint will have its own breakpoint icon. For example, if there are ten class functions, each will have its own unique breakpoint.

Figure 96 – Action Point > At Location Dialog Box

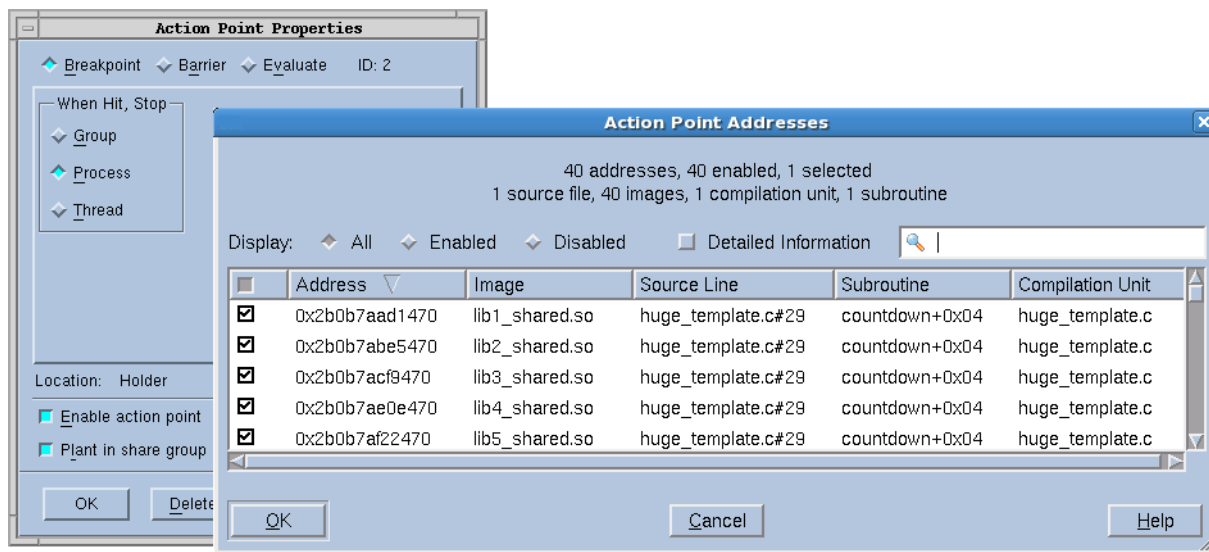


TotalView tells you that the action point is set on a virtual function or a class in the Action Points tab. If you dive on the action point in this tab, TotalView brings up its Ambiguous Function dialog box so that you can select which it should display. You may want to select the **Show full path names** check box if you can't tell which you want from the function's signature.

If a function name is overloaded, the debugger sets a breakpoint on each of these functions.

If you only want breakpoints on some functions, you will need to select the breakpoint and then get to the Properties Window. Do this either by right-clicking on the breakpoint and click **Properties** or by selecting the **Action Point > Properties** command, and then clicking **Addresses**.

Figure 97 – Action Point and Addresses Dialog Boxes



You can now individually add or remove breakpoints. Initially, addresses are either enabled or disabled, but you can change their state by clicking the checkbox in the first column. The checkbox in the columns bar enables or disables all the addresses. This dialog supports selecting multiple separate items (Ctrl-Click) or a range of items (Shift-Click or click and drag). Once the desired subset is selected, right-click one of the selected items and choose Enable Selection or Disable Selection from the context menu.

Filtering

In massively parallel programs, the number of addresses can become very large, so the Addresses dialog has several mechanisms to help you manage the data. The search box filters the currently displayed data based on one or more space-separated strings or phrases (enclosed in quotes). Remember that data not currently displayed is not included in the filtering. It may be helpful to click the Detailed Information checkbox, which displays much more complete information, giving you more possibilities for filtering.

Sorting

Clicking on the column labels performs a sort based on the data in that column. Each click toggles between ascending and descending order. If entry values in a column are the same, the values of the column to the right of the sorted column are examined and sorted based on those values. If the values are the same, the next column is examined and so on, until different values are found. The Addresses dialog uses a stable sort, i.e. if all the entries are the same in the selected column and in the columns to the right, the list is not modified.

Displaying and rearranging columns

Finally, right-clicking in the columns bar presents a context menu for displaying or hiding columns. All are initially displayed except Image. You can reorder the columns by selecting a column label and dragging it to a new location.

Keyboard Shortcuts

To provide easy access to the buttons at the bottom of the Addresses dialog, the following mnemonic keys have been assigned.

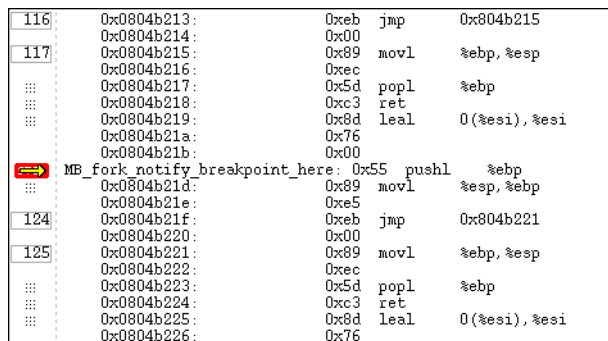
Button	Keyboard Sequence
OK	Alt-o
Cancel	Alt-c
Help	Alt-h

Setting Machine-Level Breakpoints

To set a machine-level breakpoint, you must first display assembler code. You can now select an instruction. TotalView replaces some line numbers with a dotted box (:::)—this indicates the line is the beginning of a machine instruction. If a line has a line number, this is the line number that appears in the Source Pane. Since instruction sets on some platforms support variable-length instructions, you might see a different number of lines associated with a single line contained in the dotted box. The **STOP** icon appears, indicating that the breakpoint occurs before the instruction executes.

If you set a breakpoint on the first instruction after a source statement, however, TotalView assumes that you are creating a source-level breakpoint, not an assembler-level breakpoint.

Figure 98 – Breakpoint at Assembler Instruction



```
116 0x0804b213: 0xeb jmp 0x804b215
0x0804b214: 0x00
117 0x0804b215: 0x89 movl %ebp, %esp
0x0804b216: 0xec
::: 0x0804b217: 0x5d popl %ebp
::: 0x0804b218: 0xc3 ret
::: 0x0804b219: 0x8d leal 0(%esi), %esi
0x0804b21a: 0x76
0x0804b21b: 0x00
MB_fork_notify_breakpoint_here: 0x55 pushl %ebp
::: 0x0804b21d: 0x89 movl %esp, %ebp
0x0804b21e: 0xe5
124 0x0804b21f: 0xeb jmp 0x804b221
0x0804b220: 0x00
125 0x0804b221: 0x89 movl %ebp, %esp
0x0804b222: 0xec
::: 0x0804b223: 0x5d popl %ebp
::: 0x0804b224: 0xc3 ret
::: 0x0804b225: 0x8d leal 0(%esi), %esi
0x0804b226: 0x76
```

If you set machine-level breakpoints on one or more instructions generated from a single source line, and then display source code in the Source Pane, TotalView displays an **ASM** icon (Figure 86 on page 176) on the line number. To see the actual breakpoint, you must redisplay assembler instructions.

When a process reaches a breakpoint, TotalView does the following:

- Suspends the process.

- Displays the PC arrow icon () over the stop sign to indicate that the PC is at the breakpoint.

Figure 99 – PC Arrow Over a Stop Icon

```

80 do 40 i = 1, 500
81     denorms(i) = x'00000001'
82 continue
83 do 42 i = 500, 1000
84     denorms(i) = x'80000001'
85 continue
86 local_var=100
87 ieee_array(1) = x'7f800000'      ! infinity
88 ieee_array(2) = x'ff800000'      ! -infinity
89 ieee_array(3) = x'7fc00001'      ! NANQ
90 ieee_array(4) = x'7f800001'      ! NANS
91 ieee_array(5) = x'00000001'      ! positive denormalized number
92 ieee_array(6) = x'80000001'      ! negative denormalized number

```

- Displays **At Breakpoint** in the Process Window title bar and other windows.
- Updates the Stack Trace and Stack Frame Panes and all Variable windows.

RELATED TOPICS

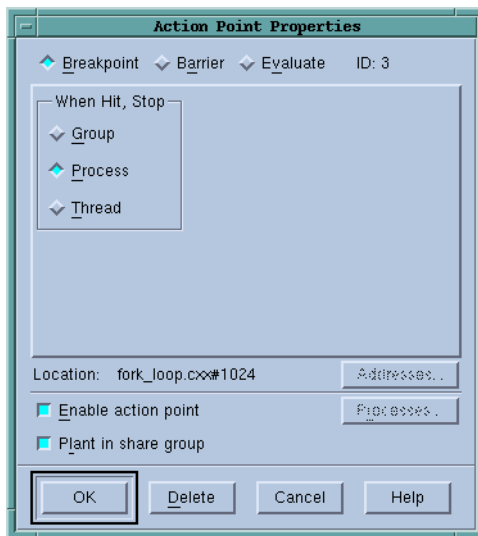
Displaying assembler code [“Viewing the Assembler Version of Your Code”](#) on page 161

Barrier points [“Setting Breakpoints and Barriers”](#) on page 179

Setting Breakpoints for Multiple Processes

In all programs, including multi-process programs, you can set breakpoints in parent and child processes before you start the program and while the program is executing. Do this using the **Action Point > Properties** Dialog Box.

Figure 100 – Action Point > Properties Dialog Box



This dialog box provides the following controls for setting breakpoints:

- **When Hit, Stop**

When your thread hits a breakpoint, TotalView can also stop the thread's **control group** or the process in which it is running.

```
CLI: dset STOP_ALL
      dbreak -p | -g | -t
```

- **Plant in share group**

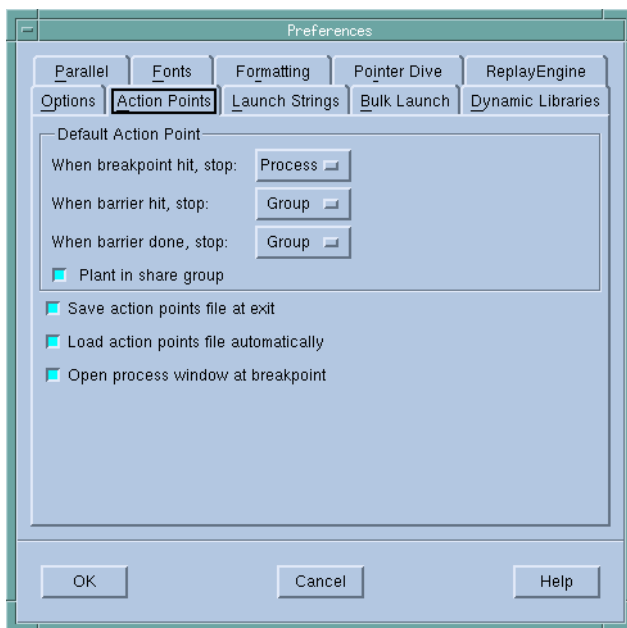
When checked, TotalView enables the breakpoint in all members of this thread's **share group** at the same time. When unchecked, you must individually enable and disable breakpoints in each member of the share group.

```
CLI: dset SHARE_ACTION_POINT
```

The **Processes** button specifies which process in a multi-process program will have enabled breakpoints. If **Plant in share group** is selected, this button is disabled since a breakpoint will be set in all of the processes.

You can preset many of the properties in this dialog box by selecting the **File > Preferences** command. Use the Action Points page to set action point preferences.

Figure 101 – File > Preferences: Action Points Page



You can find additional information about this dialog box in the online Help.

If you select the **Evaluate** button in the **Action Point > Properties** Dialog Box, you can add an expression to the action point. This expression is attached to control and **share group** members.

If you're trying to synchronize your program's threads, you need to set a barrier point.

RELATED TOPICS

Using various programming languages “Using Programming Language Elements” on page 333
in expressions

Barrier points “Setting Breakpoints and Barriers” on page 179 and “Setting Barrier Points” on page 193

Action Point > Properties dialog box **Action Point > Properties** dialog box in the in-product Help

Setting Breakpoints When Using the fork()/execve() Functions

You must link with the `dbfork` library before debugging programs that call the `fork()` and `execve()` functions. See “Compiling Programs” on page 85.

Debugging Processes That Call the fork() Function

By default, TotalView places breakpoints in all processes in a share group. (For information on share groups, see “Organizing Chaos” on page 360.) When any process in the share group reaches a breakpoint, TotalView stops all processes in the `control group`. This means that TotalView stops the control group that contains the share group. This control can contain more than one share group.

To override these defaults:

1. Dive into the line number to display the **Action Point > Properties** Dialog Box.
2. Clear the **Plant in share group** check box and make sure that the **Group** radio button is selected.

```
CLI: dset SHARE_ACTION_POINT false
```

Debugging Processes that Call the execve() Function

Shared breakpoints are not set in children that have different executables.

To set the breakpoints for children that call the `execve()` function:

1. Set the breakpoints and breakpoint options in the parent and the children that do not call the `execve()` function.
2. Start the multi-process program by displaying the **Group > Go** command.

When the first child calls the `execve()` function, TotalView displays the following message:

```
Process name has exec'd name.  
Do you want to stop it now?
```

CLI: G

3. Answer **Yes**.

TotalView opens a Process Window for the process. (If you answer **No**, you won't have an opportunity to set breakpoints.)

4. Set breakpoints for the process.

After you set breakpoints for the first child using this executable, TotalView won't prompt when other children call the **execve()** function. This means that if you do not want to share breakpoints in children that use the same executable, dive into the breakpoints and set the breakpoint options.

5. Select the **Group > Go** command.

Example: Multi-process Breakpoint

The following program excerpt illustrates the places where you can set breakpoints in a multi-process program:

```
1 pid = fork();  
2 if (pid == -1)  
3     error ("fork failed");  
4 else if (pid == 0)  
5     children_play();  
6 else  
7     parents_work();
```

The following table describes what happens when you set a breakpoint at different places:

Line Number	Result
1	Stops the parent process before it forks.
2	Stops both the parent and child processes.
3	Stops the parent process if the fork() function failed.
5	Stops the child process.
7	Stops the parent process.

RELATED TOPICS

Share groups and TotalView's default design for organizing multiple processes into groups ["Organizing Chaos"](#) on page 360

The dbfork library ["Compiling Programs"](#) on page 85, and "Linking with the dbfork Library" in the *TotalView for HPC Platforms Guide*

Setting Barrier Points

A barrier breakpoint is similar to a simple breakpoint, differing only in that it holds processes and threads that reach the barrier point. Other processes and threads continue to run. TotalView holds these processes or threads until all processes or threads defined in the barrier point reach this same place. When the last one reaches a barrier point, TotalView releases all the held processes or threads, but they do not continue executing until you explicitly restart execution. In this way, barrier points let you synchronize your program's execution.

CLI: `dbarrier`

Topics in this section are:

- [“About Barrier Breakpoint States”](#) on page 193
- [“Setting a Barrier Breakpoint”](#) on page 194
- [“Creating a Satisfaction Set”](#) on page 195
- [“Hitting a Barrier Point”](#) on page 195
- [“Releasing Processes from Barrier Points”](#) on page 196
- [“Deleting a Barrier Point”](#) on page 196
- [“Changing Settings and Disabling a Barrier Point”](#) on page 196

RELATED TOPICS

How to hold and release threads and processes

[“Holding and Releasing Processes and Threads”](#) on page 383

About Barrier Breakpoint States

Processes and threads at a barrier point are held or stopped, as follows:

- | | |
|----------------|--|
| Held | A held process or thread cannot execute until all the processes or threads in its group are at the barrier, or until you manually release it. The various <i>go</i> and <i>step</i> commands from the Group , Process , and Thread menus cannot start held processes. |
| Stopped | When all processes in the group reach a barrier point, TotalView automatically releases them. They remain stopped at the barrier point until you tell them to resume executing. |

You can manually release held processes and threads with the **Hold** and **Release** commands found in the **Group**, **Process**, and **Thread** menus. When you manually release a process, the *go* and *step* commands become available again.

CLI: `dfocus ... dhold`
`dfocus ... dunhold`

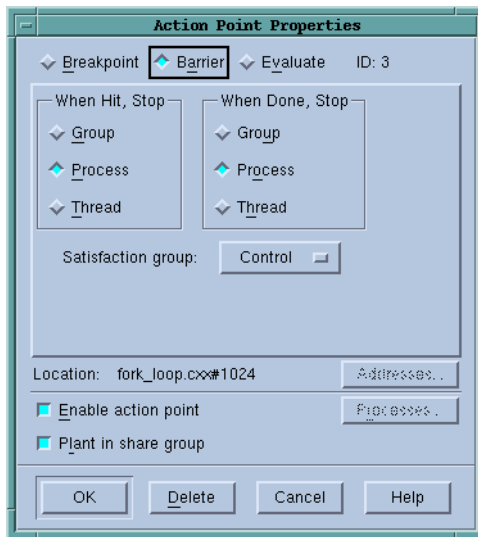
You can reuse the **Hold** command to again toggle the hold state of the process or thread. See “[Holding and Releasing Processes and Threads](#)” on page 383 for more information.

When a process or thread is held, TotalView displays **Stopped** next to the relevant process or thread in the Process State column of the Root Window.

Setting a Barrier Breakpoint

You can set a barrier breakpoint by using the **Action Point > Set Barrier** command or from the **Action Point > Properties** Dialog Box. As an alternative, you can right-click on the line. From the displayed context menu, you can select the **Set Barrier** command.

Figure 102 – Action Point > Properties Dialog Box



You most often use barrier points to synchronize a set of threads. When a thread reaches a barrier, it stops, just as it does for a breakpoint. The difference is that TotalView prevents—that is, holds—each thread reaching the barrier from responding to resume commands (for example, *step*, *next*, or *go*) until all threads in the affected set arrive at the barrier. When all threads reach the barrier, TotalView considers the barrier to be *satisfied* and releases all of the threads being held there. *They are just released; they are not continued.* That is, they are left stopped at the barrier. If you continue the process, those threads also run.

If you stop a process and then continue it, the held threads, including the ones waiting at an unsatisfied barrier, do not run. Only unheld threads run.

The **When Hit, Stop** radio buttons indicate what other threads TotalView stops when execution reaches the breakpoint, as follows:

Scope	What TotalView does:
Group	Stops all threads in the current thread's control group.
Process	Stops all threads in the current thread's process.
Thread	Stops only this thread.

CLI: `dbarrier -stop_when_hit`

After all processes or threads reach the barrier, TotalView releases all held threads. *Released* means that these threads and processes can now run.

The **When Done, Stop** radio buttons tell TotalView what else it should stop, as follows:

Scope	What TotalView does:
Group	Stops all threads in the current thread's control group.
Process	Stops all threads in the current thread's process.
Thread	Stops only this thread.

CLI: `dbarrier -stop_when_done`

Creating a Satisfaction Set

For even more control over what TotalView stops, you can select a *satisfaction set*. This setting tells TotalView which processes or threads must be held before it can release the group. That is, the barrier is *satisfied* when TotalView has held all of the indicated processes or threads. The choices from the drop-down menu for the **Satisfaction group** are **Control**, **Share**, and **Workers**. The default setting, **Control**, affects all the processes controlled by TotalView. The **Share** setting affects all the processes that share the same image as the current executable where the barrier point is set. For multi-threaded programs, to hold the threads at the barrier point, use the **Workers** setting, which holds at the thread level. **Control** and **Share** settings hold at the process level.

When you set a barrier point, TotalView places it in every process in the [share group](#).

Hitting a Barrier Point

If you run one of the processes or threads in a group and it hits a barrier point, the Root Window displays **Stopped** in the Process State column for that process's or thread's entry, and the main Process Window displays **Held** in the title bar.

CLI: `dstatus`


If you create a barrier and all the process's threads are already at that location, TotalView won't hold any of them. However, if you create a barrier and all of the processes and threads are not at that location, TotalView holds any thread that is already there.

Releasing Processes from Barrier Points

TotalView automatically releases processes and threads from a barrier point when they hit that barrier point and all other processes or threads in the group are already held at it.

Deleting a Barrier Point

You can delete a barrier point in the following ways:

- Use the **Action Point > Properties** Dialog Box.
- Click the  icon in the line number area.

```
CLI: ddelete
```

Changing Settings and Disabling a Barrier Point

Setting a barrier point at the current PC for a *stopped* process or thread holds the process there. If, however, all other processes or threads affected by the barrier point are at the same PC, TotalView doesn't hold them. Instead, TotalView treats the barrier point as if it were an ordinary breakpoint.

TotalView releases all processes and threads that are held and which have threads at the barrier point when you disable the barrier point. You can disable the barrier point in the **Action Point > Properties** Dialog Box by selecting **Enable action point** at the bottom of the dialog box.

```
CLI: ddisable
```

Defining Eval Points and Conditional Breakpoints

TotalView lets you define *eval points*. These are action points at which you have added a code fragment that TotalView executes. You can write the code fragment in C, Fortran, or assembler.

NOTE >> Assembler support is currently available on the IBM AIX operating systems. You can enable or disable TotalView's ability to compile eval points.

NOTE >> When running on many AIX systems, you can improve the performance of compiled expressions by using the **-aix_use_fast_trap** command when starting TotalView. For more information, see the *TotalView Release Notes*, available from the Rogue Wave web site. Search for "fast trap."

Topics in this section are:

- ["Setting Eval Points"](#) on page 198
- ["Creating Conditional Breakpoint Examples"](#) on page 199
- ["Patching Programs"](#) on page 200
- ["About Interpreted and Compiled Expressions"](#) on page 202
- ["Allocating Patch Space for Compiled Expressions"](#) on page 203

You can do the following when you use eval points:

- Include instructions that stop a process and its relatives. If the code fragment can make a decision whether to stop execution, it is called a *conditional breakpoint*.
- Test potential fixes for your program.
- Set the values of your program's variables.
- Automatically send data to the Visualizer. This can produce animated displays of the changes in your program's data.

You can set an eval point at any source line that generates executable code (marked with a box surrounding a line number) or a line that contains assembler-level instructions. This means that if you can set a breakpoint, you can set an eval point.

At each eval point, TotalView or your program executes the code contained in the eval point before your program executes the code on that line. Although your program can then go on to execute this source line or instruction, it can do the following instead:

- Include a **goto** in C or Fortran that transfers control to a line number in your program. This lets you test program patches.
- Execute a TotalView function. These functions can stop execution and create barriers and countdown breakpoints. For more information on these statements, see [“Using Built-in Variables and Statements”](#) on page 344.

TotalView evaluates code fragments in the context of the target program. This means that you can refer to program variables and branch to places in your program.

NOTE >> If you call a function from an eval point and there’s a breakpoint within that function, TotalView will stop execution at that point. Similarly, if there’s an eval point in the function, TotalView also evaluates that eval point.

Eval points only modify the processes being debugged—they do not modify your source program or create a permanent patch in the executable. If you save a program’s action points, however, TotalView reapplies the eval point whenever you start a debugging session for that program.

NOTE >> You should stop a process before setting an eval point in it. This ensures that the eval point is set in a stable context.

RELATED TOPICS

Saving eval points	“Saving Action Points to a File” on page 213
Writing code for an expression	“Using Programming Language Elements” on page 333
TotalView’s expression system	“Evaluating Expressions” on page 327
Using built-in TotalView statements to control execution	“Using Built-In Statements” on page 345

Setting Eval Points

This section contains the steps you must follow to create an eval point. These steps are as follows:

1. Display the **Action Point > Properties** Dialog Box. You can do this, for example, by right-clicking a **STOP** icon and selecting **Properties** or by selecting a line and then invoking the command from the menu bar.
2. Select the **Evaluate** button at the top of the dialog box.

3. Select the button for the language in which you plan to write the fragment.
4. Type the code fragment. For information on supported C, Fortran, and assembler language constructs, see [“Using Programming Language Elements”](#) on page 333.
5. For multi-process programs, decide whether to share the eval point among all processes in the program’s share group. By default, TotalView selects the **Plant in share group** check box for multi-process programs, but you can override this by clearing this setting.
6. Select the **OK** button to confirm your changes.

If the code fragment has an error, TotalView displays an error message. Otherwise, it processes the code, closes the dialog box, and places an **EVAl** icon on the line number in the Source Pane.

```
CLI: dbreak -e
     dbarrier -e
```

The variables that you refer to in your eval point can either have a global scope or be local to the block of the line that contains the eval point. If you declare a variable in the eval point, its scope is the block that contains the eval point unless, for example, you declare it in some other scope or declare it to be a static variable.

Creating Conditional Breakpoint Examples

The following are examples that show how you can create conditional breakpoints:

- The following example defines a breakpoint that is reached whenever the **counter** variable is greater than 20 but less than 25:

```
if (counter > 20 && counter < 25) $stop;
```
- The following example defines a breakpoint that stops execution every tenth time that TotalView executes the **\$count** function

```
$count 10
```
- The following example defines a breakpoint with a more complex expression:

```
$count my_var * 2
```

When the **my_var** variable equals **4**, the process stops the eighth time it executes the **\$count** function. After the process stops, TotalView reevaluates the expression. If **my_var** equals **5**, the process stops again after the process executes the **\$count** function ten more times.

The TotalView internal counter is a static variable, which means that TotalView remembers its value every time it executes the eval point. Suppose you create an eval point within a loop that executes 120 times and the eval point contains **\$count 100**. Also assume that the loop is within a subroutine. As expected, TotalView stops execution the 100th time the eval point executes. When you resume execution, the remaining 20 iterations occur.

The next time the subroutine executes, TotalView stops execution after 80 iterations because it will have counted the 20 iterations from the last time the subroutine executed.

There is good reason for this behavior. Suppose you have a function that is called from lots of different places from within your program. Because TotalView remembers every time a statement executes, you could, for example, stop execution every 100 times the function is called. In other words, while **\$count** is most often used within loops, you can use it outside of them as well.

For descriptions of the **\$stop**, **\$count**, and variations on **\$count**, see “Using Built-in Variables and Statements” on page 344.

Patching Programs

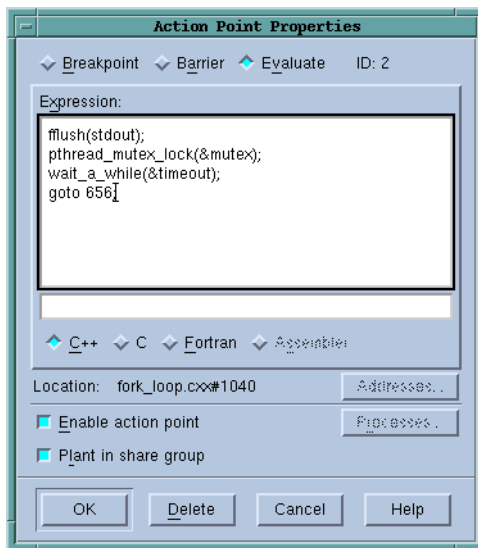
Eval points let you patch your programs and route around code that you want replaced, supporting:

- Branching around code that you don't want your program to execute.
- Adding new statements.

In many cases, correcting an error means that you will do both operations: use a **goto** to branch around incorrect lines and add corrections.

For example, suppose you need to change several statements. Just add these to an action point, then add a **goto** (C) or **GOTO** (Fortran) statement that jumps over the code you no longer want executed. For example, the eval point in [Figure 103](#) executes three statements and then skips to line 656.

Figure 103 – Patching Using an Eval Point



Branching Around Code

The following example contains a logic error where the program dereferences a null pointer:

```
1 int check_for_error (int *error_ptr)
```

```

2  {
3  *error_ptr = global_error;
4  global_error = 0;
5  return (global_error != 0);
6  }

```

The error occurs because the routine that calls this function assumes that the value of **error_ptr** can be 0. The **check_for_error()** function, however, assumes that **error_ptr** isn't null, which means that line 3 can dereference a null pointer.

You can correct this error by setting an eval point on line 3 and entering:

```
if (error_ptr == 0) goto 4;
```

If the value of **error_ptr** is null, line 3 isn't executed. Note that you are not naming a label used in your program. Instead, you are naming one of the line numbers generated by TotalView.

Adding a Function Call

The example in the previous section routed around the problem. If all you wanted to do was monitor the value of the **global_error** variable, you can add a **printf()** function call that displays its value. For example, the following might be the eval point to add to line 4:

```
printf ("global_error is %d\n", global_error);
```

TotalView executes this code fragment before the code on line 4; that is, this line executes before **global_error** is set to 0.

Correcting Code

The following example contains a coding error: the function returns the maximum value instead of the minimum value:

```

1  int minimum (int a, int b)
2  {
3  int result;          /* Return the minimum */
4  if (a < b)
5      result = b;
6  else
7      result = a;
8  return (result);
9  }

```

Correct this error by adding the following code to an eval point at line 4:

```
if (a < b) goto 7; else goto 5;
```

This effectively replaces the **if** statement on line 4 with the code in the eval point.

About Interpreted and Compiled Expressions

On all platforms, TotalView can interpret your eval points. On IBM AIX platforms, TotalView can also compile them. Compiling the expressions in eval points is *not* the default so you must explicitly request it.

With compiled eval points, performance will be significantly better, particularly if your program is using multi-processors. This is because interpreted eval points are single-threaded through the TotalView process. In contrast, compiled eval points execute on each processor.

The **TV::compile_expressions** CLI variable enables or disables compiled expressions. See “*Operating Systems*” in the *TotalView for HPC Reference Guide* for information about how TotalView handles expressions on specific platforms.

NOTE >> Using any of the following functions forces TotalView to interpret the eval point rather than compile it: **\$clid**, **\$duid**, **\$nid**, **\$processduid**, **\$systid**, **\$tid**, **\$pid**, and **\$visualize**.

About Interpreted Expressions

Interpreted expressions are interpreted by TotalView. Interpreted expressions run slower, possibly much slower, than compiled expressions. With multi-process programs, interpreted expressions run even more slowly because processes may need to wait for TotalView to execute the expression.

When you debug remote programs, interpreted expressions always run slower because the TotalView process on the host, not the TotalView server (**tvdsvr**) on the client, interprets the expression. For example, an interpreted expression could require that 100 remote processes wait for the TotalView process on the host machine to evaluate one interpreted expression. In contrast, if TotalView compiles the expression, it evaluates them on each remote process.

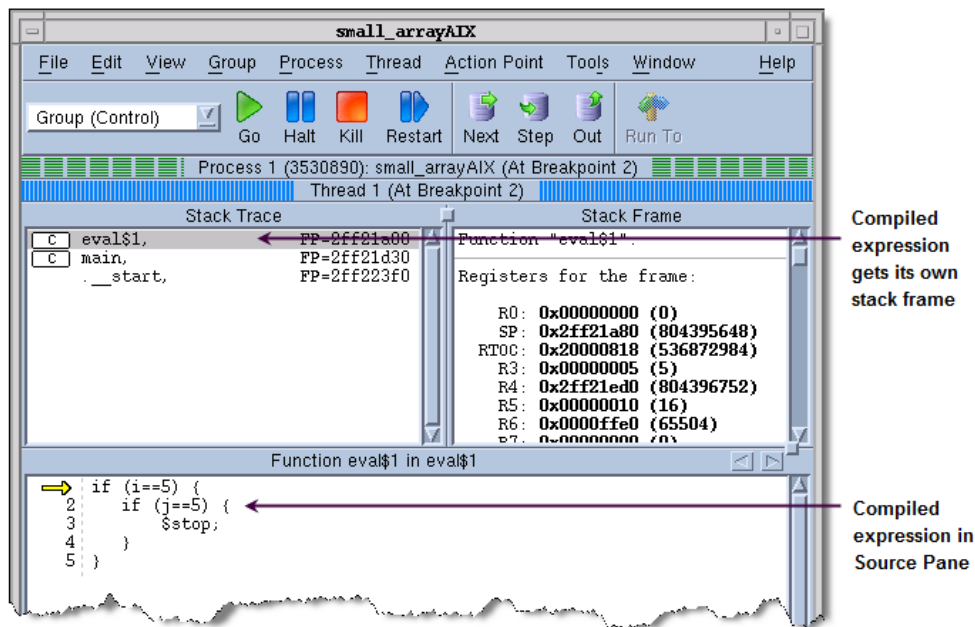
NOTE >> Whenever a thread hits an interpreted eval point, TotalView stops execution. This means that TotalView creates a new set of **lockstep groups**. Consequently, if goal threads contain interpreted patches, the results are unpredictable.

About Compiled Expressions

TotalView compiles, links, and patches expressions into the target process. Because the target thread executes this code, eval points and conditional breakpoints execute very quickly. (Conditional watchpoints are always interpreted.) Also, this code doesn't communicate with the TotalView host process until it needs to.

If the expression executes a **\$stop** function, TotalView stops executing the compiled expression. At this time, you can single-step through it and continue executing the expression as you would the rest of your code.

Figure 104 – Stopped Execution of Compiled Expressions



If you plan to use many compiled expressions or your expressions are long, you may need to think about allocating patch space. For more information, see the section “Allocating Patch Space for Compiled Expressions” on page 203.

RELATED TOPICS

The `TV::compile_expressions` variable

`TV::compile_expressions` in "TotalView Variables" in the *TotalView for HPC Reference Guide*

Allocating Patch Space for Compiled Expressions

TotalView must either allocate or find space in your program to hold the code that it generates for compiled expressions. Since this patch space is part of your program’s **address space**, the location, size, and allocation scheme that TotalView uses might conflict with your program. As a result, you may need to change how TotalView allocates this space.

You can choose one of the following patch space allocation schemes:

- **Dynamic patch space allocation:** Tells TotalView to dynamically find the space for your expression’s code.
- **Static patch space allocation:** Tells TotalView to use a statically allocated area of memory.

Allocating Dynamic Patch Space

Dynamic patch space allocation means that TotalView dynamically allocates patch space for code fragments. If you do not specify the size and location for this space, TotalView allocates 1 MB. TotalView creates this space using system calls.

TotalView allocates memory for read, write, and execute access in the addresses shown in the following table:

Platform	Address Range
IBM AIX (-q32)	0xEFF00000 - 0xEFFFFFFF
IBM AIX (-q64)	0x07f0000000000000 - 0x07fffffffffffffff

NOTE >> You can allocate dynamic patch space only for the computers listed in this table.

If the default address range conflicts with your program, or you would like to change the size of the dynamically allocated patch space, you can change the following:

- *Patch space base address* by using the **-patch_area_base** command-line option.
- *Patch space length* by using the **-patch_area_length** command-line option.

RELATED TOPICS

The **TV::comline_patch_area_base** variable

TV::comline_patch_area_base in "TotalView Variables" in the *TotalView for HPC Reference Guide*

The **TV::comline_patch_area_length** variable

TV::comline_patch_area_length in "TotalView Variables" in the *TotalView for HPC Reference Guide*

Allocating Static Patch Space

TotalView can statically allocate patch space if you add a specially named array to your program. When TotalView needs to use patch space, it uses the space created for this array.

You can include, for example, a 1 MB statically allocated patch space in your program by adding the **TVDB_patch_base_address** data object in a C module. Because this object must be 8-byte aligned, declare it as an array of doubles; for example:

```
/* 1 megabyte == size TV expects */
#define PATCH_LEN 0x100000
double TVDB_patch_base_address [PATCH_LEN / sizeof(double)]
```

If you need to use a static patch space size that differs from the 1 MB default, you must use assembler language. The following table shows sample assembler code for IBM AIX-Power and Blue Gene/Q:

Platform	Assembler Code
----------	----------------

IBM AIX-Power	<pre>.csect .data{RW}, 3 .globl TVDB_patch_base_address .globl TVDB_patch_end_address TVDB_patch_base_address: .space PATCH_SIZE TVDB_patch_end_address:</pre>
---------------	--

Blue Gene/Q	<pre>.section .TVDB_patch_space,"awx" .globl TVDB_patch_base_address .globl TVDB_patch_end_address TVDB_patch_base_address: .space 1024*1024,0 TVDB_patch_end_address: .previous</pre>
-------------	--

To use the static patch space assembler code:

1. Use an ASCII editor and place the assembler code into a file named **tvdb_patch_space.s**.
2. Replace the **PATCH_SIZE** tag with the decimal number of bytes you want. This value must be a multiple of 8.
3. Assemble the file into an object file by using a command such as:

```
cc -c tvdb_patch_space.s
```
4. Link the resulting **tvdb_patch_space.o** into your program.

Using Watchpoints

TotalView lets you monitor the changes that occur to memory locations by creating a special type of action point called a *watchpoint*. You most often use watchpoints to find a statement in your program that is writing to places to which it shouldn't be writing. This can occur, for example, when processes share memory and more than one process writes to the same location. It can also occur when your program writes off the end of an array or when your program has a dangling pointer.

Topics in this section are:

- [“Using Watchpoints on Different Architectures”](#) on page 206
- [“Creating Watchpoints”](#) on page 208
- [“Watching Memory”](#) on page 210
- [“Triggering Watchpoints”](#) on page 210
- [“Using Conditional Watchpoints”](#) on page 211

TotalView watchpoints are called *modify watchpoints* because TotalView only *triggers* a watchpoint when your program modifies a memory location. If a program writes a value into a location that is the same as what is already stored, TotalView doesn't trigger the watchpoint because the location's value did not change.

For example, if location 0x10000 has a value of 0 and your program writes a value of 0 to this location, TotalView doesn't trigger the watchpoint, even though your program wrote data to the memory location. See [“Triggering Watchpoints”](#) on page 210 for more details on when watchpoints trigger.

You can also create *conditional watchpoints*. A conditional watchpoint is similar to a conditional breakpoint in that TotalView evaluates the expression when the value in the watched memory location changes. You can use conditional watchpoints for a number of purposes. For example, you can use one to test whether a value changes its sign—that is, it becomes positive or negative—or whether a value moves above or below some threshold value.

RELATED TOPICS

Breakpoints and barrier points	“Setting Breakpoints and Barriers” on page 179
Defining eval points and conditional breakpoints	“Defining Eval Points and Conditional Breakpoints” on page 197

Using Watchpoints on Different Architectures

The number of watchpoints, and their size and alignment restrictions, differ from platform to platform. This is because TotalView relies on the operating system and its hardware to implement watchpoints.

Watchpoint support depends on the target platform where your application is running, not on the host platform where TotalView is running. For example, if you are running TotalView on host platform "H" (where watchpoints are not supported), and debugging a program on target platform "T" (where watchpoints are supported), you can create a watchpoint in a process running on "T", but not in a process running on "H".

NOTE >> Watchpoints are not available on the following target platforms: Mac OS X, and Linux-Power.

The following list describes constraints that exist on each platform:

Computer	Constraints
Blue Gene/L and Blue Gene/P	On Blue Gene/L and Blue Gene/P, you can create one watchpoint. TotalView sets the data address compare (DAC) registers of the PPC440 Embedded Processor to watch for memory writes to a range of addresses, specified by a watched address and length. The watchpoint triggers if the referenced data address is greater than or equal to the watched address and less than the watched address plus length.
Blue Gene/Q	On Blue Gene/Q, you can create two watchpoints. TotalView sets a watchpoint using the IBM CDTI debugging interface for memory writes to a range of addresses, specified by a watched address and length. The watchpoint triggers if the referenced data address is greater than or equal to the watched address and less than the watched address plus length. The watched length must be a power of 2, and the watched address must be aligned to that power of 2; that is, <code>(address % length) == 0</code> .
IBM AIX	<p>You can create one watchpoint on AIX 4.3.3.0-2 (AIX 4.3R) or later systems running 64-bit chips. These are Power3 and Power4 systems. (AIX 4.3R is available as APAR IY06844.) A watchpoint cannot be longer than 8 bytes, and you must align it within an 8-byte boundary. If your watchpoint is less than 8 bytes and it doesn't span an 8-byte boundary, TotalView figures out what to do.</p> <p>You can create compiled conditional watchpoints when you use this system. When watchpoints are compiled, they are evaluated by the process rather than having to be evaluated in TotalView where all evaluations are single-threaded and must be sent from separately executing processes. Only systems having fast traps can have compiled watchpoints.</p>
Linux x86	You can create up to four watchpoints and each must be 1, 2, or 4 bytes in length, and a memory address must be aligned for the byte length. That is, you must align a 4-byte watchpoint on a 4-byte address boundary, and you must align a 2-byte watchpoint on a 2-byte boundary, and so on.
Linux x86-64 (AMD and Intel)	You can create up to four watchpoints and each must be 1, 2, 4, or 8 bytes in length, and a memory address must be aligned for the byte length. For example, you must align a 4-byte watchpoint on a 4-byte address boundary.

Computer	Constraints
Linux-PowerLE	<p>On Linux-PowerLE platforms (but not Linux-Power big-endian platforms) TotalView uses the Linux kernel's <code>ptrace()</code> PowerPC hardware debug extension to plant watchpoints. The <code>ptrace()</code> interface implements a “hardware breakpoint” abstraction that reflects the capabilities of PowerPC BookE and server processors. If supported at all, the number of watchpoints varies by processor type. Typically, the PowerPC supports at least 1 watchpoint up to 8 bytes long. Systems with the DAWR feature support a watchpoint up to 512 bytes long. The watchpoint triggers if the referenced data address is greater than or equal to the watched address and less than the watched address plus length. Alignment constraints may apply. For example, the watched length may be required to be a power of 2, and the watched address may need to be aligned to that power of 2; that is,</p> <pre>(address % length) == 0.</pre>
Linux IA-64	<p>You can create up to four watchpoints. The length of the memory being watched must be a power of 2 and the address must be aligned to that power of 2; that is,</p> <pre>(address % length) == 0.</pre>
Solaris SPARC and Solaris x86	<p>TotalView supports watchpoints on Solaris 7 or later operating systems. These operating systems let you create hundreds of watchpoints, and there are no alignment or size constraints. However, watchpoints can't overlap.</p>

Typically, a debugging session doesn't use many watchpoints. In most cases, you are only monitoring one memory location at a time. Consequently, restrictions on the number of values you can watch seldom cause problems.

Creating Watchpoints

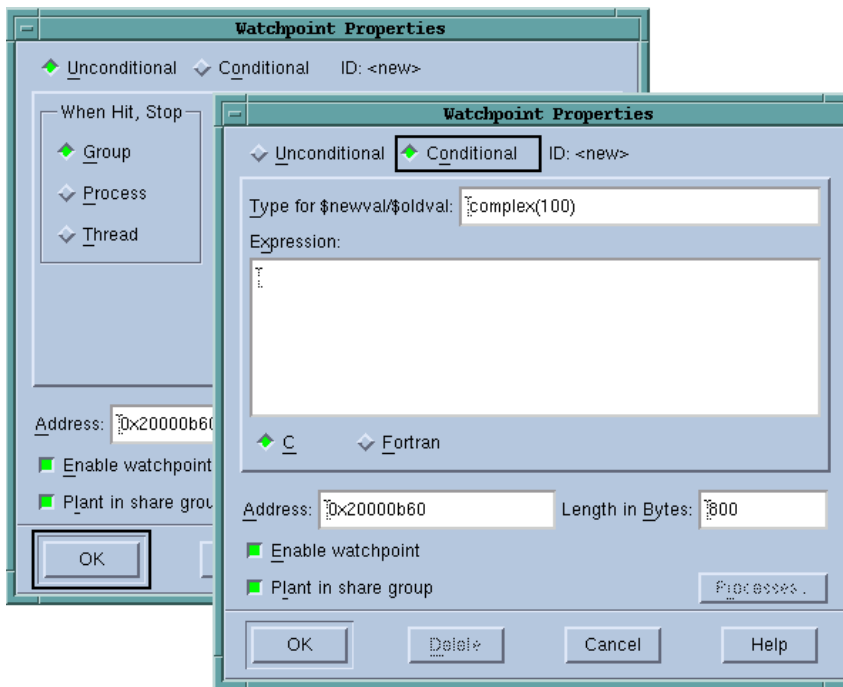
Watchpoints are created by using either the **Action Points > Create Watchpoint** command in the Process Window or the **Tools > Create Watchpoint** Dialog Box. (If your platform doesn't support watchpoints, TotalView dims this menu item.) Here are some things you should know:

- You can also set watchpoints by right-clicking within the Process and Variable Windows and then select **Create Watchpoint** from the context menu.
- You can select an expression within the Source and Stack Frame panes and then use a context menu or select the **Action Points > Create Watchpoint** command. If you invoke either of these commands and TotalView cannot determine where to set the expression, it displays a dialog box into which you type the variable's name.
- If you select the **Tools > Create Watchpoint** command and a compound variable such an array or structure is being displayed, TotalView sets the watchpoint on the first element. However, if you select an element before invoking this command, TotalView sets the watchpoint on that element.

If you set a watchpoint on a stack variable, TotalView reports that you're trying to set a watchpoint on "non-global" memory. For example, the variable is on the stack or in a block and the variable will no longer exist when the stack is popped or control leaves the block. In either of these cases, it is likely that your program will overwrite the memory and the watchpoint will no longer be meaningful. See "Watching Memory" on page 210 for more information.

After you select a **Create Watchpoint** command, TotalView displays its Watchpoint Properties dialog box.

Figure 105 – Tools > Watchpoint Dialog Boxes



Controls in this dialog box let you create unconditional and conditional watchpoints. When you set a watchpoint, you are setting it on the complete contents of the information being displayed in the Variable Window. For example, if the Variable Window displays an array, you can only set a watchpoint on the entire array (or as many bytes as TotalView can watch.) If you only want to watch one array element, dive on the element and then set the watchpoint. Similarly, if the Variable Window displays a structure and you only want to watch one element, dive on the element before you set the watchpoint.

RELATED TOPICS

The **Tools > Create Watchpoint** command **Tools > Create Watchpoint** in the in-product Help

Displaying Watchpoints

The watchpoint entry, indicated by UDWP (Unconditional Data Watchpoint) and CDWP (Conditional Data Watchpoint), displays the action point ID, the amount of memory being watched, and the location being watched.

If you select a watchpoint, TotalView toggles the enabled/disabled state of the watchpoint.

Watching Memory

A watchpoint tracks a memory location—it does not track a variable. This means that a watchpoint might not perform as you would expect it to when watching stack or automatic variables. For example, suppose that you want to watch a variable in a subroutine. When control exits from the subroutine, the memory allocated on the stack for this subroutine is deallocated. At this time, TotalView is watching unallocated stack memory. When the stack memory is reallocated to a new stack **frame**, TotalView is still watching this same position. This means that TotalView triggers the watchpoint when something changes this newly allocated memory.

Also, if your program reinvokes a subroutine, it usually executes in a different stack location. TotalView cannot monitor changes to the variable because it is at a different memory location.

All of this means that in most circumstances, you shouldn't place a watchpoint on a stack variable. If you need to watch a stack variable, you will need to create and delete the watchpoint each time your program invokes the subroutine.

This doesn't mean you can't place a watchpoint on a stack or heap variable. It just means that what happens is undefined after this memory is released. For example, after you enter a routine, you can be assured that memory locations are always tracked accurately until the memory is released.

NOTE >> In some circumstances, a subroutine may be called from the same location. This means that its local variables might be in the same location. So, you might want to try.

If you place a watchpoint on a global or static variable that is always accessed by reference (that is, the value of a variable is always accessed using a pointer to the variable), you can set a watchpoint on it because the memory locations used by the variable are not changing.

Triggering Watchpoints

When a watchpoint triggers, the thread's program counter (PC) points to the instruction *following* the instruction that caused the watchpoint to trigger. If the memory store instruction is the last instruction in a source statement, the PC points to the source line *following* the statement that triggered the watchpoint. (Breakpoints and watchpoints work differently. A breakpoint stops *before* an instruction executes. In contrast, a watchpoint stops *after* an instruction executes.)

Using Multiple Watchpoints

If a program modifies more than one byte with one program instruction or statement, which is normally the case when storing a word, TotalView triggers the watchpoint with the lowest memory location in the modified region. Although the program might be modifying locations monitored by other watchpoints, TotalView only triggers the watchpoint for the lowest memory location. This can occur when your watchpoints are monitoring adjacent memory locations and a single store instruction modifies these locations.

For example, suppose that you have two 1-byte watchpoints, one on location 0x10000 and the other on location 0x10001. Also suppose that your program uses a single instruction to store a 2-byte value at locations 0x10000 and 0x10001. If the 2-byte storage operation modifies both bytes, the watchpoint for location 0x10000 triggers. The watchpoint for location 0x10001 does not trigger.

Here's a second example. Suppose that you have a 4-byte integer that uses storage locations 0x10000 through 0x10003, and you set a watchpoint on this integer. If a process modifies location 0x10002, TotalView triggers the watchpoint. Now suppose that you're watching two adjacent 4-byte integers that are stored in locations 0x10000 through 0x10007. If a process writes to locations 0x10003 and 0x10004 (that is, one byte in each), TotalView triggers the watchpoint associated with location 0x10003. The watchpoint associated with location 0x10004 does not trigger.

Copying Previous Data Values

TotalView keeps an internal copy of data in the watched memory locations for each process that shares the watchpoint. If you create watchpoints that cover a large area of memory or if your program has a large number of processes, you increase TotalView's virtual memory requirements. Furthermore, TotalView refetches data for each memory location whenever it continues the process or thread. This can affect performance.

Using Conditional Watchpoints

If you associate an expression with a watchpoint (by selecting the **Conditional** button in the Watchpoint Properties dialog box entering an expression), TotalView evaluates the expression after the watchpoint triggers. The programming statements that you can use are identical to those used when you create an eval point, except that you can't call functions from a watchpoint expression.

The variables used in watchpoint expressions must be global. This is because the watchpoint can be triggered from any procedure or scope in your program.

NOTE >> Fortran does not have global variables. Consequently, you can't directly refer to your program's variables.

TotalView has two variables that are used exclusively with conditional watchpoint expressions:

\$oldval The value of the memory locations before a change is made.

`$newval` The value of the memory locations after a change is made.

The following is an expression that uses these values:

```
if (iValue != 42 && iValue != 44) {  
    iNewValue = $newval; iOldValue = $oldval; $stop;}
```

When the value of the **iValue** global variable is neither 42 nor 44, TotalView stores the new and old memory values in the **iNewValue** and **iOldValue** variables. These variables are defined in the program. (Storing the old and new values is a convenient way of letting you monitor the changes made by your program.)

The following condition triggers a watchpoint when a memory location's value becomes negative:

```
if ($oldval >= 0 && $newval < 0) $stop
```

And, here is a condition that triggers a watchpoint when the sign of the value in the memory location changes:

```
if ($newval * $oldval <= 0) $stop
```

Both of these examples require that you set the **Type for \$oldval/\$newval** field in the **Watchpoint Properties** Dialog Box.

For more information on writing expressions, see “Using Programming Language Elements” on page 333.

If a watchpoint has the same length as the **\$oldval** or **\$newval** data type, the value of these variables is apparent. However, if the data type is shorter than the length of the watch region, TotalView searches for the first changed location in the watched region and uses that location for the **\$oldval** and **\$newval** variables. (It aligns data in the watched region based on the size of the data's type. For example, if the data type is a 4-byte integer and byte 7 in the watched region changes, TotalView uses bytes 4 through 7 of the watchpoint when it assigns values to these variables.)

For example, suppose you're watching an array of 1000 integers called **must_be_positive**, and you want to trigger a watchpoint as soon as one element becomes negative. You declare the type for **\$oldval** and **\$newval** to be **int** and use the following condition:

```
if ($newval < 0) $stop;
```

When your program writes a new value to the array, TotalView triggers the watchpoint, sets the values of **\$oldval** and **\$newval**, and evaluates the expression. When **\$newval** is negative, the **\$stop** statement halts the process.

This can be a very powerful technique for range-checking all the values your program writes into an array. (Because of byte length restrictions, you can only use this technique on Solaris.)

NOTE >> On all platforms except for IBM AIX, TotalView always interprets conditional watchpoints; it never compiles them. Because interpreted watchpoints are single-threaded in TotalView, every process or thread that writes to the watched location must wait for other instances of the watchpoint to finish executing. This can adversely affect performance.

Saving Action Points to a File

You can save a program's action points to a file. TotalView then uses this information to reset these points when you restart the program. When you save action points, TotalView creates a file named *program_name.TVD.v3breakpoints*, where *program_name* is the name of your program.

NOTE >> TotalView does not save watchpoints because memory addresses can change radically every time you restart TotalView and your program.

Use the **Action Point > Save All** command to save your action points to a file. TotalView places the action points file in the same directory as your program. In contrast, the **Action Point > Save As** command lets you name the file to which TotalView saves this information.

```
CLI: dactions -save filename
```

If you're using a preference to automatically save breakpoints, TotalView automatically saves action points to a file. Alternatively, starting TotalView with the **-sb** option (see "*TotalView Command Syntax*" in the *TotalView for HPC Reference Guide*) also tells TotalView to save your breakpoints.

At any time, you can restore saved action points if you use the **Action Points > Load All** command. After invoking this command, TotalView displays a File Explorer Window that you can use to navigate to or name the saved file.

```
CLI: dactions -load filename
```

You control automatic saving and loading by setting preferences. (See **File > Preferences** in the online Help for more information.)

```
CLI: dset TV::auto_save_breakpoints
```

RELATED TOPICS

The **TV::auto_save_breakpoints** variable

TV::auto_save_breakpoints in "TotalView Variables" in the *TotalView for HPC Reference Guide*

The **TV::auto_load_breakpoints** variable

TV::auto_load_breakpoints in "TotalView Variables" in the *TotalView for HPC Reference Guide*



Chapter 9

Examining and Editing Data and Program Elements

This chapter explains how to examine and edit data and view the various elements of your program, with the following sections:

- “[Changing How Data is Displayed](#)” on page 215
- “[Displaying Variables](#)” on page 220
- “[Diving in Variable Windows](#)” on page 240
- “[Viewing a List of Variables](#)” on page 246
- “[Changing the Values of Variables](#)” on page 254
- “[Changing a Variable’s Data Type](#)” on page 256
- “[Changing the Address of Variables](#)” on page 267
- “[Displaying C++ Types](#)” on page 268
- “[C++View](#)” on page 270
- “[Displaying Fortran Types](#)” on page 271
- “[Displaying Thread Objects](#)” on page 278
- “[Scoping and Symbol Names](#)” on page 280

This chapter does not discuss array data. For that information, see [Chapter 10, “Examining Arrays,”](#) on page 283.

Changing How Data is Displayed

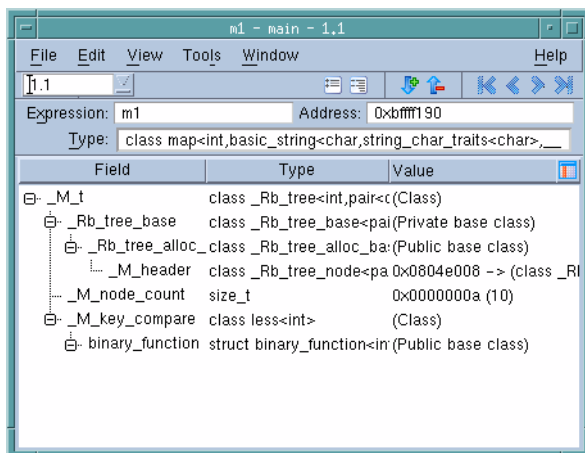
When a debugger displays a variable, it relies on the definitions of the data used by your compiler. The following two sections show how you can change the way TotalView displays this information:

- “Displaying STL Variables” on page 215
- “Changing Size and Precision” on page 218

Displaying STL Variables

The C++ STL (Standard Template Library) greatly simplifies access to data. Since it offers standard and prepackaged ways to organize data, you do not have to be concerned with the mechanics of the access method. The disadvantage to using the STL while debugging is that the information debuggers display is organized according to the compiler’s view of the data, rather than the STL’s logical view. For example, here is how your compiler sees a map compiled using the GNU C++ compiler (gcc):

Figure 106 – An Untransformed Map



Most of the information is generated by the STL template and, in most cases, is not interesting. In addition, the STL does not aggregate the information in a useful way.

STLView solves these problems by rearranging (that is, *transforming*) the data so that you can easily examine it. For example, here is the transformed map.

Figure 107 – A Transformed Map

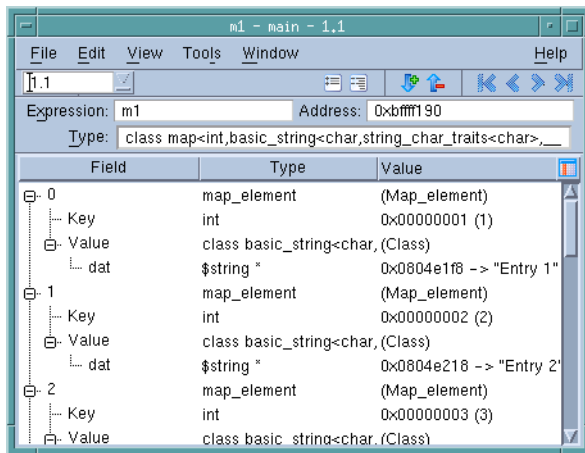
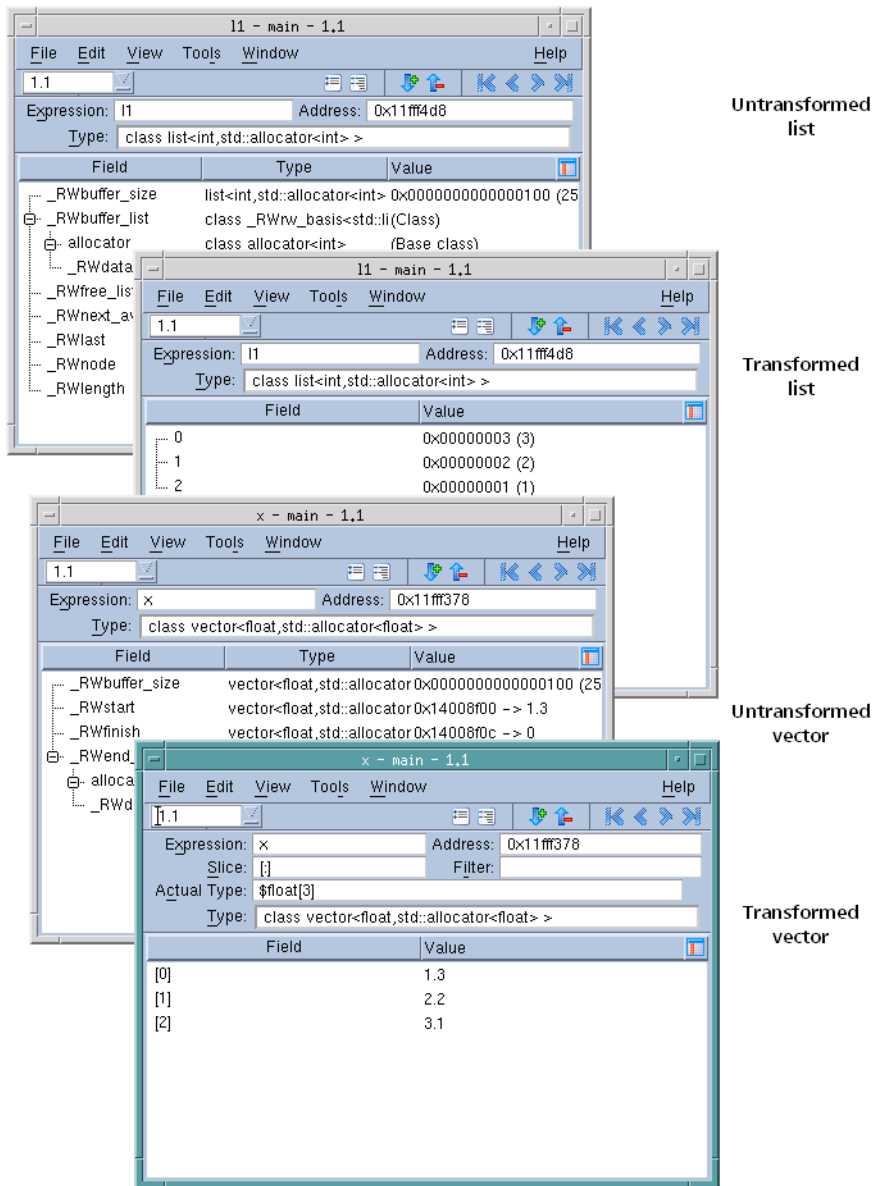


Figure 108 shows an untransformed and transformed list and vector.

Figure 108 – List and Vector Transformations



NOTE >> By default, TotalView transforms STL strings, vectors, lists, maps, multimaps, sets, and multisets. You can create transformations for other STL containers. See "Creating Type Transformations" in the *TotalView for HPC Reference Guide* for more information.

By default, TotalView transforms STL types. If you need to look at the untransformed data structures, clear the **View simplified STL containers (and user-defined transformations)** checkbox on the Options Page of the **File > Preference** Dialog Box.

```
CLI: dset TV::tff { true | false }
```

Following pointers in an STL data structure to retrieve values can be time-consuming. By default, TotalView only follows 500 pointers. You can change this by altering the value of the **TV::tff_max_length** variable.

RELATED TOPICS

General information on creating custom type transformations

"Creating Type Transformations" in the *TotalView for HPC Reference Guide*

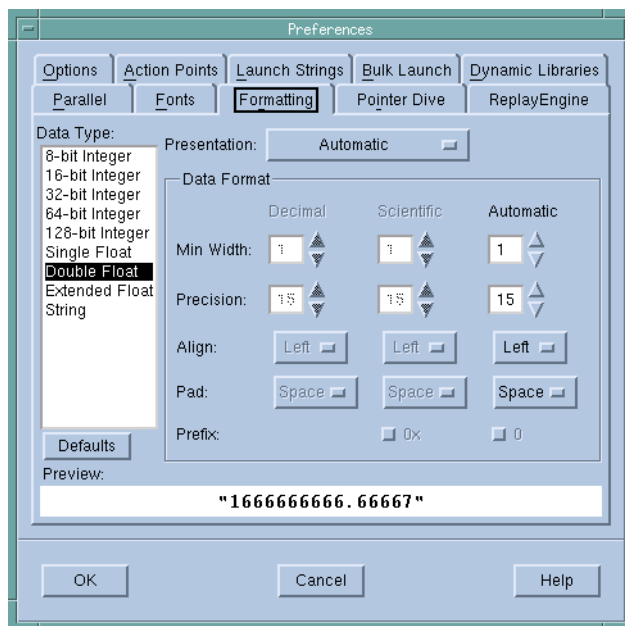
Transforming C++ types

"Displaying C++ Types" on page 268

Changing Size and Precision

If the default formats that TotalView uses to display a variable's value doesn't meet your needs, you can use the **Formatting** Page of the **File > Preferences** Dialog Box to indicate the precision for simple data types.

Figure 109 – File > Preferences Formatting Page



After selecting one of the data types listed on the left side of the Formatting Page, you can set how many character positions a value uses when TotalView displays it (**Min Width**) and how many numbers to display to the right of the decimal place (**Precision**). You can also tell TotalView how to align the value in the **Min Width** area, and if it should pad numbers with zeros or spaces.

Although the way in which these controls relate and interrelate may appear to be complex, the **Preview** area shows you the result of a change. Play with the controls for a minute or so to see what each control does. You may need to set the **Min Width** value to a larger number than you need it to be to see the results of a change. For example, if the **Min Width** value doesn't allow a number to be justified, it could appear that nothing is happening.

CLI: You can set these properties from within the CLI. To obtain a list of variables that you can set, type `"dset TV::data_format*"`.

RELATED TOPICS

The Formatting Page in the **File > Preferences** menu

The **File > Preferences Formatting Page** in the in-product Help

Data format CLI variables

A list of the TotalView data format variables in the TotalView for HPC Reference Guide

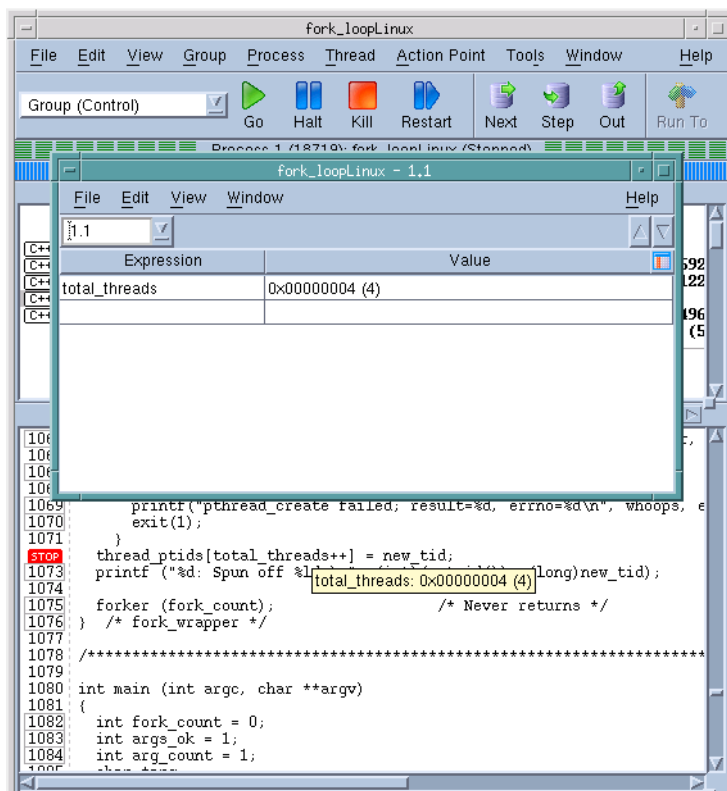
Displaying Variables

The Process Window Stack Frame Pane displays variables that are local to the current stack **frame**. This pane does not show the data for nonsimple variables, such as pointers, arrays, and structures. To see this information, dive on the variable.

NOTE >> Dive on a variable by clicking your middle mouse button on it. If your mouse doesn't have three buttons, you can single- or double-click on an item.

If you place your mouse cursor over a variable or an expression, TotalView displays its value in a tooltip window.

Figure 110 – A Tooltip



If TotalView cannot evaluate the object moused over, it still displays basic information. For example, if you place the mouse over a structure, the tooltip reports the kind of structure. In all cases, the displayed information is similar to the same information entered in the Expression List Window.

If you dive on simple variables or registers, TotalView still brings up a Variable Window and you do see some additional information about the variable or register.

Although a Variable Window is the best way to see all of an array's elements or all elements in a structure, using the Expression List Window is easier for variables with one value. Using it also cuts down on the number of windows that are open at any one time. For more information, see ["Viewing a List of Variables"](#) on page 246.

The following sections discuss how you can display variable information:

- ["Displaying Program Variables"](#) on page 221
- ["Seeing Value Changes"](#) on page 223
- ["Displaying Variables in the Current Block"](#) on page 225
- ["Viewing Variables in Different Scopes as Program Executes"](#) on page 226
- ["Scoping Issues"](#) on page 227
- ["Browsing for Variables"](#) on page 230
- ["Displaying Local Variables and Registers"](#) on page 232
- ["Dereferencing Variables Automatically"](#) on page 234
- ["Displaying Areas of Memory"](#) on page 236
- ["Displaying Machine Instructions"](#) on page 237
- ["Rebinding the Variable Window"](#) on page 238
- ["Closing Variable Windows"](#) on page 239

RELATED TOPICS

Diving in variable windows	"Diving in Variable Windows" on page 240
More on examining and editing data	"Examining and Editing Data and Program Elements" on page 214
Details on the Variable Window	The "Variable Window" in the in-product Help
Viewing lists of variables	"Viewing a List of Variables" on page 246

Displaying Program Variables

You can display local and global variables by:

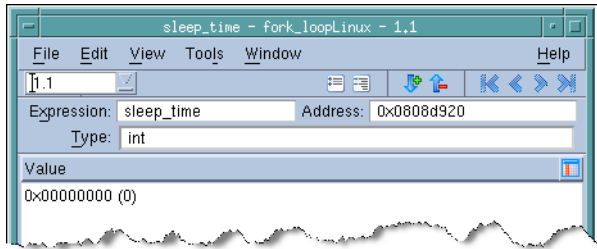
- Diving into the variable in the Source or Stack Panes.
- Selecting the **View > Lookup Variable** command. When prompted, enter the name of the variable.

```
CLI: dprint variable
```

- Using the **Tools > Program Browser** command.

After using one of these methods, TotalView displays a Variable Window that contains the information you want. The Variable Window can display simple variables, such as **ints**, sets of like elements such as arrays, or more complicated variables defined as structures and arrays of structures.

Figure 111 – Variable Window for a Global Variable



If you keep a Variable Window open while a process or thread is running, the information being displayed might not be accurate. TotalView updates the window when the process or thread stops. If TotalView can't find a stack **frame** for a displayed local variable, the variable's status is **sparse**, since the variable no longer exists. The **Status** area can contain other information that alerts you to issues and problems with a variable.

When you debug recursive code, TotalView doesn't automatically refocus a Variable Window onto different instances of a recursive function. If you have a **breakpoint** in a recursive function, you need to explicitly open a new Variable Window to see the local variable's value in that stack frame.

CLI: `dwhere`, `dup`, and `dprint`

Use **`dwhere`** to locate the stack frame, use **`dup`** to move to it, and then use **`dprint`** to display the value.

Select the **View > Compilation Scope > Floating** command to tell TotalView that it can refocus a Variable Window on different instances. For more information, see "[Viewing Variables in Different Scopes as Program Executes](#)" on page 226.

RELATED TOPICS

Using the Process Window "[Using the Process Window](#)" on page 148

Viewing lists of variables "[Viewing a List of Variables](#)" on page 246

Controlling the Displayed Information



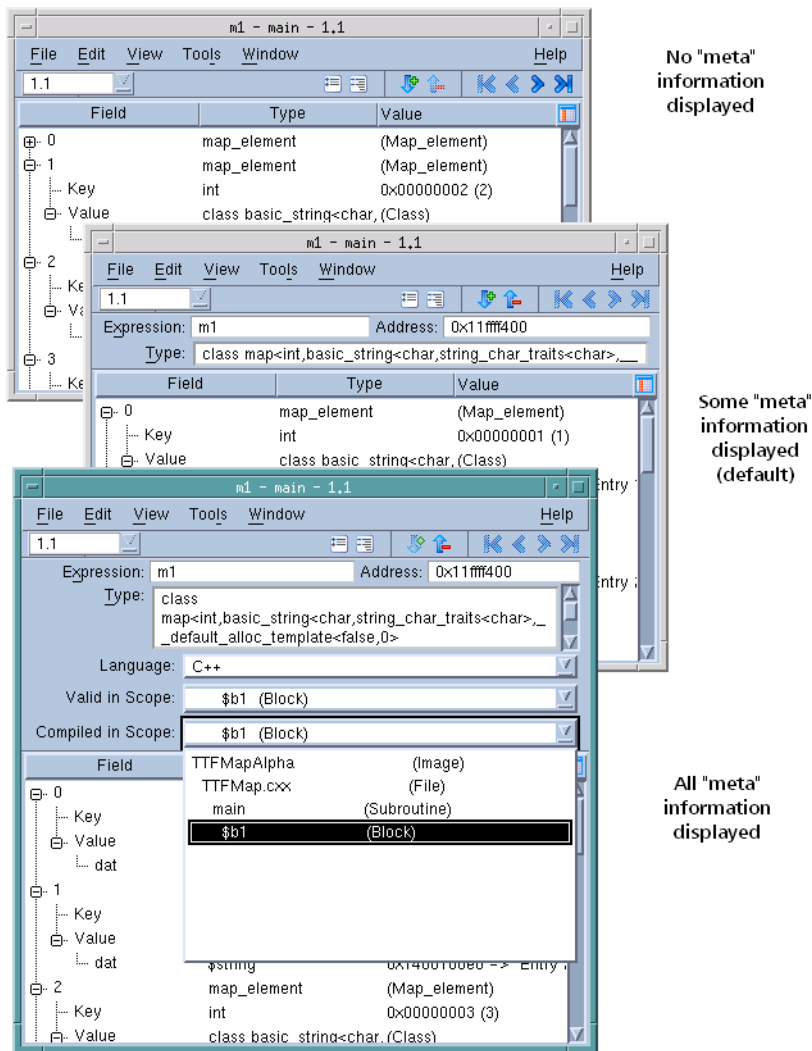
TotalView can display more information about your variable than its value. This information is sometimes called *meta-information*. You can control how much of this meta-information it displays by clicking on the **More**  and **Less**  buttons.

Figure 112 – Variable Window: Using More and Less



As the button names indicate, clicking **More** displays more meta-information and clicking **Less** displays less of it.

The two most useful fields are **Type**, which shows you what your variable's actual type is, and **Expression**, which allows you to control what is being displayed. This is sometimes needed because TotalView tries to show the type in the way that it thinks you declared it in your program.

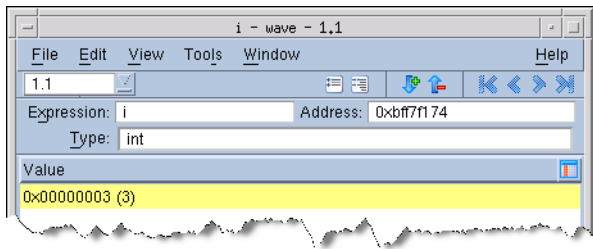
The online help describes all the meta-information fields.

Seeing Value Changes

TotalView reports when a variable's value changes in several ways.

- When your program stops at a breakpoint, TotalView adds a yellow highlight to the variable's value if it has changed, Figure 113

Figure 113 – Variable Window With “Change” Highlighting



If the thread is stopped for another reason—for example, you’ve stepped the thread—and the value has changed, TotalView does not add yellow highlighting to the line.


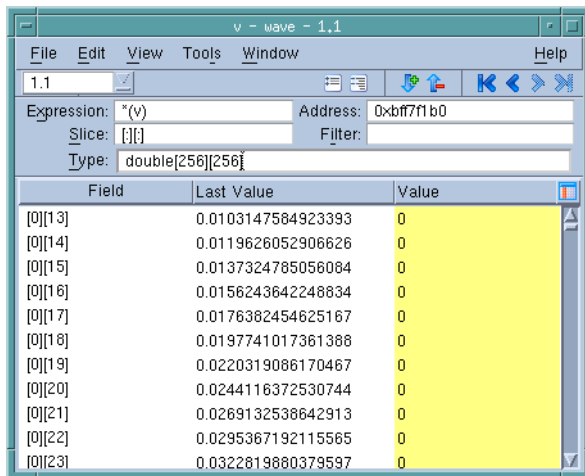
- You can tell TotalView to display the **Last Value** column. Do this by selecting **Last Value** in the column menu, which is displayed after you click on the column menu () icon, Figure 114.

Figure 114 – Variable Window Showing Last Value Column



Notice that TotalView has highlighted all items that have changed within an array. In a similar fashion it can show the individual items that have changed within a structure.

In general, TotalView only retains the value for data items displayed within the Variable Window. At times, TotalView may track adjacent values within arrays and structures, but you should not rely on additional items being tracked.

NOTE >> When you scroll the Variable Window, TotalView discards the information it is tracking and fetches new information. So, while the values may have changed, TotalView does not have information about this change. That is, TotalView only tracks what is visible. Similarly, when you scroll back to previously displayed values, TotalView needs to refetch this information. Because it is “new” information, no “last values” exist.

The Expression List window, described in “[Viewing a List of Variables](#)” on page 246, also highlights data and can display a **Last Value** column.

Seeing Structure Information

When TotalView displays a Variable Window, it displays structures in a compact form, concealing the elements within the structure. Click the **+** button to display these elements, or select the **View > Expand All** command to see all entries. If you want to return the display to a more compact form, you can click the **-** button to collapse one structure, or select the **View > Collapse All** command to return the window to what it was when you first opened it.

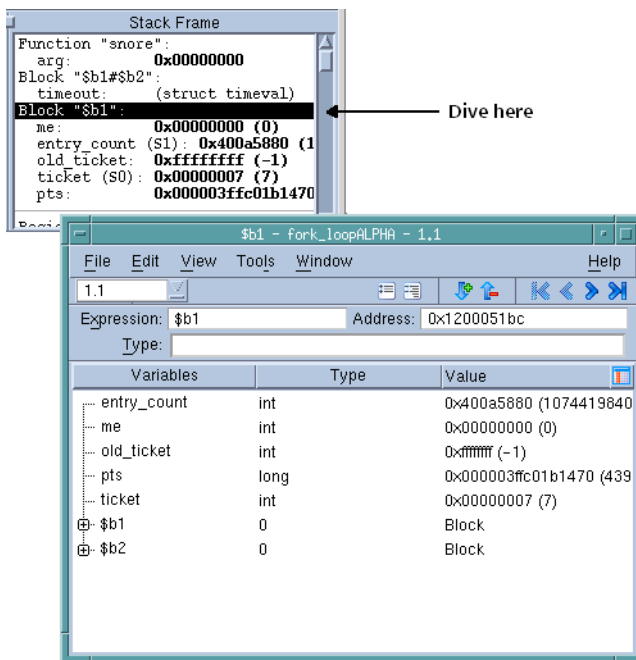
If a substructure contains more than about forty elements, TotalView does not let you expand it in line. That is, it does not place a **+** symbol in front of the substructure. To see the contents of this substructure, dive on it.

Similarly, if a structure contains an array as an element, TotalView only displays the array within the structure if it has fewer than about forty elements. To see the contents of an embedded array, dive on it.

Displaying Variables in the Current Block

In many cases, you may want to see all of the variables in the current block. If you dive on a block label in the Stack Frame Pane, TotalView opens a Variable Window that contains just those variables.

Figure 115 – Displaying Scoped Variables



After you dive on a variable in this block window, TotalView displays a Variable Window for that scoped variable. In this figure, block **\$b1** has two nested blocks.

RELATED TOPICS

Using the Process Window

["Using the Process Window" on page 148](#)

Viewing Variables in Different Scopes as Program Executes

When TotalView displays a Variable Window, it understands the scope in which the variable exists. As your program executes, this scope doesn't change. In other words, if you're looking at variable **my_var** in one routine, and you then execute your program until it is within a second subroutine that also has a **my_var** variable, TotalView does not change the scope so that you are seeing the *in scope* variable.

If you would like TotalView to update a variable's scope as your program executes, select the **View > Compilation Scope > Floating** command. This tells TotalView that, when execution stops, it should look for the variable in the current scope. If it finds the variable, it displays the variable contained within the current scope.

Select the **View > Compilation Scope > Fixed** command to return TotalView to its default behavior, which is not to change the scope.

Selecting floating scope can be very handy when you are debugging recursive routines or have routines with identical names. For example, **i**, **j**, and **k** are popular names for counter variables.

Scoping Issues

When you dive into a variable from the Source Pane, the scope that TotalView uses is that associated with the **current frame's** PC; for example:

```
1: void f()  
2: {  
3:     int x;  
4: }  
5:  
6: int main()  
7: {  
8:     int x;  
9: }
```

If the PC is at line 3, which is in **f()**, and you dive on the **x** contained in **main()**, TotalView displays the value for the **x** in **f()**, not the **x** in **main()**. In this example, the difference is clear: TotalView chooses the PC's scope instead of the scope at the place where you dove. If you are working with templated and overloaded code, determining the scope can be impossible, since the compiler does not retain sufficient information. In all cases, you can click the **More** button within the Variable window to see more information about your variable. The **Valid in Scope** field can help you determine which instance of a variable you have located.

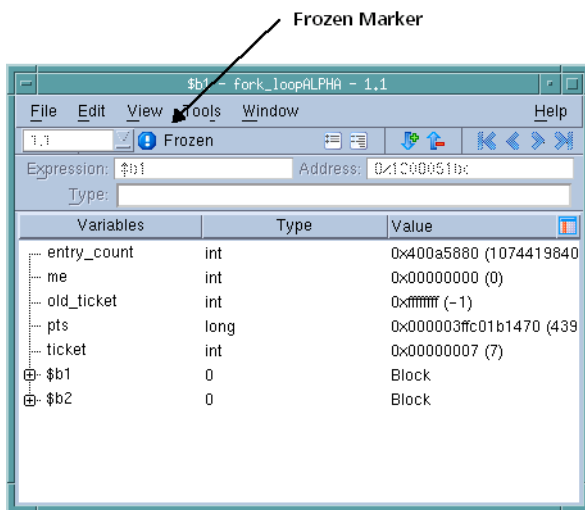
You can use the **View > Lookup Variable** command to locate the instance you are interested in.

Freezing Variable Window Data

Whenever execution stops, TotalView updates the contents of Variable Windows. More precisely, TotalView reevaluates the data based on the Expression field. If you do not want this reevaluation to occur, use the Variable Window's **View > Freeze** command. This tells TotalView that it should not change the information that is displaying.

After you select this command, TotalView adds a marker to the window indicating that the data is frozen.

Figure 116 – Variable Window Showing Frozen State



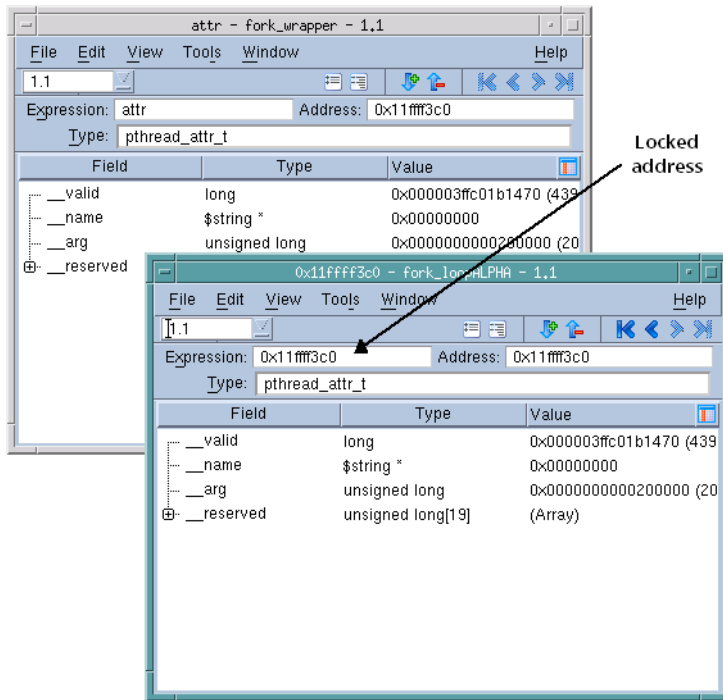
Selecting the **View > Freeze** command a second time removes the freeze. TotalView again evaluates this window's expression whenever execution stops.

In most cases, you'll want to compare the frozen information with an unfrozen copy. Do this by selecting the **Window > Duplicate** command before you freeze the display. As these two windows are identical, it doesn't matter which one you freeze. However, if you use the **Duplicate** command after you freeze the display, be aware that the new duplicated window will continue to update normally. The 'freeze' state of a window is not retained when using the **Window > Duplicate** command.

Locking the Address

Sometimes you want only to freeze the address, not the data at that address. Do this by selecting the **View > Lock Address** command. [Figure 117](#) shows two Variable Windows, one of which has had its address locked.

Figure 117 – Locked and Unlocked Variable Windows



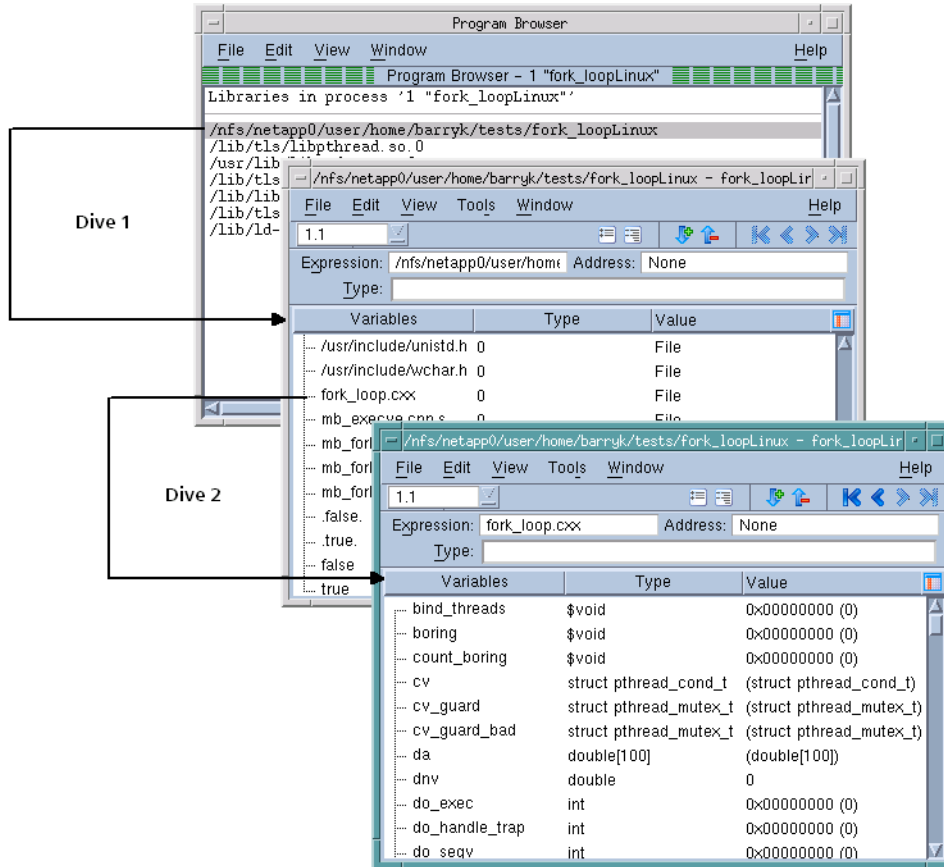
Freezing the address lets you continually reevaluate what is at that address as execution progresses. Here are two situations where you might want to do this:

- You need to look at a heap address access through a set of dive operations rooted in a stack frame that has become stale.
- You dive on a ***this** pointer to see the actual value after ***this** goes stale.

Browsing for Variables

The Process Window **Tools > Program Browser** command displays a window that contains all your executable's components. By clicking on a library or program name, you can access all of the variables contained in it.

Figure 118 – Program Browser and Variable Windows (Part 1)

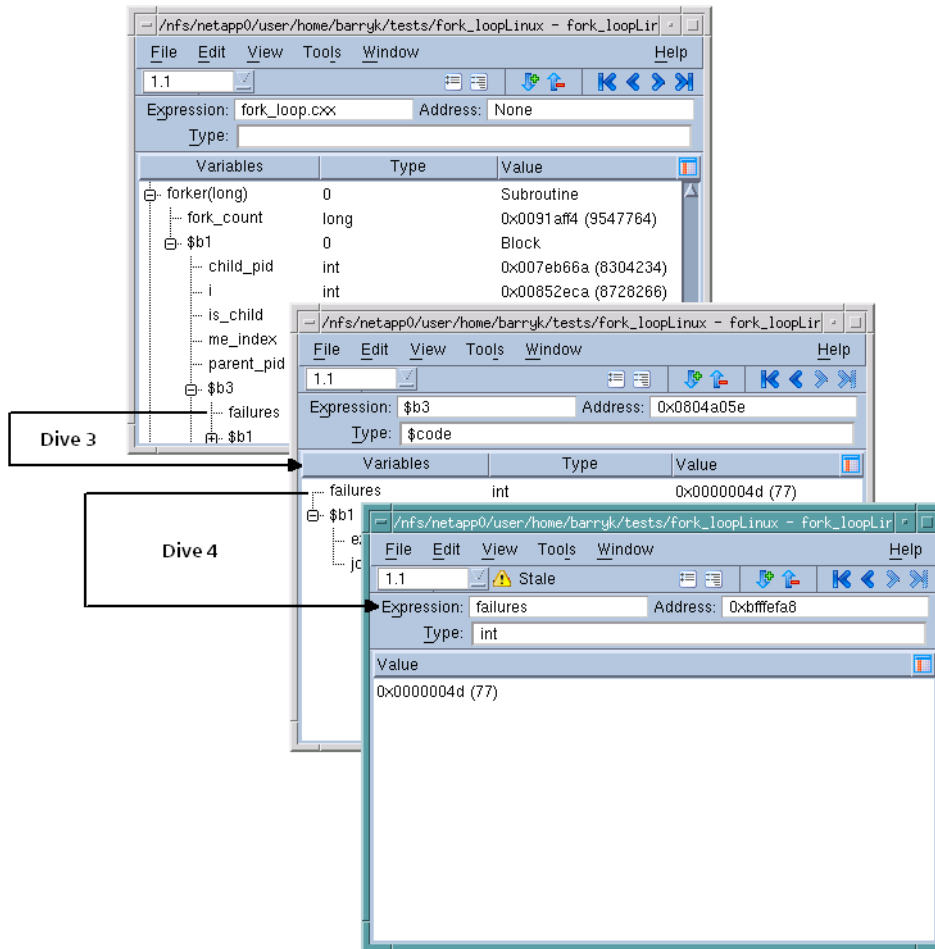



The window at the top of the figure shows programs and libraries that are loaded. If you have loaded more than one program with the **File > Debug New Program** command, TotalView displays information only for the currently selected process. After diving on an entry in this window (labeled **Dive 1**), TotalView displays a Variable Window that contains a list of files that make up the program, as well as other related information.

Diving on an entry in this Variable Window (**Dive 2** in this figure) changes the display to contain variables and other information related to the file. A list of functions defined within the program is at the end of this list.

Diving on a function changes the Variable Window again. The window shown at the top of the next figure was created by diving on one of these functions. The window shown in the center is the result of diving on a block in that subroutine. The bottom window shows a variable.

Figure 119 – Program Browser and Variable Window (Part 2)



If you dive on a line in a Variable Window, the new contents replace the old contents, and you can use the undo/redo  buttons to move back and forth.

If you are examining a complex program with large numbers of subroutines at file scope, often a result of a large number of include files and/or template class expansions, you may experience a performance slowdown. By default, the windows in this view display as much information as possible, including all symbols for all subroutines in a file scope. You can restrict views to initially show only the names of subroutines within a file scope by adding this to your `.tvdrc` file:

```
dset TV::recurse_subroutines false
```

You can then still examine the symbols within a particular subroutine by diving on that subroutine.

RELATED TOPICS

Diving in variable windows

[“Diving in Variable Windows” on page 240](#)

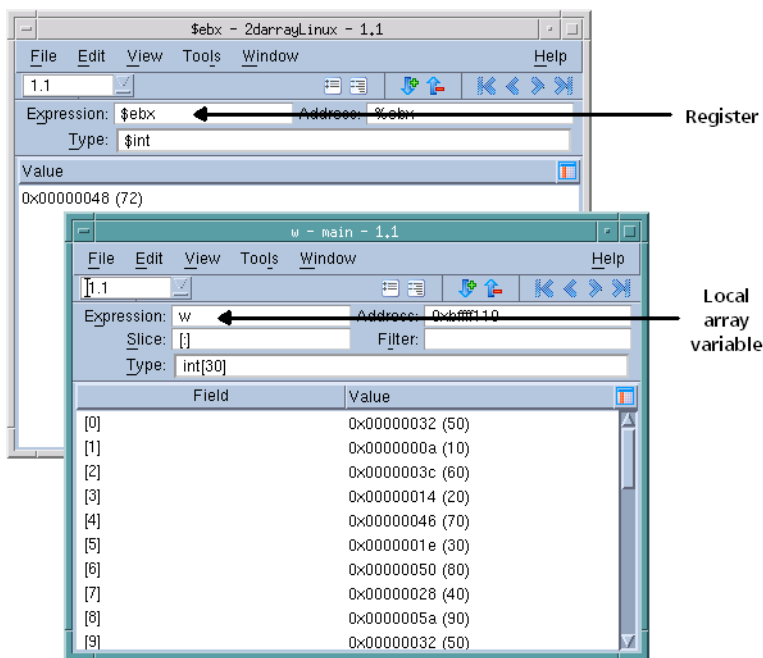
Details on the Variable Window

The “Variable Window” in the in-product Help

Displaying Local Variables and Registers

In the Stack Frame Pane, diving on a function’s parameter, local variable, or register displays information in a Variable Window. You can also dive on parameters and local variables in the Source Pane. The displayed Variable Window shows the name, address, data type, and value for the object.

Figure 120 – Diving on Local Variables and Registers



The window at the top of the figure shows the result of diving on a register, while the bottom window shows the results of diving on an array variable.

CLI: `dprint variable`

This command lets you view variables and expressions without having to select or find them.

You can also display local variables by using the **View > Lookup Variable** command.

RELATED TOPICS

Diving in variable windows

[“Diving in Variable Windows” on page 240](#)

RELATED TOPICS

Using the Process Window	“Using the Process Window” on page 148
Details on the Variable Window	The “Variable Window” in the in-product Help

Interpreting the Status and Control Registers

The Stack Frame Pane in the Process Window lists the contents of CPU registers for the selected **frame**—you might need to scroll past the stack local variables to see them.

CLI: `dprint register`

You must quote the initial `$` character in the register name; for example, `dprint \"$r1`.

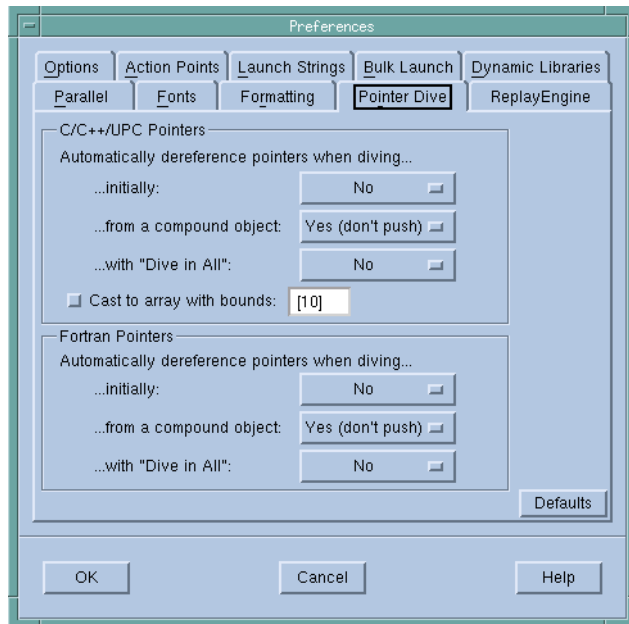
For your convenience, TotalView displays the bit settings of many CPU registers symbolically. For example, TotalView symbolically displays registers that control rounding and exception enable modes. You can edit the values of these registers and then resume program execution. For example, you might do this to examine the behavior of your program with a different rounding mode.

Since the registers that are displayed vary from platform to platform, see “*Architectures*” in the *TotalView for HPC Reference Guide* for information on how TotalView displays this information on your CPU. For general information on editing the value of variables (including registers), see “[Displaying Areas of Memory](#)” on page 236. To learn about the meaning of these registers, see the documentation for your CPU.

Dereferencing Variables Automatically

In most cases, you want to see what a pointer points to, rather than what the value of its variable is. Using the controls on the **File > Preferences** Pointer Dive tab, you can tell TotalView to automatically dereference pointers (Figure 121).

Figure 121 – File > Preferences Pointer Dive Page



Dereferencing pointers is especially useful when you want to visualize the data linked together with pointers, since it can present the data as a unified array. Because the data appears as a unified array, you can use TotalView's array manipulation commands and the Visualizer to view the data.

Each pulldown list on the Pointer Dive tab has three settings: **No**, **Yes**, and **Yes (don't push)**. **No** means do not automatically dereference pointers. **Yes** means automatically dereference pointers, and allow use of the **Back** command to see the undereferenced pointer value. **Yes (don't push)** also enables automatic dereferencing, but disallows use of the **Back** command to see the pointer value.

```
CLI: TV::auto_array_cast_bounds
     TV::auto_deref_in_all_c
     TV::auto_deref_in_all_fortran
     TV::auto_deref_initial_c
     TV::auto_deref_initial_fortran
     TV::auto_deref_nested_c
     TV::auto_deref_nested_fortran
```

Automatic dereferencing can occur in the following situations:

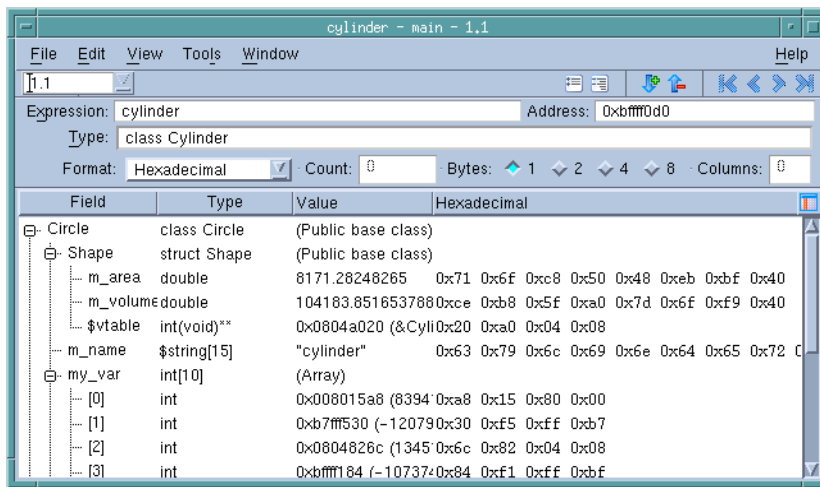
- When TotalView *initially* displays a value.

- When you dive on a value in an aggregate or structure.
- When you use the **Dive in All** command.

Examining Memory

TotalView lets you display the memory used by a variable in different ways. If you select the **View > Examine Format > Structured** or **View > Examine Format > Raw** commands from within the Variable Window, TotalView displays raw memory contents. Figure 122 shows a structured view.

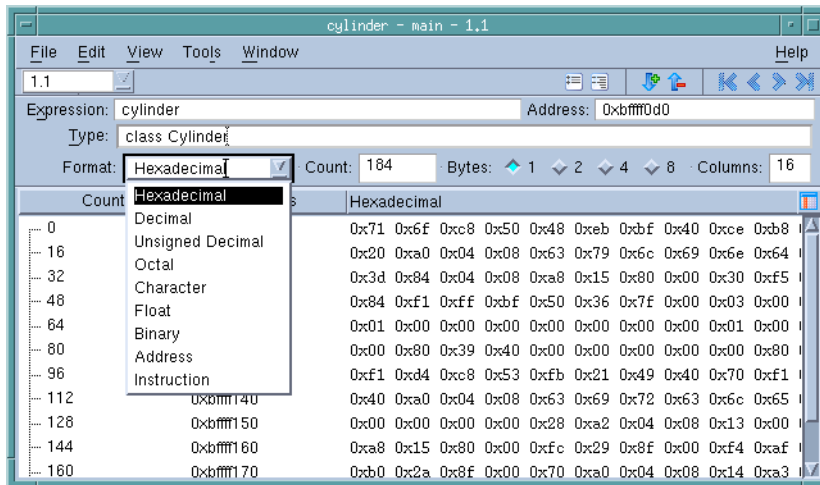
Figure 122 – View > Examine Format > Structured Display



NOTE >> The way this command displays data is similar to the way dump commands such as `od` that exist in your operating system display data.

When displaying a structured view, the left portion of the Variable Window shows the elements of the data, whether it be a structure or an array. The right portion shows the value of the data in the way that it is normally displayed within TotalView. The right-most column displays the raw memory data. By default, this information is displayed in hexadecimal. However, you can change it to other formats by selecting a representation within the **Format** pulldown. [Figure 123](#) shows a raw display with this pulldown extended:

Figure 123 – View > Examine Format > Raw Display



In either the raw or structured display, you can change the number of bytes grouped together and the range of memory being displayed.

If you select the **View > Block Status** command, TotalView will also give you additional information about memory. For example, you are told if the memory is in a **text**, **data**, or **bss** section. (If you see **unknown**, you are probably seeing a stack variable.)

In addition, if you right-click on the header area of the table, a context menu lets you add a **Status** column. This column contains information such as “Allocated”, “PostGuard”, “Corrupted PreGuard”, etc.

If you have enabled the Memory Debugger, this additional information includes whether memory is allocated or deallocated, or being used by a guard block, or hoarded.

Displaying Areas of Memory

You can display areas of memory using hexadecimal, octal, or decimal values. Do this by selecting the **View > Lookup Variable** command, and then entering one of the following in the dialog box that appears:

- **An address**

When you enter a single address, TotalView displays the word of data stored at that address.

```
CLI: dprint address
```

- **A pair of addresses**

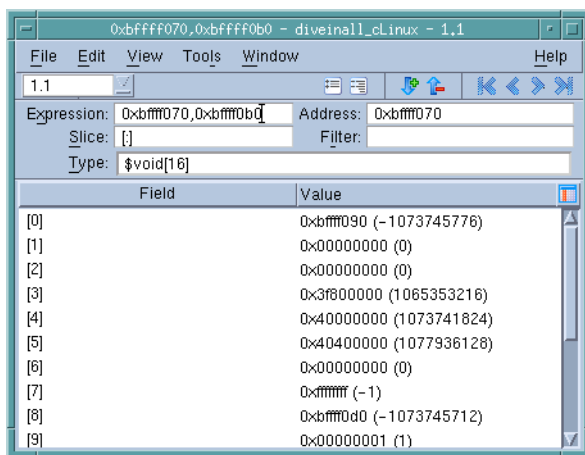
When you enter a pair of addresses, TotalView displays the data (in word increments) from the first to the last address. To enter a pair of addresses, enter the first address, a comma, and the last address.

```
CLI: dprint address,address
```

NOTE >> All octal constants must begin with 0 (zero). Hexadecimal constants must begin with 0x.

The Variable Window for an area of memory displays the address and contents of each word.

Figure 124 – Variable Window for an Area of Memory



TotalView displays the memory area's starting location at the top of the window's data area. In the window, TotalView displays information in hexadecimal and decimal notation.

If a Variable Window is already being displayed, you can change the type to **\$void** and add an array specifier. If you do this, the results are similar to what is shown in this figure.

You can also edit the value listed in the **Value** field for each machine instruction.

Displaying Machine Instructions

You can display the machine instructions for entire routines as follows:

- Dive on the address of an assembler instruction in the Source Pane (such as **main+0x10** or **0x60**). A Variable Window displays the instructions for the entire function, and highlights the instruction you dove on.
- Dive on the PC in the Stack Frame Pane. A Variable Window displays the instructions for the entire function that contains the PC, and also highlights the instruction pointed to by the PC.

- Cast a variable to type **\$code** or array of **\$code**. For example:

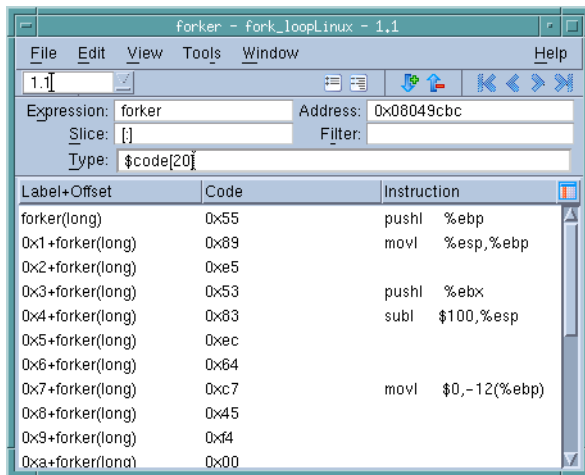
```
$code[20]
```

displays twenty code instructions, as shown in [Figure 125](#).

The Variable Window lists the following information about each machine instruction:

- Offset+Label** The symbolic address of the location as a hexadecimal offset from a routine name.
- Code** The hexadecimal value stored in the location.
- Instruction** The instruction and operands stored in the location.

Figure 125 – Variable Window with Machine Instructions



Rebinding the Variable Window

When you restart your program, TotalView must identify the thread in which the variable existed. For example, suppose variable **my_var** was in thread 3.6. When you restart your program, TotalView tries to rebind the thread to a newly created thread. Because the order in which the operating system starts and executes threads can differ, there's no guarantee that the thread 3.6 in the current context is the same thread as what it was previously. Problems can occur. To correct rebinding issues, use the **Threads** box in the upper left-hand corner of the Variable Window to specify the thread to which you want to bind the variable.

Another way to use the **Threads** box is to change to a different thread to see the variable or expression's value there. For example, suppose variable **my_var** is being displayed in thread 3.4. If you type 3.5 in the Threads box, TotalView updates the information in the Expression List Window so that it is what exists in thread 3.5.

Closing Variable Windows

When you finish analyzing the information in a Variable Window, use the **File > Close** command to close the window. You can also use the **File > Close Similar** command to close all Variable Windows.

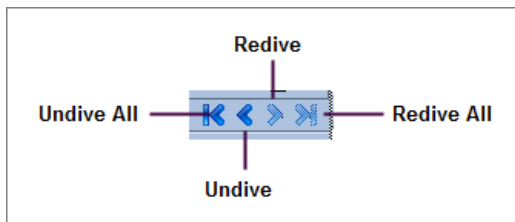
Diving in Variable Windows

If the variable being displayed in a Variable Window is a pointer, structure, or array, you can dive on the value. This new dive, which is called a *nested dive*, tells TotalView to replace the information in the Variable Window with information about the selected variable. If this information contains nonscalar data types, you can also dive on these data types. Although a typical data structure doesn't have too many levels, repeatedly diving on data lets you follow pointer chains. That is, diving lets you see the elements of a linked list.

TotalView lets you see a member of an array of structures as a single array across all the structures. See [“Displaying an Array of Structure’s Elements”](#) on page 242 for more information.

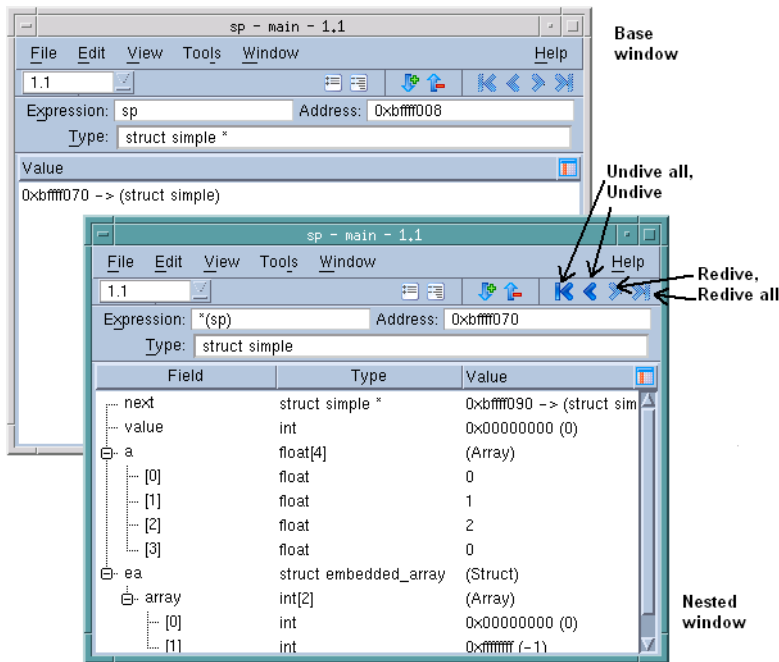
TotalView remembers your dives. This means that you can use the undive/redive buttons to view where you already dove.

Figure 126 – Undive/Redive Buttons



The following figure shows a Variable Window after diving into a pointer variable named **sp** with a type of **simple***. The first Variable Window, which is called the *base window*, displays the value of **sp**. (This is **Window 1** in Figure 127.)

Figure 127 – Nested Dives



The nested dive window (**Window 2** in this figure) shows the structure referenced by the **simple*** pointer.

You can manipulate Variable Windows and nested dive windows by using the undive/redive buttons, as follows:

- To undive from a nested dive, click the undive arrow button. The previous contents of the Variable Window appear.
- To undive from all your dive operations, click the undive all arrow button.
- To redive after you undive, click the redive arrow button. TotalView restores a previously executed dive operation.
- To redive from all your undive operations, click on the **Redive All** arrow button.

If you dive on a variable that already has a Variable Window open, the Variable Window pops to the top of the window display.

If you select the **Window > Duplicate** command, a new Variable Window appears, which is a duplicate of the current Variable Window.

RELATED TOPICS

Diving into objects

“About Diving into Objects” on page 152

Displaying an Array of Structure’s Elements

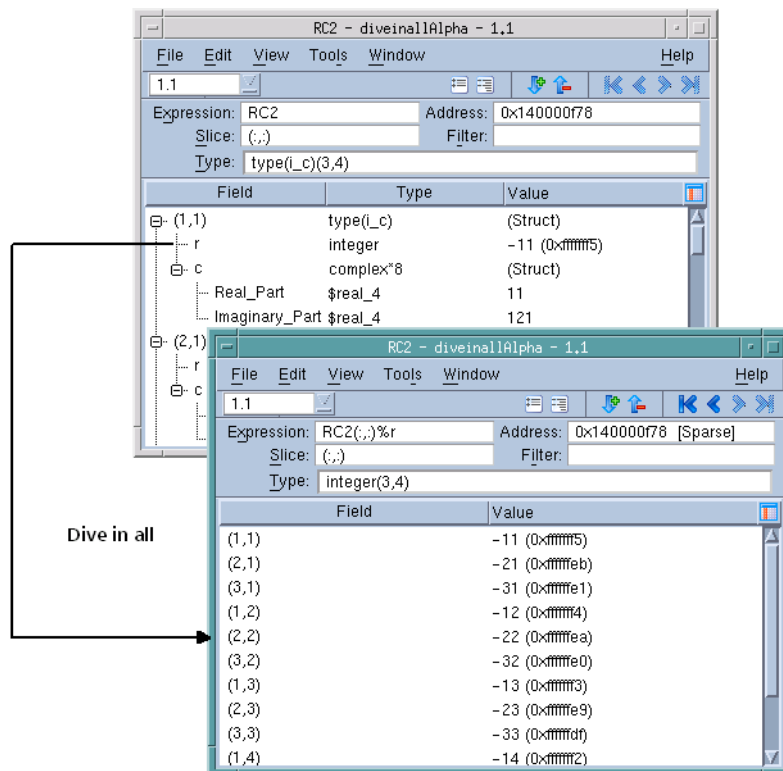
The **View > Dive In All** command, which is also available when you right-click on a field, lets you display an element in an array of structures as if it were a simple array. For example, suppose you have the following Fortran definition:

```
type i_c
  integer r
  complex c
end type i_c

type(i_c), target :: rc2(3,4)
```

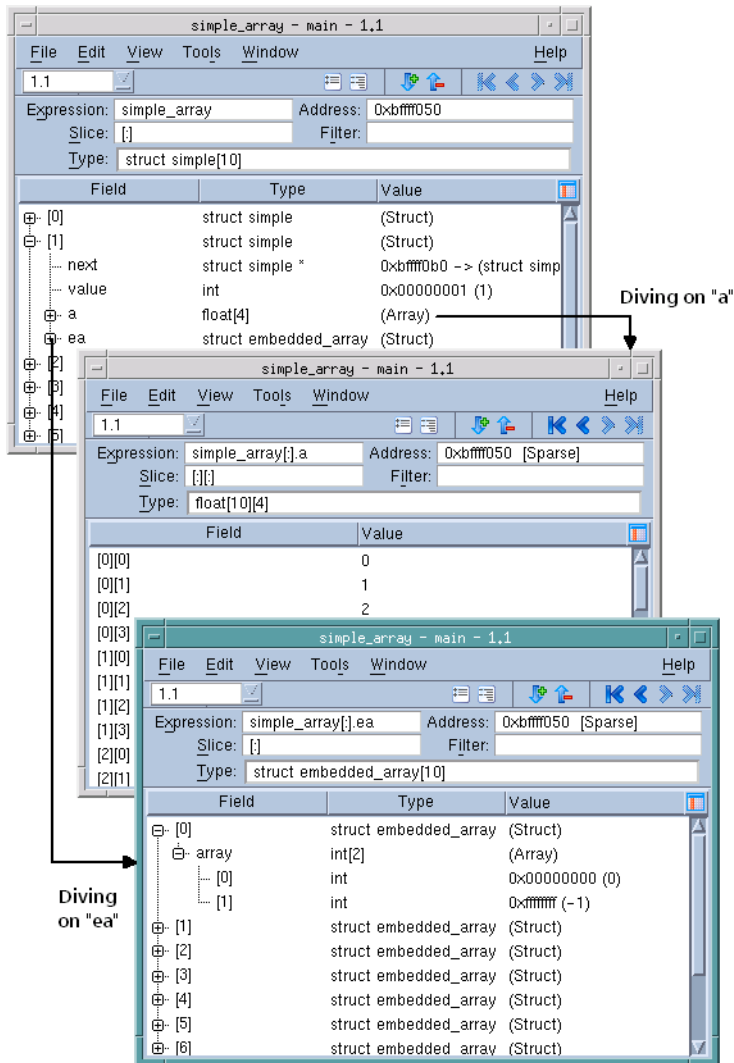
After selecting an **r** element, select the **View > Dive In All** command. TotalView displays all of the **r** elements of the **rc2** array as if they were a single array.

Figure 128 – Displaying a Fortran Structure



The **View > Dive in All** command can also display the elements of a C array of structures as arrays. [Figure 129](#) shows a unified array of structures and a multidimensional array in a structure.

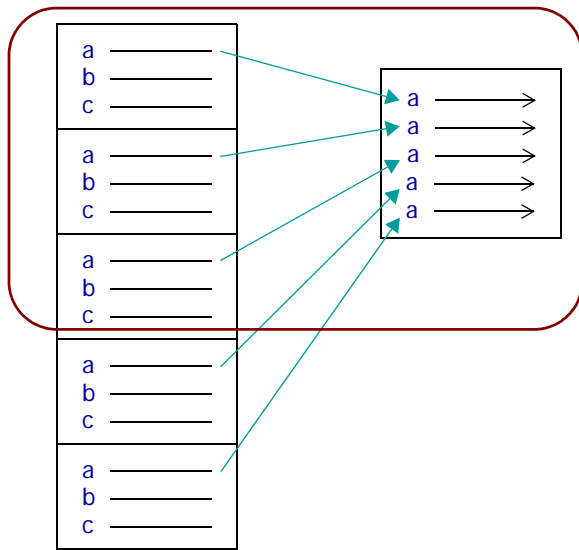
Figure 129 – Displaying C Structures and Arrays



NOTE >> As the array manipulation commands (described in [Chapter 10](#)) generally work on what's displayed and not what is stored in memory, TotalView commands that refine and display array information work on this virtual array. For example, you can visualize the array, obtain statistics about it, filter elements in it, and so on.

Figure 130 is a high-level look at what a dive in all operation does.

Figure 130 – Dive in All



In this figure, the rounded rectangle represents a Variable Window. On the left is an array of five structures. After you select the **Dive in All** command with element **a** selected, TotalView *replaces* the contents of your Variable Window with an array that contains all of these **a** elements.

RELATED TOPICS

Arrays [“Examining Arrays” on page 283](#)

Structures [“Viewing Structures” on page 259](#)

Changing What the Variable Window Displays

When TotalView displays a Variable Window, the **Expression** field contains either a variable or an expression. Technically, a variable is also an expression. For example, **my_var.an_element** is actually an addressing expression. Similarly, **my_var.an_element[10]** and **my_var[10].an_element** are also expressions, since both TotalView and your program must figure out where the data associated with the element resides.

The expression in the **Expression** field is dynamic. That is, you can tell TotalView to evaluate what you enter before trying to obtain a memory address. For example, if you enter **my_var.an_element[i]**, TotalView evaluates the value of **i** before it redisplay your information. A more complicated example is **my_var.an_element[i+1]**. In this example, TotalView must use its internal expression evaluation system to create a value before it retrieves data values.

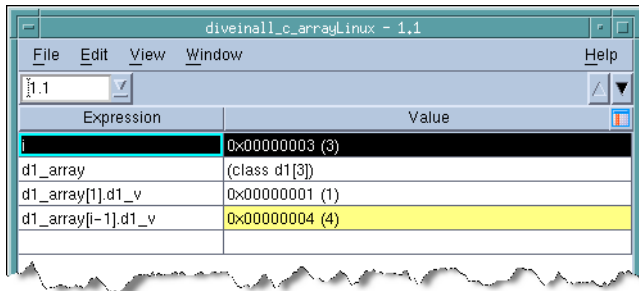
You can replace the variable expression with something completely different, such as **i+1**, and TotalView simply displays the value produced by evaluating the expression.

Chapter 12, “Evaluating Expressions,” on page 327 has a discussion of the evaluation system and typing expressions in an eval point in the **Tools > Evaluate** Window. In contrast, the expressions you can type in the Expression List Window are restricted, with the principal restriction being that what you type cannot have side effects. For example, you cannot use an expression that contains a function call or an operator that changes memory, such as `++` or `--`.

Viewing a List of Variables

As you debug your program, you may want to monitor a variable's value as your program executes. For many types of information, the Expression List Window offers a more compact display than the Variable Window for displaying scalar variables.

Figure 131 – The Tools > Expression List Window



For more information, see the **Tools > Expression List Command**.

The topics discussing the Expression List Window are:

- “Entering Variables and Expressions” on page 246
- “Seeing Variable Value Changes in the Expression List Window” on page 248
- “Entering Expressions into the Expression Column” on page 249
- “Using the Expression List with Multi-process/Multi-threaded Programs” on page 250
- “Reevaluating, Reopening, Rebinding, and Restarting” on page 251
- “Seeing More Information” on page 251
- “Sorting, Reordering, and Editing” on page 252

Entering Variables and Expressions

To display an initial, empty window, select the **Tools > Expression List** command.

You can place information in the first column of the Expression List Window in the following ways:

- Enter it into a blank cell in the **Expression** column. When you do this, the context is the current PC in the process and thread indicated in the **Threads** box. If you type **my_var** in the window shown in the previous section, you would type the value of **my_var** in process 1, thread 1.

- Right-click on a line in the Process Window Source or Stack Frame Panes. From the displayed context menu, select **Add to Expression List**. Here is the context menu that TotalView displays in the Source Pane:



- Right-click on something in a Variable Window. Select **Add to Expression List** from the displayed context menu. You can also use the **View > Add to Expression List** command.

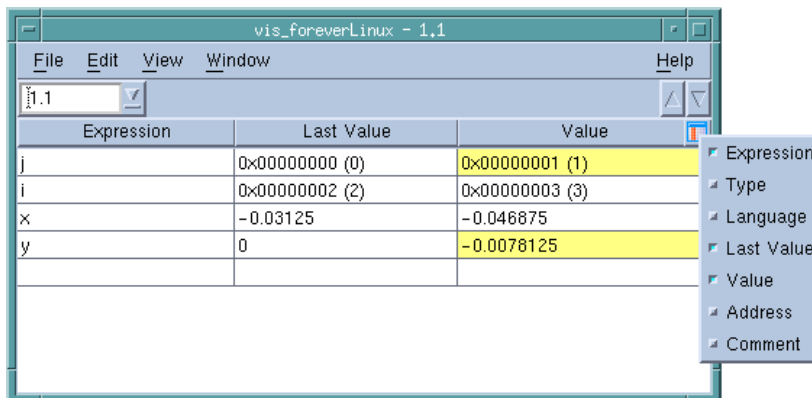
When you enter information in the **Tools > Expression List** Window, where you place the cursor and what you select make a difference. If you click on a variable or select a row in the Variable Window, TotalView adds that variable to the Expression List Window. If you instead select text, TotalView adds that text. What's the difference?

Figure 131 on page 246 shows three variations of **d1_array**, each obtained in a different way, as follows:

- The first entry was added by selecting just part of what was displayed in the Source Pane.
- The second entry was added by selecting a row in the Variable Window.
- The third entry was added by clicking at a random point in the variable's text in the Source Pane.

You can tell TotalView to look for a variable in the scope that exists when your program stops executing, rather than keeping it locked to the scope from which it was added to the **Tools > Expression List** Window. Do this by right-clicking an item, then selecting **Compilation Scope > Floating** from the context menu.

Figure 132 – Expression List Window Context Menu



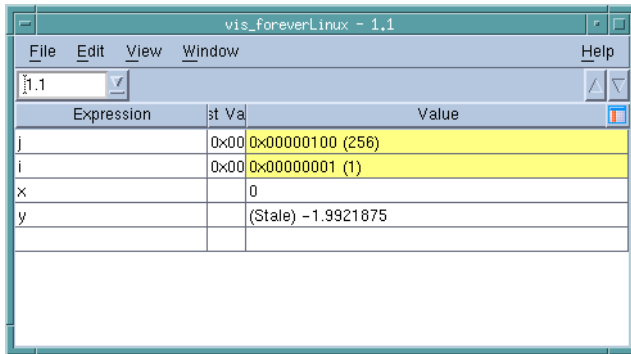
For more information, see “Viewing Variables in Different Scopes as Program Executes” on page 226.

Seeing Variable Value Changes in the Expression List Window

TotalView can tell you when a variable's value changes in several ways.

- When your program stops at a breakpoint, TotalView adds a yellow highlight to the variable's value if it has changed, Figure 133.

Figure 133 – Expression List Window With “Change” Highlighting



If the thread is stopped for another reason—for example, you've stepped the thread—and the value has changed, TotalView does not add yellow highlighting to the line.


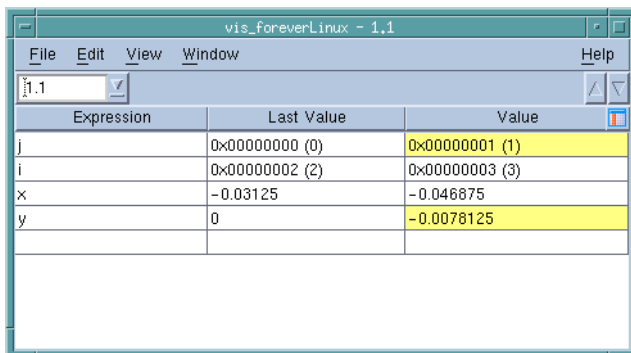
- You can tell TotalView to display the **Last Value** column. Do this by selecting **Last Value** in the column menu, which is displayed after you click on the column menu () icon.

Figure 134 – Variable Window Showing Last Value Column

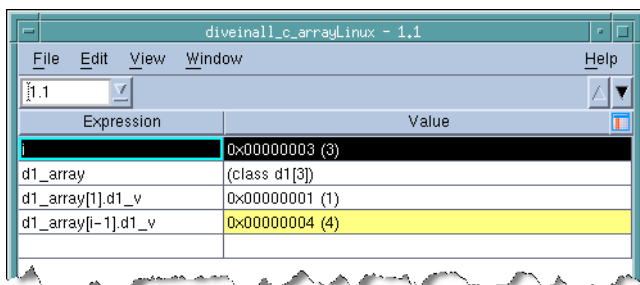


Notice that TotalView has highlighted all items that have changed within an array. In a similar fashion it can show the individual items that have changed within a structure.

Entering Expressions into the Expression Column

The following Expression List Window shows four different types of expressions.

Figure 135 – The Tools > Expression List Window

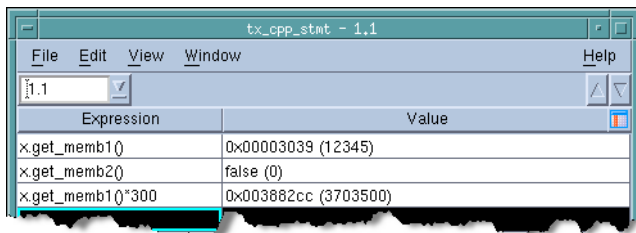


The expressions in this window are:

- i** A variable with one value. The **Value** column shows its value.
- d1_array** An aggregate variable; that is, an array, a structure, a class, and so on. Its value cannot be displayed in one line. Consequently, TotalView just gives you some information about the variable. To see more information, dive on the variable. After diving, TotalView displays the variable in a Variable Window.
When you place an aggregate variable in the **Expression** column, you need to dive on it to get more information.
- d1_array[1].d1_v** An element in an array of structures. If TotalView can resolve what you enter in the **Expression** column into a single value, it displays a value in the **Value** column. If TotalView can't, it displays information in the same way that it displays information in the **d1_array** example.
- d1_array[i-1].d1_v** An element in an array of structures. This expression differs from the previous example in that the array index is an expression. Whenever execution stops in the current thread, TotalView re-evaluates the **i-1** expression. This means that TotalView might display the value of a different array item every time execution stops.
The expressions you enter cannot include function calls.

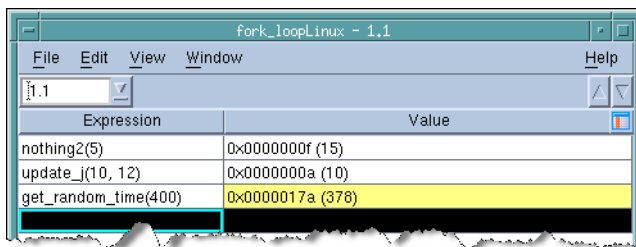
You can also enter methods and functions within an Expression. [Figure 136](#) shows two get methods and a get method used in an expression.

Figure 136 – Using Methods in the Tools > Expression List Window



In a similar fashion, you can even directly enter functions, Figure 137.

Figure 137 – Using Functions in the Tools > Expression List Window



Using the Expression List with Multi-process/Multi-threaded Programs

You can change the thread in which TotalView evaluates your expressions by typing a new thread value in the **Threads** box at the top of the window. A second method is to select a value by using the drop-down list in the **Threads** box.

When you use an **Add to Expression List** command, TotalView checks whether an Expression List Window is already open for the current thread. If one is open, TotalView adds the variable to the bottom of the list. If an Expression List Window isn't associated with the thread, TotalView duplicates an existing window, changes the thread of the duplicated window, and then adds the variable to all open **Tools > Expression List** Windows. That is, you have two **Tools > Expression List** Windows. Each has the same list of expressions. However, the results of the expression evaluation differ because TotalView is evaluating them in different threads.

In all cases, the list of expressions in all **Tools > Expression List** Windows is the same. What differs is the thread in which TotalView evaluates the window's expressions.

Similarly, if TotalView is displaying two or more **Tools > Expression List** Windows, and you send a variable from yet another thread, TotalView adds the variable to all of them, duplicates one of them, and then changes the thread of the duplicated window.

Reevaluating, Reopening, Rebinding, and Restarting

This section explains what happens in the **Tools > Expression List** Window as TotalView performs various operations.

Reevaluating Contents

TotalView reevaluates the value of everything in the **Tools > Expression List** Window **Expression** column whenever your thread stops executing. More precisely, if a thread stops executing, TotalView reevaluates the contents of all **Tools > Expression List** Windows associated with the thread. In this way, you can see how the values of these expressions change as your program executes.

You can use the **Window > Update All** command to update values in all other **Tools > Expression List** Windows.

Reopening Windows

If you close all open **Tools > Expression List** Windows and then reopen one, TotalView remembers the expressions you added previously. That is, if the window contains five variables when you close it, it has the same five variables when you open it. The thread TotalView uses to evaluate the window's contents is based on the Process Window from which you invoked the **Tools > Expressions List** command.

Rebinding Windows

The values displayed in an **Expression List** Window are the result of evaluating the expression in the thread indicated in the **Threads** box at the top of the window. To change the thread in which TotalView evaluates these expressions, you can either type a new thread value in the **Threads** box or select a thread from the pulldown list in the **Threads** box. (Changing the thread to evaluate expressions in that thread's context is called *rebinding*.)

Restarting a Program

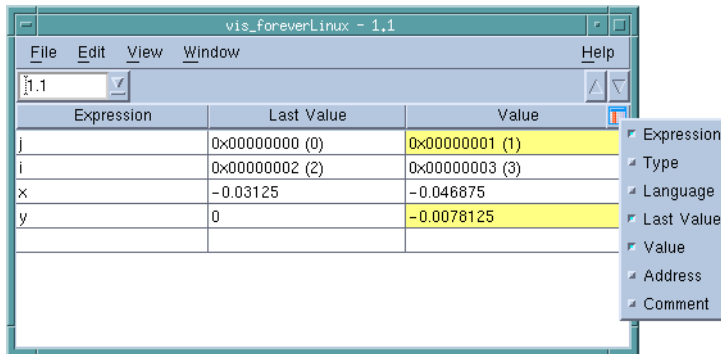
When you restart your program, TotalView attempts to rebind the expressions in a **Tools > Expression List** Window to the *correct* thread. Unfortunately, it is not possible to select the right thread with 100% accuracy. For example, the order in which your operating system creates threads can differ each time you run your program. Or, your program's logic can cause threads to be created in a different order.

You may need to manually change the thread by using the **Threads** box at the top of the window.

Seeing More Information

When you first open the **Tools > Expression List** Window, it contains two columns, but TotalView can display other columns. If you right-click on a column heading line, TotalView displays a context menu that indicates all possible columns. Clicking on a heading name listed in the context menu changes it from displayed to hidden or vice versa.

Figure 138 – The Tools > Expression List Window Showing Column Selector



Even when you add additional columns, the **Expression List** Window might not show you what you need to know about a variable. If you dive on a row (or select **Dive** from a context menu), TotalView opens a Variable Window for what you just dove on.

You can combine the **Expression List** Window and diving to bookmark your data. For example, you can enter the names of structures and arrays. When you want to see information about them, dive on the name. In this way, you don't have to clutter up your screen with the Variable Windows that you don't need to refer to often.

Sorting, Reordering, and Editing

This section describes operations you can perform on **Tools > Expression List** Window data.

Sorting Contents

You can sort the contents of the **Tools > Expression List** Window by clicking on the column header. After you click on the header, TotalView adds an indicator that shows that the column was sorted and the way in which it was sorted. In the figure in the previous topic, the **Value** column is sorted in ascending order.

Reordering Row Display

The up and down arrows (▲▼) on the right side of the **Tools > Expression List** Window toolbar let you change the order in which TotalView displays rows. For example, clicking the down arrow moves the currently selected row (indicated by the highlight) one row lower in the display.

Editing Expressions

You can change an expression by clicking in it, and then typing new characters and deleting others. Select **Edit > Reset Defaults** to remove all edits you have made. When you edit an expression, TotalView uses the scope that existed when you created the variable.

Changing Data Type

You can edit an expression's data type by displaying the **Type** column and making your changes. Select **Edit > Reset Defaults** to remove all edits you have made.

Changing an Expression's Value

You can change an expression's value if that value is stored in memory by editing the contents of the **Value** column.

About Other Commands

You can also use the following commands when working with expressions:

Edit > Delete Expression

Deletes the selected row. This command is also on a context (right-click) menu. If you have more than one **Expression List** Window open, deleting a row from one window deletes the row from all open windows.

Edit > Delete All Expressions

Deletes all of the **Expression List** Window rows. If you have more than one **Expression List** Window open, deleting all expressions from one window deletes all expressions in all windows.

View > Dive

Displays the expression or variable in a Variable Window. Although this command is also on a context menu, you can just double-click or middle-click on the variable's name instead.

Edit > Duplicate Expression

Duplicates the selected column. You would duplicate a column to see a similar variable or expression. For example, if **myvar_looks_at[i]** is in the **Expression** column, duplicating it and then modifying the new row is an easy way to see **myvar_looks_at[i]** and **myvar_looks_at[i+j-k]** at the same time.

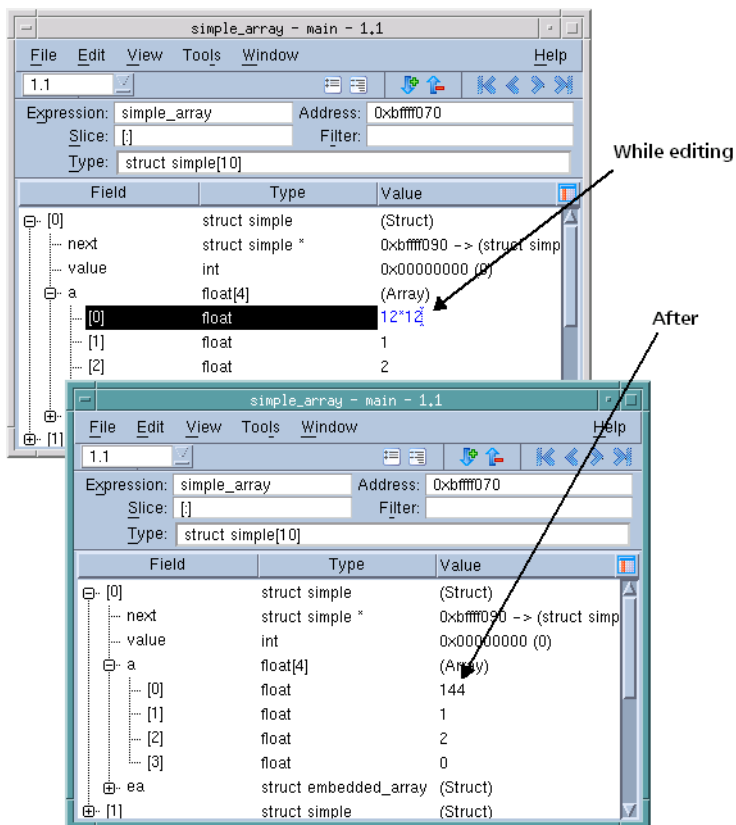
This command is also on a context menu.

Changing the Values of Variables

You can change the value of any variable or the contents of any memory location displayed in a Variable Window, Expression List Window, or Stack Frame Pane by selecting the value and typing the new value. In addition to typing a value, you can also type an expression. For example, you can enter **12*12** as shown in the following figure. You can include logical operators in all TotalView expressions.

```
CLI: set my_var [expr 1024*1024]
      dassign int8_array(3) $my_var
```

Figure 139 – Using an Expression to Change a Value



In most cases, you can edit a variable's value. If you right-click on a variable and the **Change Value** command isn't faded, you can edit the displayed value.

TotalView does not let you directly change the value of bit fields; you can use the **Tools > Evaluate** Window to assign a value to a bit field. See [Chapter 12, "Evaluating Expressions,"](#) on page 327.

```
CLI: Tcl lets you use operators such as & and | to manipulate bit fields on Tcl values.
```

RELATED TOPICS

Editing text in source code [“Editing Source Text”](#) on page 164

Details on the Variable Window [The "Variable Window" in the in-product Help](#)

Changing a Variable's Data Type

The data type declared for the variable determines its format and size (amount of memory). For example, if you declare an **int** variable, TotalView displays the variable as an integer.

The following sections discuss the different aspects of data types:

- “[Displaying C and C++ Data Types](#)” on page 256
- “[Viewing Pointers to Arrays](#)” on page 258
- “[Viewing Arrays](#)” on page 258
- “[Viewing typedef Types](#)” on page 259
- “[Viewing Structures](#)” on page 259
- “[Viewing Unions](#)” on page 260
- “[Casting Using the Built-In Types](#)” on page 261
- “[Type-Casting Examples](#)” on page 266

You can change the way TotalView displays data in the Variable Window and the Expression List Window by editing the data type. This is known as *casting*. TotalView assigns types to all data types, and in most cases, they are identical to their programming language counterparts.

When a C or C++ variable is displayed in TotalView, the data types are identical to their C or C++ type representations, except for pointers to arrays. TotalView uses a simpler syntax for pointers to arrays. (See “[Viewing Pointers to Arrays](#)” on page 258.) Similarly, when Fortran is displayed in TotalView, the types are identical to their Fortran type representations for most data types, including **INTEGER**, **REAL**, **DOUBLE PRECISION**, **COMPLEX**, **LOGICAL**, and **CHARACTER**.

If the window contains a structure with a list of fields, you can edit the data types of the listed fields.

NOTE >> When you edit a data type, TotalView changes how it displays the variable in the current window. Other windows listing the variable do not change.

Displaying C and C++ Data Types

The syntax for displaying data is identical to C and C++ language cast syntax for all data types except pointers to arrays. That is, you use C and C++ cast syntax for data types. For example, you can cast using types such as **int**, **char**, **unsigned**, **float**, **double**, **union**, all named **struct** types, and so on. In addition, TotalView has a built-in type called **\$string**. Unless you tell it otherwise, TotalView maps **char** arrays to this type. (For information on wide characters, see “[Viewing Wide Character Arrays \(\\$wchar Data Types\)](#)” on page 264.)

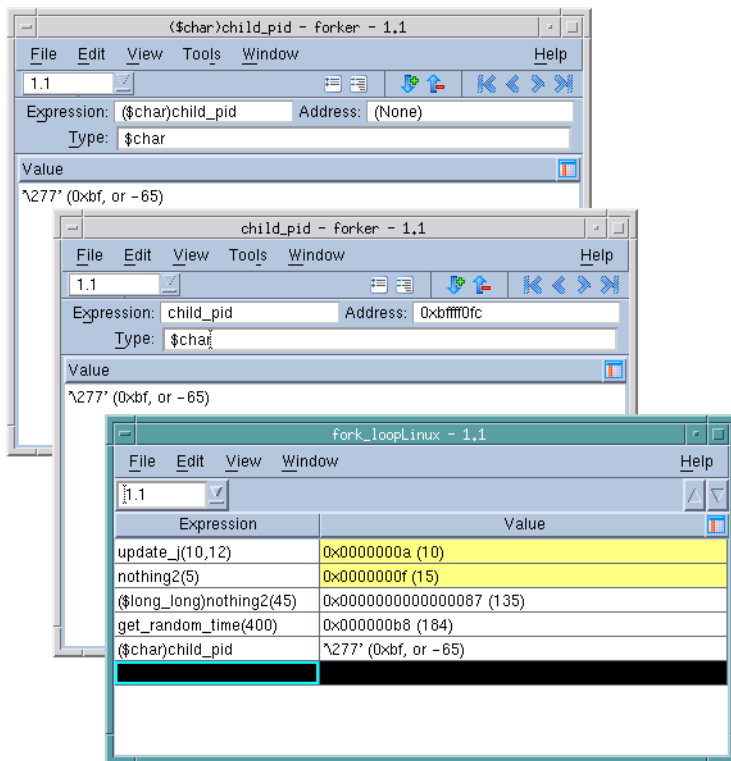
Read TotalView types from right to left. For example, **\$string*[20]*** is a pointer to an array of 20 pointers to **\$string**.

The following table shows some common TotalView data types:

Data Type String	Description
int	Integer
int*	Pointer to an integer
int[10]	Array of 10 integers
\$string	Null-terminated character string
\$string**	Pointer to a pointer to a null-terminated character string
\$string*[20]*	Pointer to an array of 20 pointers to null-terminated strings

You can enter C and C++ Language cast syntax in the **Type** field. [Figure 140](#) shows three different ways to cast:

Figure 140 – Three Casting Examples



The two Variable Windows cast the same data in the same way. In the top-left window, a cast was used in the **Expression** field. In the other Variable Window, the data type was changed from **int** to **\$char**. In the first cast, TotalView changed the **Type** for you. In the second, it did not alter the **Expression** field.

The Expression List Window contains two casting examples. The first casts a function's returned value to **long long**. The second is the same cast as was made in the two Variable Windows.

TotalView also lets you cast a variable into an array. In the GUI, add an array specifier to the **Type** declaration. For example, adding **[3]** to a variable declared as an **int** changes it into an array of three **ints**.

When TotalView displays some complex arrays and structures, it displays the compound object or array types in the Variable Window.

NOTE >> Editing a compound object or array data type can produce undesirable results. TotalView tries to give you what you ask for, so if you get it wrong, the results are unpredictable. Fortunately, the remedy is quite simple: close the Variable Window and start over again.

The following sections discuss more complex data types.

- [“Viewing Pointers to Arrays”](#) on page 258
- [“Viewing Arrays”](#) on page 258
- [“Viewing typedef Types”](#) on page 259
- [“Viewing Structures”](#) on page 259
- [“Viewing Unions”](#) on page 260

Viewing Pointers to Arrays

Suppose you declared a variable **vbl** as a pointer to an array of 23 pointers to an array of 12 objects of type **mytype_t**. The C language declaration for this is:

```
mytype_t (*( *vbl)[23]) [12];
```

Here is how you would cast the **vbl** variable to this type:

```
(mytype_t (*( *) [23]) [12])vbl
```

The TotalView cast for **vbl** is:

```
mytype_t[12]*[23]*
```

Viewing Arrays

When you specify an array, you can include a lower and upper bound separated by a colon (:).

NOTE >> See Chapter 10, “Examining Arrays,” on page 283 for more information on arrays.

By default, the lower bound for a C or C++ array is **0**, and the lower bound for a Fortran array is **1**. In the following example, an array of ten integers is declared in C and then in Fortran:

```
int a[10];
integer a(10)
```

The elements of the array range from **a[0]** to **a[9]** in C, while the elements of the equivalent Fortran array range from **a(1)** to **a(10)**.

TotalView also lets you cast a variable to an array. In the GUI, just add an array specifier to the **Type** declaration. For example, adding **(3)** to a variable declared as an **integer** changes it to an array of three **integers**.

When the lower bound for an array dimension is the default for the language, TotalView displays only the **extent** (that is, the number of elements in the dimension). Consider the following Fortran array declaration:

```
integer a(1:7,1:8)
```

Since both dimensions of this Fortran array use the default lower bound, which is **1**, TotalView displays the data type of the array by using only the extent of each dimension, as follows:

```
integer(7,8)
```

If an array declaration doesn't use the default lower bound, TotalView displays both the lower bound and upper bound for each dimension of the array. For example, in Fortran, you declare an array of integers with the first dimension ranging from -1 to 5 and the second dimension ranging from 2 to 10, as follows:

```
integer a(-1:5,2:10)
```

TotalView displays this the same way.

When editing an array's dimension, you can enter just the extent (if using the default lower bound), or you can enter the lower and upper bounds separated by a colon.

TotalView also lets you display a subsection of an array, or filter a scalar array for values that match a filter expression. See [“Displaying Array Slices”](#) on page 284 and [“Filtering Array Data Overview”](#) on page 290 for more information.

Viewing typedef Types

TotalView recognizes the names defined with **typedef**, and displays these user-defined types; for example:

```
typedef double *dptr_t;
dptr_t p_vbl;
```

TotalView displays the type for **p_vbl** as **dptr_t**.

Viewing Structures

TotalView lets you use the **struct** keyword as part of a type string. In most cases, this is optional.

NOTE >> This behavior depends upon which compiler you are using. In most cases, you'll see what is described here.

If you have a structure and another data type with the same name, however, you must include the **struct** keyword so that TotalView can distinguish between the two data types.

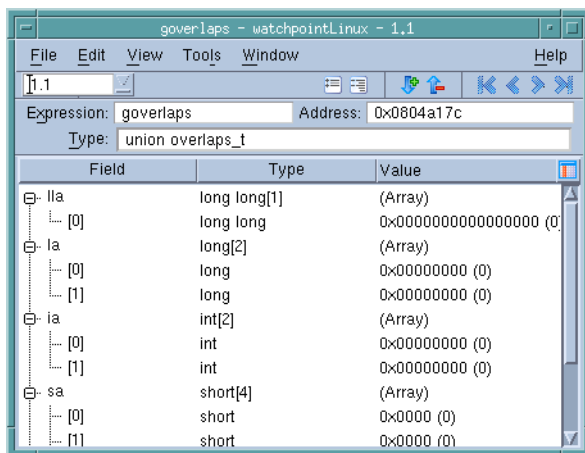
If you use a **typedef** statement to name a structure, TotalView uses the **typedef** name as the type string. Otherwise, TotalView uses the structure tag for the **struct**.

Viewing Unions

TotalView displays a union in the same way that it displays a structure. Even though the fields of a union are overlaid in storage, TotalView displays the fields on separate lines.

CLI: `dprint variable`

Figure 141 – Displaying a Union



Casting Using the Built-In Types

TotalView provides a number of predefined types. These types are preceded by a **\$**. You can use these built-in types anywhere you can use the ones defined in your programming language. These types are also useful in debugging executables with no debugging symbol table information. The following table describes the built-in types:

Type String	Language	Size	Description
\$address	C	void*	Void pointer (address).
\$char	C	char	Character.
\$character	Fortran	character	Character.
\$code	C	architecture-dependent	Machine instructions. The size used is the number of bytes required to hold the shortest instruction for your computer.
\$complex	Fortran	complex	Single-precision floating-point complex number. The complex types contain a real part and an imaginary part, which are both of type real .
\$complex_8	Fortran	complex*8	A real*4 -precision floating-point complex number. The complex*8 types contain a real part and an imaginary part, which are both of type real*4 .
\$complex_16	Fortran	complex*16	A real*8 -precision floating-point complex number. The complex*16 types contain a real part and an imaginary part, which are both of type real*8 .
\$double	C	double	Double-precision floating-point number.
\$double_precision	Fortran	double precision	Double-precision floating-point number.
\$extended	C	architecture-dependent; often long double	Extended-precision floating-point number. Extended-precision numbers must be supported by the target architecture. In addition, the format of extended floating point numbers varies depending on where it's stored. For example, the x86 register has a special 10-byte format, which is different than the in-memory format. Consult your vendor's architecture documentation for more information.
\$float	C	float	Single-precision floating-point number.
\$int	C	int	Integer.
\$integer	Fortran	integer	Integer.
\$integer_1	Fortran	integer*1	One-byte integer.

Type String	Language	Size	Description
\$integer_2	Fortran	integer*2	Two-byte integer.
\$integer_4	Fortran	integer*4	Four-byte integer.
\$integer_8	Fortran	integer*8	Eight-byte integer.
\$logical	Fortran	logical	Logical.
\$logical_1	Fortran	logical*1	One-byte logical.
\$logical_2	Fortran	logical*2	Two-byte logical.
\$logical_4	Fortran	logical*4	Four-byte logical.
\$logical_8	Fortran	logical*8	Eight-byte logical.
\$long	C	long	Long integer.
\$long_long	C	long long	Long long integer.
\$real	Fortran	real	Single-precision floating-point number. When using a value such as real , be careful that the actual data type used by your computer is not real*4 or real*8 , since different results can occur.
\$real_4	Fortran	real*4	Four-byte floating-point number.
\$real_8	Fortran	real*8	Eight-byte floating-point number.
\$real_16	Fortran	real*16	Sixteen-byte floating-point number.
\$short	C	short	Short integer.
\$string	C	char	Array of characters.
\$void	C	long	Area of memory.
\$wchar	C	<i>platform-specific</i>	Platform-specific wide character used by wchar_t data types
\$wchar_s16	C	16 bits	Wide character whose storage is signed 16 bits (not currently used by any platform)
\$wchar_u16	C	16 bits	Wide character whose storage is unsigned 16 bits
\$wchar_s32	C	32 bits	Wide character whose storage is signed 32 bits
\$wchar_u32	C	32 bits	Wide character whose storage is unsigned 32 bits
\$wstring	C	<i>platform-specific</i>	Platform-specific string composed of wchar characters
\$wstring_s16	C	16 bits	String composed of wchar_s16 characters (not currently used by any platform)
\$wstring_u16	C	16 bits	String composed of wchar_u16 characters

Type String	Language	Size	Description
<code>\$wstring_s32</code>	C	32 bits	String composed of <code>\$wchar_s32</code> characters
<code>\$wstring_u32</code>	C	32 bits	String composed of <code>\$wchar_u32</code> characters

Viewing Character Arrays (`$string` Data Type)

If you declare a character array as `char vbl[n]`, TotalView automatically changes the type to `$string[n]`; that is, a null-terminated, quoted string with a maximum length of n . This means that TotalView displays an array as a quoted string of n characters, terminated by a null character. Similarly, TotalView changes `char*` declarations to `$string*` (a pointer to a null-terminated string).

Since most character arrays represent strings, the TotalView `$string` type can be very convenient. But if this isn't what you want, you can change the `$string` type back to a `char` (or `char[n]`), to display the variable as you declared it.

Viewing Wide Character Arrays (\$wchar Data Types)

If you create an array of **wchar_t** wide characters, TotalView automatically changes the type to **\$wstring[n]**; that is, it is displayed as a null-terminated, quoted string with a maximum length of *n*. For an array of wide characters, the null terminator is **L'0'**. Similarly, TotalView changes **wchar_t*** declarations to **\$wstring*** (a pointer to a null-terminated string).

Figure 142 – Displaying wchar_t Data

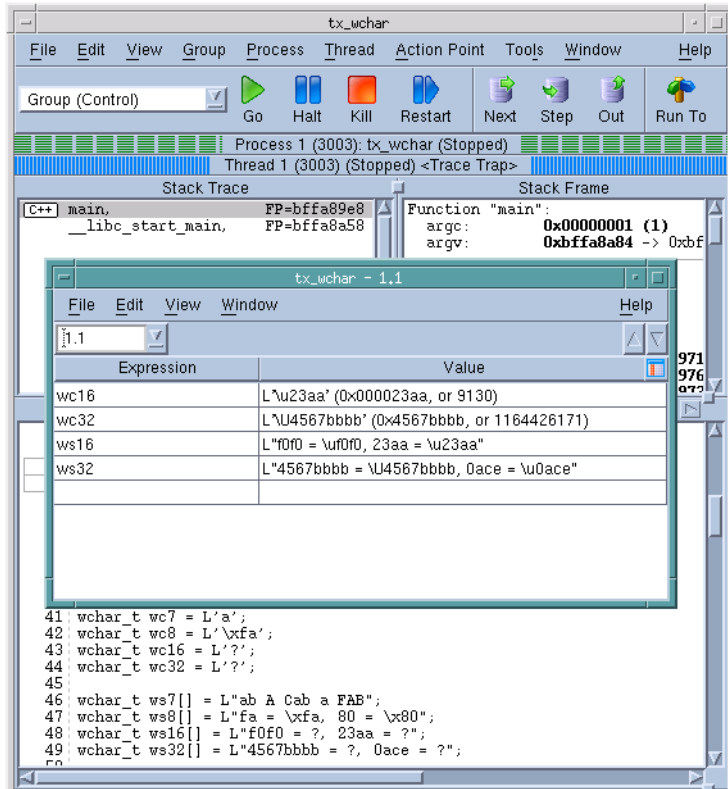


Figure 142 shows the declaration of two wide characters in the Process Window. The Expression List Window shows how TotalView displays their data. The **L** in the data indicates that TotalView is displaying a wide literal.

Since most wide character arrays represent strings, the **\$wstring** type can be very convenient. But if this isn't what you want, you can change the **\$wstring** type back to a **wchar_t** (or **wchar[n]** or **\$wchar** or **\$wchar[n]**), to display the variable as you declared it.

If the wide character uses from 9 to 16 bits, TotalView displays the character using the following universal-character code representation:

\uXXXX

X represents a hexadecimal digit. If the character uses from 17 to 32 bits, TotalView uses the following representation:

\UXXXXXXXX

NOTE >> Platforms and compilers differ in the way they represent `wchar_t`. In consequence, TotalView allows you to see this information in platform-specific ways. For example, you can cast a string to `$wstring_s16` or `$wstring_s32`. In addition, many compilers have problems either using wide characters or handing off information about wide characters so they can be interpreted by any debugger (not just TotalView). For information on supported compilers, see the TotalView Release Notes at <http://www.roguewave.com/help-support/documentation/totalview>.

Viewing Areas of Memory (\$void Data Type)

TotalView uses the **\$void** data type for data of an unknown type, such as the data contained in registers or in an arbitrary block of memory. The **\$void** type is similar to the **int** type in the C Language.

If you dive on registers or display an area of memory, TotalView lists the contents as a **\$void** data type. If you display an array of **\$void** variables, the index for each object in the array is the address, not an integer. This address can be useful when you want to display large areas of memory.

If you want, you can change a **\$void** to another type. Similarly, you can change any type to a **\$void** to see the variable in decimal and hexadecimal formats.

Viewing Instructions (\$code Data Type)

TotalView uses the **\$code** data type to display the contents of a location as machine instructions. To look at disassembled code stored at a location, dive on the location and change the type to **\$code**. To specify a block of locations, use **\$code[n]**, where *n* is the number of locations being displayed.

RELATED TOPICS

Viewing assembler code [“Viewing the Assembler Version of Your Code” on page 161](#)

Viewing Opaque Data

An opaque type is a data type that could be hidden, not fully specified, or defined in another part of your program. For example, the following C declaration defines the data type for **p** to be a pointer to **struct foo**, and **foo** is not yet defined:

```
struct foo;  
struct foo *p;
```

When TotalView encounters a variable with an opaque type, it searches for a **struct**, **class**, **union**, or **enum** definition with the same name as the opaque type. If TotalView doesn't find a definition, it displays the value of the variable using an opaque type name; for example:

(Opaque foo)

Some compilers do not store sufficient information for TotalView to locate the type. This could be the reason why TotalView uses the opaque type.

You can tell TotalView to use the correct data type by having it read the source file. For example, if TotalView is showing you **(Opaque foo)** and you know that **struct foo** is defined in source file **foo.c**, use the **File > Open Source** Command. While this command's primary purpose is to display the file within the Process Window, it also causes TotalView to read the file's debugging information. As a side-effect, **struct foo** should now be defined. Because TotalView now knows its definition, it can resolve the opaque type.

Type-Casting Examples

This section contains three type-casting examples:

- [Displaying Declared Arrays](#)
- [Displaying Allocated Arrays](#)
- [Displaying the argv Array](#)

Displaying Declared Arrays

TotalView displays arrays the same way it displays local and global variables. In the Stack Frame or Source Pane, dive on the declared array. A Variable Window displays the elements of the array.

```
CLI: dprint array-name
```

Displaying Allocated Arrays

The C Language uses pointers for dynamically allocated arrays; for example:

```
int *p = malloc(sizeof(int) * 20);
```

Since TotalView doesn't know that **p** actually points to an array of integers, you need to do several things to display the array:

1. Dive on the variable **p** of type **int***.
2. Change its type to **int[20]***.
3. Dive on the value of the pointer to display the array of 20 integers.

Displaying the argv Array

Typically, **argv** is the second argument passed to **main()**, and it is either a **char **argv** or **char *argv[]**. Suppose **argv** points to an array of three pointers to character strings. Here is how you can edit its type to display an array of three pointers:

1. Select the type string for **argv**.

```
CLI: dprint argv
```

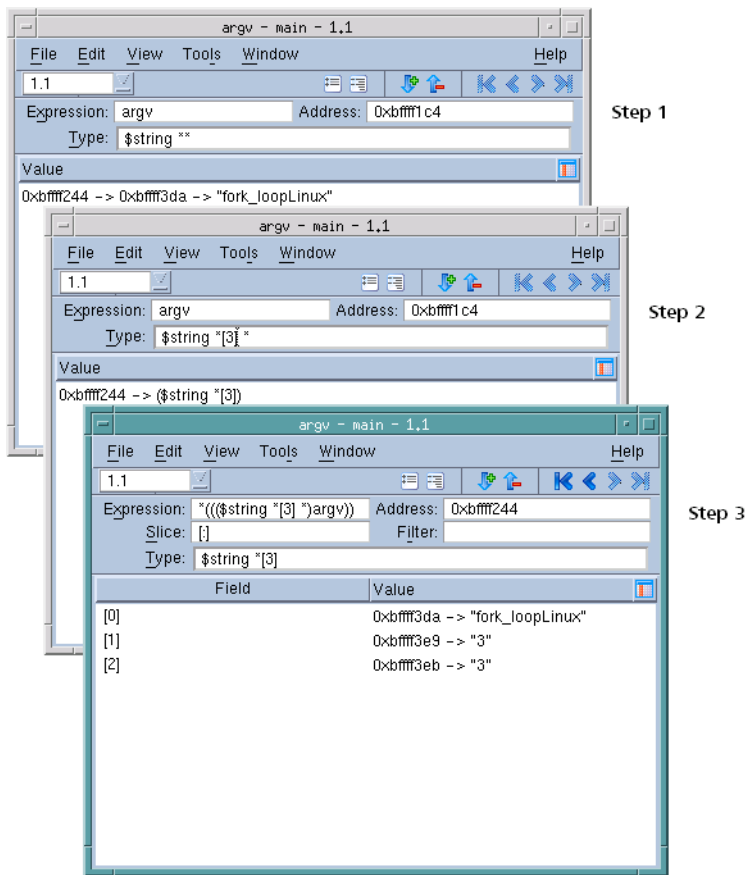
2. Edit the type string by using the field editor commands. Change it to:

```
$string*[3]*
```

```
CLI: dprint {($string*[3]*)argv}
```

3. To display the array, dive on the value field for **argv**.

Figure 143 – Editing the argv Argument



Changing the Address of Variables

You can edit the address of a variable in a Variable Window by editing the value shown in the **Address** field. When you edit this address, the Variable Window shows the contents of the new location.

You can also enter an address expression such as **0x10b8 - 0x80** in this area.

Displaying C++ Types

RELATED TOPICS

STL variable display	“Displaying STL Variables” on page 215
Changing the data type of a variable	“Changing a Variable’s Data Type” on page 256
A variable’s scope	“Scoping and Symbol Names” on page 280

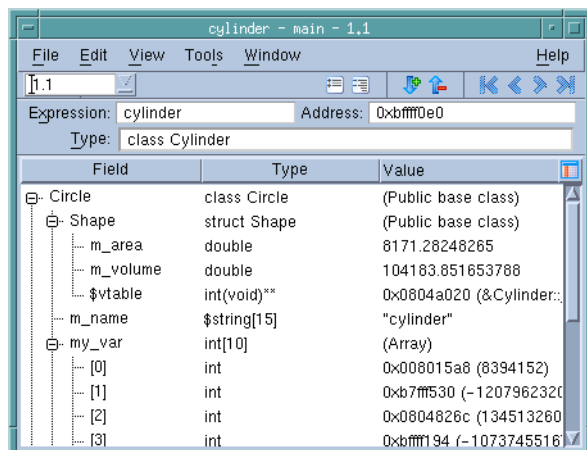
Viewing Classes

TotalView displays C++ classes and accepts **class** as a keyword. When you debug C++, TotalView also accepts the *unadorned* name of a **class**, **struct**, **union**, or **enum** in the type field. TotalView displays nested classes that use inheritance, showing derivation by indentation.

NOTE >> Some C++ compilers do not write accessibility information. In these cases, TotalView cannot display this information.

For example, [Figure 144](#) displays an object of a **class c**.

Figure 144 – Displaying C++ Classes That Use Inheritance



Its definition is as follows:

```
class b {
    char * b_val;
public:
    b() {b_val = "b value";}
};
```

```
class d : virtual public b {
    char * d_val;
public:
    d() {d_val = "d value";}
};

class e {
    char * e_val;
public:
    e() {e_val = "e value";}
};

class c : public d, public e {
    char * c_val;
public:
    c() {c_val = "c value";}
};
```

TotalView tries to display the correct data when you change the type of a Variable Window while moving up or down the derivation hierarchy. Unfortunately, many compilers do not contain the information that TotalView needs so you might need to cast your class.

RELATED TOPICS

More on using C++ with TotalView ["Using C++" on page 331](#)

C++View

C++View (CV) is a facility that allows you to format program data in a more useful or meaningful form than the concrete representation that you see in TotalView when you inspect data in a running program. To use C++View, you must write a function for each type whose format you would like to control. The signature of the function must be:

```
int TV_ttf_display_type ( const T *p )
```

where T is the type. Your function must use a TotalView-provided API to communicate the formatted representation of your data to TotalView.

When TotalView needs to display data, it checks to see if there is a function registered for the type to which the data belong. If there is, TotalView calls that function, and uses the results generated. Otherwise, if there is no matching function defined, TotalView presents the data in their raw form.

For complete details on using C++View, refer to the C++View chapter in the *TotalView for HPC Reference Guide*.

C++View is available from the Preferences window. (See [“Setting Preferences”](#) on page 128.)

Displaying Fortran Types

TotalView lets you display FORTRAN 77 and Fortran 90 data types.

The topics in this section describe the various types and how the debugger handles them:

- [“Displaying Fortran Common Blocks”](#) on page 271
- [“Displaying Fortran Module Data”](#) on page 273
- [“Debugging Fortran 90 Modules”](#) on page 274
- [“Viewing Fortran 90 User-Defined Types”](#) on page 275
- [“Viewing Fortran 90 Deferred Shape Array Types”](#) on page 276
- [“Viewing Fortran 90 Pointer Types”](#) on page 276
- [“Displaying Fortran Parameters”](#) on page 277

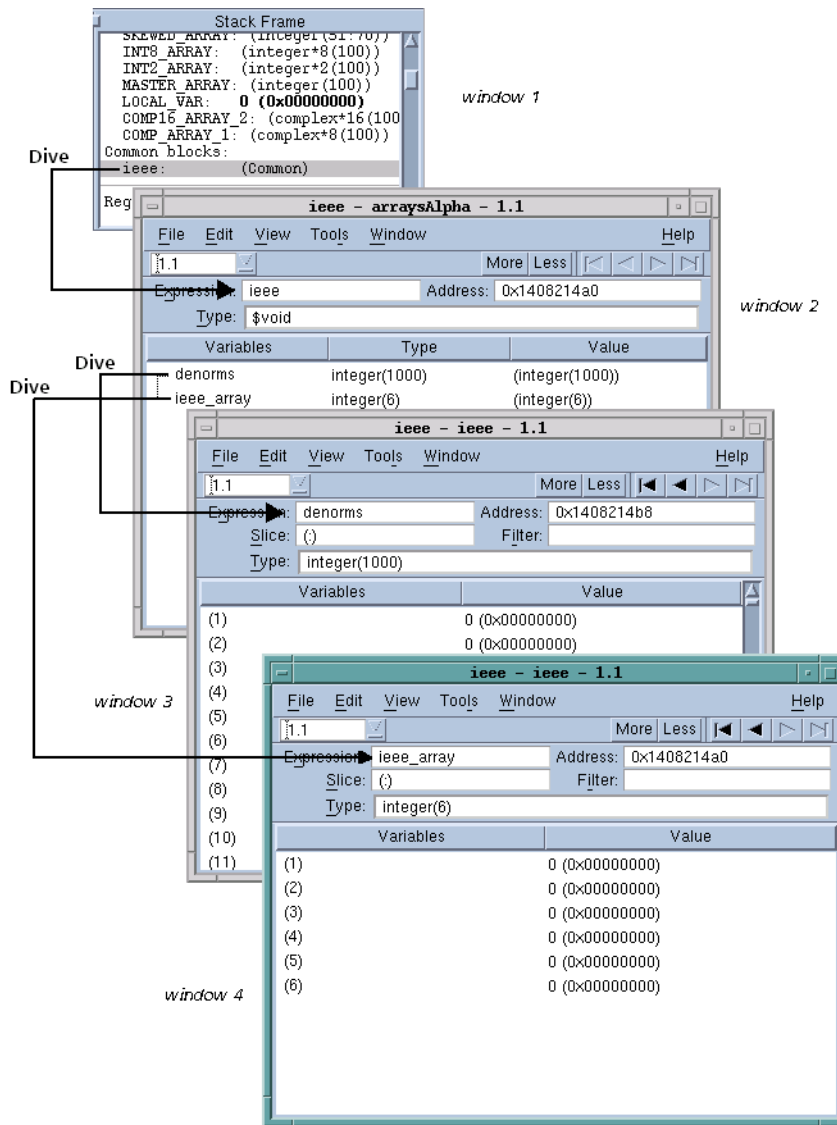
Displaying Fortran Common Blocks

For each common block defined in the scope of a subroutine or function, TotalView creates an entry in that function’s common block list. The Stack Frame Pane displays the name of each common block for a function. The names of common block members have function scope, not global scope.

CLI: `dprint variable-name`

If you dive on a common block name in the Stack Frame Pane, the debugger displays the entire common block in a Variable Window, as shown in Figure 145.)

Figure 145 – Diving on a Common Block List in the Stack Frame Pane



Window 1 in this figure shows a common block list in a Stack Frame Pane. After several dives, **Window 2** contains the results of diving on the common block.

If you dive on a common block member name, TotalView searches all common blocks in the function's scope for a matching member name, and displays the member in a Variable Window.

Displaying Fortran Module Data

TotalView tries to locate all data associated with a Fortran module and display it all at once. For functions and subroutines defined in a module, TotalView adds the full module data definition to the list of modules displayed in the Stack Frame Pane.

TotalView only displays a module if it contains data. Also, the amount of information that your compiler gives TotalView can restrict what is displayed.

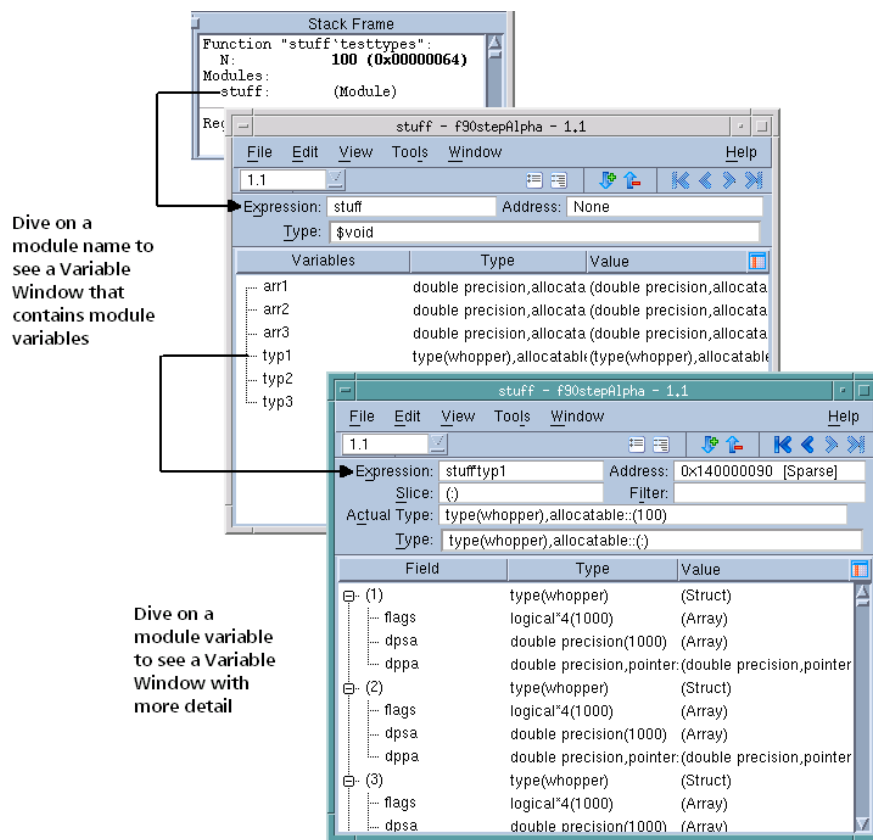
Although a function may use a module, TotalView doesn't always know if the module was used or what the true names of the variables in the module are. If this happens, either of the following occurs:

- Module variables appear as local variables of the subroutine.
- A module appears on the list of modules in the Stack Frame Pane that contains (with renaming) only the variables used by the subroutine.

CLI: `dprint variable-name`

Alternatively, you can view a list of all the known modules by using the **Tools > Fortran Modules** command. Because Fortran modules display in a Variable Window, you can dive on an entry to display the actual module data, as shown in [Figure 146](#).

Figure 146 – Fortran Modules Window



NOTE >> If you are using the SUNPro compiler, TotalView can only display module data if you force TotalView to read the debug information for a file that contains the module definition or a module function. For more information, see “Finding the Source Code for Functions” on page 157.

Debugging Fortran 90 Modules

Fortran 90 lets you place functions, subroutines, and variables inside modules. You can then include these modules elsewhere by using a **USE** command. When you do this, the names in the module become available in the *using* compilation unit, unless you either exclude them with a **USE ONLY** statement or rename them. This means that you don't need to explicitly qualify the name of a module function or variable from the Fortran source code.

When debugging this kind of information, you need to know the location of the function being called. Consequently, TotalView uses the following syntax when it displays a function contained in a module:

modulename`functionname

You can also use this syntax in the **File > Debug New Program** and **View > Lookup Variable** commands.

Fortran 90 also lets you create a contained function that is only visible in the scope of its parent and siblings. There can be many contained functions in a program, all using the same name. If the compiler gave TotalView the function name for a nested function, TotalView displays it using the following syntax:

```
parentfunction() `containedfunction
```

CLI: `dprint module_name`variable_name`

Viewing Fortran 90 User-Defined Types

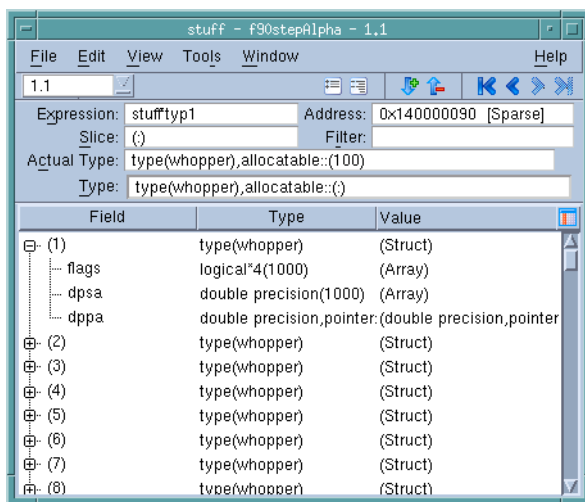
A Fortran 90 user-defined type is similar to a C structure. TotalView displays a user-defined type as **type(name)**, which is the same syntax used in Fortran 90 to create a user-defined type. For example, the following code fragment defines a variable **typ2** of **type(whopper)**:

```
TYPE WHOPPER
  LOGICAL, DIMENSION( ISIZE ) :: FLAGS
  DOUBLE PRECISION, DIMENSION( ISIZE ) :: DPSA
  DOUBLE PRECISION, DIMENSION( : ), POINTER :: DPPA
END TYPE WHOPPER

TYPE( WHOPPER ), DIMENSION( : ), ALLOCATABLE :: TYP2
```

TotalView displays this type, as shown in Figure 147.

Figure 147 – Fortran 90 User-Defined Type



Viewing Fortran 90 Deferred Shape Array Types

Fortran 90 lets you define deferred shape arrays and pointers. The actual bounds of a deferred shape array are not determined until the array is allocated, the pointer is assigned, or, in the case of an assumed shape argument to a subroutine, the subroutine is called. TotalView displays the type of deferred shape arrays as **type(:)**.

When TotalView displays the data for a deferred shape array, it displays the type used in the definition of the variable and the actual type that this instance of the variable has. The actual type is not editable, since you can achieve the same effect by editing the definition's type. The following example shows the type of a deferred shape rank 2 array of **real** data with runtime lower bounds of **-1** and **2**, and upper bounds of **5** and **10**:

```
Type: real(:, :)
Actual Type: real(-1:5, 2:10)
Slice: (:, :)
```

Viewing Fortran 90 Pointer Types

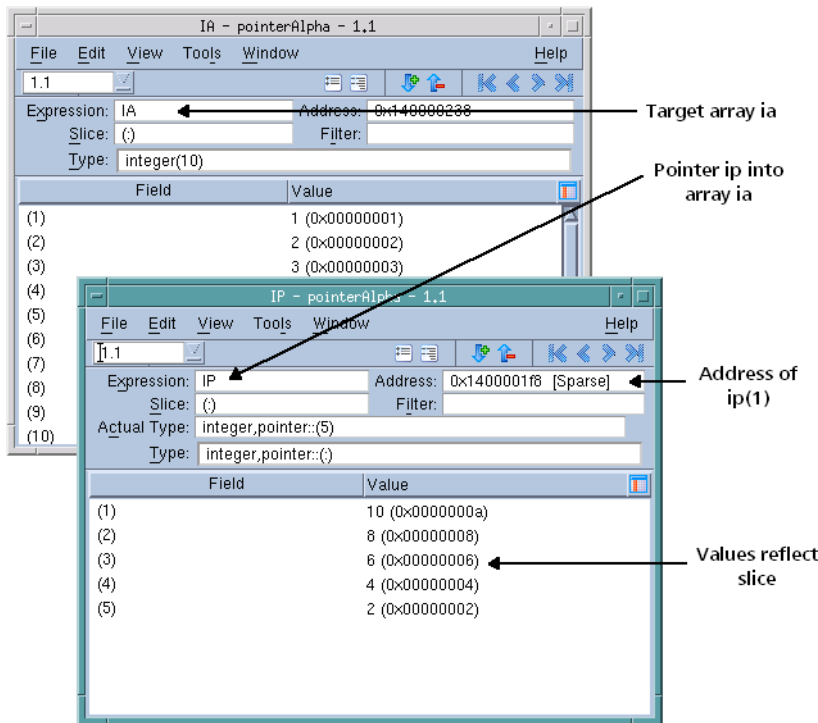
A Fortran 90 pointer type lets you point to scalar or array types.

TotalView implicitly handles slicing operations that set up a pointer or assumed shape subroutine argument so that indices and values it displays in a Variable Window are the same as in the Fortran code; for example:

```
integer, dimension(10), target :: ia
integer, dimension(:), pointer :: ip
do i = 1, 10
    ia(i) = i
end do
ip => ia(10:1:-2)
```

After diving through the **ip** pointer, TotalView displays the windows shown in Figure 148:

Figure 148 – Fortran 90 Pointer Value



The address displayed is not that of the array's base. Since the array's stride is negative, array elements that follow are at lower absolute addresses. Consequently, the address displayed is that of the array element that has the lowest index. This might not be the first displayed element if you used a slice to display the array with reversed indices.

Displaying Fortran Parameters

A Fortran **PARAMETER** defines a named constant. If your compiler generates debug information for parameters, they are displayed in the same way as any other variable. However, some compilers do not generate information that TotalView can use to determine the value of a **PARAMETER**. This means that you must make a few changes to your program if you want to see this type of information.

If you're using Fortran 90, you can define variables in a module that you initialize to the value of these **PARAMETER** constants; for example:

```
INCLUDE 'PARAMS.INC'  
MODULE CONSTS  
SAVE  
INTEGER PI_C = PI  
...  
END MODULE CONSTS
```

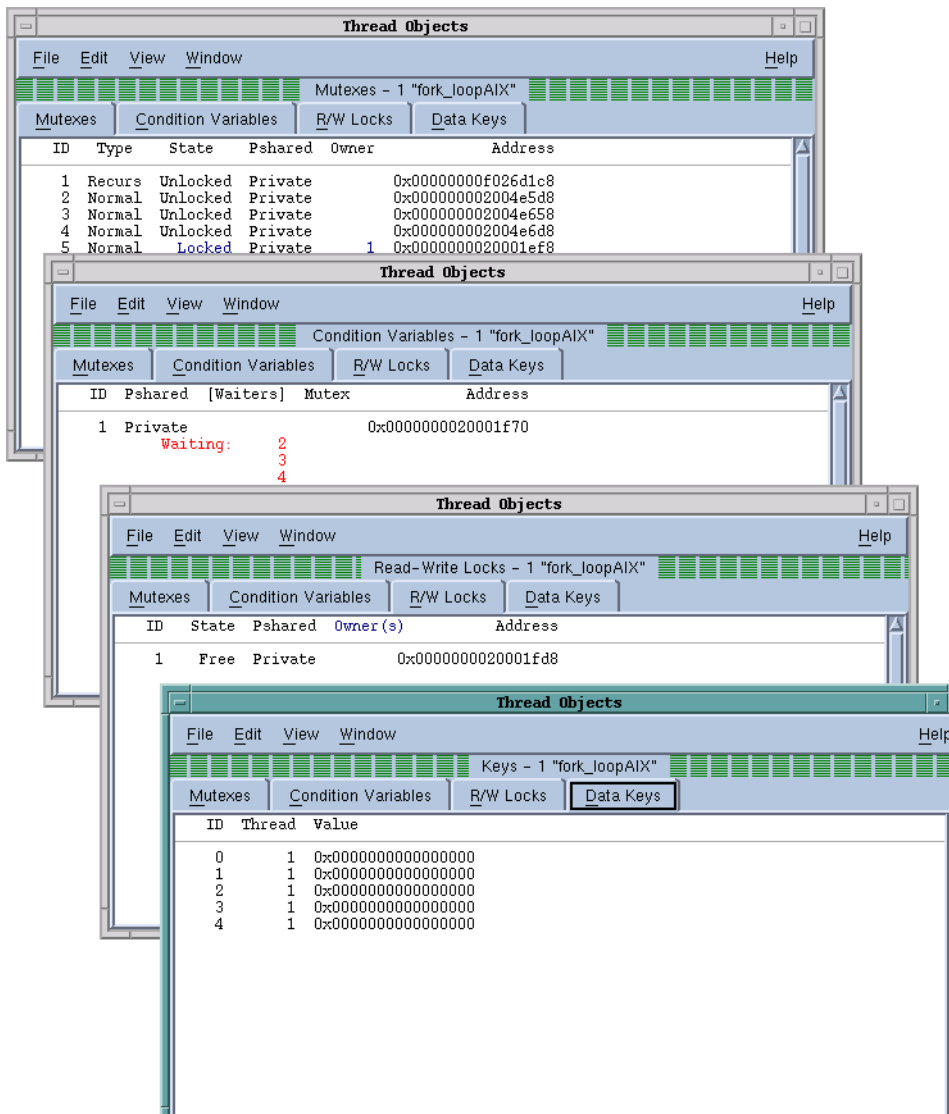

The **PARAMS.INC** file contains your parameter definitions. You then use these parameters to initialize variables in a module. After you compile and link this module into your program, the values of these parameter variables are visible.

If you're using FORTRAN 77, you can achieve the same results if you make the assignments in a common block and then include the block in **main()**. You can also use a block data subroutine to access this information.

Displaying Thread Objects

On IBM AIX systems, TotalView can display information about mutexes and conditional variables, read/write locks and data keys. You can obtain this information by selecting the **Tools > Thread Objects** command. After selecting this command, TotalView displays a window that contains four tabs. [Figure 149](#) shows examples based on AIX.

Figure 149 – Thread Objects Page on an IBM AIX Computer



Diving on any line in these windows displays a Variable Window that contains additional information about the item. Some notes:

- If you're displaying data keys, many applications initially set keys to **0** (the NULL pointer value). TotalView doesn't display a key's information, however, until a thread sets a non-NULL value to the key.
- If you select a thread ID in a data key window, you can dive on it using the **View > Dive Thread** and **View > Dive Thread in New Window** commands to display a Process Window for that thread ID.

The online Help contains information on the contents of the displayed windows.

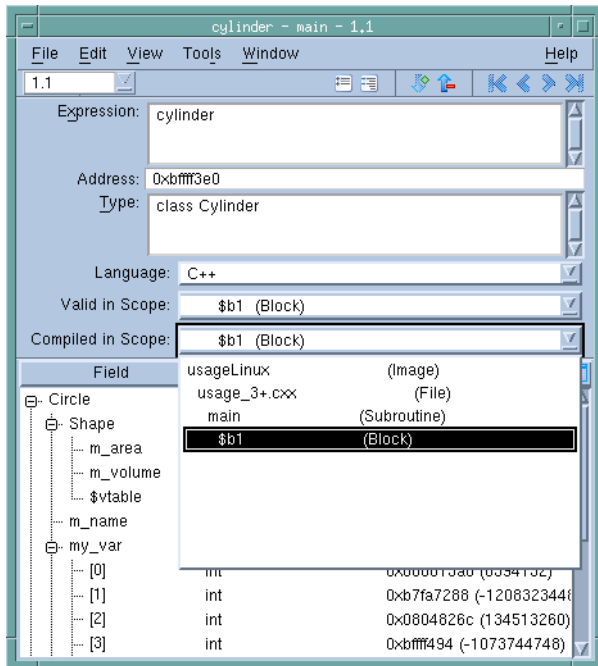
Scoping and Symbol Names

TotalView assigns a unique name to every element in your program based on the scope in which the element exists. A *scope* defines the part of a program that knows about a symbol. For example, the scope of a variable that is defined at the beginning of a subroutine is all the statements in the subroutine. The variable's scope does not extend outside of this subroutine. A program consists of multiple *scopes*. Of course, a block contained in the subroutine could have its own definition of the same variable. This would *hide* the definition in the enclosing scope.

All scopes are defined by your program's structure. Except for the simplest of programs, scopes are embedded in other scopes. The only exception is the outermost scope, which is the one that contains **main()**, which is not embedded. Every element in a program is associated with a scope.

To see the scope in which a variable is valid, click the **More** button in the Variable Window until the scope fields are visible. The Variable Window now includes additional information about your variable, as is shown in [Figure 150](#).

Figure 150 – Variable Window: Showing Variable Properties



The **Valid in Scope** list indicates the scope in which the variable resides. That is, when this scope is active, the variable is defined. The **Compiled in Scope** list can differ if you modify the variable with an expression. It indicates where variables in this expression have meaning.

When you tell the CLI or the GUI to execute a command, TotalView consults the program's symbol table to discover which object you are referring to—this process is known as *symbol lookup*. Symbol lookup is performed with respect to a particular context, and each context uniquely identifies the scope to which a symbol name refers.

RELATED TOPICS

Issues with scoping [“Scoping Issues” on page 227](#)

Variables in a current block [“Displaying Variables in the Current Block” on page 225](#)

Qualifying Symbol Names

The way you describe a scope is similar to the way you specify a file. The scopes in a program form a tree, with the outermost scope (which is your program) as the root. At the next level are executable files and dynamic libraries; further down are compilation units (source files), procedures, modules, and other scoping units (for example, blocks) supported by the programming language. Qualifying a symbol is equivalent to describing the path to a file in UNIX file systems.

A symbol is fully scoped when you name all levels of its tree. The following example shows how to scope a symbol and also indicates parts that are optional:

```
[##executable-or-lib#][file#][procedure-or-line#]symbol
```

The pound sign (#) separates elements of the fully qualified name.

NOTE >> Because of the number of different types of elements that can appear in your program, a complete description of what can appear and their possible order is complicated and unreadable. In contrast, after you see a name in the Stack Frame Pane, it is easy to read a variable's scoped name.

TotalView interprets most programs and components as follows:

- If a qualified symbol begins with ##, the name that follows indicates the name of the executable or shared library (just as an absolute file path begins with a directory immediately in the root directory). If you omit the executable or library component, the qualified symbol doesn't begin with #.
- The source file's name can appear after the possibly omitted executable or shared library.
- Because programming languages typically do not let you name blocks, that portion of the qualifier is specified using the symbols **\$b** followed by a number that indicates which block. For example, the first unnamed block is named **\$b1**, the second is **\$b2**, and so on.

RELATED TOPICS

Issues with scoping	“Scoping Issues” on page 227
The dbreak command	dbreak command description
Breakpoints at locations	“Setting Breakpoints at Locations” on page 182
Lookup Function	The View > Lookup Function topic in the in-product help
Lookup Variable	The View > Lookup Variable topic in the in-product help



Chapter 10

Examining Arrays

This chapter explains how to examine and change array data as you debug your program. Since arrays also appear in the Variable Window, you need to be familiar with the information in [Chapter 9, “Examining and Editing Data and Program Elements,”](#) on page 214.

The topics in this chapter are:

- [“Examining and Analyzing Arrays”](#) on page 284
- [“Displaying a Variable in all Processes or Threads”](#) on page 300
- [“Visualizing Array Data”](#) on page 302

Examining and Analyzing Arrays

TotalView can quickly display very large arrays in Variable Windows. An array can be the elements that you define in your program, or it can be an area of memory that you cast into an array.

If an array extends beyond the memory section in which it resides, the initial portion of the array is formatted correctly. If memory isn't allocated for an array element, TotalView displays **Bad Address** in the element's subscript.

Topics in this section are:

- “[Displaying Array Slices](#)” on page 284
- “[Array Slices and Array Sections](#)” on page 287
- “[Viewing Array Data](#)” on page 288
- “[Filtering Array Data Overview](#)” on page 290
- “[Sorting Array Data](#)” on page 296
- “[Obtaining Array Statistics](#)” on page 297

Displaying Array Slices

TotalView lets you display array subsections by editing the **Slice** field in an array's Variable Window. (An array subsection is called a *slice*.) The **Slice** field contains placeholders for all array dimensions. For example, the following is a C declaration for a three-dimensional array:

```
integer an_array[10][20][5]
```

Because this is a three-dimensional array, the initial slice definition is `[:][:][:]`. This lets you know that the array has three dimensions and that TotalView is displaying all array elements.

The following is a deferred shape array definition for a two-dimensional array variable:

```
integer, dimension (:,:) :: another_array
```

The TotalView slice definition is `(:,:)`.

TotalView displays as many colons (`:`) as there are array dimensions. For example, the slice definition for a one-dimensional array (a vector) is `[:]` for C arrays and `(:)` for Fortran arrays.

```
CLI: dprint -slice “[n:m\]” an_array
      dprint -slice “(n:m,p;q)” an_array
```

Using Slices and Strides

A slice has the following form:

lower_bound:upper_bound[:stride]

The *stride*, which is optional, tells TotalView to skip over elements and not display them. Adding a *stride* to a slice tells the debugger to display every *stride* element of the array, starting at the *lower_bound* and continuing through the *upper_bound*, inclusive.

For example, a slice of **[0:9:9]** used on a ten-element C array tells TotalView to display the first element and last element, which is the ninth element beyond the lower bound.

If the stride is negative and the lower bound is greater than the upper bound, TotalView displays a dimension with its indices reversed. That is, TotalView treats the slice as if it was defined as follows:

[upperbound : lowerbound : stride]

CLI: `dprint an_array(n:m:p,q:r:s)`

For example, the following definition tells TotalView to display an array beginning at its last value and moving to its first:

[::-1]

This syntax differs from Fortran 90 syntax in that Fortran 90 requires that you explicitly enter the upper and lower bounds when you're reversing the order for displaying array elements.

Because the default value for the stride is **1**, you can omit the stride (and the colon that precedes it) from your definition. For example, the following two definitions display array elements 0 through 9:

[0:9:1]
[0:9]

If the lower and upper bounds are the same, just use a single number. For example, the following two definitions tell TotalView to display array element 9:

[9:9:1]
[9]

NOTE >> The *lower_bound*, *upper_bound*, and *stride* must be constants. They cannot be expressions.

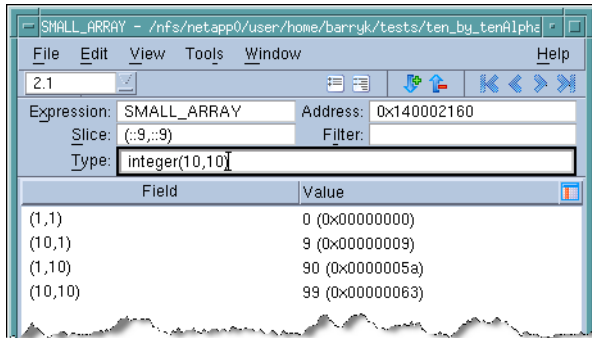
Example 1

A slice declaration of **[::2]** for a C or C++ array (with a default lower bound of **0**) tells TotalView to display elements with even indices of the array; that is, 0, 2, 4, and so on. However, if this were defined for a Fortran array (where the default lower bound is **1**), TotalView displays elements with odd indices of the array; that is, 1, 3, 5, and so on.

Example 2

Figure 151 displays a stride of **(::9,::9)**. This definition displays the four corners of a ten-element by ten-element Fortran array.

Figure 151 – Stride Displaying the Four Corners of an Array



Example 3

You can use a stride to invert the order *and* skip elements. For example, the following slice begins with the upper bound of the array and displays every other element until it reaches the lower bound of the array:

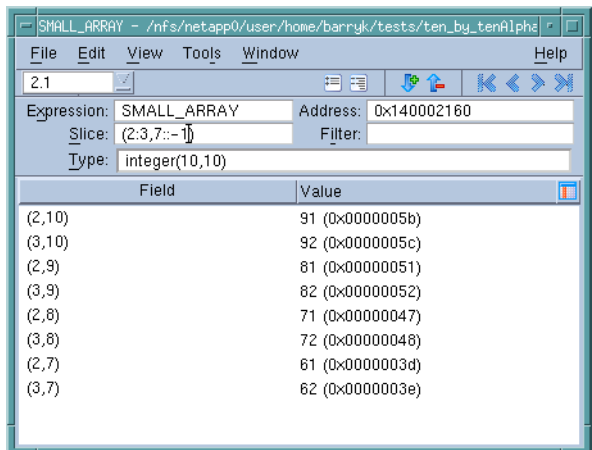
`(::-2)`

Using `(::-2)` with a Fortran `integer(10)` array tells TotalView to display the elements 10, 8, 6, 4, and 2.

Example 4

You can simultaneously invert the array's order and limit its extent to display a small section of a large array. The following figure shows how to specify a `(2:3,7::-1)` slice with an `integer*4(-1:5,2:10)` Fortran array.

Figure 152 – Fortran Array with Inverse Order and Limited Extent



After you enter this slice value, TotalView only shows elements in rows 2 and 3 of the array, beginning with column 10 and ending with column 7.

Using Slices in the Lookup Variable Command

When you use the **View > Lookup Variable** command to display a Variable Window, you can include a slice expression as part of the variable name. Specifically, if you type an array name followed by a set of slice descriptions in the **View > Lookup Variable** command dialog box, TotalView initializes the **Slice** field in the Variable Window to this slice description.

If you add subscripts to an array name in the **View > Lookup Variable** dialog box, TotalView will look up just that array element.

```
CLI: dprint small_array(5,5)
```

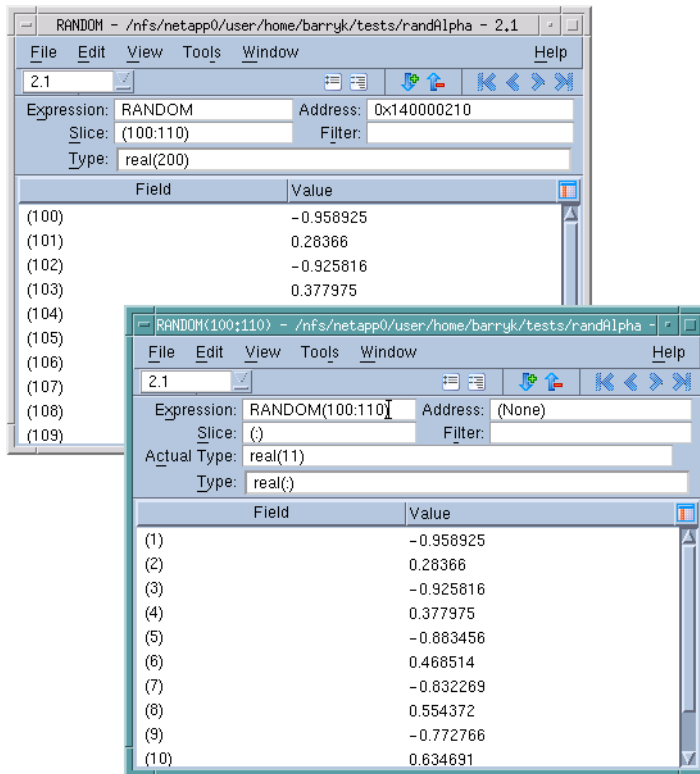
You can, of course, type an expression into the **View > Lookup Variable** dialog box; for example, you could type `small_array(i-1,j-1)`.

Array Slices and Array Sections

An array slice allows you to see a part of an array. The slice allows you to remove parts of the array you do not want to see. For example, if you have a 10,000 element array, you could tell TotalView that it should only display 100 of these elements. Fortran has introduced the concept of an array section. When you create an array section, you are creating a new array that is a subset of the old array. Because it is a new array, its first array index is 1.

In [Figure 153](#), the top left Variable Window displays an eleven-element array slice. The bottom right Variable Window displays an eleven-element array.

Figure 153 – An Array Slice and an Array Section

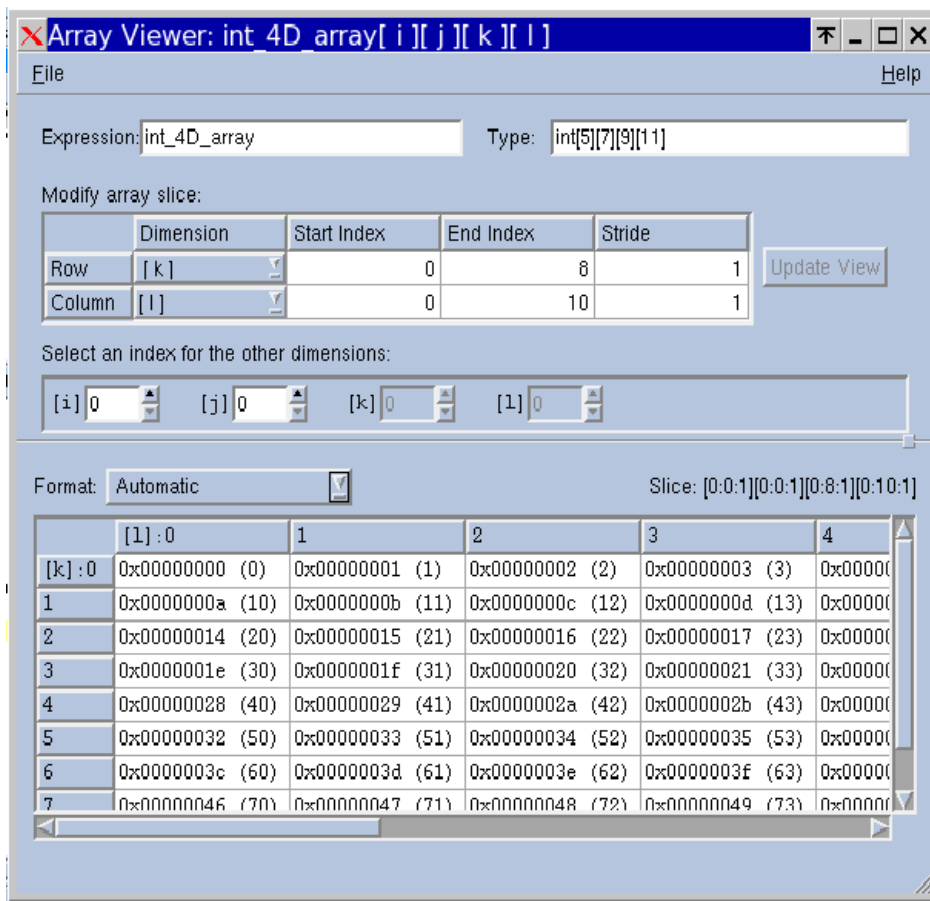


While the data in both is identical, notice that the array numbering is different. In addition, the array slice shows an address for the array. The section, however, only exists within TotalView. Consequently, there is no address associated with it.

Viewing Array Data

TotalView provides another way to look at the data in a multi-dimensional array. The Variable Window's **Tools > Array Viewer** command opens a window that presents a slice of array data in a table format, [Figure 154](#). You can think of this as viewing a “plane” of two-dimensional data in your array.

Figure 154 – Array Viewer



When the Array Viewer opens, the initial slice of displayed data depends on the values you entered in the Variable Window. You can change the displayed data by modifying the Expression, Type, or slice controls in the Array Viewer and then pressing the Update View button.

Expression Field

The Expression field contains an array expression based on the value you entered in the Variable Window. You can control the display by changing the value of this field; for example, you can cast the array to another array expression.

Type Field

The Type field also reflects the data you initially entered in the Variable Window. You can modify the type to cast the array to a different array type.

Slice Definition

Initially, TotalView selects the array slice by placing the appropriate array dimension as the row and the column, setting the indices for the lower and upper bounds of the dimensions with a stride of one. Any additional dimensions are held at 0. This is the slice or plane of data that is displayed in the table.

You have full control over all settings, including the ability to change which dimensions appear as rows and columns, as well as their indices and strides. As you change the row and column dimensions, the controls for the other dimensions are enabled/disabled accordingly. You can change the indices of the other dimensions to further refine the slice of data. The section [“Using Slices and Strides”](#) on page 284 provides more information on slicing arrays.

Update View Button

When you have finished making changes to the expression, type, and/or slice settings, press the **Update View** button to update the data in the table display.

Data Format Selection Box

The selection box at the top left corner of the data table allows you to select the format for displaying the data. The table automatically refreshes in the selected format.

The Slice field at the top right corner of the data table reflects the displayed slice of data.

Filtering Array Data Overview

You can restrict what TotalView displays in a Variable Window by adding a filter to the window. You can filter arrays of type character, integer, or floating point. Your filtering options are:

- Arithmetic comparison to a constant value
- Equal or not equal comparison to IEEE NaNs, Infs, and Denorms
- Within a range of values, inclusive or exclusive
- General expressions

When an element of an array matches the filter expression, TotalView includes the element in the Variable Window display.

The following topics describe filtering options:

- [“Filtering Array Data”](#) on page 291
- [“Filtering by Comparison”](#) on page 291
- [“Filtering for IEEE Values”](#) on page 292

- “Filtering a Range of Values” on page 294
- “Creating Array Filter Expressions” on page 295
- “Using Filter Comparisons” on page 295

Filtering Array Data

The procedure for filtering an array is simple: select the **Filter** field, enter the array filter expression, and then press Enter.

TotalView updates the Variable Window to exclude elements that do not match the filter expression. TotalView only displays an element if its value matches the filter expression and the slice operation.

If necessary, TotalView converts the array element before evaluating the filter expression. The following conversion rules apply:

- If the filter operand or array element type is floating point, TotalView converts the operand to a double-precision floating-point value. TotalView truncates extended-precision values to double precision. Converting integer or unsigned integer values to double-precision values might result in a loss of precision. TotalView converts unsigned integer values to nonnegative double-precision values.
- If the filter operand or the array element is an unsigned integer, TotalView converts the operand to an unsigned 64-bit integer.
- If both the filter operand and array element are of type integer, TotalView converts the values to a 64-bit integer.

TotalView conversion operations modify a copy of the array's elements—conversions never alter the actual array elements.

To stop filtering an array, delete the contents of the **Filter** field in the Variable Window and press Enter. TotalView then updates the Variable Window so that it includes all elements.

Filtering by Comparison

The simplest filters are ones whose formats are as follows:

operator value

where *operator* is either a C/C++ or Fortran-style comparison operator, and *value* is a signed or unsigned integer constant or a floating-point number. For example, the filter for displaying all values greater than 100 is:

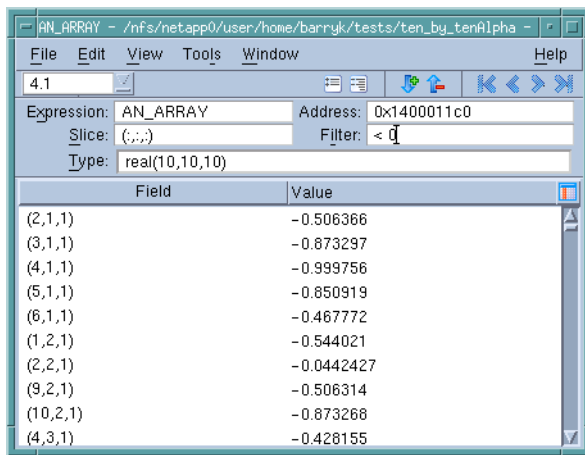
> 100

The following table lists the comparison operators:

Comparison	C/C++ Operator	Fortran Operator
Equal	==	.eq.
Not equal	!=	.ne.
Less than	<	.lt.
Less than or equal	<=	.le.
Greater than	>	.gt.
Greater than or equal	>=	.ge.

Figure 155 shows an array whose filter is `< 0`. This tells TotalView to display only array elements whose value is less than 0 (zero).

Figure 155 – Array Data Filtering by Comparison



If the *value* you are using in the comparison is an integer constant, TotalView performs a signed comparison. If you add the letter **u** or **U** to the constant, TotalView performs an unsigned comparison.

Filtering for IEEE Values

You can filter IEEE NaN, Infinity, or denormalized floating-point values by specifying a filter in the following form:

operator ieee-tag

The only comparison operators you can use are *equal* and *not equal*.

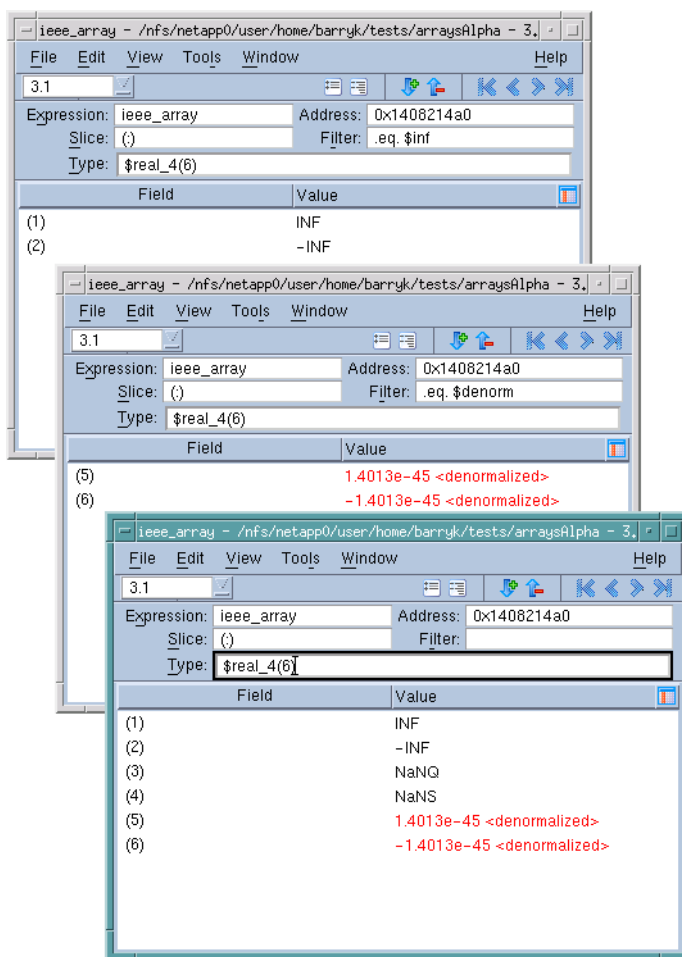
The *ieee-tag* represents an encoding of IEEE floating-point values, as the following table describes:

IEEE Tag Value	Meaning
<code>\$nan</code>	NaN (Not a number), either quiet or signaling
<code>\$nanq</code>	Quiet NaN

IEEE Tag Value	Meaning
\$nans	Signaling NaN
\$inf	Infinity, either positive or negative
\$pinf	Positive Infinity
\$ninf	Negative Infinity
\$denorm	Denormalized number, either positive or negative
\$pdenorm	Positive denormalized number
\$ndenorm	Negative denormalized number

Figure 156 shows an example of filtering an array for IEEE values. The bottom window in this figure shows how TotalView displays the unfiltered array. Notice the NaNQ, and NaNS, INF, and -INF values. The other two windows show filtered displays: the top window shows only infinite values; the second window only shows the values of denormalized numbers.

Figure 156 – Array Data Filtering for IEEE Values



If you are writing an expression, you can use the following Boolean functions to check for a particular type of value:

IEEE Intrinsic	Meaning
<code>\$is_denorm(value)</code>	Is a denormalized number, either positive or negative
<code>\$is_finite(value)</code>	Is finite
<code>\$is_inf(value)</code>	Is Infinity, either positive or negative
<code>\$is_nan(value)</code>	Is a NaN (Not a number), either quiet or signaling
<code>\$is_ndenorm(value)</code>	Is a negative denormalized number
<code>\$is_ninf(value)</code>	Is negative Infinity
<code>\$is_nnorm(value)</code>	Is a negative normalized number
<code>\$is_norm(value)</code>	Is a normalized number, either positive or negative
<code>\$is_nzero(value)</code>	Is negative zero
<code>\$is_pdenorm(value)</code>	Is a positive denormalized number
<code>\$is_pinf(value)</code>	Is positive Infinity
<code>\$is_pnorm(value)</code>	Is a positive normalized number
<code>\$is_pzero(value)</code>	Is positive zero
<code>\$is_qnan(value)</code>	Is a quiet NaN
<code>\$is_snan(value)</code>	Is a signaling NaN
<code>\$is_zero(value)</code>	Is zero, either positive or negative

Filtering a Range of Values

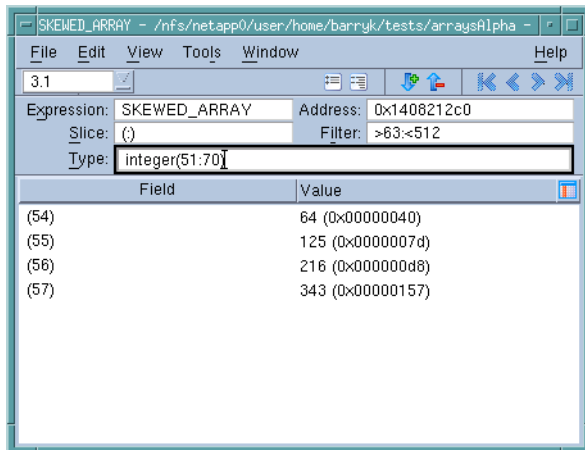
You can also filter array values by specifying a range, as follows:

```
[>] low-value : [<] high-value
```

where *low-value* specifies the lowest value to include, and *high-value* specifies the highest value to include, separated by a colon. The high and low values are inclusive unless you use less-than (<) and greater-than (>) symbols. If you specify a > before *low-value*, the low value is exclusive. Similarly, a < before *high-value* makes it exclusive.

The values of *low-value* and *high-value* must be constants of type integer, unsigned integer, or floating point. The data type of *low-value* must be the same as the type of *high-value*, and *low-value* must be less than *high-value*. If *low-value* and *high-value* are integer constants, you can append the letter **u** or **U** to the value to force an unsigned comparison. The following figure shows a filter that tells TotalView to only display values greater than 63, but less than 512. (See [Figure 157](#).)

Figure 157 – Array Data Filtering by Range of Values



Creating Array Filter Expressions

The filtering capabilities described in the previous sections are those that you use most often. In some circumstances, you may need to create a more general expression. When you create a filter expression, you're creating a Fortran or C Boolean expression that TotalView evaluates for every element in the array or the [array slice](#). For example, the following expression displays all array elements whose contents are greater than 0 and less than 50, or greater than 100 and less than 150:

```
($value > 0 && $value < 50) ||  
($value > 100 && $value < 150)
```

Here's the Fortran equivalent:

```
($value .gt. 0 && $value .lt. 50) .or.  
($value .gt. 100 .and. $value .lt.150)
```

The **\$value** variable is a special TotalView variable that represents the current array element. You can use this value when creating expressions.

Notice how the **and** and **or** operators are used in these expressions. The way in which TotalView computes the results of an expression is identical to the way it computes values at an eval point. For more information, see ["Defining Eval Points and Conditional Breakpoints"](#) on page 197.

Using Filter Comparisons

TotalView provides several different ways to filter array information. For example, the following two filters display the same array items:

```
> 100  
$value > 100
```

The following filters display the same array items:

```
>0:<100
```

```
$value > 0 && $value < 100
```

The only difference is that the first method is easier to type than the second, so you're more likely to use the second method when you're creating more complicated expressions.

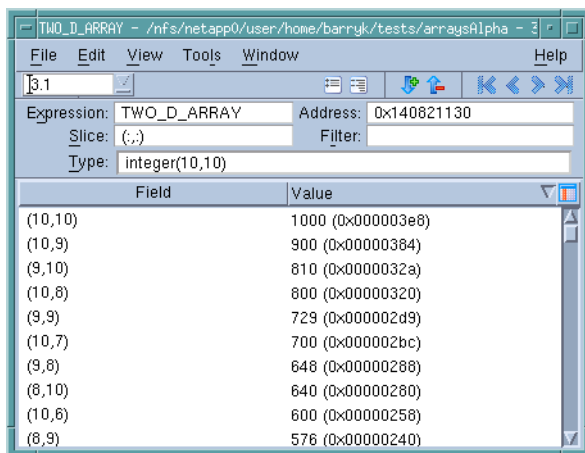
Sorting Array Data

TotalView lets you sort the displayed array data into ascending or descending order. (It does not sort the actual data.) To sort (or remove the sort), click the **Value** label.

- The first time you click, TotalView sorts the array's values into ascending order.
- The next time you click on the header, TotalView reverses the order, sorting the array's values into descending order.
- If you click again on the header, TotalView returns the array to its unsorted order.

Here is an example that sorts an array into descending order:

Figure 158 – Sorted Variable Window



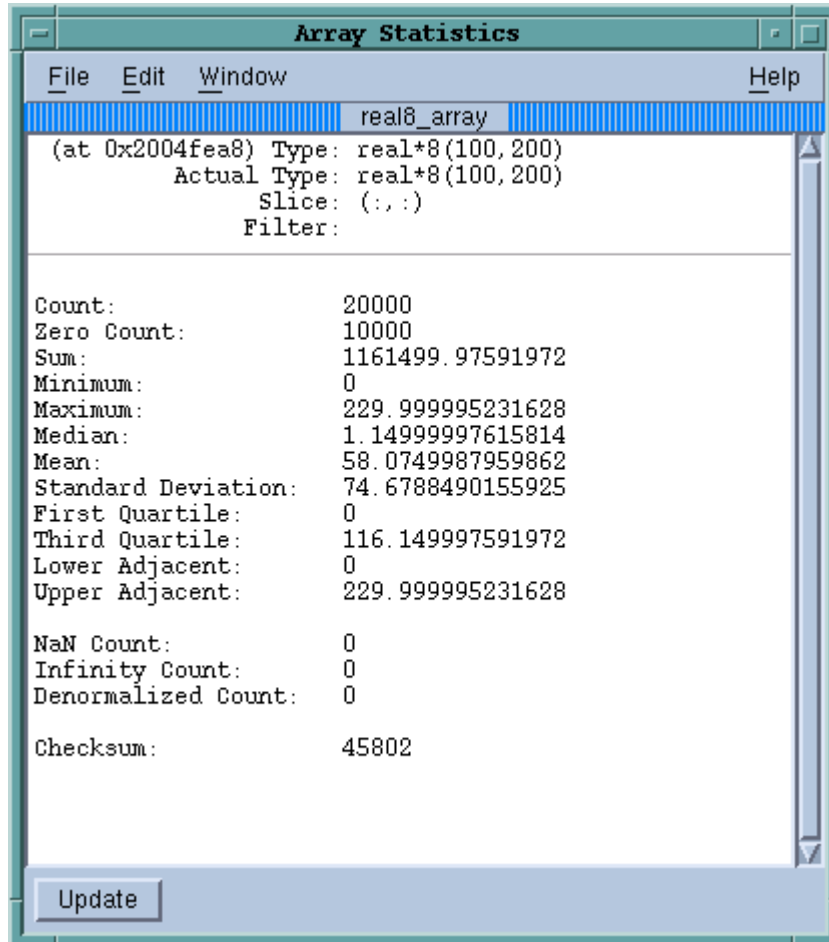
When you sort an array's values, you are just rearranging the information that's displayed in the Variable Window. Sorting does not change the order in which values are stored in memory. If you alter what TotalView is displaying by using a filter or a slice, TotalView just sorts the values that could be displayed; it doesn't sort all of the array.

If you are displaying the array created by a **Show across** command—see [“Displaying a Variable in all Processes or Threads”](#) on page 300 for more information—you can sort your information by process or thread.

Obtaining Array Statistics

The **Tools > Statistics** command displays a window that contains information about your array. [Figure 159](#) shows an example.

Figure 159 – Array Statistics Window



If you have added a filter or a slice, these statistics describe only the information currently being displayed; they do not describe the entire unfiltered array. For example, if 90% of an array's values are less than 0 and you filter the array to show only values greater than 0, the median value is positive even though the array's real median value is less than 0.

NOTE >> Array statistics are available through the CLI, as switches to the `dprint` command. See the `dprint` description in the Reference Guide for details.

TotalView displays the following statistics:

- **Checksum**

A checksum value for the array elements.

- **Count**

The total number of displayed array values. If you're displaying a floating-point array, this number doesn't include NaN or Infinity values.

- **Denormalized Count**

A count of the number of denormalized values found in a floating-point array. This includes both negative and positive denormalized values as defined in the IEEE floating-point standard. Unlike other floating-point statistics, these elements participate in the statistical calculations.

- **Infinity Count**

A count of the number of infinity values found in a floating-point array. This includes both negative and positive infinity as defined in the IEEE floating-point standard. These elements do not participate in statistical calculations.

- **Lower Adjacent**

This value provides an estimate of the lower limit of the distribution. Values below this limit are called *outliers*. The lower adjacent value is the first quartile value minus the value of 1.5 times the difference between the first and third quartiles.

- **Maximum**

The largest array value.

- **Mean**

The average value of array elements.

- **Median**

The middle value. Half of the array's values are less than the median, and half are greater than the median.

- **Minimum**

The smallest array value.

- **NaN Count**

A count of the number of NaN (not a number) values found in a floating-point array. This includes both signaling and quiet NaNs as defined in the IEEE floating-point standard. These elements do not participate in statistical calculations.

- **Quartiles, First and Third**

Either the 25th or 75th percentile values. The first quartile value means that 25% of the array's values are less than this value and 75% are greater than this value. In contrast, the third quartile value means that 75% of the array's values are less than this value and 25% are greater.

- **Standard Deviation**

The standard deviation for the array's values.

- **Sum**

The sum of all the displayed array's values.

- **Upper Adjacent**

This value provides an estimate of the upper limit of the distribution. Values above this limit are called *outliers*. The upper adjacent value is the third quartile value plus the value of 1.5 times the difference between the first and third quartiles.

- **Zero Count**

The number of elements whose value is 0.

Displaying a Variable in all Processes or Threads

When you're debugging a parallel program running many instances of the same executable, you usually need to view or update the value of a variable in all of the processes or threads at once.

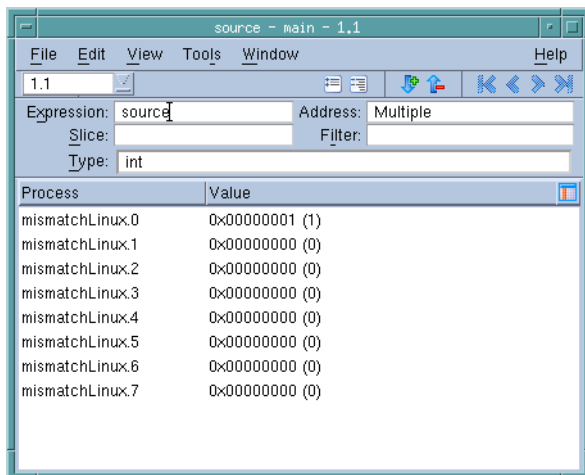
Before displaying a variable's value in all threads or processes, you must display an instance of the variable in a Variable Window. In this window, use one of the following commands:

- **View > Show Across > Process**, displays the value of the variable in all processes.
- **View > Show Across > Thread**, displays the value of a variable in all threads within a single process.
- **View > Show Across > None**, returns the window to what it was before you used other Show Across commands.

NOTE >> You cannot simultaneously Show Across processes and threads in the same Variable Window.

After selecting a command, the Variable Window provides an array-like display of the value of the variable in each process or thread. [Figure 160](#) shows a simple, scalar variable in each of the processes in an OpenMP program.

Figure 160 – Viewing Across Threads



When looking for a matching stack frame, TotalView matches frames starting from the top **frame**, and considers calls from different memory or stack locations to be different calls. For example, the following definition of **recurse()** contains two additional calls to **recurse()**. Each of these calls generates a nonmatching **call frame**.

```
void recurse(int i) {  
    if (i <= 0)  
        return;  
}
```

```

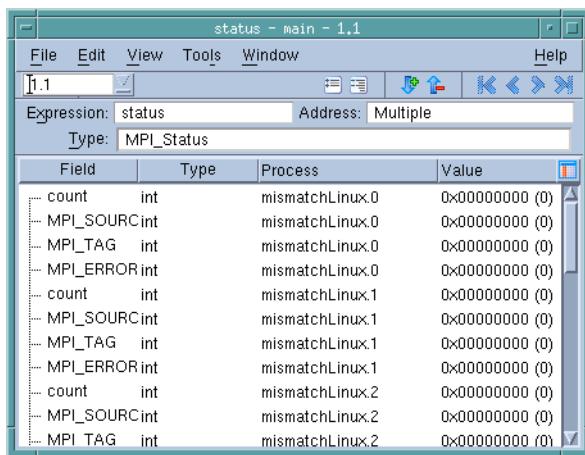
if (i & 1)
    recurse(i - 1);
else
    recurse(i - 1);
}

```

If the variables are at different addresses in the different processes or threads, the field to the left of the **Address** field displays **Multiple**, and the unique addresses appear with each data item.

TotalView also lets you Show Across arrays and structures. When you Show Across an array, TotalView displays each element in the array across all processes. You can use a slice to select elements to be displayed in an “across” display. The following figure shows the result of applying a **Show Across > Processes** command to an array of structures.

Figure 161 – Viewing across an Array of Structures



RELATED TOPICS

Viewing a structure’s elements as an array [“Displaying an Array of Structure’s Elements” on page 242](#)

Diving on a “Show Across” Pointer

You can dive through pointers in a Show Across display. This dive applies to the associated pointer in each process or thread.

Editing a “Show Across” Variable

If you edit a value in a “Show Across” display, TotalView asks if it should apply this change to all processes or threads or only the one in which you made a change. This is an easy way to update a variable in all processes.

Visualizing Array Data

The Visualizer lets you create graphical images of array data. This presentation lets you see your data in one glance and can help you quickly find problems with your data while you are debugging your programs.

You can execute the Visualizer from within TotalView, or you can run it from the command line to visualize data dumped to a file in a previous TotalView session.

For information about running the Visualizer, see [Chapter 11, “Visualizing Programs and Data,”](#) on page 303.

Visualizing a “Show Across” Variable Window

You can export data created by using a *Show Across* command to the Visualizer by using the **Tools > Visualize** command. When visualizing this kind of data, the process (or thread) index is the first axis of the visualization. This means that you must use one less data dimension than you normally would. If you do not want the process/thread axis to be significant, you can use a normal Variable Window, since all of the data must be in one process.



Chapter 11

Visualizing Programs and Data

TotalView provides a set of tools to visualize your program activity, including its arrays, and MPI message data. This chapter describes:

- “[Displaying Call Trees and Call Graphs](#)” on page 304
- “[Parallel Backtrace View](#)” on page 307
- “[Array Visualizer](#)” on page 309

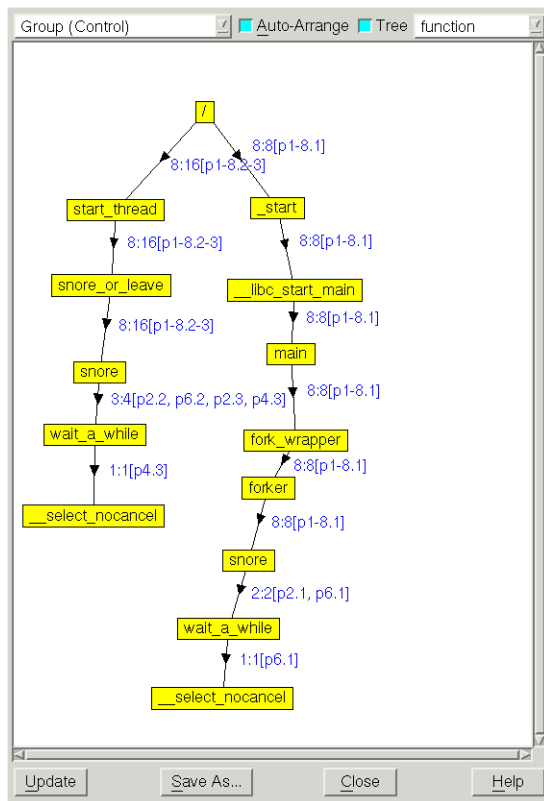
Displaying Call Trees and Call Graphs

Debugging is an art, not a science. Debugging often requires the intuition to guess what a program is doing and where to look for problems. Just locating a problem can be 90% or more of the effort. A call tree or call graph can help you understand what your program is doing so that you can understand how your program is executing.

To display a call tree or call graph, select **Tools > Call Graph** from the Process Window. A sample call tree is shown in [Figure 162](#).

The call tree or call graph shows all currently active routines linked by arrows indicating if one routine is called by another. The display is *dynamic* in that it shows activity at the moment it is created. The **Update** button recreates the display.

Figure 162 – Tools > Call Graph Dialog Box



You can toggle between displaying a call tree or call graph for specific processes and threads using the controls at the top of this window. By default, TotalView displays a tree representing the backtrace of all the selected processes and threads. To change to a Graph Style display, deselect the **Tree** button.

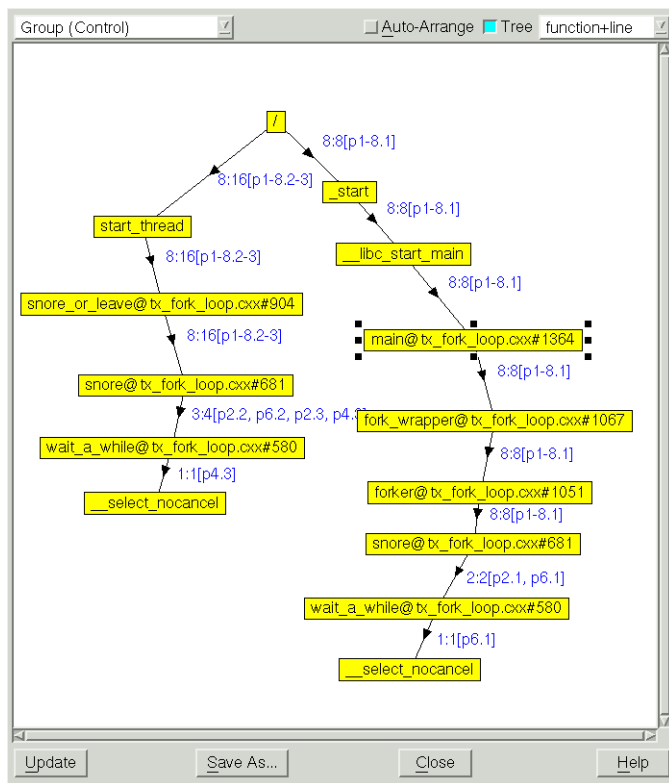
For multi-process or multi-threaded programs, a compressed process/thread list (**ptlist**) next to the arrows indicates which threads have a routine on their call stack.

Similar to the CLI's **dwhere -group_by** option, the dropdown in the call tree window enables you to aggregate the backtraces according to different properties, as follows:

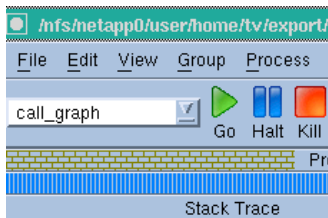
- **function**: Equivalence based on the name of the function containing the PC for the frame. This is the default.
- **function+line**: Equivalence based on the name of the function and the file and line number containing the PC for the frame.
- **function+offset**: Equivalence based on the name of the function containing the PC for the frame and offset from the beginning of the function to the PC for the frame.

For example, [Figure 163](#) displays the call tree grouped by function and line:

Figure 163 – Tools > Call Graph grouped by function and line



Diving on a routine within the call tree or call graph creates a group called **call_graph**, containing all the threads that have the routine you dived on in its call stack. If you look at the Process Window's Processes tab, you'll see that the **call_graph** set is selected in the scope pulldown.



In addition, the context of the Process Window changes to the first thread in the set.

As you begin to understand your program, you will see that this diagram reflects your program's rhythm and dynamic. As you examine and understand this structure, you will sometimes see things that don't look right — these are often places where you should look for problems.

Diving on a routine that doesn't look right can isolate the processes into their own group so that you can find out what is occurring there. Be aware that diving on a routine overwrites the group, so if you want to preserve the group, use the **Groups > Custom Groups** command to make a copy.

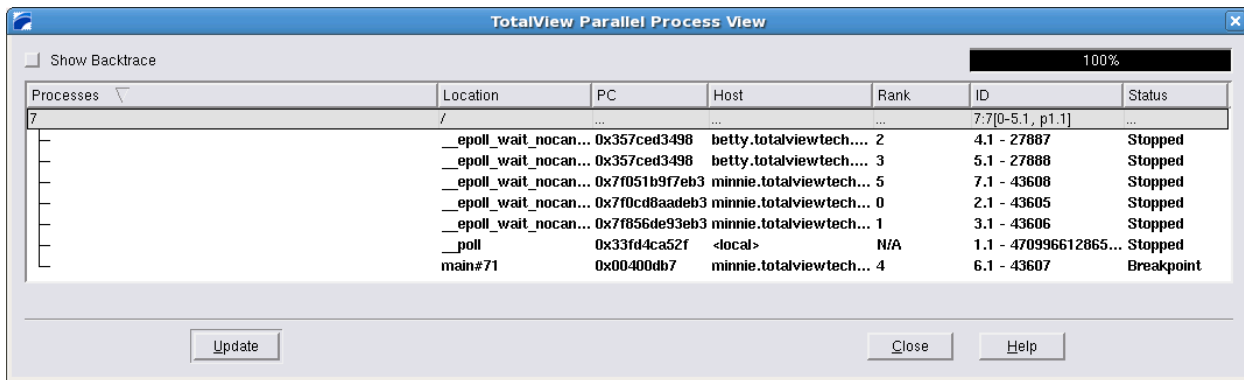
A call tree or call graph can also reveal bottlenecks. For example, if one routine is used by many other routines and controls a shared resource, this thread might be negatively affecting performance.

Diving (with the right mouse button) on each expanded item displays its process window

0x357ceca566 <local>	2
0x357	0
0x33f Dive	7
0x33f Dive in New Window	5
0x33898ca566 veronica.ib	3
0x33898ca566 veronica.ib	4

The progress indicator in the upper right reports the progress of collecting and displaying information.

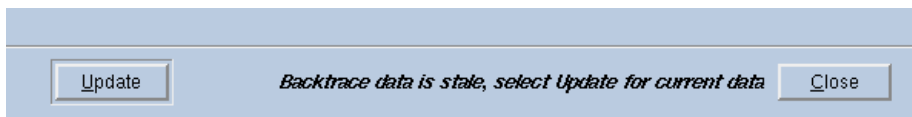
Figure 165 – Parallel Backtrace View without Branches



Using the Show Backtrace toggle in the upper left hides the intervening branches and displays the start routine and current execution location of the processes or threads. This removes some of the clutter in the display, as shown above.

If a thread/process state changes, the data becomes stale, and an alert is displayed at the bottom of the window, Figure 166.

Figure 166 – Stale Data Message



Use the Update button to refresh the display.

RELATED TOPICS

The **dcalltree** command **dcalltree** in “CLI Commands” in the *TotalView for HPC Reference Guide*

Array Visualizer

The TotalView Visualizer creates graphic images of your program's array data. Topics in this section are:

- [“Command Summary”](#) on page 309
- [“How the Visualizer Works”](#) on page 310
- [“Viewing Data Types in the Visualizer”](#) on page 311
- [“Visualizing Data Manually”](#) on page 312
- [“Using the Visualizer”](#) on page 312
- [“Using the Graph Window”](#) on page 315
- [“Using the Surface Window”](#) on page 317
- [“Visualizing Data Programmatically”](#) on page 322
- [“Launching the Visualizer from the Command Line”](#) on page 323
- [“Configuring TotalView to Launch the Visualizer”](#) on page 323

NOTE >> The Visualizer is available on all platforms other than Linux Alpha. If you are using a release older than 7.0.1, see the documentation for that release.

Command Summary

This section summarizes Visualizer commands.

Action		Click or Press
Camera mode	Actor mode	
Rotate camera around focal point (surface only)	Rotate actor around focal point (surface only)	Left mouse button
Zoom	Scale	Right mouse button
Pan	Translate	Middle mouse button or Shift-left mouse button
Other Functions		
Pick (show value)		p
Camera mode: mouse events affect the camera position and focal point. (The axis moves and you don't.)		c

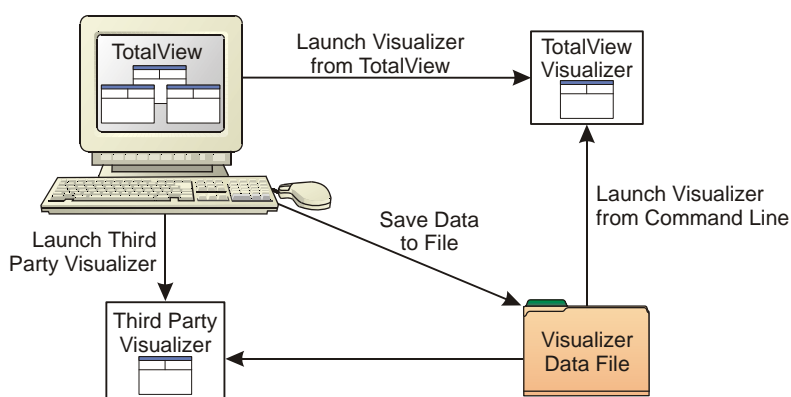
Action	Click or Press
Actor mode: mouse events affect the actor that is under the mouse pointer. (You move and the axis doesn't.)	a
Joystick mode: motion occurs continuously while a mouse button is pressed	j
Trackball mode: motion occurs only when the mouse button is pressed and the mouse pointer moves.	t
Wireframe view	w
Surface view	s
Reset	r
Initialize	l
Exit or Quit	Ctrl-Q

How the Visualizer Works

The Visualizer is a stand-alone program to which TotalView sends information. Because it is separate, you can use it in multiple ways:

- You can see your program's data while debugging in TotalView.
- You can save the data that would be sent to the Visualizer, and view it later by invoking the Visualizer from the command line.

Figure 167 – TotalView Visualizer Relationships



- You can use a third party tool to read the data stream sent by TotalView, rather than using the Visualizer.

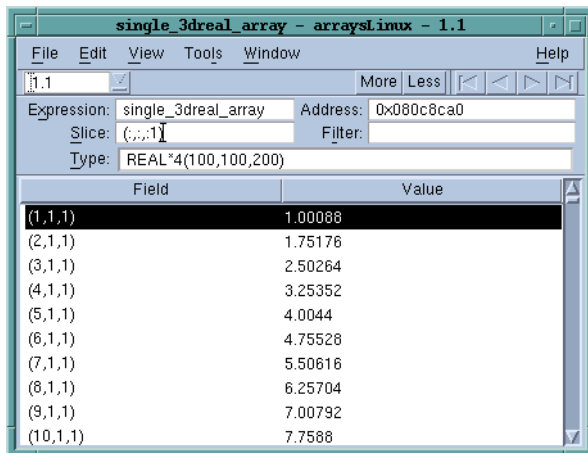
NOTE >> For more information on adapting a third-party visualizer so that it can be used with TotalView, see “Adapting a Third Party Visualizer” on page 325.

Viewing Data Types in the Visualizer

The data selected for visualization is called a **dataset**. TotalView treats stack variables at different recursion levels or call paths as different datasets.

TotalView can visualize one- and two-dimensional arrays of integer or floating-point data. If an array has more than two dimensions, you can visualize part of it using an **array slice** that creates a subarray with fewer dimensions. **Figure 168** shows a three-dimensional variable sliced so that one of the dimensions is invariant.

Figure 168 – A Three-Dimensional Array Sliced into Two Dimensions



Field	Value
(1,1,1)	1.00088
(2,1,1)	1.75176
(3,1,1)	2.50264
(4,1,1)	3.25352
(5,1,1)	4.0044
(6,1,1)	4.75528
(7,1,1)	5.50616
(8,1,1)	6.25704
(9,1,1)	7.00792
(10,1,1)	7.7588

RELATED TOPICS

Other ways to examine arrays “Examining Arrays” on page 283

Viewing Data

Different datasets can require different views to display their data. For example, a graph is more suitable for displaying one- or two-dimensional datasets if one of the dimensions has a small **extent**. However, a surface view is better for displaying a two-dimensional **dataset**.

When TotalView launches the Visualizer, one of the following actions occurs:

- If the Visualizer is displaying the dataset, it raises the dataset’s window to the top of the desktop. If you had minimized the window, the Visualizer restores it.

- If you previously visualized a dataset but you've killed its window, the Visualizer creates a new window using the most recent visualization method.
- If you haven't visualized the dataset, the Visualizer chooses an appropriate method. You can disable this feature by using the **Options > Auto Visualize** command in the Visualizer Directory Window.

Visualizing Data Manually

Before you can visualize an array:

- Open a Variable Window the array.
- Stop program execution when the array's values reflect what you want to visualize.

You can restrict the visualized data by editing the **Slice** field. (See “[Displaying Array Slices](#)” on page 284.) Limiting the amount of data increases the speed of the Visualizer.

After selecting the Variable Window **Tools > Visualize** command, the Visualizer creates its window.

NOTE >> As you step through your program, be aware that the data sent to the Visualizer is not automatically updated; explicitly update the display using *Tools > Visualize*.

TotalView can visualize variables across threads or processes. (See “[Visualizing a “Show Across” Variable Window](#)” on page 302.) In this case, the Visualizer uses the process or thread index as one dimension, meaning that you can visualize only scalar or vector information. If you do not want the process or thread index to be a dimension, do not use a **Show Across** command.

Using the Visualizer

The Visualizer uses two types of windows:

- **Dataset Window**

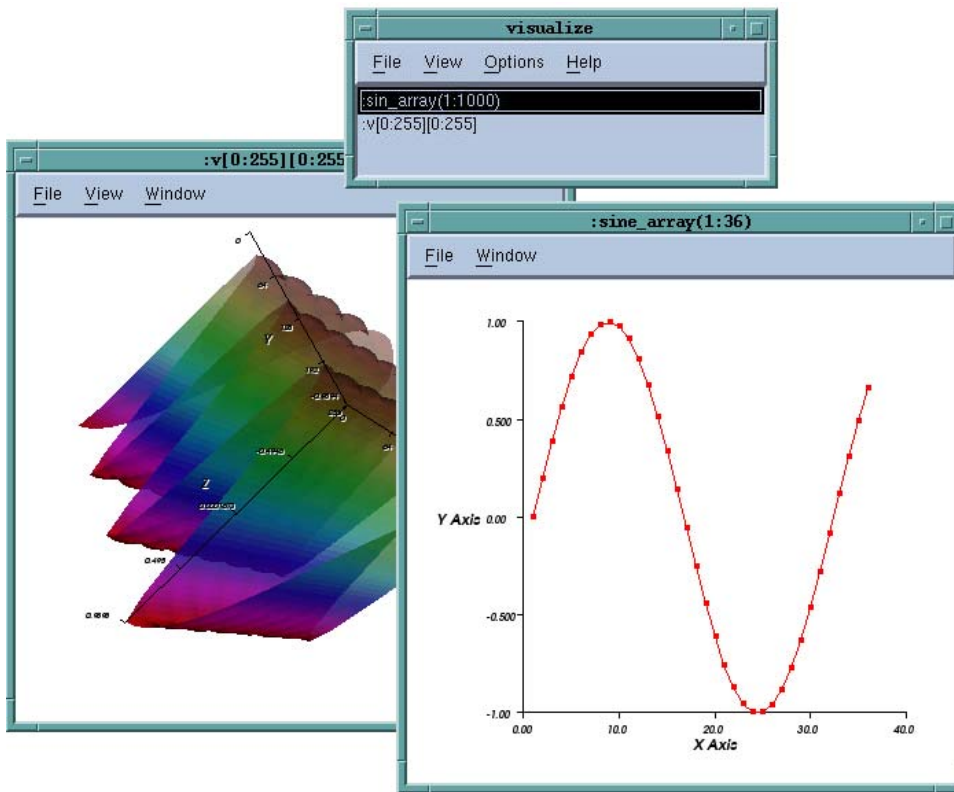
This window contains the [datasets](#) that you can visualize. Use this window to set global options and to create views of your datasets. Commands in this window provide different views of the same data by allowing you to open more than one View Window.

- **View Window**

These windows actually display your data. The commands in a View Window set viewing options and change the way the Visualizer displays your data.

In Figure 169, the top window is a Dataset Window. The two remaining windows show a surface and a graph view.

Figure 169 – Sample Visualizer Windows



Using Dataset Window Commands

The Dataset Window lists the datasets you can display. Double-click on a dataset to display it.

The **View** menu supports either **Graph** or **Surface** visualization. When TotalView sends a new dataset to the Visualizer, the Visualizer updates its dataset list. To delete a dataset from the list, click on it, display the File menu, and then select Delete. (It's usually easier to just close the Visualizer.)

The following commands are in the Dataset Window menu bar:

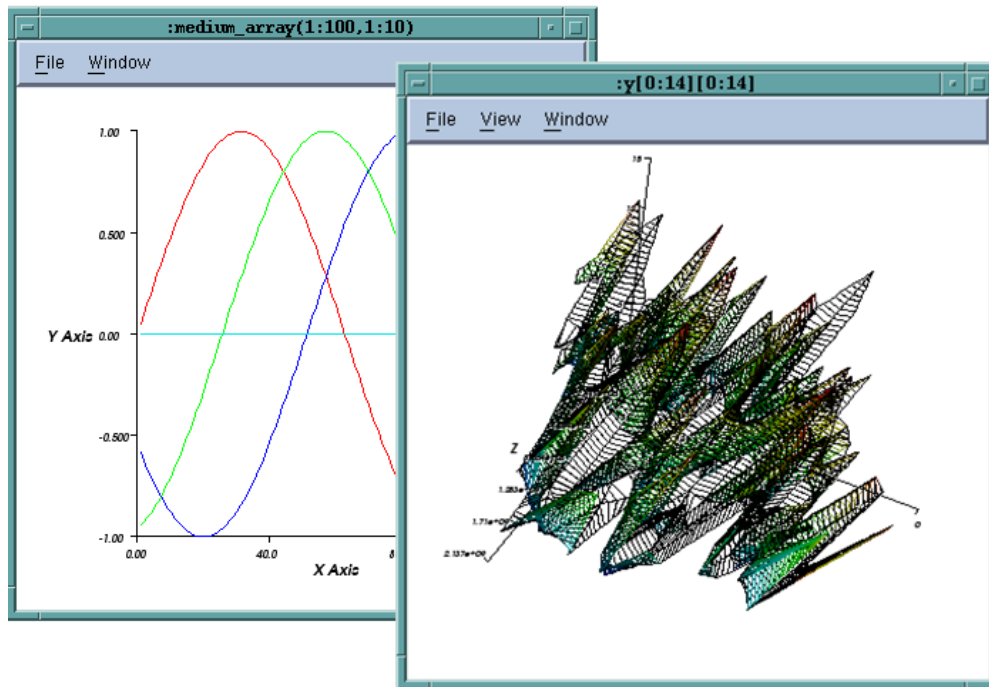
- File > Delete** Deletes the currently selected dataset. It removes the dataset from the list and *destroys* the View Window that displays it.
- File > Exit** Closes all windows and exits the Visualizer.
- View > Graph** Creates a new Graph Window; see “Using the Graph Window” on page 315.
- View > Surface** Creates a new Surface Window; see “Using the Surface Window” on page 317.

This item is a toggle; when enabled, the Visualizer automatically visualizes new datasets as they are read. Typically, this option is left on. If, however, you have large datasets and want to configure how the Visualizer displays the graph, disable this option.

Using View Window Commands

View Windows display graphic images of your data. [Figure 170](#) shows a graph view and a surface view. The View Window's title is the text that appears in the Dataset Window.

Figure 170 – Graph and Surface Visualizer Windows



The View Window menu commands are:

- File > Close** Closes the View Window.
- File > Dataset** Raises the Dataset Window to the front of the desktop. If you minimized the Dataset Window, the Visualizer restores it.
- File > Delete** Deletes the View Window dataset from the list. This also destroys other View Windows that view the dataset.
- File > Options** Pops up a window of viewing options.
- Window > Duplicate Base Window** Creates a new View Window with the same visualization method and dataset as the current View Window.

Ways to view data

The drawing area displays the image of your data. You can interact with the drawing area to alter the view of your data. For example:

- If the Visualizer is displaying a surface, you can rotate the surface to view it from different angles.
- You can get the value and indices of the dataset element nearest the cursor by clicking on it and typing “P”. A pop-up window displays the information.

These operations are discussed in “[Using the Graph Window](#)” on page 315 and “[Using the Surface Window](#)” on page 317.

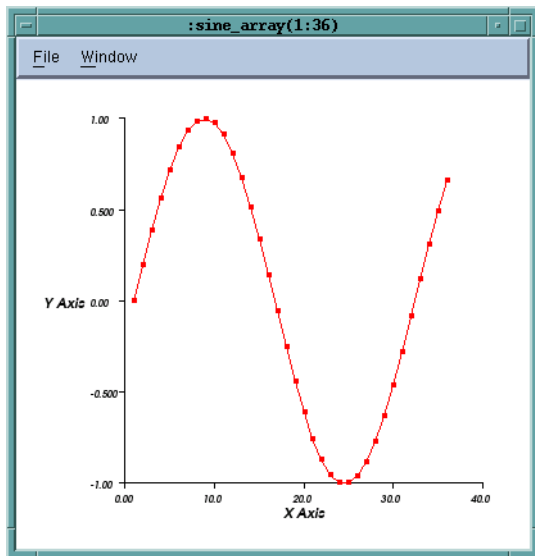
Using the Graph Window

The Graph Window displays a two-dimensional graph of one- or two-dimensional datasets. If the **dataset** is two-dimensional, the Visualizer displays multiple graphs. When you first create a Graph Window on a two-dimensional dataset, the Visualizer uses the dimension with the larger number of elements for the **X** axis. It then draws a separate graph for each subarray that has the smaller number of elements. If you don’t like this choice, you can transpose the data by selecting a checkbox within the **File > Options** Dialog Box.

NOTE >> You probably don’t want to use a graph to visualize two-dimensional datasets with large **extents** in both dimensions as the display can be very cluttered. If you try, the Visualizer shows only the first ten.

You can display graphs with points for each element of the dataset, with lines connecting dataset elements, or with both lines and points, as demonstrated in [Figure 171](#).

Figure 171 – Visualizer Graph View Window

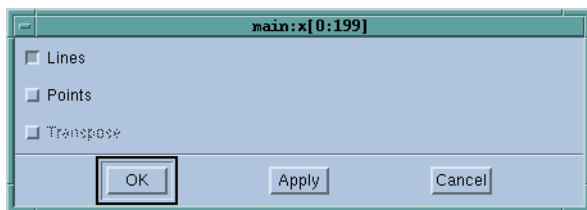


If the Visualizer is displaying more than one graph, each is a different color. The **X** axis is annotated with the indices of the long dimension. The **Y** axis shows you the data value.

Displaying Graph Views

The **File > Options** Dialog Box controls graph display. (A different dialog box appears if the Visualizer is displaying a surface view.)

Figure 172 – Graph Options Dialog Box

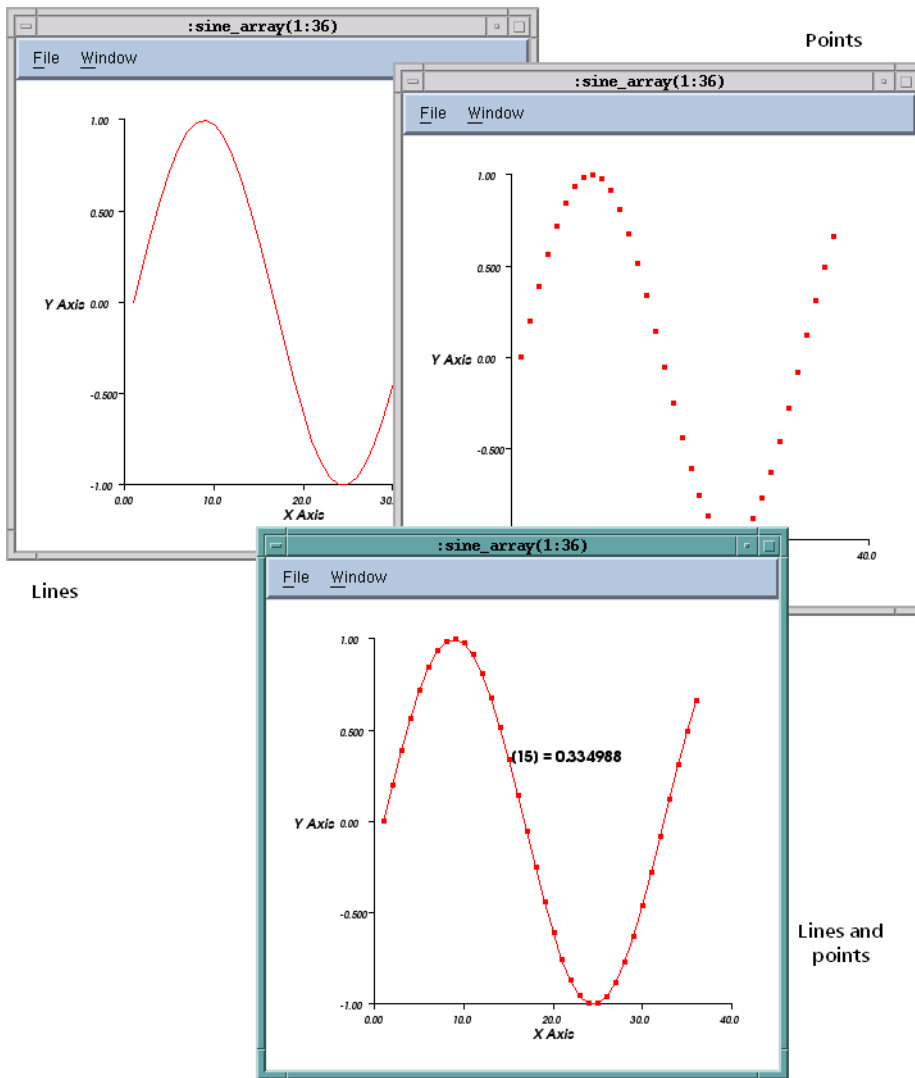


Options:

- | | |
|-----------|---|
| Lines | Displays lines connecting dataset elements. |
| Points | Displays points (markers) for dataset elements. |
| Transpose | Inverts which axis is held constant when generating a graph of a two-dimensional object. For other than two dimensions, this option is not available. |

[Figure 173](#) shows a sine wave displayed in three different ways:

Figure 173 – Sine wave Displayed in Three Ways



To see the value of a dataset's element, place your cursor near a graph marker, and type "P". The bottom graph in Figure 173 shows the value of a data point.

Using the Surface Window

The Surface Window displays two-dimensional datasets as a surface in two or three dimensions. The dataset's array indices map to the first two dimensions (X and Y axes) of the display. Figure 174 shows a surface view:

Figure 174 – A Surface View

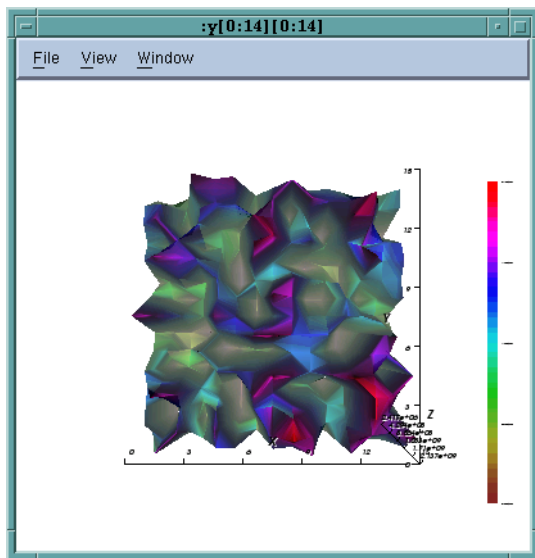
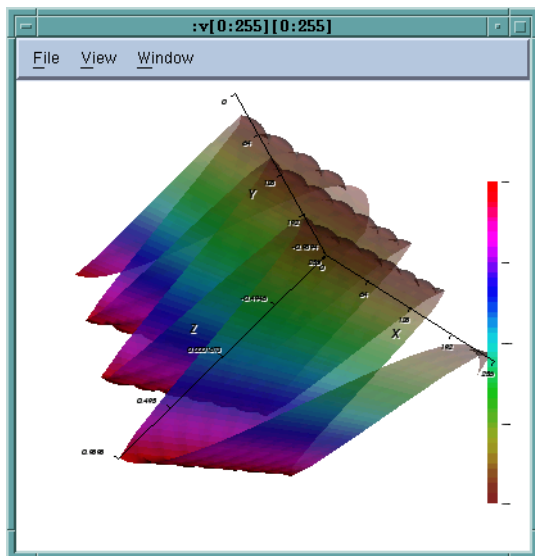


Figure 175 shows a three-dimensional surface that maps element values to the height (**Z** axis).

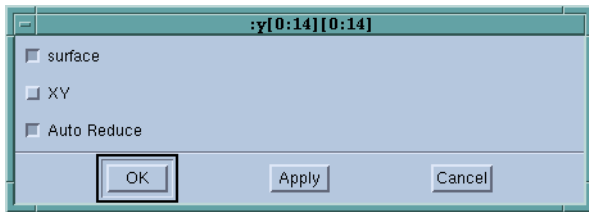
Figure 175 – A Surface View of a Sine Wave



Displaying Surface Views

The Surface Window **File > Options** command controls surface display, Figure 176 (A different dialog box controls Graph View.)

Figure 176 – Surface Options Dialog Box



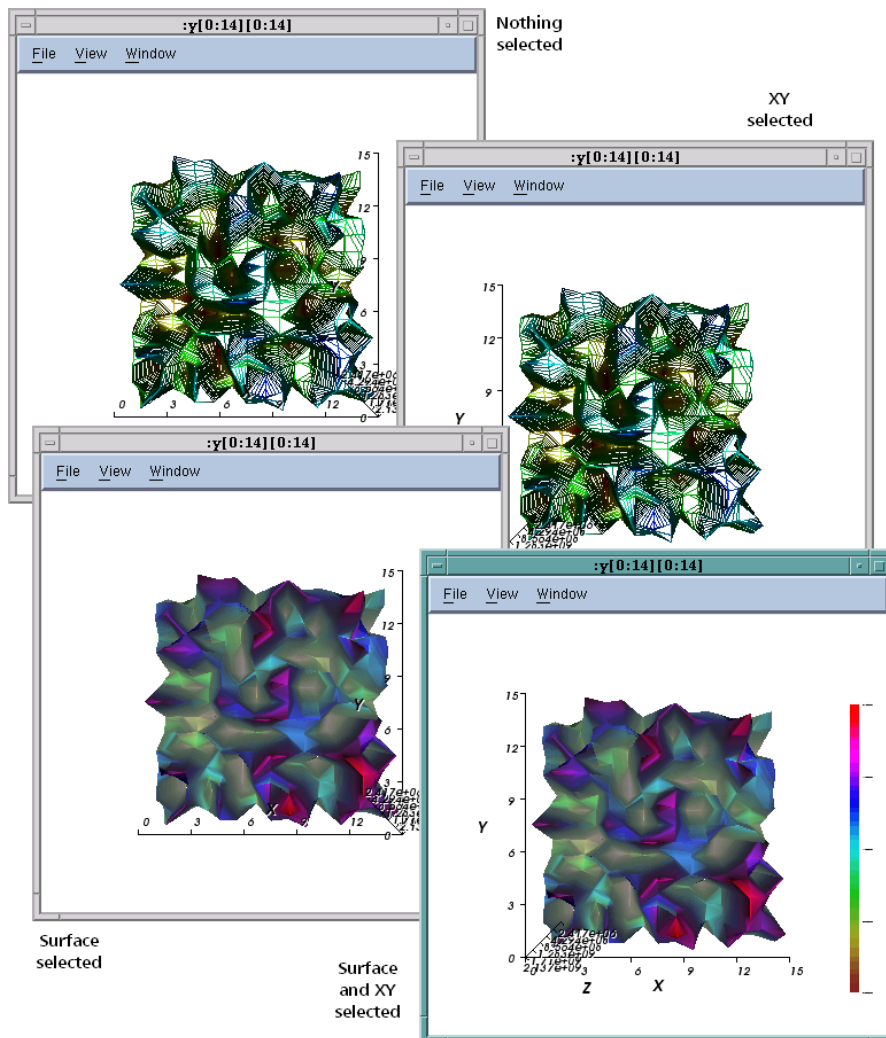
Options:

- | | |
|-------------|--|
| Surface | Displays the array's data as a three-dimensional surface; otherwise, displays the surface as a grid. |
| XY | Reorients the view's XY axes. The Z axis is perpendicular to the display. |
| Auto Reduce | Derives the displayed surface by averaging neighboring elements in the original dataset, in order to speed visualization by reducing surface resolution. Clear this option to accurately visualize all dataset elements.

This option supports either viewing all your data points — which takes longer to appear in the display — or viewing the data average over a number of nearby points. |

Figure 177 shows different views of the same data, based on Surface and XY options.

Figure 177 – Four Surface Views



To restore initial state of translation, rotation, and scaling options, select **View > Initialize View**.

Manipulating Surface Data

The Surface Window supports various viewing modes. Camera mode is the default, in which the Visualizer behaves as a “camera” moving around the object. Actor mode, by contrast, displays the object as if you, the viewer, were changing position. The difference between these is subtle. In some circumstances, actions such as pan and zoom in camera mode can also add a slight rotation to the object.

From within TotalView, you can see only one array at a time. However, if you combine multiple datasets and visualize them externally, the differences between camera and actor mode can help differentiate the objects.

The following table defines all surface view general commands. Command letters can be typed in either upper- or lower-case.

Action	Press
Pick (show value): Displays the value of the data point at the cursor.	p
Camera mode : Mouse events affect the camera position and focal point. (Axes move, and you don't.)	c
Actor mode : Mouse events affect the actor under the mouse pointer. (You move, not the axes.)	a
Joystick mode : Motion occurs continuously while you press a mouse button.	j
Trackball mode : Motion occurs only when you press the mouse button <i>and</i> you move the mouse pointer.	t
Wireframe view : Displays the surface as a mesh. (This is the same as not checking the Surface option.)	w
Surface view : Displays the surface as a solid. (This is the same as having checked the Surface option.)	s
Reset : Removes the changes you've made to the way the Visualizer displays an object.	r
Initialize : Restores the object to its initial state before you interacted with the Visualizer. As this is a menubar accelerator, the window must have focus.	i
Exit or Quit : Close the Visualizer.	Ctrl-Q

The following table defines the actions you can perform using your mouse:

Action		Click or Press
Camera mode	Actor mode	
Rotate camera around focal point (surface only)	Rotate actor around focal point (surface only)	Left mouse button
Zoom : Zooms in on the object.	Scale : the object appears to get larger	Right mouse button
Pan : Moves the "camera". For example, moving the camera up means the object moves down.	Translate : The object moves in the direction you pull it.	Middle mouse button or Shift-left mouse button

Visualizing Data Programmatically

The **\$visualize** function supports data visualization from within eval points and the **Tools > Evaluate** Window. Because you can enter more than one **\$visualize** function within an eval point or Evaluate Window, you can simultaneously visualize multiple variables.

If you enter the **\$visualize** function in an eval point, TotalView interprets rather than compiles the expression, which can greatly decrease performance. See “[Defining Eval Points and Conditional Breakpoints](#)” on page 197 for information about compiled and interpreted expressions.

Using the **\$visualize** function in an eval point lets you animate the changes that occur in your data, because the Visualizer updates the array's display every time TotalView reaches the eval point. Here is this function's syntax:

```
$visualize ( array [, slice_string ])
```

The *array* argument names the **dataset** being visualized. The optional *slice_string* argument is a quoted string that defines a constant slice expression that modifies the *array* parameter's dataset. In Fortran, you can use either a single (') or double (") quotation mark. You must use a double quotation mark in C or C++.

The following examples show how you can use this function. Notice that the array's dimension ordering differs between C/C++ and Fortran.

C and C++

```
$visualize(my_array);  
$visualize (my_array, "[::2][10:15]");  
$visualize (my_array, "[12][:]");
```

Fortran

```
$visualize (my_array)  
$visualize (my_array, '(11:16, ::2)')  
$visualize (my_array, '(:,13)')
```

The first example in each programming language group visualizes the entire array. The second example selects every second element in the array's major dimension; it also clips the minor dimension to all elements in the range. The third example reduces the dataset to a single dimension by selecting one subarray.

You may need to cast your data so that TotalView knows what the array's dimensions are. For example, here is a C function that passes a two-dimensional array parameter that does not specify the major dimension's extent.

```
void my_procedure (double my_array[][32])  
{ /* procedure body */ }
```

You would need to cast this before TotalView can visualize it. For example:

```
$visualize (*(double[32][32]*)my_array);
```

Sometimes, it's hard to know what to specify. You can quickly refine array and slice arguments, for example, by entering the **\$visualize** function into the **Tools > Evaluate** Dialog Box. When you select the **Evaluate** button, you quickly see the result. You can even use this technique to display several arrays simultaneously.

RELATED TOPICS

Eval points and conditional breakpoints “Defining Eval Points and Conditional Breakpoints” on page 197
Writing expressions in various TotalView- supported languages “Using Programming Language Elements” on page 333

Launching the Visualizer from the Command Line

To start the Visualizer from the shell, use the following syntax:

```
visualize [ -file filename | -persist ]
```

where:

- file** *filename* Reads data from *filename* instead of reading from standard input. For information on creating this file, see “[Setting the Visualizer Launch Command](#)” on page 325.
- persist** Continues to run after encountering an EOF (End-of-File) on standard input. If you don’t use this option, the Visualizer exits as soon as it reads all the data.

By default, the Visualizer reads its datasets from standard input and exits when it reads an EOF. When started by TotalView, the Visualizer reads its data from a pipe, ensuring that the Visualizer exits when TotalView does. If you want the Visualizer to continue to run after it exhausts all input, invoke it by using the **-persist** option.

If you want to read data from a file, invoke the Visualizer with the **-file** option:

```
visualize -file my_data_set_file
```

The Visualizer reads all the datasets in the file. This means that the images you see represent the last versions of the datasets in the file.

The Visualizer supports the generic X toolkit command-line options. For example, you can start the Visualizer with the Directory Window minimized by using the **-iconic** option. Your system manual page for the X server or the *X Window System User’s Guide* by O’Reilly & Associates lists the generic X command-line options in detail.

You can also customize the Visualizer by setting X resources in your resource files or on the command line with the **-xrm resource_setting** option.

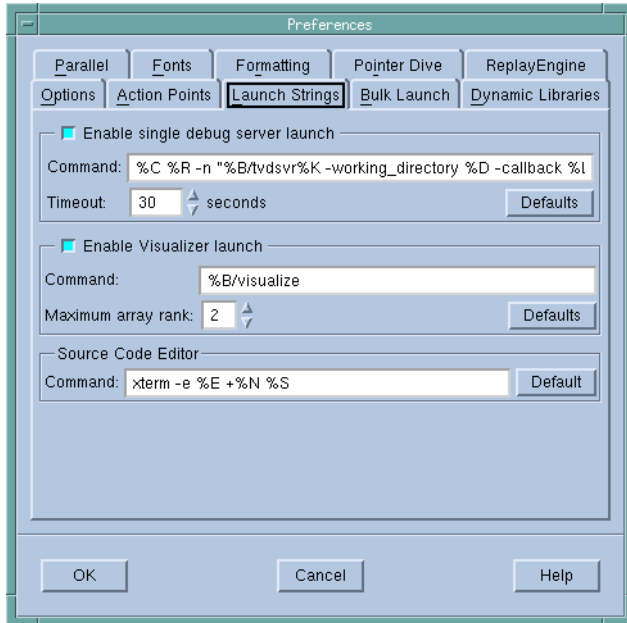
Configuring TotalView to Launch the Visualizer

TotalView launches the Visualizer when you select the **Tools > Visualize** command from the Variable Window. It also launches it when using a **\$visualize** function in an eval point and the **Tools > Evaluate** Dialog Box.

You can disable visualization entirely. This lets you turn off visualization when your program executes code that contains eval points, without having to individually disable them all.

To change the Visualizer launch options interactively, select **File > Preferences**, and then select the Launch Strings Tab.

Figure 178 – File > Preferences Launch Strings Page



Options:

- Customize the command used to start a visualizer by entering the visualizer's start up command in the **Command** edit box.
- Change the [autolaunching](#) option. If you want to disable visualization, clear the **Enable Visualizer launch** check box.
- Change the maximum permissible rank. Edit the value in the **Maximum array rank** field to save the data exported from TotalView or display it in a different visualizer. A rank's value can range from **1** to **16**.

Setting the maximum permissible rank to either 1 or 2 (the default is 2) ensures that the Visualizer can use your data—the Visualizer displays only two dimensions of data. This limit doesn't apply to data saved in files or to third-party visualizers that can display more than two dimensions of data.

- Clicking the **Defaults** button returns all values to their default values. This reverts options to their default values even if you have used X resources to change them.

If you disable visualization while the Visualizer is running, TotalView closes its connection to the Visualizer. If you reenables visualization, TotalView launches a new Visualizer process the next time you visualize something.

RELATED TOPICS

The **File > Preferences** command

File > Preferences in the in-product Help

Setting the Visualizer Launch Command

You can change the shell command that TotalView uses to launch the Visualizer by editing the Visualizer launch command. (In most cases, the only reason you'd do this is if you're having path problems or you're running a different visualizer.) You can also change what's entered here so that you can view this information at another time; for example:

```
cat > your_file
```

Later, you can visualize this information by typing either:

```
visualize -persist < your_file  
visualize -file your_file
```

You can preset the Visualizer launch options by setting X resources.

Adapting a Third Party Visualizer

TotalView passes a stream of datasets to the Visualizer encoded in the format described below, thus supporting the use of this data with other programs, with these requirements:

- TotalView and the Visualizer must be running on the same machine architectures; that is, TotalView assumes that word lengths, byte order, and floating-point representations are identical. While sufficient information in the dataset header exists to detect when this is not the case (with the exception of floating-point representation), no method for translating this information is supplied.
- TotalView transmits datasets down the pipe in a simple unidirectional flow. There is no handshaking protocol in the interface. This requires the Visualizer to be an eager reader on the pipe. If the Visualizer does not read eagerly, the pipe will back up and block TotalView.

Visualizer dataset format

The dataset format is described in the TotalView distribution in a header file named **include/visualize.h** in the TotalView installation directory. Each dataset is encoded with a fixed-length header followed by a stream of array elements. The header contains the following fields:

vh_axis_order	Contains one of the constants vis_ao_row_major or vis_ao_column_major .
vh_dims	Contains information on each dimension of the dataset. This includes a base, count, and stride. Only the count is required to correctly parse the dataset. The base and stride give information only on the valid indices in the original data. Note that all VIS_MAXDIMS of dimension information is included in the header, even if the data has fewer dimensions.

vh_effective_rank	Contains the number of dimensions that have an extent larger than 1.
vh_id	Contains the dataset ID. Every dataset in a stream of datasets is numbered with a unique ID so that updates to a previous dataset can be distinguished from new datasets.
vh_item_count	Contains the total number of expected elements.
vh_item_length	Contains the length (in bytes) of a single element of the array.
vh_magic	Contains VIS_MAGIC , a symbolic constant to provide a check that this is a dataset header and that byte order is compatible.
vh_title	Contains a plain text string of length VIS_MAXSTRING that annotates the dataset.
vh_type	Contains one of the constants vis_signed_int , vis_unsigned_int , or vis_float .
vh_version	Contains VIS_VERSION , a symbolic constant to provide a check that the reader understands the protocol.

Types in the dataset are encoded by a combination of the **vh_type** field and the **vh_item_length** field. This allows the format to handle arbitrary sizes of both signed and unsigned integers, and floating-point numbers.

The **vis_float** constant corresponds to the default floating-point format (usually, IEEE) of the target machine. The Visualizer does not handle values other than the default on machines that support more than one floating-point format.

Although a three-byte integer is expressible in the Visualizer's dataset format, it is unlikely that the Visualizer will handle one. The Visualizer handles only data types that correspond to the C data types permitted on the machine where the Visualizer is running.

Similarly, the long double type varies significantly depending on the C compiler and target machine. Therefore, visualization of the long double type is unlikely to work if you run the Visualizer on a machine different from the one where you extracted the data.

In addition, be aware of these data type differences if you write your own visualizer and plan to run it on a machine that is different from the one where you extract the data.

The data following the header is a stream of consecutive data values of the type indicated in the header. Consecutive data values in the input stream correspond to adjacent elements in **vh_dims[0]**.

You can verify that your reader's idea of the size of this type is consistent with TotalView by checking that the value of the **n_bytes** field of the header matches the product of the size of the type and the total number of array elements.



Chapter 12

Evaluating Expressions

Whether you realize it or not, you've been telling TotalView to evaluate expressions and you've even been entering them. In every programming language, variables are actually expressions—actually they are lvalues—whose evaluation ends with the interpretation of memory locations into a displayable value. Structure, pointer and array variables, particularly arrays where the index is also a variable, are slightly more complicated.

While debugging, you also need to evaluate expressions that contain function calls and programming language elements such as **for** and **while** loops.

This chapter discusses what you can do evaluating expressions within TotalView. The topics discussed are:

- [“Why is There an Expression System?”](#) on page 328
- [“Using Programming Language Elements”](#) on page 333
- [“Using the Evaluate Window”](#) on page 337
- [“Using Built-in Variables and Statements”](#) on page 344
- [“Expression Evaluation with ReplayEngine”](#) on page 348

Why is There an Expression System?

Either directly or indirectly, accessing and manipulating data requires an evaluation system. When your program (and TotalView, of course) accesses data, it must determine where this data resides. The simplest data lookups involve two operations: looking up an address in your program's symbol table and interpreting the information located at this address based on a variable's datatype. For simple variables such as an integer or a floating point number, this is all pretty straightforward.

Looking up array data is slightly more complicated. For example, if the program wants **my_var[9]**—this chapter will most often use C and C++ notation rather than Fortran—it looks up the array's starting address, then applies an offset to locate the array's 10th element. In this case, if each array element uses 32 bits, **my_var[9]** is located 9 times 32 bits away.

In a similar fashion, your program obtains information about variables stored in structures and arrays of structures.

Structures complicate matters slightly. For example **ptr->my_var** requires three operations: extract the data contained within address of the **my_var** variable, use this information to access the data at the address being pointed to, then display the data according to the variable's datatype.

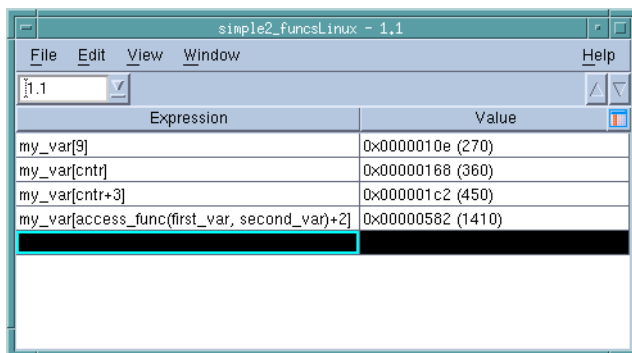
Accessing an array element such as **my_var[9]** where the array index is an integer constant is rare in most programs. In most cases, your program uses variables or expressions as array indices; for example, **my_var[ctr]** or **my_var[ctr+3]**. In the later case, TotalView must determine the value of **ctr+3** before it can access an array element.

Using variables and expressions as array indices are common. However, the array index can be (and often is) an integer returned by a function. For example:

```
my_var[access_func(first_var, second_var)+2]
```

In this example, a function with two arguments returns a value. That returned value is incremented by two, and the resulting value becomes the array index. Here is an illustration showing TotalView accessing the **my_var** array in the four ways discussed in this section:

Figure 179 – Expression List Window: Accessing Array Elements



In Fortran and C, access to data is usually through variables with some sort of simple evaluation or a function. Access to variable information can be the same in C++ as it is in these languages. However, accessing private variables within a class almost always uses a method. For example:

```
myDataStructureList.get_current_place()
```

TotalView built-in expression evaluation system is able to understand your class inheritance structure in addition to following C++ rules for method invocation and polymorphism. (This is discussed in “Using C++” on page 331.)

Calling Functions: Problems and Issues

Unfortunately, calling functions in the expression system can cause problems. Some of these problems are:

- What happens if the function has a side effect For example, suppose you have entered **my_var[cntr]** in one row in an Expression List Window, followed by **my_var[++cntr]** in another. If **cntr** equals 3, you'll be seeing the values of **my_var[3]** and **my_var[4]**. However, since **cntr** now equals 4, the first entry is no longer correct.
- What happens when the function crashes (after all you are trying to debug problems), doesn't return, returns the wrong value, or hits a breakpoint?
- What does calling functions do to your debugging interaction if evaluation takes an excessive amount of time?
- What happens if a function creates processes and threads? Or worse, kills them?

In general, there are some protections in the code. For example, if you're displaying items in an **Expression List** Window, TotalView avoids being in an infinite loop by only evaluating items once. This does mean that the information is only accurate at the time at which TotalView made the evaluation.

In most other cases, you're basically on your own. If there's a problem, you'll get an error message. If something takes too long, you can press the Halt button. But if a function alters memory values or starts or stops processes or threads and you can't live with it, you'll need to restart your program. However, if an error occurs while using the **Evaluate** Window, pressing the **Stop** button pops the stack, leaving your program in the state it was in before you used the **Evaluate** command. However, changes made to heap variables will, of course, not be undone.

Expressions in Eval Points and the Evaluate Window

Expression evaluation is not limited to a Variable Window or an Expression List Window. You can use expressions within eval points and in the **Tools > Evaluate** Window. The expressions you type here also let you use programming language constructs. For example, here's a trivial example of code that can execute within the **Evaluate** Window:

```
int i, j, k;  
j = k = 10;  
for (i=0; i < 20; i++)
```

```

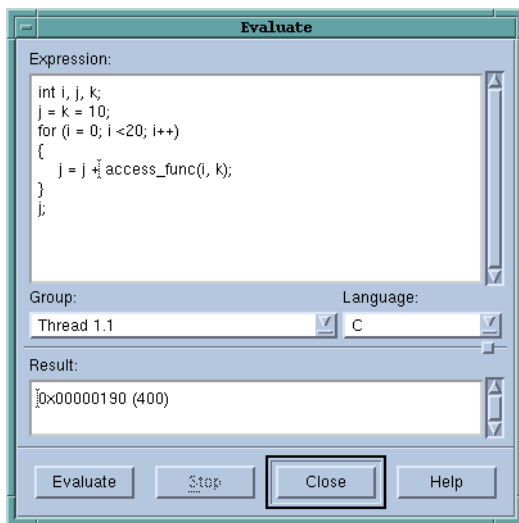
{
    j = j + access_func(i, k);
}
j;

```

This code fragment declares a couple of variables, runs them through a **for** loop, then displays the value of **j**. In all cases, the programming language constructs being interpreted or compiled within TotalView are based on code within TotalView. TotalView is not using the compiler you used to create your program or any other compiler or interpreter on your system.

Notice the last statement in [Figure 180](#). TotalView displays the value returned by the last statement. This value is displayed. (See “[Displaying the Value of the Last Statement](#)” on page 330.)

Figure 180 – Displaying the Value of the Last Statement



TotalView assumes that there is always a return value, even if it's evaluating a loop or the results of a subroutine returning a void. The results are, of course, not well-defined. If the value returned is not well-defined, TotalView displays a zero in the **Result** area.

The code within eval points and the **Evaluate** Window does not run in the same address space as that in which your program runs. Because TotalView is a debugger, it knows how to reach into your program's address space. The reverse isn't true: your program can't reach into the TotalView address space. This forces some limitations upon what you can do. In particular, you can not enter anything that directly or indirectly needs to pass an address of a variable defined within the TotalView expression into your program. Similarly, invoking a function that expects a pointer to a value and whose value is created within TotalView can't work. However, you can invoke a function whose parameter is an address and you name something within that program's address space. For example, you could say something like **adder(an_array)** if **an_array** is contained within your program.

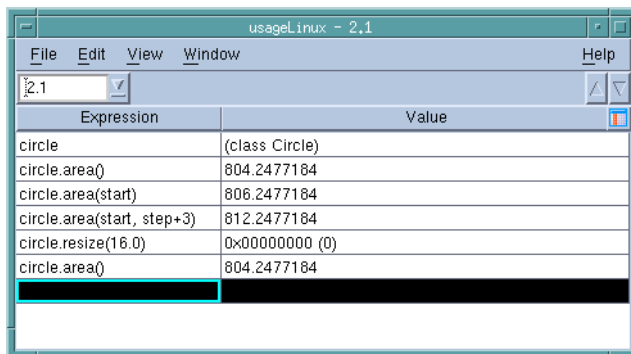
Using C++

The TotalView expression system is able to interpret the way you define your classes and their inheritance hierarchy. For example, if you declare a method in a base class and you invoke upon an object instantiated from a derived class, TotalView knows how to access the function. It also understands when a function is virtual. For example, assume that you have the following declarations:

```
class Circle : public Shape {
public:
    ...
    virtual double area();
    virtual double area(int);
    double area(int, int);
```

Figure 181 shows an expression list calling an overloaded function. It also shows a setter (mutator) that changes the size of the circle object. A final call to area shows the new value.

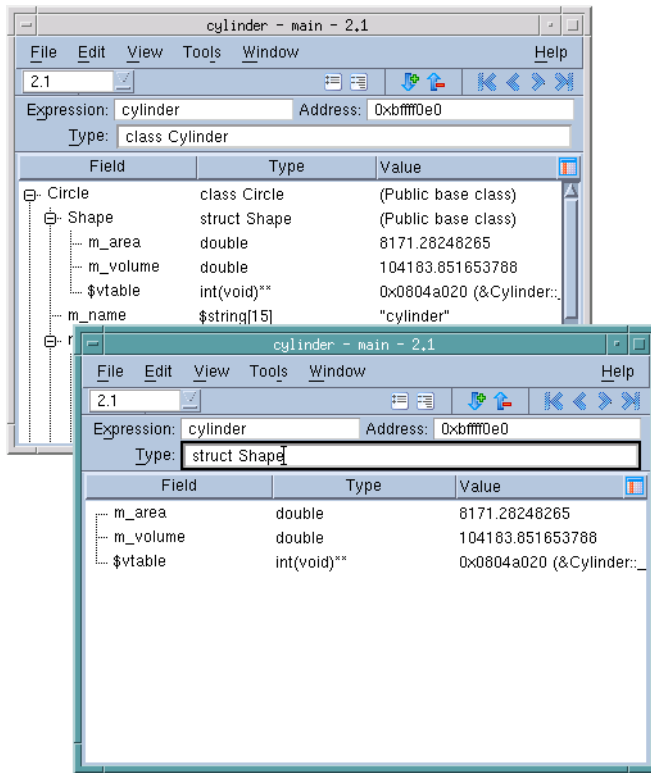
Figure 181 – Expression List Window: Showing Overloads



Expression	Value
circle	(class Circle)
circle.area()	804.2477184
circle.area(start)	806.2477184
circle.area(start, step+3)	812.2477184
circle.resize(16.0)	0x00000000 (0)
circle.area()	804.2477184

If your object is instantiated from a class that is part of an inheritance hierarchy, TotalView shows you the hierarchy when you dive on the object.

Figure 182 - Class Casting



Using Programming Language Elements

Using C and C++

This section contains guidelines for using C and C++ in expressions.

- You can use C-style (***/* comment */***) and C++-style (***// comment***) comments; for example:

```
// This code fragment creates a temporary patch  
i = i + 2; /* Add two to i */
```
- You can omit semicolons if the result isn't ambiguous.
- You can use dollar signs (\$) in identifiers. However, we recommend that you do not use dollar signs in names created within the expression system.

NOTE >> If your program does not use a templated function within a library, your compiler may not include a reference to the function in the symbol table. That is, TotalView does not create template instances. In some cases, you might be able to overcome this limitation by preloading the library. However, this only works with some compilers. Most compilers only generate STL operators if your program uses them.

You can use the following C and C++ data types and declarations:

- You can use all standard data types such as **char**, **short**, **int**, **float**, and **double**, modifiers to these data types such as **long int** and **unsigned int**, and pointers to any primitive type or any named type in the target program.
- You can only use simple declarations. Do not define **struct**, **class**, **enum** or **union** types or variables. You can define a pointer to any of these data types. If an **enum** is already defined in your program, you can use that type when defining a variable.
- The **extern** and **static** declarations are not supported.

You can use the following the C and C++ language statements.

- You can use the **goto** statement to define and branch to symbolic labels. These labels are local to the window. You can also refer to a line number in the program. This line number is the number displayed in the Source Pane. For example, the following **goto** statement branches to source line number 432 of the target program:

```
goto 432;
```
- Although you can use function calls, you can't pass structures.
- You can use type casting.

- You can use assignment, **break**, **continue**, **if/else** structures, **for**, **goto**, and **while** statements. Creating a **goto** that branches to another TotalView evaluation is undefined.

Using Fortran

When writing code fragments in Fortran, you need to follow these guidelines:

- In general, you can use free-form syntax. You can enter more than one statement on a line if you separate the statements with semi-colons (;). However, you cannot continue a statement onto more than one line.
- You can use **GOTO**, **GO TO**, **ENDIF**, and **END IF** statements; Although **ELSEIF** statements aren't allowed, you can use **ELSE IF** statements.
- Syntax is free-form. No column rules apply.
- The space character is significant and is sometimes required. (Some Fortran 77 compilers ignore all space characters.) For example:

Valid	Invalid
<code>DO 100 I=1,10</code>	<code>DO100I=1,10</code>
<code>CALL RINGBELL</code>	<code>CALL RING BELL</code>
<code>X .EQ. 1</code>	<code>X.EQ.1</code>

You can use the following data types and declarations in a Fortran expression:

- You can use the **INTEGER**, **REAL**, **DOUBLE PRECISION**, and **COMPLEX** data types.
- You can't define or declare variables that have implied or derived data types.
- You can only use simple declarations. You can't use a **COMMON**, **BLOCK DATA**, **EQUIVALENCE**, **STRUCTURE**, **RECORD**, **UNION**, or array declaration.
- You can refer to variables of any type in the target program.
- TotalView assumes that **integer (kind=n)** is an n-byte integer.

Fortran Statements

You can use the Fortran language statements:

- You can use assignment, **CALL** (to subroutines, functions, and all intrinsic functions except **CHARACTER** functions in the target program), **CONTINUE**, **DO**, **GOTO**, **IF** (including block **IF**, **ENDIF**, **ELSE**, and **ELSE IF**), and **RETURN** (but not alternate return) statements.
- If you enter a comment in an expression, precede the comment with an exclamation point (!).

- You can use array sections within expressions. For more information, see “[Array Slices and Array Sections](#)” on page 287.
- A **GOTO** statement can refer to a line number in your program. This line number is the number that appears in the Source Pane. For example, the following **GOTO** statement branches to source line number 432:

```
GOTO $432;
```

You must use a dollar sign (\$) before the line number so that TotalView knows that you’re referring to a source line number rather than a statement label.

You cannot branch to a label within your program. You can instead branch to a TotalView line number.

- The following expression operators are not supported: **CHARACTER** operators and the **.EQV.**, **.NEQV.**, and **.XOR.** logical operators.
- You can’t use subroutine function and entry definitions.
- You can’t use Fortran 90 pointer assignment (the => operator).
- You can’t call Fortran 90 functions that require assumed shape array arguments.

Fortran Intrinsic

TotalView supports some Fortran intrinsics. You can use these supported intrinsics as elements in expressions. The classification of these intrinsics into groups is that contained within Chapter 13 of the *Fortran 95 Handbook*, by Jeanne C. Adams, *et al.*, published by the MIT Press.

TotalView does not support the evaluation of expressions involving complex variables (other than as the arguments for **real** or **aimag**). In addition, we do not support function versions. For example, you cannot use **dcos** (the double-precision version of **cos**).

The supported intrinsics are:

- Bit Computation functions: **btest**, **iand**, **ibclr**, **ibset**, **ieor**, **ior**, and **not**.
- Conversion, Null and Transfer functions: **achar**, **aimag**, **char**, **dbble**, **iachar**, **ichar**, **int**, and **real**.
- Inquiry and Numeric Manipulation Functions: **bit_size**.
- Numeric Computation functions: **acos**, **asin**, **atan**, **atan2**, **ceiling**, **cos**, **cosh**, **exp**, **floor**, **log**, **log10**, **pow**, **sin**, **sinh**, **sqrt**, **tan**, and **tanh**.
Complex arguments to these functions are not supported. In addition, on Macintosh and AIX, the **log10**, **ceiling**, and **floor** intrinsics are not supported.

The following are not supported:

- Array functions

- Character computation functions.
- Intrinsic subroutines

NOTE >> If you statically link your program, you can only use intrinsics that are linked into your code. In addition, if your operating system is Mac OS X, AIX, or Linux/Power, you can only use math intrinsics in expressions if you directly linked them into your program. The ****** operator uses the **pow** function. Consequently, it too must either be used within your program or directly linked. In addition, **ceiling** and **log10** are not supported on these three platforms.

Using the Evaluate Window

TotalView lets you open a window to evaluate expressions in the context of a particular process and evaluate them in C, Fortran, or assembler.

NOTE >> Not all platforms let you use assembler constructs. See “Architectures” in the *TotalView for HPC Reference Guide* for details.

You can use the **Tools > Evaluate** Dialog Box in many different ways. The following are two examples:

- Expressions can contain loops, so you can use a **for** loop to search an array of structures for an element set to a certain value. In this case, you use the loop index at which the value is found as the last expression in the expression field.
- Because you can call subroutines, you can test and debug a single routine in your program without building a test program to call it.

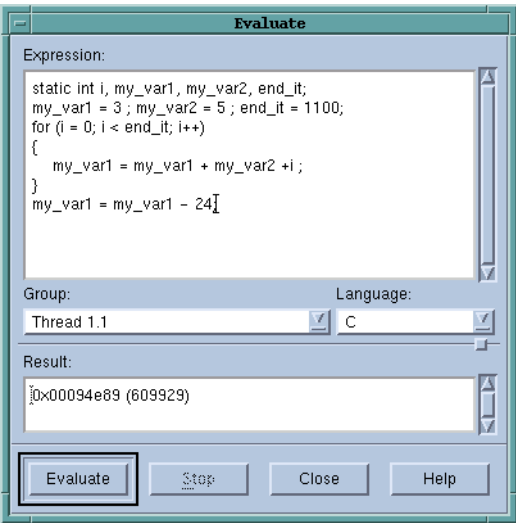
NOTE >> Although the CLI does not have an evaluate command, the information in the following sections does apply to the expression argument of the `dbreak`, `dbarrier`, `dprint`, and `dwatch` commands.

To evaluate an expression: Display the **Evaluate** Dialog Box by selecting the **Tools > Evaluate** command.

An **Evaluate** Dialog Box appears. If your program hasn't yet been created, you won't be able to use any of the program's variables or call any of its functions.

1. Select a button for the programming language you're writing the expression in (if it isn't already selected).
2. Move to the **Expression** field and enter a code fragment. For a description of the supported language constructs, see “[Using Built-in Variables and Statements](#)” on page 344.

Below is a sample expression. The last statement in this example assigns the value of **my_var1-3** back to **my_var1**. Because this is the last statement in the code fragment, the value placed in the **Result** field is the same as if you had just typed **my_var1-3**.

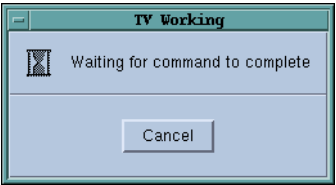


3. Click the **Evaluate** button.

If TotalView finds an error, it places the cursor on the incorrect line and displays an error message. Otherwise, it interprets (or on some platforms, compiles and executes) the code, and displays the value of the last expression in the **Result** field.

While the code is being executed, you can't modify anything in the dialog box. TotalView might also display a message box that tells you that it is waiting for the command to complete, [Figure 183](#).

Figure 183 – Waiting to Complete Message Box



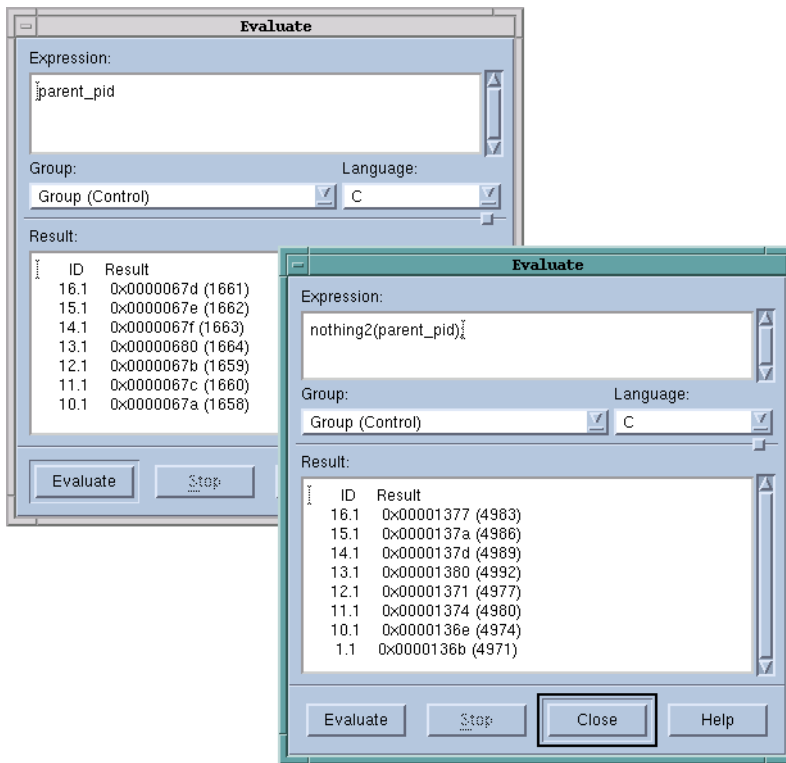
If you click **Cancel**, TotalView stops execution.

Since TotalView evaluates code fragments in the context of the target process, it evaluates stack variables according to the current program counter. If you declare a variable, its scope is the block that contains the program counter unless, for example, you declare it in some other scope or declare it to be a static variable.

If the fragment reaches a breakpoint (or stops for any other reason), TotalView stops evaluating your expression. Assignment statements in an expression can affect the target process because they can change a variable's value.

The controls at the top of the dialog box let you refine the scope at which TotalView evaluates the information you enter. For example, you can evaluate a function in more than one process. The following figure shows TotalView displaying the value of a variable in multiple processes, and then sending the value as it exists in each process to a function that runs on each of these processes.

Figure 184 – Evaluating Information in Multiple Processes



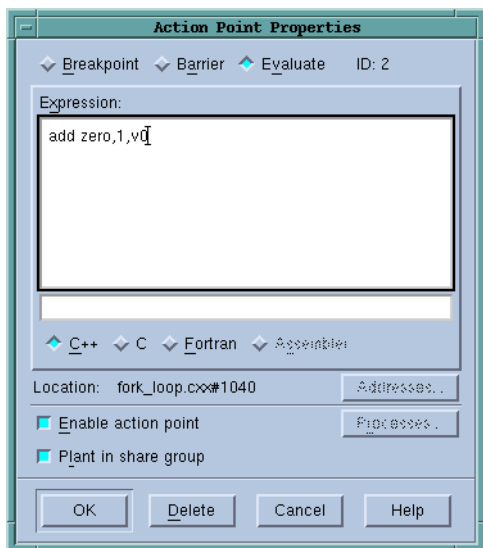
See Chapter 21, “Group, Process, and Thread Control,” on page 513 for information on using the P/T set controls at the top of this window.

Writing Assembler Code

On the RS/6000 IBM AIX operating system, TotalView lets you use assembler code in eval points, conditional breakpoints, and in the **Tools > Evaluate** Dialog Box. However, if you want to use assembler constructs, you must enable compiled expressions. See “[About Interpreted and Compiled Expressions](#)” on page 202 for instructions.

To indicate that an expression in the breakpoint or **Evaluate** Dialog Box is an assembler expression, click the **Assembler** button in the **Action Point > Properties** Dialog Box.

Figure 185 – Using Assembler Expressions



You write assembler expressions in the target machine's native assembler language and in a TotalView assembler language. However, the operators available to construct expressions in instruction operands, and the set of available pseudo-operators, are the same on all machines, and are described below.

The TotalView assembler accepts instructions using the same mnemonics recognized by the native assembler, and it recognizes the same names for registers that native assemblers recognize.

Some architectures provide extended mnemonics that do not correspond exactly with machine instructions and which represent important, special cases of instructions, or provide for assembling short, commonly used sequences of instructions. The TotalView assembler recognizes mnemonics if:

- They assemble to exactly one instruction.
- The relationship between the operands of the extended mnemonics and the fields in the assembled instruction code is a simple one-to-one correspondence.

Assembler language labels are indicated as *name:* and appear at the beginning of a line. You can place a label alone on a line. The symbols you can use include labels defined in the assembler expression and all program symbols.

The TotalView assembler operators are described in the following table:

Operators	Description
+	Plus
-	Minus (also unary)

Operators	Description
*	Multiplication
#	Remainder
/	Division
&	Bitwise AND
^	Bitwise XOR
!	Bitwise OR NOT (also unary minus, bitwise NOT)
	Bitwise OR
(<i>expr</i>)	Grouping
<<	Left shift
>>	Right shift
" <i>text</i> "	Text string, 1-4 characters long, is right-justified in a 32-bit word
hi16 (<i>expr</i>)	Low 16 bits of operand <i>expr</i>
hi32 (<i>expr</i>)	High 32 bits of operand <i>expr</i>
lo16 (<i>expr</i>)	High 16 bits of operand <i>expr</i>
lo32 (<i>expr</i>)	Low 32 bits of operand <i>expr</i>

The TotalView assembler pseudo-operations are as follows:

Pseudo Ops	Description
\$debug [0 1]	<i>Internal debugging option.</i> With no operand, toggle debugging; 0 => turn debugging off 1 => turn debugging on
\$hold \$holdprocess	Hold the process
\$holdstopall \$holdprocessstopall	Hold the process and stop the control group
\$holdthread	Hold the thread
\$holdthreadstop \$holdthreadstopprocess	Hold the thread and stop the process
\$holdthreadstopall	Hold the thread and stop the control group
\$long_branch <i>expr</i>	Branch to location <i>expr</i> using a single instruction in an architecture-independent way; using registers is not required

Pseudo Ops	Description
\$ptree	Internal debugging option. Print assembler tree
\$stop \$stopprocess	Stop the process
\$stopall	Stop the control group
\$stopthread	Stop the thread
<i>name=expr</i>	Same as def <i>name,expr</i>
align <i>expr</i> [, <i>expr</i>]	Align location counter to an operand 1 alignment; use operand 2 (or 0) as the fill value for skipped bytes
ascii <i>string</i>	Same as <i>string</i>
asciz <i>string</i>	Zero-terminated string
bss <i>name,size-expr</i> [, <i>expr</i>]	Define <i>name</i> to represent <i>size-expr</i> bytes of storage in the bss section with alignment optional <i>expr</i> ; the default alignment depends on the size: if <i>size-expr</i> >= 8 then 8 else if <i>size-expr</i> >= 4 then 4 else if <i>size-expr</i> >= 2 then 2 else 1
byte <i>expr</i> [, <i>expr</i>] ...	Place <i>expr</i> values into a series of bytes
comm <i>name,expr</i>	Define <i>name</i> to represent <i>expr</i> bytes of storage in the bss section; <i>name</i> is declared global; alignment is as in bss without an alignment argument
data	Assemble code into data section (data)
def <i>name,expr</i>	Define a symbol with <i>expr</i> as its value
double <i>expr</i> [, <i>expr</i>] ...	Place <i>expr</i> values into a series of doubles
equiv <i>name,name</i>	Make operand 1 an abbreviation for operand 2
fill <i>expr, expr, expr</i>	Fill storage with operand 1 objects of size operand 2, filled with value operand 3
float <i>expr</i> [, <i>expr</i>] ...	Place <i>expr</i> values into a series of floating point numbers
global <i>name</i>	Declare <i>name</i> as global
half <i>expr</i> [, <i>expr</i>] ...	Place <i>expr</i> values into a series of 16-bit words
lcomm <i>name,expr</i> [, <i>expr</i>]	Identical to bss
lsym <i>name,expr</i>	Same as def <i>name,expr</i> but allows redefinition of a previously defined name

Pseudo Ops	Description
org <i>expr</i> [, <i>expr</i>]	Set location counter to operand 1 and set operand 2 (or 0) to fill skipped bytes
quad <i>expr</i> [, <i>expr</i>] ...	Place <i>expr</i> values into a series of 64-bit words
string <i>string</i>	Place <i>string</i> into storage
text	Assemble code into text section (code)
word <i>expr</i> [, <i>expr</i>] ...	Place <i>expr</i> values into a series of 32-bit words
zero <i>expr</i>	Fill <i>expr</i> bytes with zeros

Using Built-in Variables and Statements

TotalView contains a number of built-in variables and statements that can simplify your debugging activities. You can use these variables and statements in eval points and in the **Tools > Evaluate** Dialog Box.

Topics in this section are:

- “Using TotalView Variables” on page 344
- “Using Built-In Statements” on page 345

RELATED TOPICS

Creating an eval or conditional breakpoint [“Defining Eval Points and Conditional Breakpoints”](#) on page 197

How to use watchpoints [“Using Watchpoints”](#) on page 206

Using TotalView Variables

TotalView variables that let you access special thread and process values. All variables are 32-bit integers, which is an **int** or a **long** on most platforms. The following table describes built-in variables:

Name	Returns
\$clid	The cluster ID. (Interpreted expressions only.)
\$duid	The TotalView-assigned Debugger Unique ID (DUID). (Interpreted expressions only.)
\$newval	The value just assigned to a watched memory location. (Watchpoints only.)
\$nid	The node ID. (Interpreted expressions only.)
\$oldval	The value that existed in a watched memory location before a new value modified it. (Watchpoints only.)
\$pid	The process ID.
\$processduid	The DUID (debugger ID) of the process. (Interpreted expressions only.)
\$systid	The thread ID assigned by the operating system. When this is referenced from a process, TotalView throws an error.
\$tid	The thread ID assigned by TotalView. When this is referenced from a process, TotalView throws an error.

The built-in variables let you create thread-specific breakpoints from the expression system. For example, the **\$tid** variable and the **\$stop** built-in function let you create a thread-specific breakpoint, as the following code shows:

```
if ($tid == 3)
    $stop;
```

This tells TotalView to stop the process only when the third thread evaluates the expression.

You can also create complex expressions using these variables; for example:

```
if ($pid != 34 && $tid > 7)
    printf ("Hello from %d.%d\n", $pid, $tid);
```

Using any of the following variables means that the eval point is interpreted instead of compiled: **\$clid**, **\$duid**, **\$nid**, **\$processduid**, **\$systid**, **\$tid**, and **\$visualize**. In addition, **\$pid** forces interpretation on AIX.

You can't assign a value to a built-in variable or obtain its address.

Using Built-In Statements

TotalView statements help you control your interactions in certain circumstances. These statements are available in all languages, and are described in the following table. The most commonly used statements are **\$count**, **\$stop**, and **\$visualize**.

Statement	Use
\$count <i>expression</i>	Sets a process-level countdown breakpoint.
\$countprocess <i>expression</i>	When any thread in a process executes this statement for the number of times specified by <i>expression</i> , the process stops. The other processes in the control group continue to execute.
\$countall <i>expression</i>	Sets a program-group-level countdown breakpoint. All processes in the control group stop when any process in the group executes this statement for the number of times specified by <i>expression</i> .

Statement	Use
\$countthread <i>expression</i>	<p>Sets a thread-level countdown breakpoint.</p> <p>When any thread in a process executes this statement for the number of times specified by <i>expression</i>, the thread stops. Other threads in the process continue to execute.</p> <p>If the target system cannot stop an individual thread, this statement performs the same as \$countprocess.</p> <p>A thread evaluates <i>expression</i> when it executes \$count for the first time. This expression must evaluate to a positive integer. When TotalView first encounters this variable, it determines a value for <i>expression</i>. TotalView does not reevaluate until the expression actually stops the thread. This means that TotalView ignores changes in the value of <i>expression</i> until it hits the breakpoint. After the breakpoint occurs, TotalView reevaluates the expression and sets a new value for this statement.</p> <p>The internal counter is stored in the process and shared by all threads in that process.</p>
\$hold \$holdprocess	<p>Holds the current process.</p> <p>If all other processes in the group are already held at this eval point, TotalView releases all of them. If other processes in the group are running, they continue to run.</p>
\$holdstopall \$holdprocessstopall	<p>Like \$hold, except that any processes in the group which are running are <i>stopped</i>. The other processes in the group are not automatically held by this call—they are just stopped.</p>
\$holdthread	<p>Freezes the current thread, leaving other threads running.</p>
\$holdthreadstop \$holdthreadstopprocess	<p>Like \$holdthread, except that it <i>stops</i> the process. The other processes in the group are left running.</p>
\$holdthreadstopall	<p>Like \$holdthreadstop, except that it stops the entire group.</p>
\$stop \$stopprocess	<p>Sets a process-level breakpoint. The process that executes this statement stops; other processes in the control group continue to execute.</p>
\$stopall	<p>Sets a program-group-level breakpoint. All processes in the control group stop when any thread or process in the group executes this statement.</p>

Statement	Use
\$stopthread	Sets a thread-level breakpoint. Although the thread that executes this statement stops, all other threads in the process continue to execute. If the target system cannot stop an individual thread, this statement performs the same as to \$stopprocess .
\$visualize (<i>expression</i> [, <i>slice</i>])	Visualizes the data specified by <i>expression</i> and modified by the optional <i>slice</i> value. <i>Expression</i> and <i>slice</i> must be expressed using the code fragment's language. The <i>expression</i> must return a dataset (after modification by <i>slice</i>) that can be visualized. <i>slice</i> is a quoted string that contains a slice expression. For more information on using \$visualize in an expression, see "Using the Visualizer" on page 312.

Expression Evaluation with ReplayEngine

When you enable ReplayEngine, you still have the ability to evaluate expressions, but the behavior is different. In regular, forward debugging, your expression may change the state of your program, for example, by changing the value of a variable. But when ReplayEngine is enabled, expression evaluation takes place in a separate, temporary space, and the results have no side effects in your program. When the evaluation is complete, the temporary space is released and any changes resulting from the evaluation no longer exist.

This is important to remember if you are actually counting on an expression evaluation to change something in your program. Note, too, that this is true even when ReplayEngine is in Record mode. If you want to regain the ability to affect your program state through expressions, you need to disable ReplayEngine.

With ReplayEngine enabled and in Record mode, there are still two ways to change memory or registers: with the CLI `dassign` command, and by directly editing the value in the TotalView user interface. However, an attempt to modify memory or registers in this way in Replay mode results in an error or the new value being discarded.

Expressions can call functions when ReplayEngine is enabled, but if the called function stops for any reason, for example, hits a breakpoint or receives a signal, the expression is suspended and limitations are imposed. You can continue to debug forward in a function called from an expression, but you cannot debug backwards until the expression evaluation is complete. Using an expression to write to `stdout` and `stderr` (file descriptors 1 and 2) is allowed with the following limitations: Writes to those file descriptors work for any type of file in Record mode. However, writes to those file descriptors fail in Playback mode unless the file is a TTY.

All of the above also applies to the transformations in C++View.



Chapter 13

About Groups, Processes, and Threads

While the specifics of how multi-process, multi-threaded programs execute differ greatly between hardware platforms, operating systems, and compilers, all share some general characteristics. This chapter defines a general model for conceptualizing the way processes and threads execute and introduces the concepts of *threads*, *processes*, and *groups*. [Chapter 21, “Group, Process, and Thread Control,”](#) on page 513 is a more exacting and comprehensive look at these topics.

This chapter contains the following sections:

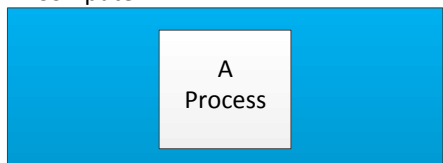
- [“A Couple of Processes”](#) on page 350
- [“Threads”](#) on page 353
- [“Complicated Programming Models”](#) on page 355
- [“Types of Threads”](#) on page 357
- [“Organizing Chaos”](#) on page 360
- [“How TotalView Creates Groups”](#) on page 364
- [“Simplifying What You’re Debugging”](#) on page 370

A Couple of Processes

When programmers write single-threaded, single-process programs, they can almost always answer the question “Do you know where your program is?” These types of programs are rather simple, looking something like [Figure 186](#).

Figure 186 – A Uniprocessor

A Computer



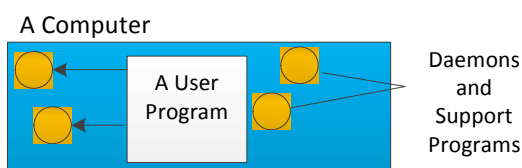
If you use any debugger on these types of programs, you can almost always figure out what’s going on. Before the program begins executing, you set a **breakpoint**, let the program run until it hits the breakpoint, and then inspect variables to see their values. If you suspect that there’s a logic problem, you can step the program through its statements to see where things are going wrong.

What is actually occurring, however, is a lot more complicated, since other programs are always executing on your computer. For example, your computing environment could have daemons and other support programs executing, and your program can interact with them.

These additional processes can simplify your program because it can hand off some tasks and not have to focus on how that work gets done.

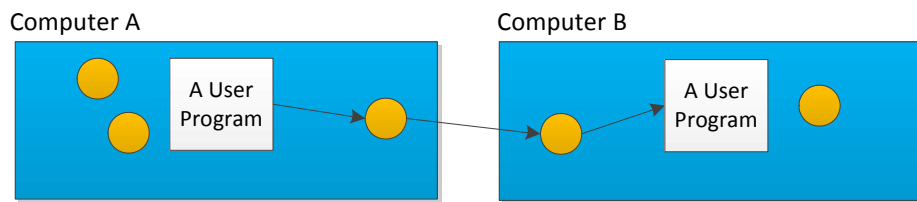
[Figure 187](#) shows a very simple architecture in which the application program just sends requests to a daemon.

Figure 187 – A Program and Daemons



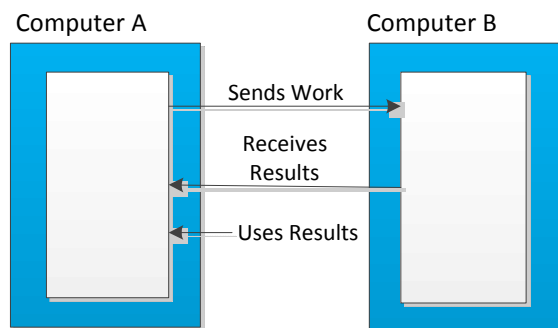
The type of architecture shown in [Figure 188](#) is more typical. In this example, an email program communicates with a daemon on one computer. After receiving a request, this daemon sends data to an email daemon on another computer, which then delivers the data to another mail program.

Figure 188 – Mail Using Daemons to Communicate



This architecture has one program handing off work to another. After the handoff, the programs do not interact. The program handing off the work just assumes that the work gets done. Some programs can work well like this. Most don't. Most computational jobs do better with a model that allows a program to divide its work into smaller jobs, and parcel this work to other computers. Said in a different way, this model has other machines do some of the first program's work. To gain any advantage, however, the work a program parcels out must be work that it doesn't need right away. In this model, the two computers act more or less independently. And, because the first computer doesn't have to do all the work, the program can complete its work faster.

Figure 189 – Two Computers Working on One Problem



Using more than one computer doesn't mean that less computer time is being used. Overhead due to sending data across the network and overhead for coordinating multi-processing always means more work is being done. It does mean, however, that your program finishes sooner than if only one computer were working on the problem.

The TotalView Server Solution to Debugging Across Computers

One problem with this model is how a programmer debugs behavior on the second computer. One solution is to have a debugger running on each computer. The TotalView solution to this debugging problem places a server on each remote processor as it is launched. These servers then communicate with the main TotalView process. This debugging architecture gives you one central location from which you can manage and examine all aspects of your program.

NOTE >> TotalView can also attach to programs already running on other computers. In other words, programs don't have to be started from within TotalView to be debugged by TotalView.

In all cases, it is far easier to initially write your program so that it only uses one computer. After it is working, you can split up its work so that it uses other computers. It is likely that any problems you find will occur in the code that splits the program or in the way the programs manipulate shared data, or in some other area related to the use of more than one thread or process.

NOTE >> Initially designing a multi-process application as a single-process program may not always be practical. For instance, some algorithms may take weeks to execute a program on one computer.

RELATED TOPICS

How TotalView organizes groups, processes, and threads [“Group, Process, and Thread Control”](#) on page 513

Debugging remotely [“Setting Up Remote Debugging Sessions”](#) on page 442

Attaching to a running program [“Attaching to a Running Program”](#) on page 101

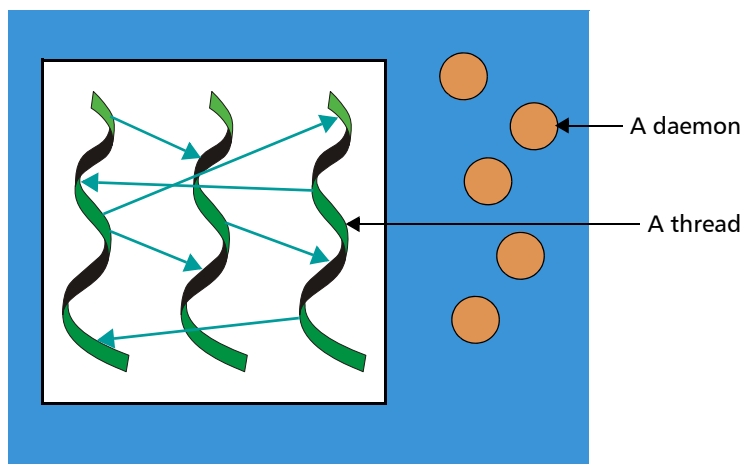
Threads

The operating system owns the daemon programs discussed in the previous section [A Couple of Processes](#). These daemons perform a variety of activities, from managing computer resources to providing standard services such as printing.

While operating systems can have many independently executing components, a program can as well, accomplished in various ways. One programming model splits the work off into somewhat independent tasks within the same process. This is the *threads* model.

[Figure 190](#) also shows the daemon processes that are executing. (The figures in the rest of this chapter won't show these daemons.)

Figure 190 - Threads



In this computing model, a program (the main thread) creates threads. If they need to, these newly created threads can also create threads. Each thread executes relatively independently from other threads. You can, of course, program them to share data and to synchronize how they execute.

The debugging issue here is similar to the problem of processes running on different machines. In both, a debugger must intervene with more than one executing entity, having to understand multiple address spaces and multiple contexts.

NOTE >> Little difference exists between a multi-threaded or a multi-process program when using TotalView. The way in which TotalView displays process information is very similar to how it displays thread information.

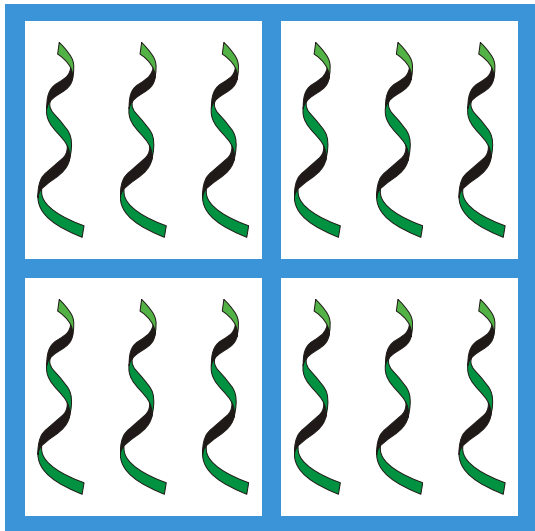
RELATED TOPICS

TotalView's design on organizing groups, processes, and threads	"Group, Process, and Thread Control" on page 513
Debugging multi-threaded, multi-process programs	"Manipulating Processes and Threads" on page 372
Setting breakpoints	"Setting Breakpoints for Multiple Processes" on page 189 "Setting Breakpoints When Using the fork()/execve() Functions" on page 191
Barrier points in multi-threaded programs	"Setting Barrier Points" on page 193

Complicated Programming Models

While most computers have one or two processors, high-performance computing often uses computers with many more. And as hardware prices decrease, this model is starting to become more widespread. Having more than one processor means that the threads model in [Figure 190](#) changes to something similar to that shown in [Figure 191](#).

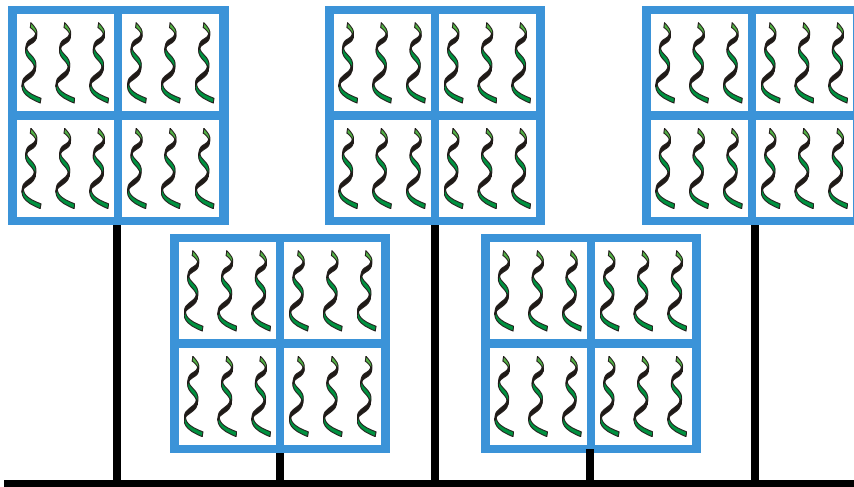
Figure 191 – Four-Processor Computer



This figure shows four cores in one computer, each of which has three threads. (Only four cores are shown even though many more could be on a chip.) This architecture is an extension to the model that links more than one computer together. Its advantage is that the processor doesn't need to communicate with other processors over a network as it is completely self-contained.

The next step is to join many multi-processor computers together. [Figure 192](#) shows five computers, each with four processors, with each processor running three threads. If this figure shows the execution of one program, then the program is using 60 threads.

Figure 192 – Four Processors on a Network



This figure depicts only processors and threads. It doesn't have any information about the nature of the programs and threads or even whether the programs are copies of one another or represent different executables.

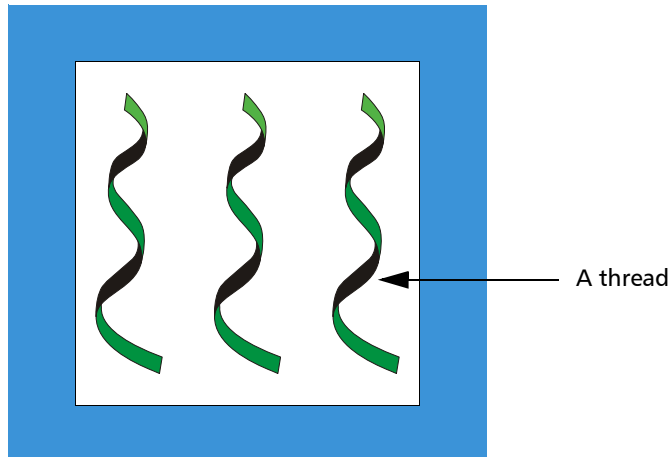
At any time, it is next to impossible to guess which threads are executing and what a thread is actually doing. Even more complex, many multi-processor programs begin by invoking a process such as **mpirun** or IBM **poe**, whose function is to distribute and control the work being performed. In this kind of environment, a program is using another program to control the workflow across processors.

In this model, traditional debuggers and solutions don't work. TotalView, on the other hand, organizes this mass of executing procedures for you, distinguishing between threads and processes that the operating system uses from those that your program uses.

Types of Threads

All threads aren't the same. Figure 193 shows a program with three threads.

Figure 193 – Threads (again)



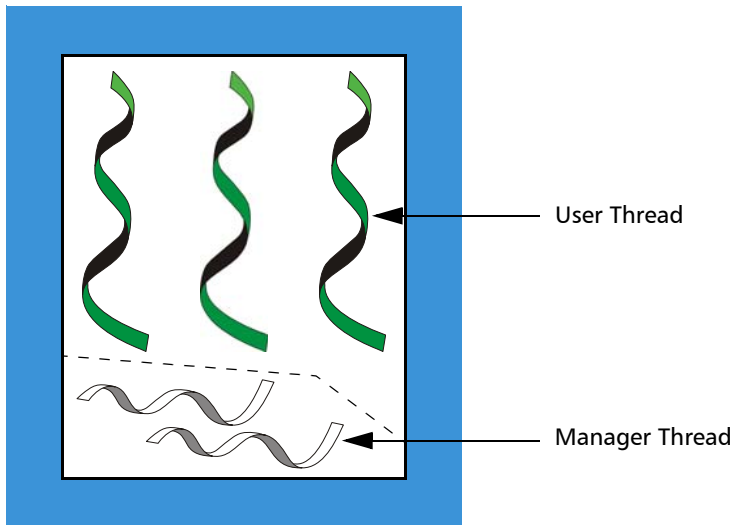
Assume that all these threads are *user threads*; that is, they are threads that perform some activity that you've programmed.

NOTE >> Many computer architectures have something called user mode, user space, or something similar. In TotalView, the definition of a user thread is simply a unit of execution created by a program.

Because the program creates user threads to do its work, they are also called *worker threads*.

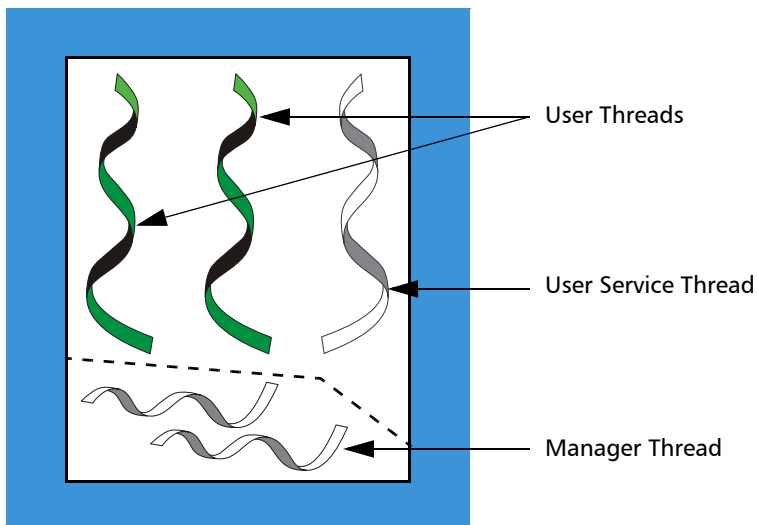
Other threads can also be executing. For example, there are always threads that are part of the operating environment. These threads are called *manager threads*. Manager threads exist to help your program get its work done. In [Figure 194](#), the horizontal threads at the bottom are user-created manager threads.

Figure 194 – User and Service Threads



All threads are not created equal, and all threads do not execute equally. Many programs also create manager-like threads. Since these user-created manager threads perform services for other threads, they are called *service threads*, [Figure 195](#).

Figure 195 – User, Service, and Manager Threads



These service threads are also worker threads. For example, the sole function of a user service thread might be to send data to a printer in response to a request from the other two threads.

One reason you need to know which of your threads are service threads is that a service thread performs different types of activities than your other threads. Because their activities are different, they are usually developed separately and, in many cases, are not involved with the fundamental problems being solved by the program. Here are two examples:

- The code that sends messages between processes is far different than the code that performs fast Fourier transforms. Its bugs are quite different than the bugs that create the data that is being transformed.
- A service thread that queues and dispatches messages sent from other threads might have bugs, but the bugs are different than the rest of your code, and you can handle them separately from the bugs that occur in nonservice user threads.

Being able to distinguish between the two kinds of threads means that you can focus on the threads and processes that actively participate in an activity, rather than on threads performing subordinate tasks.

Although [Figure 195](#) shows five threads, most of your debugging effort will focus on just two threads.

RELATED TOPICS

TotalView's design on organizing groups, processes, and threads

["Group, Process, and Thread Control"](#) on page 513

Setting the focus

["Setting Process and Thread Focus"](#) on page 520 and
["Setting Group Focus"](#) on page 526

Organizing Chaos

It is possible to debug programs that are running thousands of processes and threads across hundreds of computers by individually looking at each. However, this is almost always impractical. The only workable approach is to organize your processes and threads into groups and then debug your program by using these groups. In other words, in a multi-process, multi-threaded program, you are most often not programming each process or thread individually. Instead, most high-performance computing programs perform the same or similar activities on different sets of data.

TotalView cannot know your program's architecture; however, it can make some intelligent guesses based on what your program is executing and where the program counter is. Using this information, TotalView automatically organizes your processes and threads into the following predefined groups:

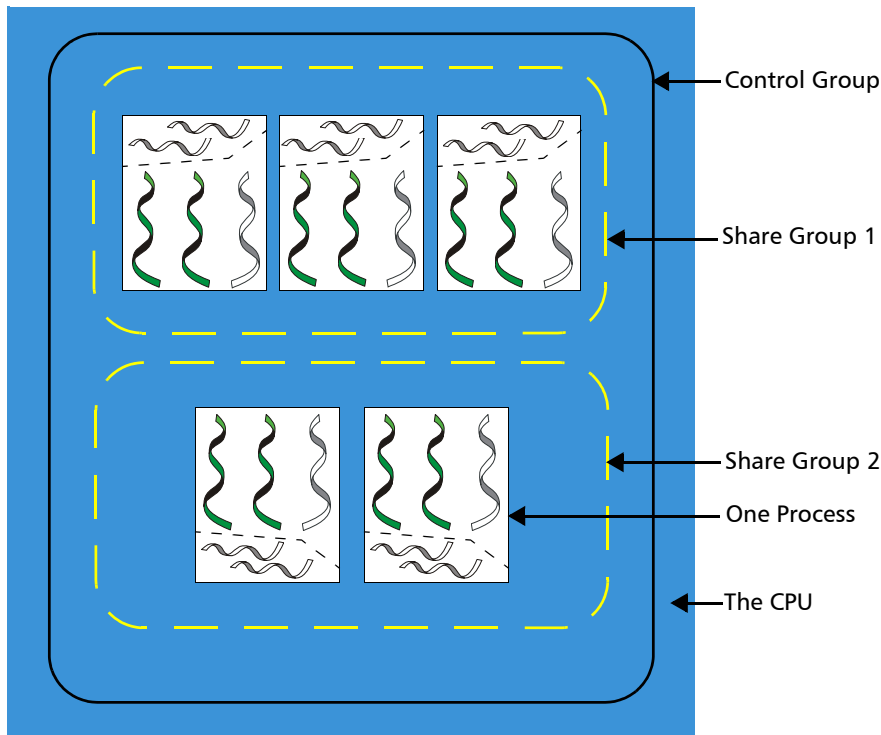
- **Control Group:** All the processes that a program creates. These processes can be local or remote. If your program uses processes that it did not create, TotalView places them in separate control groups. For example, a client/server program that has two distinct executables that run independently of one another has each executable in a separate control group. In contrast, processes created by `fork()/exec()` are in the same control group.
- **Share Group:** All the processes within a control group that share the same code. *Same code* means that the processes have the same executable file name and path. In most cases, your program has more than one share group. Share groups, like control groups, can be local or remote.
- **Workers Group:** All the worker threads within a control group. These threads can reside in more than one share group.
- **Lockstep Group:** All threads that are at the same PC (program counter). This group is a subset of a workers group. A lockstep group only exists for stopped threads. By definition, all members of a lockstep group are within the same workers group. That is, a lockstep group cannot have members in more than one workers group or more than one control group. A lockstep group only means anything when the threads are stopped.

The control and share groups contain only processes; the workers and lockstep groups contain only threads.

TotalView lets you manipulate processes and threads individually and by groups. In addition, you can create your own groups and manipulate a group's contents (to some extent). For more information, see [Chapter 21, "Group, Process, and Thread Control,"](#) on page 513.

Figure 196 shows a processor running five processes (ignoring daemons and other programs not related to your program) and the threads within the processes, along with a **control group** and two **share groups** within the control group.

Figure 196 – Five-Processes: Their Control and Share Groups



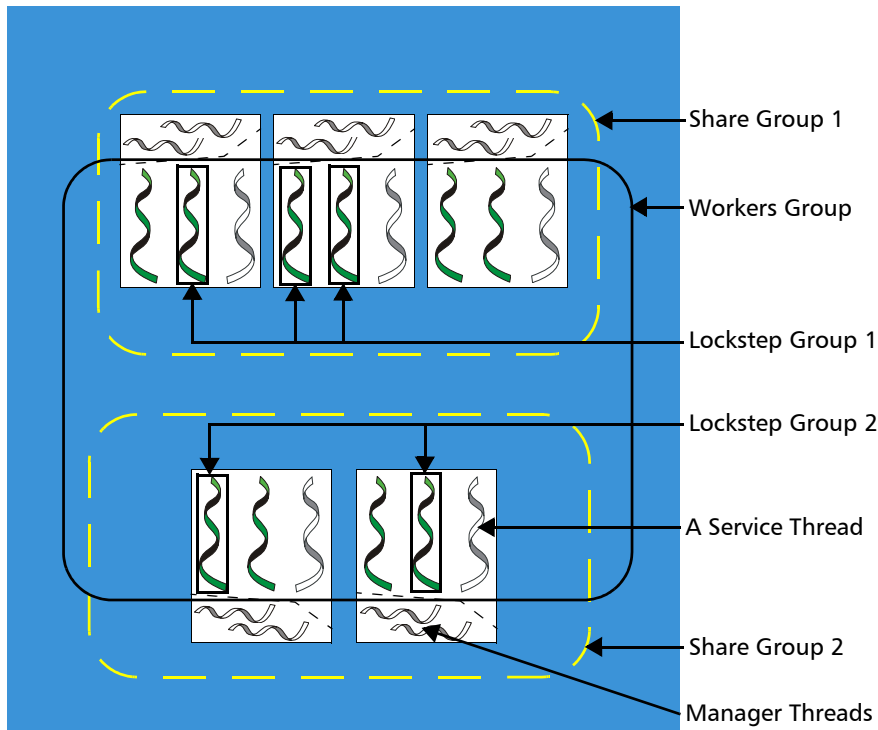
Many of the elements in this figure are used in other figures in this book. These elements are as follows:

- CPU** The one outer square represents the CPU. All elements in the drawing operate within one CPU.
- Processes** The five white inner squares represent processes being executed by the CPU.
- Control Group** The large rounded rectangle that surrounds the five processes shows one control group. This diagram doesn't indicate which process is the main procedure.
- Share Groups** The two smaller rounded rectangles having yellow dashed lines surround processes in a share group. This drawing shows two share groups within one control group. The three processes in the first share group have the same executable. The two processes in the second share group share a second executable.

The control group and the share group contain only processes.

Figure 197 shows how TotalView organizes the threads in the previous figure, adding a workers group and two lockstep groups.

Figure 197 – Five Processes: Adding Workers and Lockstep Groups



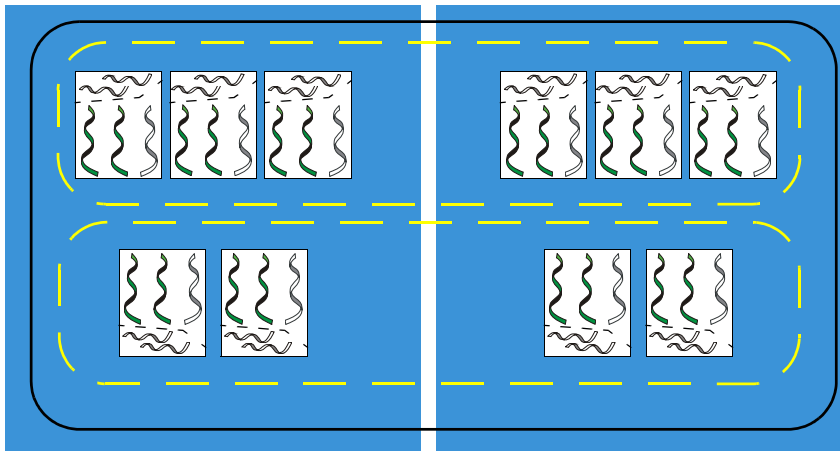
NOTE >> This figure doesn't show the control group since it encompasses everything in this figure. That is, this example's control group contains all of the program's lockstep, share, and worker group's processes and threads.

The additional elements in this figure are as follows:

- Workers Group** All nonmanager threads within the control group make up the workers group. This group includes service threads.
- Lockstep Groups** Each **share group** has its own **lockstep group**. The previous figure shows two lockstep groups, one in each share group.
- Service Threads** Each process has one service thread. A process can have any number of service threads, but this figure shows only one.
- Manager Threads** The ten manager threads are the only threads that do not participate in the workers group.

Figure 198 extends Figure 197 to show the same kinds of information executing on two processors.

Figure 198 – Five Processes and Their Groups on Two Computers



This figure differs from others in this section because it shows ten processes executing within *two* processors rather than five processes within one processor. Although the number of processors has changed, the number of control and share groups is unchanged. Note that, while this makes a nice example, most programs are not this regular.

RELATED TOPICS

TotalView's design on organizing groups, processes, and threads

["Group, Process, and Thread Control"](#) on page 513

Setting the focus

["Setting Process and Thread Focus"](#) on page 520 and
["Setting Group Focus"](#) on page 526

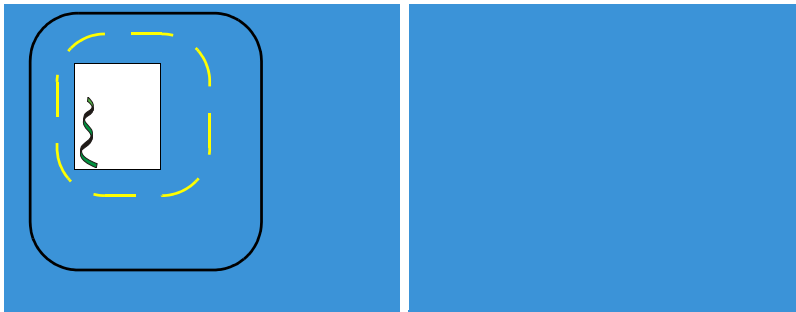
How TotalView Creates Groups

TotalView places processes and threads in groups as your program creates them, except for the **lockstep groups** that are created or changed whenever a process or thread hits an **action point** or is stopped for any reason. There are many ways to build this type of organization. The following steps indicate how TotalView might do this.

Step 1

TotalView and your program are launched, and your program begins executing.

Figure 199 – Step 1: A Program Starts

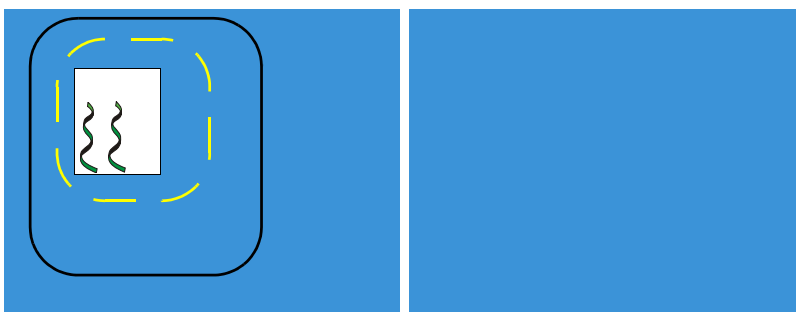


- **Control group:** The program is loaded and creates a group.
- **Share group:** The program begins executing and creates a group.
- **Workers group:** The thread in the **main()** routine is the workers group.
- **Lockstep group:** There is no lockstep group because the thread is running. (Lockstep groups contain only stopped threads.)

Step 2

The program creates a thread.

Figure 200 – Step 2: A Thread is Started



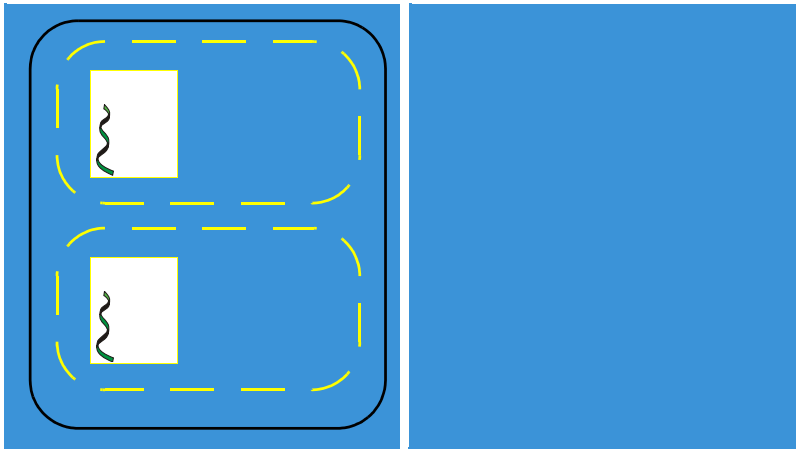
- **Control group:** The control group is unchanged.

- **Share group:** The share group is unchanged.
- **Workers group:** TotalView adds the thread to the existing group.
- **Lockstep group:** There are no lockstep groups because the threads are running.

Step 3

The first process uses the **exec()** function to create a second process, [Figure 201](#).

Figure 201 – Step 3: Creating a Process using exec()



- **Control group:** The group is unchanged.
- **Share group:** TotalView creates a second share group with the process created by the **exec()** function as a member. TotalView removes this process from the first share group.
- **Workers group:** Both threads are in the workers group.
- **Lockstep group:** There are no lockstep groups because the threads are running.

Step 4

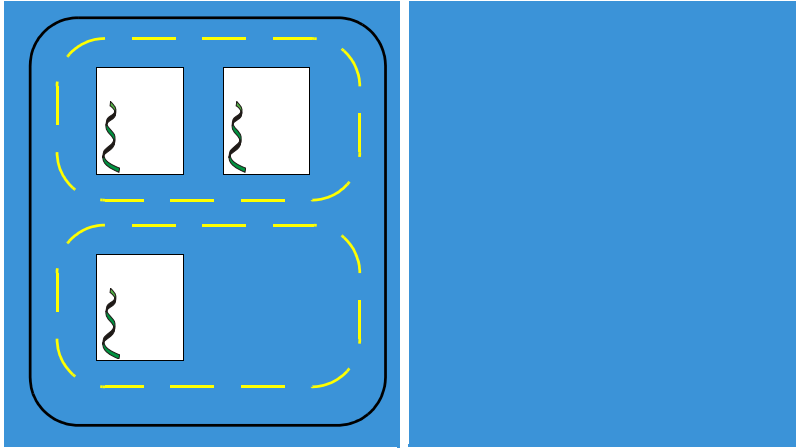
The first process hits a breakpoint.

- **Control group:** The group is unchanged.
- **Share group:** The groups are unchanged.
- **Workers group:** The group is unchanged.
- **Lockstep group:** TotalView creates a lockstep group whose member is the thread of the current process. (In this example, each thread is its own lockstep group.)

Step 5

The program is continued and TotalView starts a second version of your program from the shell. You attach to it within TotalView and put it in the same control group as your first process.

Figure 202 – Step 5: Creating a Second Version

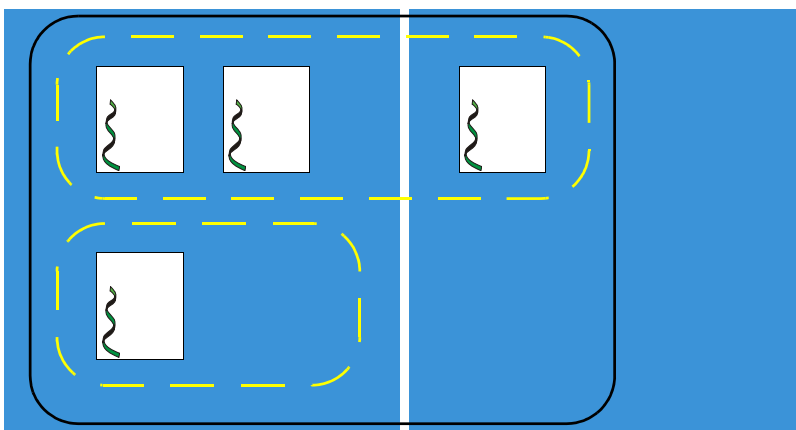


- **Control group:** TotalView adds a third process.
- **Share group:** TotalView adds this third process to the first share group.
- **Workers group:** TotalView adds the thread in the third process to the group.
- **Lockstep group:** There are no lockstep groups because the threads are running.

Step 6

Your program creates a process on another computer.

Figure 203 – Step 6: Creating a Remote Process



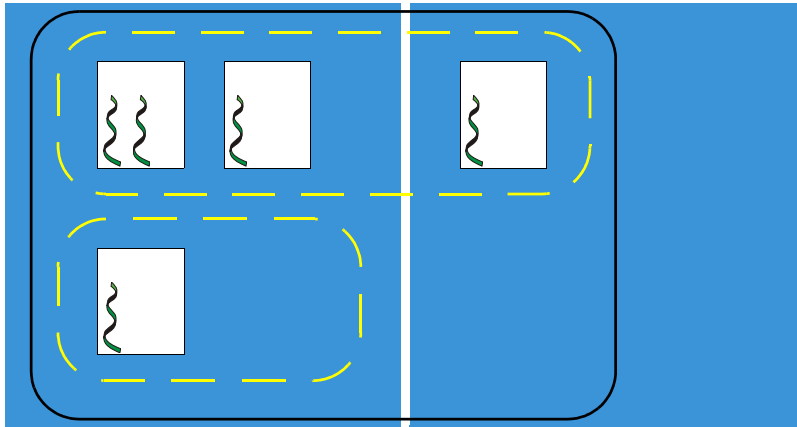
- **Control group:** TotalView extends the control group so that it contains the fourth process, which is running on the second computer.

- **Share group:** The first share group now contains this newly created process, even though it is running on the second computer.
- **Workers group:** TotalView adds the thread within this fourth process to the workers group.
- **Lockstep group:** There are no lockstep groups because the threads are running.

Step 7

A process within the control group creates a thread. This adds a second thread to one of the processes.

Figure 204 – Step 7: Creating a Thread

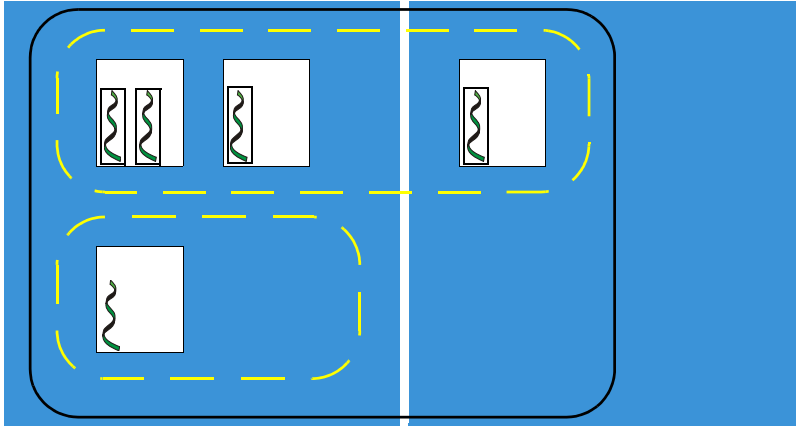


- **Control group:** The group is unchanged.
- **Share group:** The group is unchanged.
- **Workers group:** TotalView adds a fifth thread to this group.
- **Lockstep group:** There are no lockstep groups because the threads are running.

Step 8

A breakpoint is set on a line in a process executing in the first share group. By default, TotalView shares the breakpoint. The program executes until all three processes are at the breakpoint.

Figure 205 – Step 8: Hitting a Breakpoint

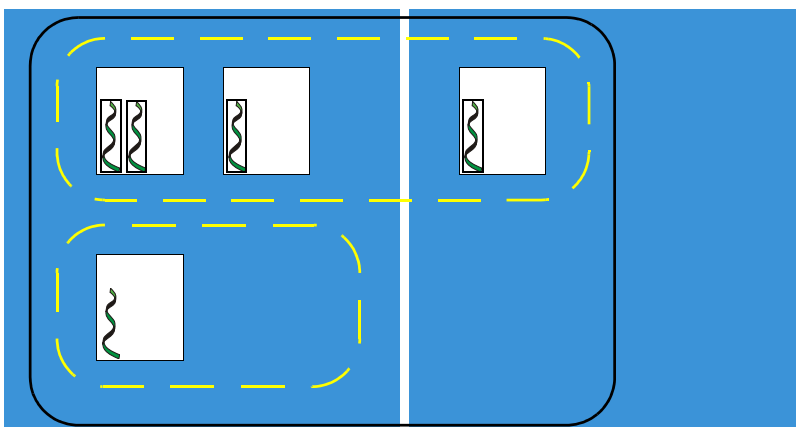


- **Control group:** The group is unchanged.
- **Share group:** The groups are unchanged.
- **Workers group:** The group is unchanged.
- **Lockstep groups:** TotalView creates a lockstep group whose members are the four threads in the first share group.

Step 9

You tell TotalView to step the lockstep group.

Figure 206 – Step 9: Stepping the Lockstep Group



- **Control group:** The group is unchanged.

- **Share group:** The groups are unchanged.
- **Workers group:** The group is unchanged.
- **Lockstep group:** The lockstep groups are unchanged. (There are other lockstep groups as explained in [Chapter 21, “Group, Process, and Thread Control,”](#) on page 513.)

What Comes Next

This example could continue to create a more complicated system of processes and threads. However, adding more processes and threads would not change the described behavior.

Simplifying What You're Debugging

The reason you're using a debugger is because your program isn't operating correctly, and the method you think will solve the problem is to stop your program's threads, examine the values assigned to variables, and step your program so you can observe execution.

Unfortunately, your multi-process, multi-threaded program and the computers upon which it executes are running several threads or processes that you want TotalView to ignore. For example, you don't want to examine manager and service threads that the operating system, your programming environment, and your program create.

Also, most of us are incapable of understanding exactly how a program is acting when perhaps thousands of processes are executing **asynchronously**. Fortunately, only a few problems require full asynchronous behavior at all times.

One of the first simplifications you can make is to change the number of processes. For example, suppose you have a buggy MPI program running on 128 processors. Your first step might be to have it execute in an 8-processor environment.

After the program is running under TotalView control, run the process being debugged to an action point so that you can inspect the program's state at that point. In many cases, because your program has places where processes are forced to wait for an interaction with other processes, you can ignore what they are doing.

NOTE >> TotalView lets you control as many groups, processes, and threads as you need to control. Although you can control each one individually, it would be very complicated to try to control large numbers of these independently. TotalView creates and manages groups so that you can focus on portions of your program.

In most cases, you don't need to interact with everything that is executing. Instead, you want to focus on one process and the data that this process manipulates. Things get complicated when the process being investigated is using data created by other processes, and these processes might be dependent on other processes.

The following is a typical way to use TotalView to locate problems:

1. At some point, make sure that the groups you are manipulating do not contain service or manager threads. (You can remove processes and threads from a group by using the **Group > Custom Group** command.)

```
CLI: dgroups -remove
```

2. Place a breakpoint in a process or thread and begin investigating the problem. In many cases, you are setting a breakpoint at a place where you hope the program is still executing correctly. Because you are debugging a multi-process, multi-threaded program, set a **barrier point** so that all threads and processes stop at the same place.

NOTE >> Don't step your program unless you need to individually look at a thread. Using barrier points is much more efficient. Barrier points are discussed in "Setting Barrier Points" on page 193 and online in the Action Point area within the TotalView Tips archive at <http://kb.roguewave.com/kb/>.

3. After execution stops at a barrier point, look at the contents of your variables. Verify that your program state is actually correct.
4. Begin stepping your program through its code. In most cases, step your program synchronously or set barriers so that everything isn't running freely.

Things begin to get complicated at this point. You've been focusing on one process or thread. If another process or thread modifies the data and you become convinced that this is the problem, you need to go off to it and see what's going on.

Keep your focus narrow so that you're investigating only a limited number of behaviors. This is where debugging becomes an art. A multi-process, multi-threaded program can be doing a great number of things. Understanding where to look when problems occur is the art.

For example, you most often execute commands at the default focus. Only when you think that the problem is occurring in another process do you change to that process. You still execute in the default focus, but this time the default focus changes to another process.

Although it seems like you're often shifting from one focus to another, you probably will do the following:

- Modify the focus so that it affects just the next command. If you are using the GUI, you might select this process and thread from the list displayed in the Root Window. If you are using the CLI, you use the **dfocus** command to limit the scope of a future command. For example, the following is the CLI command that steps thread 7 in process 3:

```
dfocus t3.7 dstep
```

- Use the **dfocus** command to change focus temporarily, execute a few commands, and then return to the original focus.

RELATED TOPICS

Detailed information on TotalView threads, processes, and groups	"Group, Process, and Thread Control" on page 513
Solving problems when starting MPI applications	"Starting MPI Issues" on page 489
Setting barrier points	"Setting Barrier Points" on page 193
More specific debugging tips for parallel applications	Chapter 15, "Debugging Strategies for Parallel Applications," on page 398



Chapter 14

Manipulating Processes and Threads

This chapter illustrates some foundational parallel debugging tasks and is based on the shipped program, **wave_extended_threads**, located in the directory `install_dir/toolworks/totalview.version/platform/examples`. This is a simple program that creates an array and then increments its values to simulate a wave form which can then be viewed using the Visualizer. The program requires user input to provide the number of times to increment.

The first steps when debugging programs with TotalView are similar to those using other debuggers:

- Use the **-g** option to compile the program. (Compiling is not discussed here. Please see “[Compiling Programs](#)” on page 85.)
- Start the program under TotalView control.
- Start the debugging process, including setting breakpoints and examining your program’s data.

When working with multi-process, multi-threaded programs, you have many options for controlling thread and process execution, viewing specific threads and processes, and organizing processes in to groups in order to better view the various elements of your program. This chapter includes:

- “[Viewing Process and Thread States](#)” on page 374
- “[Using the Toolbar to Select a Target](#)” on page 377
- “[Stopping Processes and Threads](#)” on page 378
- “[Using the Processes/Ranks and Threads Tabs](#)” on page 379
- “[Updating Process Information](#)” on page 382
- “[Holding and Releasing Processes and Threads](#)” on page 383
- “[Using Barrier Points](#)” on page 386

- [“Barrier Point Illustration”](#) on page 387
- [“Examining Groups”](#) on page 389
- [“Placing Processes in Groups”](#) on page 391
- [“Starting Processes and Threads”](#) on page 392
- [“Creating a Process Without Starting It”](#) on page 393
- [“Creating a Process by Single-Stepping”](#) on page 394
- [“Stepping and Setting Breakpoints”](#) on page 395

Viewing Process and Thread States

Process and thread states are displayed in the following:

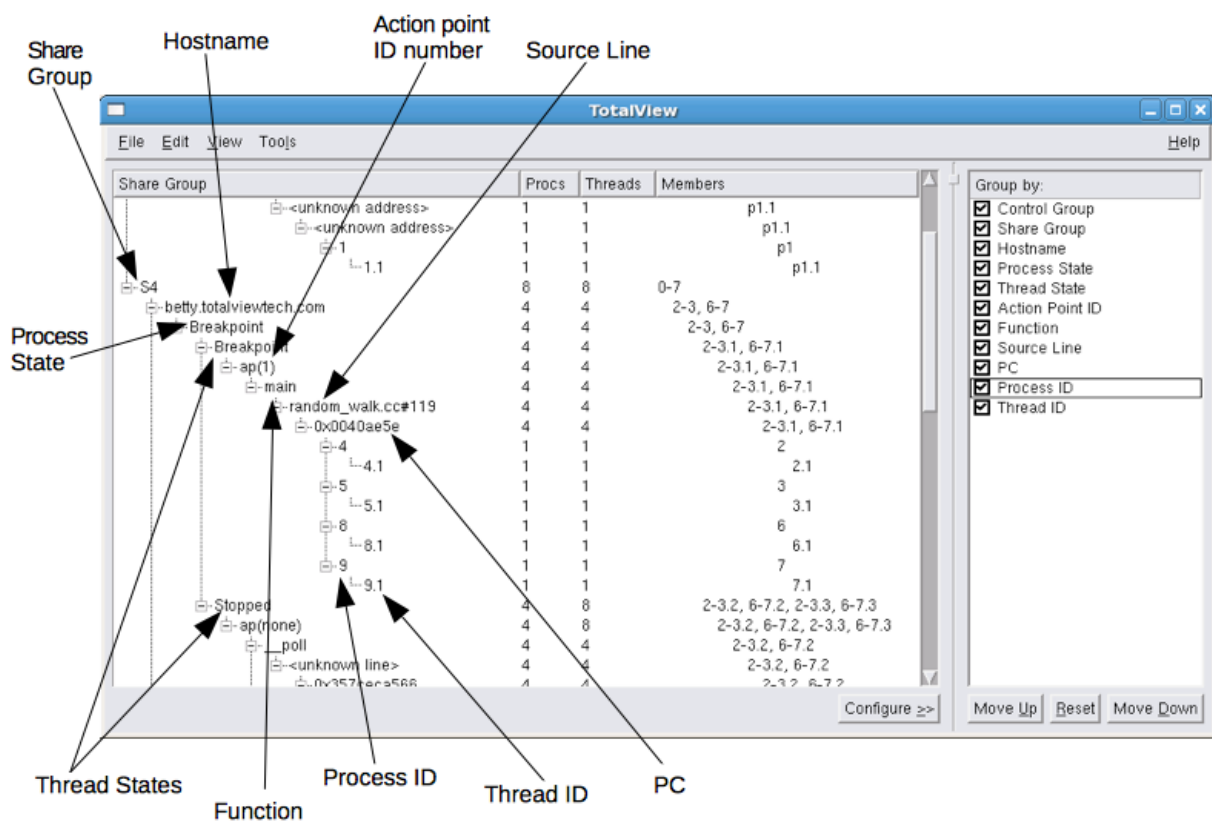
- The Root Window.
- The information within the **File > Attach to a Running Program** dialog.
- The process and thread status bars of the Process Window.
- The Threads tab of the Process Window.

Figure 207 shows TotalView displaying process state information in the Root Window.

CLI: `dstatus` and `dptsets`

When you use either of these commands, TotalView also displays state information.

Figure 207 – Root Window Showing Process and Thread Status



The **Status** of a process includes the process location, the process ID, and the state of the process. (These characters are explained in “Seeing Attached Process States” on page 375.)

If you need to attach to a process that is not yet being debugged, open the **File > Attach to a Running Program** dialog. TotalView displays all processes associated with your username. Notice that some of the processes will be dim (drawn in a lighter font). This indicates either you cannot attach to the process or you're already attached to it.

Notice that the status bars in the Process Window also display status information, [Figure 208](#).

Figure 208 – Process and Thread Labels in the Process Window



NOTE >> If the thread ID that TotalView assigns is the same as the operating system thread ID, TotalView only displays ID. If you are debugging an MPI program, TotalView displays the thread's rank number.

RELATED TOPICS

- The Root Window ["Using the Root Window"](#) on page 140
- The Process Window ["Using the Process Window"](#) on page 148
- Process state definition and display ["Seeing Attached Process States"](#) on page 375

Seeing Attached Process States

The Root Window displays the Process and/or Thread State. To view these states, enable the "Process State" and/or "Thread State" check boxes in the Configure pane. Once enabled, the states display in the first column.

CLI: The CLI prints out a word indicating the state; for example, "breakpoint."

Seeing Unattached Process States

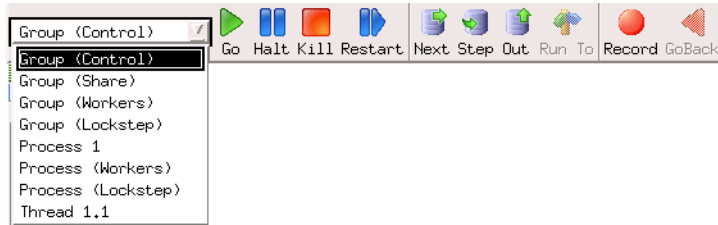
TotalView derives the state information for a process displayed in the **File > Attach to a Running Program** dialog box from the operating system. The state characters TotalView uses to summarize the state of an unattached process do not necessarily match those used by the operating system. The following table describes the state indicators that TotalView displays:

State Code	State Description
I	Idle
R	Running
S	Sleeping
T	Stopped
Z	Zombie (no apparent owner)

Using the Toolbar to Select a Target

The Process Window toolbar has a dropdown list that controls process and thread focus. The selection in this dropdown list defines the *focus*, or target of the toolbar commands. (The selected target in this pulldown is also called a *scope modifier*.)

Figure 209 – The Toolbar



For example, if you select a thread and then select **Step**, TotalView steps the current thread. If **Process (workers)** is selected and you select **Halt**, TotalView halts all processes associated with the current thread's **workers group**. If you are running a multi-process program, other processes continue to execute.

In a multi-process, multi-threaded program, this is important, as TotalView needs to know which processes and threads to act on.

In the CLI, specify this target using the **dfocus** command.

NOTE >> [Chapter 21, “Group, Process, and Thread Control,”](#) on page 513 describes how TotalView manages processes and threads. While TotalView gives you the ability to control the precision your application requires, most applications do not need this level of interaction. In almost all cases, using the controls in the toolbar gives you all the control you need.

RELATED TOPICS

The Processes/Ranks tab in the Process Window [“Using the Processes/Ranks and Threads Tabs”](#) on page 379

How to create custom groups [“Creating Custom Groups”](#) on page 542

Stopping Processes and Threads

To stop a group, process, or thread, select a **Halt** command from the **Group**, **Process**, or **Thread** pulldown menus in the menubar.

CLI: dhalt

Halts a group, process, or thread. Setting the focus changes the scope.

The three **Halt** commands differ in the scope of what they halt. In all cases, TotalView uses the current thread, which is called the thread of interest or TOI, to determine what else it will halt. For example, selecting **Process > Halt** tells TotalView to determine the process in which the TOI is running. It then halts this process. Similarly, if you select **Group > Halt**, TotalView determines what processes are in the group in which the current thread participates. It then stops all of these processes.

NOTE >> For more information on the Thread of Interest, see [“Defining the GOI, POI, and TOI”](#) on page 514.

When you select the **Halt** button in the toolbar instead of the commands in the menubar, TotalView decides what it should stop based on what is set in the toolbar pulldown list.

After entering a **Halt** command, TotalView updates any windows that can be updated. When you restart the process, execution continues from the point where TotalView stopped the process.

Using the Processes/Ranks and Threads Tabs

The Processes Tab

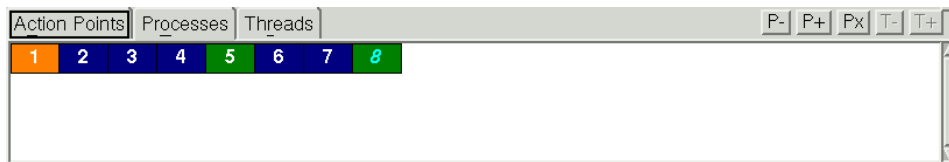
The Processes Tab was displayed by default in previous versions of TotalView, but now it is off by default. This is because it can significantly affect performance, particularly for large, massively parallel applications. The tab can be turned back on with the command line switch **-processgrid** and/or by setting **TV::GUI::process_grid_wanted** to **true** in the `.tvdrc` file. If you enable this tab in the `.tvdrc` file, you can disable it for a particular session with the **-noprocessgrid** command line switch.

The Processes tab, which is called a Ranks tab if you are running an MPI program, contains a grid. Each block in the grid represents one process. The color that TotalView uses to display a process indicates the process's state, as follows:

Color	Meaning
Blue	Stopped; usually due to another process or thread hitting a breakpoint.
Orange	At breakpoint.
Green	All threads in the process are running or can run.
Red	The Error state. Signals such as SIGSEGV , SIGBUS , and SIGFPE can indicate an error in your program.
Gray	The process has not begun running.

Figure 210 shows a tab with processes in three different states:

Figure 210 – The Processes Tab



If you select a group by using the Process Window's group selector pulldown (see "Using the Toolbar to Select a Target" on page 377 for information), TotalView dims the blocks for processes not in the group, Figure 211.

CLI: `dptsets`

Figure 211 – The Processes Tab: Showing Group Selection

Action Points		Processes			Threads						F		
0	1	2	3	4	5	6	7	8	9	10	11	12	13
17	18	19	20	21	22	23	24	25	26	27	28	29	

If you click on a block, the context within the Process Window changes to the first thread in that process.

CLI: dfocus

Clicking on the **P+** and **P-** buttons in the tab bar changes the process being displayed within the Process Window. Click on **Px** to launch a **Jump To** dialog in which you can specify a particular process or thread to focus on, [Figure 212](#).

Figure 212 – The Jump To Dialog

Enter MPI rank, process ID, or thread ID to display.
Example: "5" or "5.2":

Search by:

- ◆ dpid or dpid.dtid
- ▼ rank or rank.dtid

RELATED TOPICS

- Custom group creation [“Creating Custom Groups”](#) on page 542
- More on controlling processes and threads [“Using the Toolbar to Select a Target”](#) on page 377

The Threads Tab

The Threads Tab displays information about the state of your threads. Clicking on a thread tells TotalView to shift the focus within the Process Window to that thread.

Figure 213 – The Threads Tab

Action Points		Processes		Threads				P-	P+	Px	T-	T+
1.1	(47118580301408)	T										
1.2	(1082132800)	T										
1.3	(1090525504)	B5										
1.4	(1098918208)	T										

Clicking on the **T+** and **T-** buttons in the tab bar also changes the thread being displayed within the Process Window.

Updating Process Information

Normally, TotalView updates information only when the thread being executed stops executing. You can force TotalView to update a window by using the **Window > Update** command. You need to use this command if you want to see what a variable's value is while your program is executing.

NOTE >> When you use this command, TotalView momentarily stops execution to obtain update information, then restarts the thread.

Holding and Releasing Processes and Threads

Many times when you are running a multi-process or multi-threaded program, you want to synchronize execution to the same place. You can do this manually using a *hold* command, or automatically by setting a barrier point.

When a process or a thread is *held*, it ignores any command to resume executing. For example, assume that you place a hold on a process in a **control group** that contains three processes. If you select **Group > Go**, two of the three processes resume executing. The held process ignores the **Go** command.

Use the **Release** command to remove the hold. When you release a process or a thread, it can resume execution, but you still need to tell it to do so. That is, you must resume execution with a command such as **Go**, **Out**, or **Step**.

Manually holding and releasing processes and threads is useful when:

- You need to run a subset of the processes and threads. You can manually hold all but the ones you want to run.
- A process or thread is held at a barrier point and you want to run it without first running all the other processes or threads in the group to that barrier. In this case, you release the process or the thread manually and then run it.

See “[Setting Barrier Points](#)” on page 193 for more information on manually holding and releasing barrier breakpoints.

When TotalView is holding a process, the Root Window displays **Stopped**, and the Process Window displays a held indicator, which is the uppercase letter **H**. When TotalView is holding a thread, it displays a lowercase **h**.

You can hold or release a thread, process, or group of processes in one of the following ways:

- You can hold a group of processes using the **Group > Hold** command.
- You can release a group of processes using the **Group > Release** command.
- You can toggle the hold/release state of a process by selecting and clearing the **Process > Hold** command.
- You can toggle the hold/release state of a thread by selecting and clearing the **Thread > Hold** command.

CLI: dhold and dunhold
Setting the focus changes the scope.

If a process or a thread is running when you use a hold or release command, TotalView stops the process or thread and then holds it. TotalView lets you hold and release processes independently from threads.

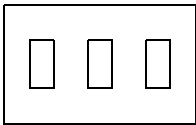
The Process pulldown menu contains the commands **Hold Threads** and **Release Threads**, which act on all the threads in a multi-process program. The result is seldom what you actually want as you really do want something to run. You can select one or more threads and use the **Thread > Hold** toggle command to clear them so that TotalView lets them run. This may appear awkward, but it is actually an easy way to run just one or more threads when your program has a lot of threads. You can verify that you're doing the right thing by looking at the thread status in the Root Window.

```
CLI: dhold -thread
      dhold -process
      dunhold -thread
```

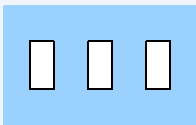
Here are some examples of using hold commands:

Held/Release State

What Can Be Run Using Process > Go

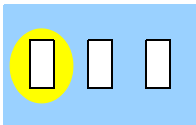


This figure shows a process with three threads. Before you do anything, all threads in the process can be run.



Select the **Process > Hold** toggle. The blue shading indicates that you held the process.

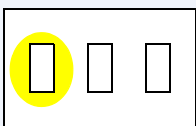
Nothing runs when you select **Process > Go**.



Go to the **Threads** menu. The button next to the **Hold** command isn't selected. This is because the *thread hold* state is independent from the *process hold* state.

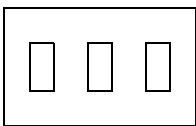
Select it. The circle indicates that thread 1 is held. At this time, there are two different holds on thread 1. One is at the process level; the other is at thread level.

Nothing will run when you select **Process > Go**.



Select the **Process > Hold** command.

Select **Process > Go**. The second and third threads run.



Select **Process > Release Threads**. This releases the hold placed on the first thread by the **Thread > Hold** command. You could also release the thread individually with **Thread > Hold**.

When you select **Process > Go**, all threads run.

RELATED TOPICS

Barrier points [“Setting Barrier Points” on page 193](#)

The CLI **dbarrier** command [**dbarrier** in the "CLI Commands" in the *TotalView for HPC Reference Guide*](#)

Using Barrier Points

Because threads and processes are often executing different instructions, keeping threads and processes together is difficult. The best strategy is to define places where the program can run freely and places where you need control. This is where barrier points come in.

To keep things simple, this section only discusses multi-process programs. You can do the same types of operations when debugging multi-threaded programs.

Why breakpoints don't work (part 1)

If you set a breakpoint that stops all processes when it is hit and you let your processes run using the **Group > Go** command, you might get lucky and have all of your threads reach the breakpoint together. More likely, though, some processes won't have reached the breakpoint and TotalView will stop them wherever they happen to be. To get your processes synchronized, you would need to find out which ones didn't get there and then individually get them to the breakpoint using the **Process > Go** command. You can't use the **Group > Go** command since this also restarts the processes stopped at the breakpoint.

Why breakpoints don't work (part 2)

If you set the breakpoint's property so that only the process hitting the breakpoint stops, you have a better chance of getting all your processes there. However, you must be careful not to have any other breakpoints between where the program is currently at and the target breakpoint. If processes hit these other breakpoints, you are once again left to run processes individually to the breakpoint.

Why single stepping doesn't work

Single stepping is just too tedious if you have a long way to go to get to your synchronization point, and stepping just won't work if your processes don't execute exactly the same code.

Why barrier points work

If you use a barrier point, you can use the **Group > Go** command as many times as it takes to get all of your processes to the barrier, and you won't have to worry about a process running past the barrier.

The Root Window shows you which processes have hit the barrier, grouping all held processes under **Breakpoint** in the first column.

RELATED TOPICS

Barrier points	"Setting Barrier Points" on page 193
The CLI dbarrier command	dbarrier in "CLI Commands" in the <i>TotalView for HPC Reference Guide</i>

Barrier Point Illustration

Creating a barrier point tells TotalView to *hold* a process when it reaches the barrier. Other processes that can reach the barrier but aren't yet at it continue executing. One-by-one, processes reach the barrier and, when they do, TotalView holds them.

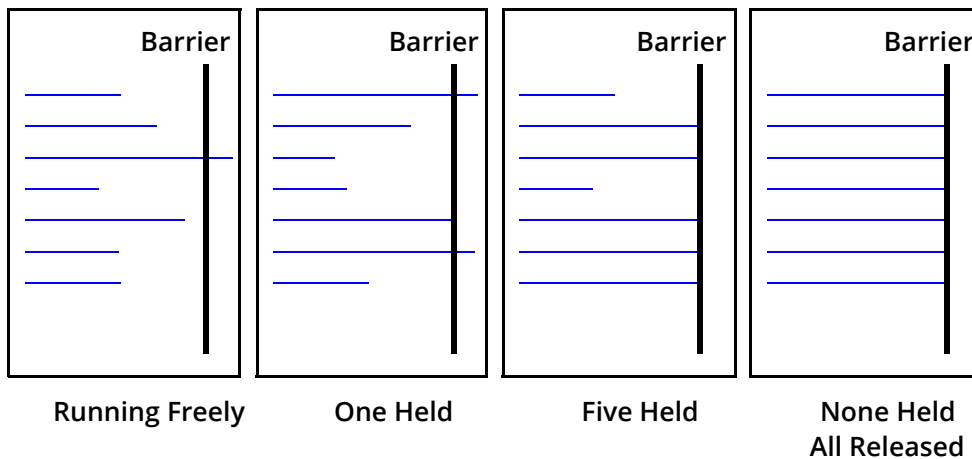
When a process is *held*, it ignores commands that tell it to execute. This means, for example, that you can't tell it to go or to step. If, for some reason, you want the process to execute, you can manually release it using either the **Group > Release** or **Process > Release Threads** command.

When all processes that share a barrier reach it, TotalView changes their state from *held* to *released*, which means they no longer ignore a command that tells them to begin executing.

The following figure shows seven processes that are sharing the same barrier. (Processes that aren't affected by the barrier aren't shown.)

- First block: All seven processes are running freely.
- Second block: One process hits the barrier and is held. Six processes are executing.
- Third block: Five of the processes have now hit the barrier and are being held. Two are executing.
- Fourth block: All processes have hit the barrier. Because TotalView isn't waiting for anything else to reach the barrier, it changes the processes' states to *released*. Although the processes are released, none are executing.

Figure 214 – Running To Barriers



For more information on barriers, see "[Setting Barrier Points](#)" on page 193.

RELATED TOPICS

Barrier points

[“Setting Barrier Points”](#) on page 193

The CLI **dbarrier** command

dbarrier in "CLI Commands" in the *TotalView for HPC Reference Guide*

Examining Groups

When you debug a multi-process program, TotalView adds processes to both a control and a **share group** as the process starts. These groups are not related to either UNIX process groups. (See [Chapter 13, “About Groups, Processes, and Threads,”](#) on page 349 for information on groups.)

Because a program can have more than one **control group** and more than one share group, TotalView decides where to place a process based on the type of system call—which can either be **fork()** or **execve()**—that created or changed the process. The two types of process groups are:

Control Group	The parent process and all related processes. A control group includes children that a process forks (processes that share the same source code as the parent). It also includes forked children that subsequently call a function such as execve() . That is, a control group can contain processes that don't share the same source code as the parent. Control groups also include processes created in parallel programming disciplines like MPI.
Share Group	The set of processes in a control group that shares the same source code. Members of the same share group share action points .

NOTE >> See [Chapter 21, “Group, Process, and Thread Control,”](#) on page 513 for a complete discussion of groups.

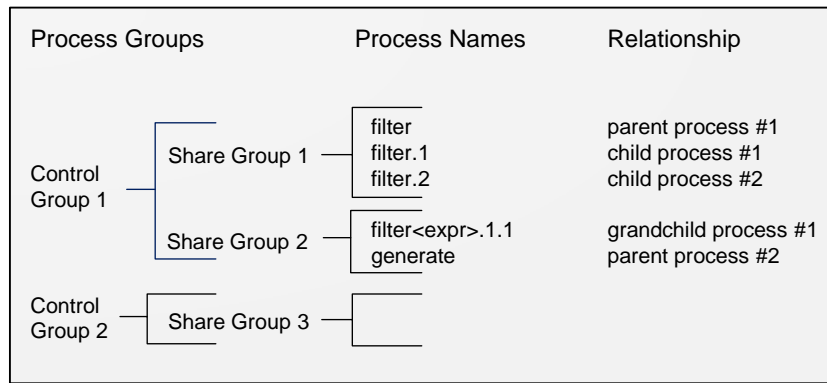
TotalView automatically creates share groups when your processes fork children that call the **execve()** function, or when your program creates processes that use the same code as some parallel programming models such as MPI do.

TotalView names processes according to the name of the source program, using the following naming rules:

- TotalView names the parent process after the source program.
- The name for forked child processes differs from the parent in that TotalView appends a numeric suffix (*.n*). If you're running an MPI program, the numeric suffix is the process's rank in **COMM_WORLD**.
- If a child process calls the **execve()** function after it is forked, TotalView places a new executable name in angle brackets (<>).

In [Figure 215](#), assume that the **generate** process doesn't fork any children, and that the **filter** process forks two child processes. Later, the first child forks another child, and then calls the **execve()** function to execute the **expr** program. In this figure, the middle column shows the names that TotalView uses.

Figure 215 – Control and Share Groups Example



RELATED TOPICS

- Custom group creation [“Creating Custom Groups” on page 542](#)
- Understanding threads and processes and how TotalView organizes them [About Groups, Processes, and Threads](#)
- TotalView’s process/thread model in detail [Group, Process, and Thread Control](#)

Placing Processes in Groups

TotalView uses your executable's name to determine the **share group** that the program belongs to. If the path names are identical, TotalView assumes that they are the same program. If the path names differ, TotalView assumes that they are different, even if the file name in the path name is the same, and places them in different share groups.

RELATED TOPICS

Using the **Group > Edit Group** command **Group > Edit Group** in the in-product Help

Starting Processes and Threads

To start a process, select a **Go** command from the **Group**, **Process**, or **Thread** pulldown menus.

After you select a **Go** command, TotalView determines what to execute based on the current thread. It uses this thread, which is called the Thread of Interest (TOI), to decide other threads that should run. For example, if you select **Group > Go**, TotalView continues all threads in the current group that are associated with this thread.

CLI: `dfocus g dgo`
Abbreviation: **G**

The commands you will use most often are **Group > Go** and **Process > Go**. The **Group > Go** command creates and starts the current process and all other processes in the multi-process program. There are some limitations, however. TotalView only resumes a process if the following are true:

- The process is not being held.
- The process already exists and is stopped.
- The process is at a breakpoint.

Using a **Group > Go** command on a process that's already running starts the other members of the process's [control group](#).

CLI: `dgo`

If the process hasn't yet been created, a **Go** command creates and starts it. *Starting* a process means that all threads in the process resume executing unless you are individually holding a thread.

NOTE >> TotalView disables the **Thread > Go** command if [asynchronous](#) thread control is not available. If you enter a thread-level command in the CLI when asynchronous thread controls aren't available, TotalView tries to perform an equivalent action. For example, it continues a process instead of a thread.

For a single-process program, the **Process > Go** and **Group > Go** commands are equivalent. For a single-threaded process, the **Process > Go** and **Thread > Go** commands are equivalent.

Creating a Process Without Starting It

The **Process > Create** command creates a process and stops it before the first statement in your program executes. If you link a program with shared libraries, TotalView allows the dynamic loader to map into these libraries. Creating a process without starting it is useful when you need to do the following:

- Create watchpoints or change the values of global variables after a process is created, but before it runs.
- Debug C++ static constructor code.

CLI: `dstepi`

While there is no CLI equivalent to the Process > Create command, executing the `dstepi` command produces the same effect.

Creating a Process by Single-Stepping

The TotalView single-stepping commands let you create a process and run it to the beginning of your program. The single-stepping commands available from the **Process** menu are as shown in the following table:

GUI command	CLI command	Creates the process and ...
Process > Step	<code>dfocus p dstep</code>	Runs it to the first line of the <code>main()</code> routine.
Process > Next	<code>dfocus p dnext</code>	Runs it to the first line of the <code>main()</code> routine; this is the same as Process > Step .
Process > Step Instruction	<code>dfocus p dstepi</code>	Stops it before any of your program executes.
Process > Next Instruction	<code>dfocus p dnexti</code>	Runs it to the first line of the <code>main()</code> routine. This is the same as Process > Step .

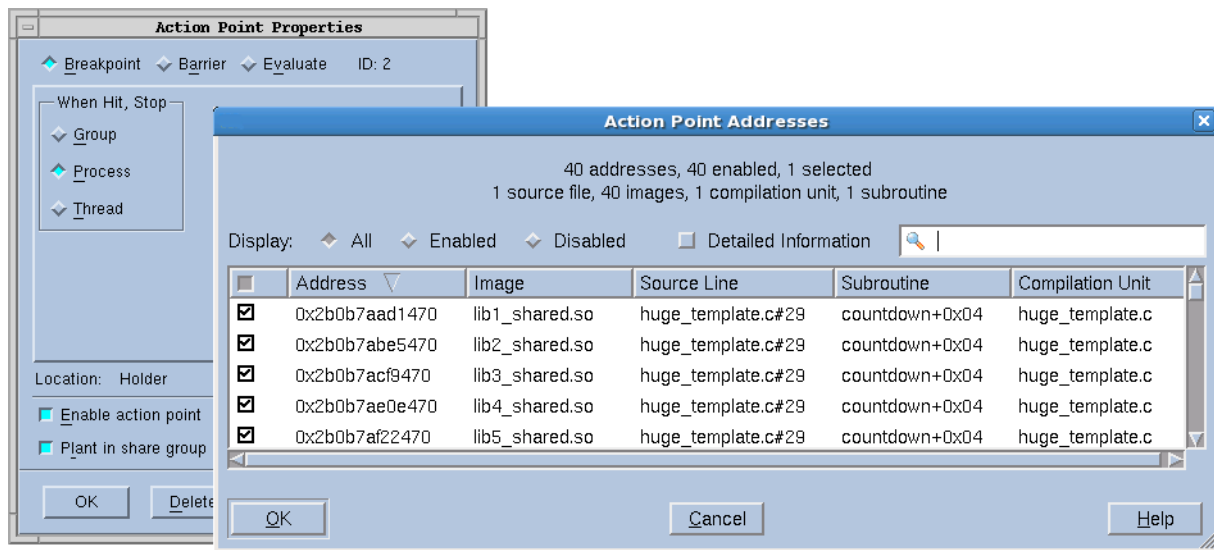
If a group-level or thread-level stepping command creates a process, the behavior is the same as if it were a process-level command.

NOTE >> [Chapter 21, “Group, Process, and Thread Control,”](#) on page 513 contains a detailed discussion of setting the focus for stepping commands.

Stepping and Setting Breakpoints

Several of the single-stepping commands require that you select a source line or machine instruction in the Source Pane. To select a source line, place the cursor over the line and click your left mouse button. If you select a source line that has more than one instantiation, TotalView will try to do the right thing. For example, if you select a line within a template so you can set a **breakpoint** on it, you'll actually set a breakpoint on all of the template's instantiations. If this isn't what you want, select the **Addresses** button in the **Action Point > Properties** Dialog Box to change which instantiations will have a breakpoint.

Figure 216 – Action Point and Addresses Dialog Boxes



Initially, addresses are either enabled or disabled, but you can change their state by clicking the checkbox in the first column. The checkbox in the columns bar enables or disables all the addresses. This dialog supports selecting multiple separate items (Ctrl-Click) or a range of items (Shift-Click or click and drag). Once the desired subset is selected, right-click one of the selected items and choose Enable Selection or Disable Selection from the context menu.

Filtering

In massively parallel programs, the number of addresses can become very large, so the Addresses dialog has several mechanisms to help you manage the data. The search box filters the currently displayed data based on one or more space-separated strings or phrases (enclosed in quotes). Remember that data not currently displayed is not included in the filtering. It may be helpful to click the Detailed Information checkbox, which displays much more complete information, giving you more possibilities for filtering.

Sorting

Clicking on the column labels performs a sort based on the data in that column. Each click toggles between ascending and descending order. If entry values in a column are the same, the values of the column to the right of the sorted column are examined and sorted based on those values. If the values are the same, the next column is examined and so on, until different values are found. The Addresses dialog uses a stable sort, i.e. if all the entries are the same in the selected column and in the columns to the right, the list is not modified.

Displaying and rearranging columns

Finally, right-clicking in the columns bar presents a context menu for displaying or hiding columns. All are initially displayed except Image. You can reorder the columns by selecting a column label and dragging it to a new location.

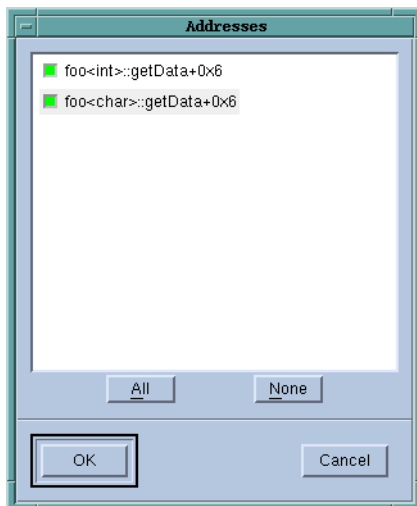
Keyboard Shortcuts

To provide easy access to the buttons at the bottom of the Addresses dialog, the following mnemonic keys have been assigned.

Button	Keyboard Sequence
OK	Alt-o
Cancel	Alt-c
Help	Alt-h

Similarly, if TotalView cannot figure out which instantiation to set a breakpoint at, it displays its **Address** Dialog Box.

Figure 217 – Ambiguous Address Dialog Box



RELATED TOPICS

Action points [“Setting Action Points” on page 174](#)



Chapter 15

Debugging Strategies for Parallel Applications

This chapter provides tips and strategies for debugging parallel programs, including:

- “General Parallel Debugging Tips” on page 399
 - “Breakpoints, Stepping, and Program Execution” on page 399
 - “Viewing Processes, Threads, and Variables” on page 400
 - “Restarting from within TotalView” on page 401
 - “Attaching to Processes Tips” on page 401
- “MPI Debugging Tips and Tools” on page 405
 - “MPI Display Tools” on page 405
 - “MPICH Debugging Tips” on page 411
- “IBM PE Debugging Tips” on page 413

RELATED TOPICS

A general discussion on ways to simplify the debugging of complex, multi-threaded and multi-process applications

“Simplifying What You’re Debugging” on page 370

General Parallel Debugging Tips

This section provides debugging tips relevant to most parallel programs.

Breakpoints, Stepping, and Program Execution

Setting Breakpoint Behavior

When you're debugging message-passing and other multi-process programs, it is usually easier to understand the program's behavior if you change the default stopping action of breakpoints and barrier breakpoints. By default, when one process in a multi-process program hits a breakpoint, TotalView stops all other processes.

To change the default stopping action of breakpoints and barrier breakpoints, you can set debugger preferences. The online Help contains information on these preference. These preferences tell TotalView whether to continue to run when a process or thread hits the breakpoint.

These options affect only the default behavior. You can choose a behavior for a breakpoint by setting the breakpoint properties in the **File > Preferences** Action Points Page. See "[Setting Breakpoints for Multiple Processes](#)" on page 189.

Synchronizing Processes

TotalView has two features that make it easier to get all of the processes in a multi-process program synchronized and executing a line of code. Process barrier breakpoints and the process hold/release features work together to help you control the execution of your processes. See "[Setting Barrier Points](#)" on page 193.

The Process Window **Group > Run To** command is a special stepping command. It lets you run a group of processes to a selected source line or instruction. See "[Stepping \(Part I\)](#)" on page 516.

Using Group Commands

Group commands are often more useful than process commands.

It is often more useful to use the **Group > Go** command to restart the whole application instead of the **Process > Go** command.

```
CLI: dfocus g dgo
Abbreviation: G
```

You would then use the **Group > Halt** command instead of **Process > Halt** to stop execution.

```
CLI: dfocus g dhalt
Abbreviation: H
```

The group-level single-stepping commands such as **Group > Step** and **Group > Next** let you single-step a group of processes in a parallel. See “[Stepping \(Part I\)](#)” on page 516.

```
CLI: dfocus g dstep
      Abbreviation: S
      dfocus g dnext
      Abbreviation: N
```

Stepping at Process Level

If you use a process-level single-stepping command in a multi-process program, TotalView may appear to hang (it continuously displays the watch cursor). If you single-step a process over a statement that can't complete without allowing another process to run, and that process is stopped, the stepping process appears to hang. This can occur, for example, when you try to single-step a process over a communication operation that cannot complete without the participation of another process. When this happens, you can abort the single-step operation by selecting **Cancel** in the **Waiting for Command to Complete** Window that TotalView displays. As an alternative, consider using a group-level single-step command.

```
CLI: Type Ctrl+C
```

NOTE >> Rogue Wave receives many bug reports on hung processes, usually because one process is waiting for another. Using the **Group** debugging commands almost always solves this problem.

Viewing Processes, Threads, and Variables

Identifying Process and Thread Execution

The Root Window helps you determine where various processes and threads are executing. When you select a line of code in the Process Window, the Root Window updates to show which processes and threads are executing that line.

Viewing Variable Values

You can view the value of a variable that is replicated across multiple processes or multiple threads in a single Variable Window. See “[Displaying a Variable in all Processes or Threads](#)” on page 300.

Restarting from within TotalView

You can restart a parallel program at any time. If your program runs past the point you want to examine, you can kill the program by selecting the **Group > Kill** command. This command kills the master process and all the slave processes. Restarting the master process (for example, **mpirun** or **poe**) recreates all of the slave processes. Start up is faster when you do this because TotalView doesn't need to reread the symbol tables or restart its **tvdsrv** processes, since they are already running.

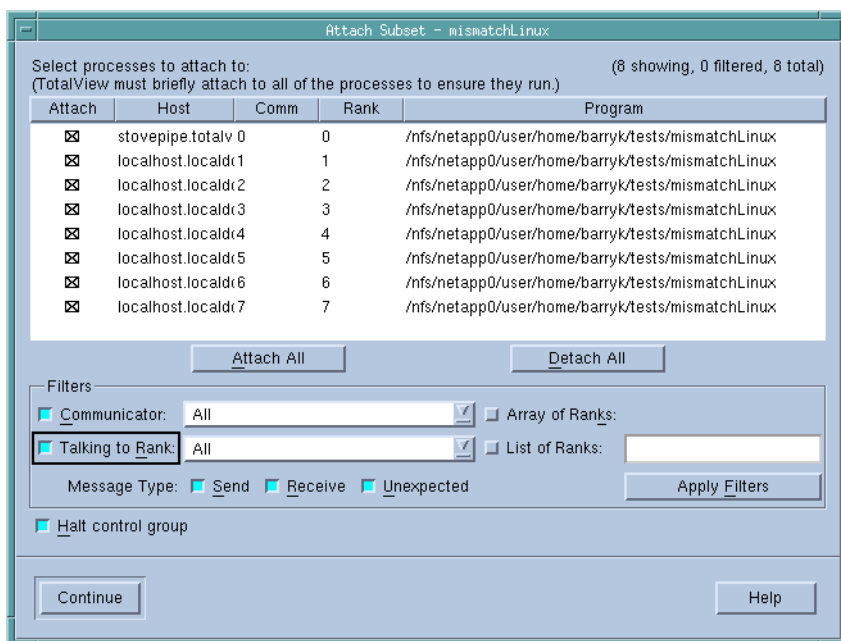
```
CLI: dfocus g dkill
```

Attaching to Processes Tips

In a typical multi-process job, you're interested in some processes and not as much in others. By default, TotalView tries to attach to all of the processes that your program starts. If there are a lot of processes, there can be considerable overhead involved in opening and communicating with the jobs.

You can minimize this overhead by using the **Attach Subset** dialog box, shown in [Figure 218](#).

Figure 218 – Group > Attach Subset Dialog Box



NOTE >> You can start MPI jobs in two ways. One requires that the starter program be under TotalView control and have special instrumentation for TotalView, while the other does not. In the first case, you will enter the name of the starter program on the command line. The other requires that you enter information into the File > Debug New Program or File > Debug New Parallel Program > dialog boxes. The Attach Subset command is available only if you directly name a starter program on the command line.

The Subset Attach dialog box can be launched in multiple ways. It is automatically available when you launch your job with the parallel preference set to “Ask what to do.” (See [Figure 220](#)). It is also available through other menu options after the job has been started, as discussed later in this section.

Selecting check boxes in the Attach column defines the processes to attach to. Although your program will launch all these processes, TotalView attaches only to the those you have selected.

The **Attach All** and **Detach All** buttons elect or deselect all the processes at once. You can then use the check boxes to select and deselect individual processes. For example, to attach to only a few processes in a lengthy list, use **Detach All** and then select those to which TotalView should attach.

The **Filter** controls restrict which processes are displayed; filtering is unrelated to attaching or detaching.

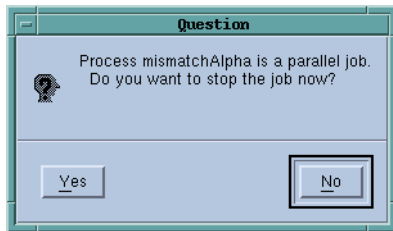
- The **Communicator** control specifies that the processes displayed must be involved with the communicators that you select. For example, if something goes wrong that involves a communicator, selecting it from the list displays only the processes that use that communicator. You can then use **Attach All** to attach to only those processes.
- The **Talking to Rank** control limits the processes displayed to those that receive messages from the indicated ranks. In addition to your rank numbers, you can also select **All** or **MPI_ANY_SOURCE**.
- The **Array of Ranks** option is automatically selected and the array name displayed if you have invoked **Tools > Attach Subset (Array of Ranks)** from the Variable Window. In this case, the dialog box will only display the list of processes whose ranks match the array elements.
- The **List of Ranks** control allows you to enter rank numbers to filter on. Use a dash to indicate a range of ranks, and commas to indicate individual ranks. For example: 3, 10-16, 24.
- The three checkboxes in the **Message Type** area add yet another qualifier. Checking a box displays only communicators that are involved with a **Send**, **Receive**, or **Unexpected** message.

The **Halt Control Group** button is not active if the dialog box is launched after the job is already started. It is active only at the initial startup of a parallel job. You typically want to halt processes to allow the setting of breakpoints.

Many applications place values that indicate ranks in an array variable so that the program can refer to them as needed. You can display the variable in a Variable Window and then select the **Tools > Attach Subset (Array of Ranks)** command to display this dialog box. (See the **Array of Ranks** explanation above.)

You can use the **Group > Attach Subset** command at any time, but you would probably use it immediately before TotalView launches processes. Unless you have set preferences otherwise, TotalView stops and asks if you want it to stop your processes. When selected, the **Halt control group** check box also stops a process just before it begins executing.

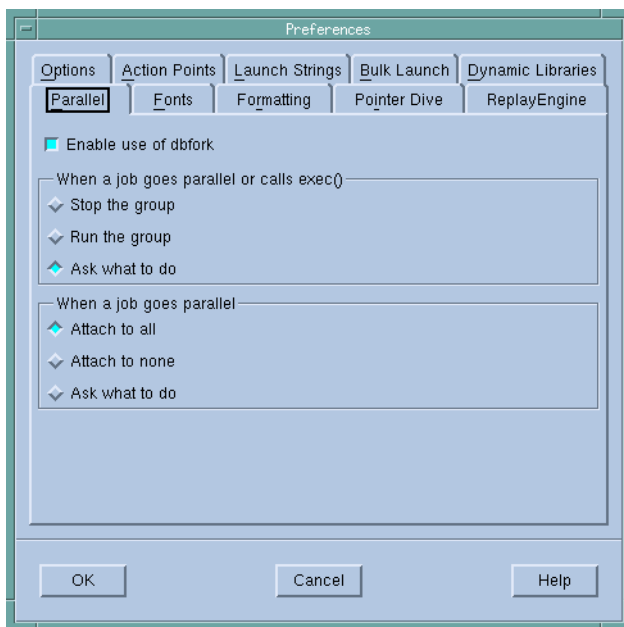
Figure 219 – Stop Before Going Parallel Question Box



If you click Yes, when the job stops the starter process should be at a “magic breakpoint.” These are set by TotalView behind the scene, and usually not visible. The other processes may or may not be at a “magic breakpoint.”

The commands on the Parallel Page in the **File > Preferences** Dialog Box control what TotalView does when your program goes parallel.

Figure 220 – File > Preferences: Parallel Page



NOTE >> TotalView displays the preceding question box only when you directly name a starter program on the command line.

The radio buttons in the **When a job goes parallel or calls exec()** area:

- **Stop the group:** Stops the **control group** immediately after the processes are created.
- **Run the group:** Allows all newly created processes in the **control group** to run freely.
- **Ask what to do:** Asks whether TotalView should start the created processes.

CLI: `dset TV::parallel_stop`

The radio buttons in the **When a job goes parallel** area:

- **Attach to all:** Automatically attaches to all processes at executing.
- **Attach to none:** Does not attach to any created process at execution.
- **Ask what to do:** Asks what processes to attach to. For this option, the same dialog box opens as that displayed for **Group > Attach Subset**. TotalView then attaches to the processes that you have selected. Note that this dialog box isn't displayed when you set the preference; rather, it controls behavior when your program actually creates parallel processes.

CLI: `dset TV::parallel_attach`

MPI Debugging Tips and Tools

TotalView provides specific tools to view MPI program status, including rank and message queues.

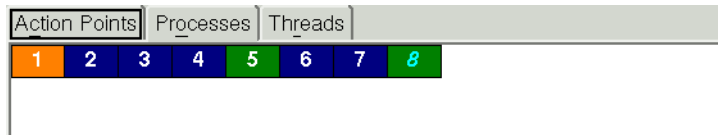
This section discusses these display tools as well as any other information specific to an MPI program.

MPI Display Tools

MPI Rank Display

The Processes/Ranks Tab at the bottom of the Process Window displays the status of each rank. For example, in Figure 221, one rank is at a breakpoint, two are running, and five are stopped.

Figure 221 – Ranks Tab



RELATED TOPICS

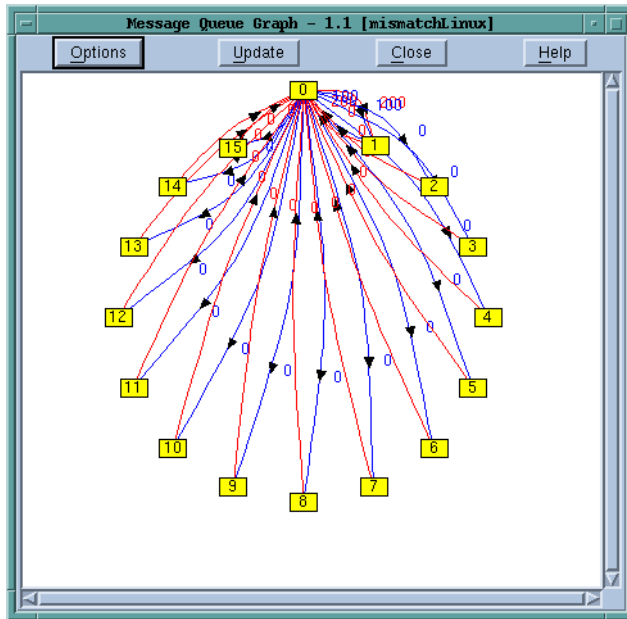
Creating Custom Groups [“Creating Custom Groups” on page 542](#)

The Processes/Rank Tab [“Using the Processes/Ranks and Threads Tabs” on page 379.](#)

Displaying the Message Queue Graph Window

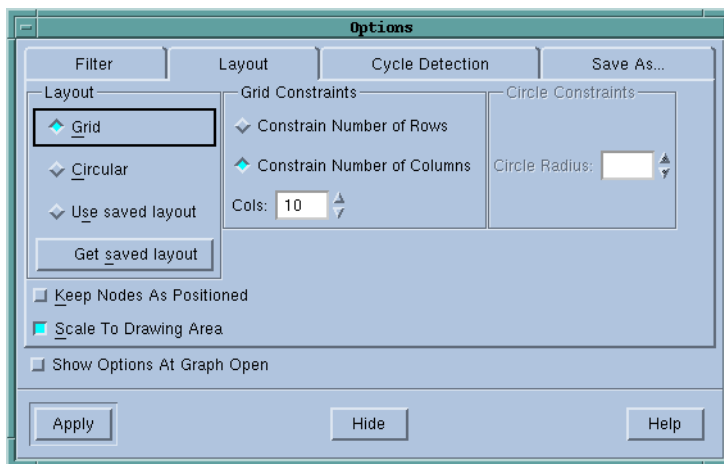
TotalView can graphically display your MPI program's message queue state. Select the Process Window **Tools > Message Queue Graph** command to display a graph of the current message queue state.

Figure 222 – Tools > Message Queue Graph Window



If you want to restrict the display, select the **Options** button, Figure 223.

Figure 223 – Tools > Message Queue Graph Options Window

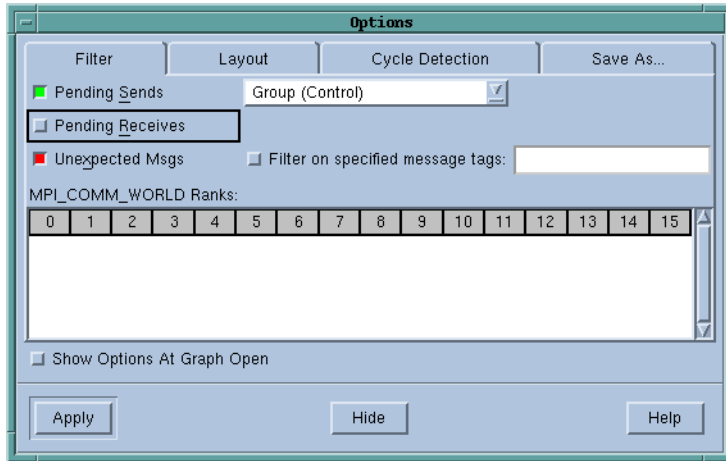


Here, you can alter the way in which TotalView displays ranks within this window—for example, as a grid or in a circle.

Use the commands within the **Cycle Detection** tab to receive reports about cycles in your messages. This is a quick and efficient way to detect when messages are blocking one another and causing deadlocks.

Perhaps the most used of these tabs is **Filter**.

Figure 224 – Tools > Message Queue Graph Options. Filter Tab



The button colors used for selecting messages are the same as those used to draw the lines and arrows in the **Message Queue Graph** Window, as follows:

- **Green:** Pending Sends
- **Blue:** Pending Receives
- **Red:** Unexpected Messages

You can directly select which ranks you want displayed in the lower part of the window. The **Filter on specified message tags** area lets you name the tags to be used as filters. Finally, you can select a group or a communicator in the group pulldown. If you have created your own communicators and groups, they appear here.

Changes made within the **Options** dialog box do not occur until you click **Apply**. The graph window then updates to reflect your changes.

The message queue graph shows your program's state at a particular instant. Select **Update** to fetch new information and redraw the graph.

The numbers in the boxes within the **Message Queue Graph** Window indicate the MPI message source or destination process rank. Diving on a box opens a Process Window for that process.

The numbers next to the arrows indicate the MPI message tags that existed when TotalView created the graph. Diving on an arrow displays the **Tools > Message Queue** Window, with detailed information about the messages. If TotalView has not attached to a process, it displays this information in a grey box.

You can use the **Message Queue Graph** Window in many ways, including the following:

- Pending messages often indicate that a process can't keep up with the amount of work it is expected to perform. These messages indicate places where you may be able to improve your program's efficiency.
- Unexpected messages can indicate that something is wrong with your program because the receiving process doesn't know how to process the message. The red lines indicate unexpected messages.
- After a while, the shape of the graph tends to tell you something about how your program is executing. If something doesn't look right, you will want to determine why.
- You can change the shape of the graph by dragging nodes or arrows. This is often useful when you're comparing sets of nodes and their messages with one another. By default, TotalView does not persist changes to the graph shape. This means that if you select **Update** after you arrange the graph, your changes are lost. To retain your changes, select **Keep nodes as positioned** from with the **Options** dialog box.

Displaying the Message Queue

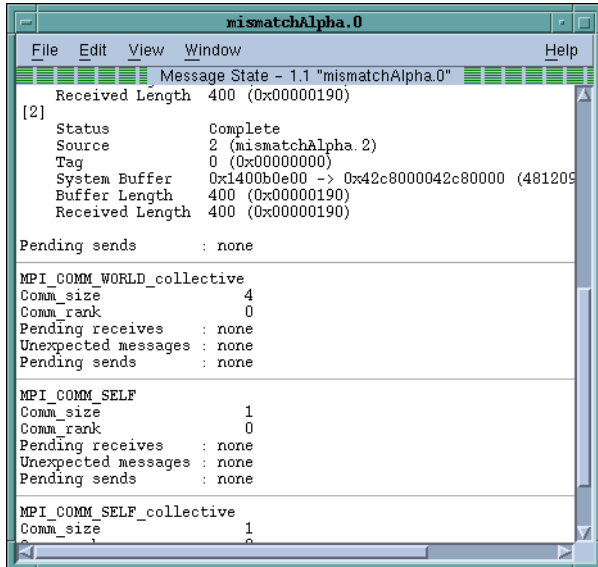
The **Tools > Message Queue** Window displays your MPI program's message queue state textually. This can be useful when you need to find out why a deadlock occurred.

MPI versions that support message queue display are described in the *Platforms Guide*. This document is also available on the Web site at <http://www.roguewave.com/help-support/documentation/totalview>.

About the Message Queue Display

After an MPI process returns from the call to **MPI_Init()**, you can display the internal state of the MPI library by selecting the **Tools > Message Queue** command, [Figure 225](#).

Figure 225 – Message Queue Window



This window displays the state of the process' MPI communicators. If user-visible communicators are implemented as two internal communicator structures, TotalView displays both. One is used for point-to-point operations and the other is used for collective operations.

NOTE >> You cannot edit any of the fields in the Message Queue Window.

The contents of the Message Queue Window are valid only when a process is stopped.

Using Message Operations

For each communicator, TotalView displays a list of pending receive operations, pending unexpected messages, and pending send operations. Each operation has an index value displayed in brackets (**[*n*]**).

RELATED TOPICS

Message Queue field descriptions available for display "Message Queue Window" in the in-product help

Message operations "Message Operations" in the in-product Help

Diving on MPI Processes

To display more detail, you can dive into fields in the Message Queue Window. When you dive into a process field, TotalView does one of the following:

- Raises its Process Window if it exists.
- Sets the focus to an existing Process Window on the requested process.
- Creates a new Process Window for the process if a Process Window doesn't exist.

Diving on MPI Buffers

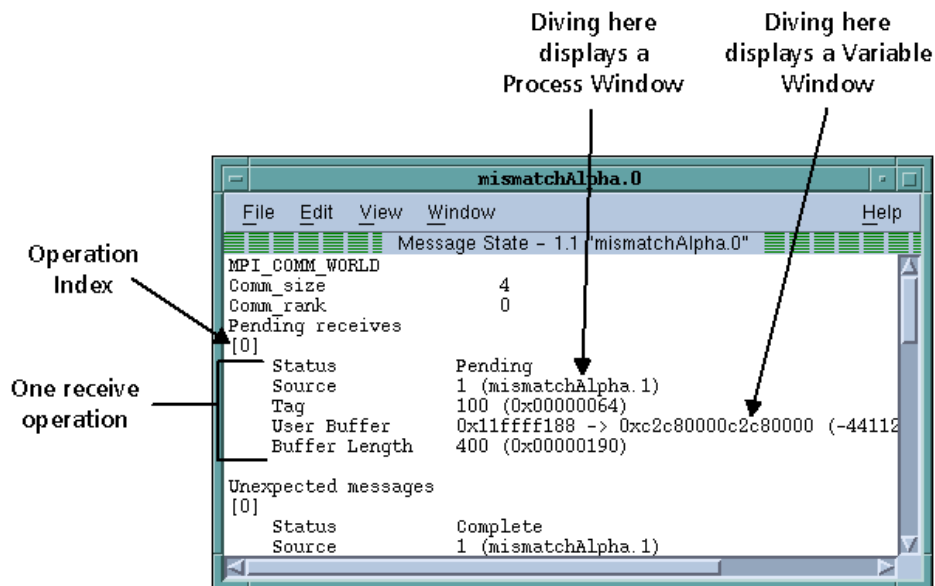
When you dive into the buffer fields, TotalView opens a Variable Window. It also guesses the correct format for the data based on the buffer length and data alignment. You can edit the **Type** field within the Variable Window, if necessary.

NOTE >> TotalView doesn't use the MPI data type to set the buffer type.

About Pending Receive Operations

TotalView displays each pending receive operation in the **Pending receives** list. [Figure 226](#) shows an example of an MPICH pending receive operation.

Figure 226 – Message Queue Window Showing Pending Receive Operation



NOTE >> TotalView displays all receive operations maintained by the IBM MPI library. Set the environment variable `MP_EUIDEVELOP` to **DEBUG** to make blocking operations visible; otherwise, the library maintains only nonblocking operations. For more details on this variable, see the IBM Parallel Environment Operations and Use manual.

About Unexpected Messages

The **Unexpected messages** portion of the **Message Queue** Window shows information for retrieved and enqueued messages that are not yet matched with a receive operation.

Some MPI libraries, such as MPICH, only retrieve messages that have already been received as a side effect of calls to functions such as **MPI_Recv()** or **MPI_Iprobe()**. (In other words, while some versions of MPI may know about the message, the message may not yet be in a queue.) This means that TotalView can't list a message until after the destination process makes a call that retrieves it.

About Pending Send Operations

TotalView displays each pending send operation in the **Pending sends** list.

MPICH does not normally keep information about pending send operations. If you want to see them, start your program under TotalView control and use the **mpirun -ksq** or **-KeepSendQueue** command.

Depending on the device for which MPICH was configured, blocking send operations may or may not be visible. However, if TotalView doesn't display them, you can see that these operations occurred because the call is in the stack backtrace.

If you attach to an MPI program that isn't maintaining send queue information, TotalView displays the following message:

```
Pending sends : no information available
```

MPICH Debugging Tips

These debugging tips apply only to MPICH:

- **Passing options to mpirun**

You can pass options to TotalView using the MPICH **mpirun** command.

To pass options to TotalView when running **mpirun**, you can use the **TOTALVIEW** environment variable. For example, you can cause **mpirun** to invoke TotalView with the **-no_stop_all** option, as in the following C shell example:

```
setenv TOTALVIEW "totalview -no_stop_all"
```

- **Using ch_p4**

If you start remote processes with MPICH/**ch_p4**, you may need to change the way TotalView starts its servers.

By default, TotalView uses **ssh** to start its remote server processes. This is the same behavior as **ch_p4** uses. If you configure **ch_p4** to use a different start-up mechanism from another process, you probably also need to change the way that TotalView starts the servers.

RELATED TOPICS

MPICH configuration and session setup	“MPICH Applications” on page 468 and “MPICH2 Applications” on page 472
tvdsvr and ssh	“TotalView Server Launch Options and Commands” on page 452
ssh specifically	“Setting the Single-Process Server Launch Command” on page 455

IBM PE Debugging Tips

These debugging tips apply only to IBM MPI (PE):

- **Avoid unwanted timeouts**

Timeouts can occur if you place breakpoints that stop other processes too soon after calling **MPI_Init()** or **MPL_Init()**. If you create “stop all” breakpoints, the first process that gets to the breakpoint stops all the other parallel processes that have not yet arrived at the breakpoint. This can cause a timeout.

To turn the option off, select the Process Window **Action Point > Properties** command while the line with the stop symbol is selected. After the **Properties** Dialog Box appears, select the **Process** button in the **When Hit, Stop** area, and also select the **Plant in share group** button.

```
CLI: dbarrier location -stop_when_hit process
```

- **Control the poe process**

Even though the **poe** process continues under debugger control, do not attempt to start, stop, or otherwise interact with it. Your parallel tasks require that **poe** continues to run. For this reason, if **poe** is stopped, TotalView automatically continues it when you continue any parallel task.

- **Avoid slow processes due to node saturation**

If you try to debug a PE program in which more than three parallel tasks run on a single node, the parallel tasks on each node can run noticeably slower than they would run if you were not debugging them.

In general, the number of processes running on a node should be the same as the number of processors in the node.

This becomes more noticeable as the number of tasks increases, and, in some cases, the parallel tasks does not progress. This is because PE uses the **SIGALRM** signal to implement communications operations, and AIX requires that debuggers must intercept all signals. As the number of parallel tasks on a node increases, TotalView becomes saturated and can't keep up with the **SIGALRM** signals being sent, thus slowing the tasks.

RELATED TOPICS

Detail on IBM PE configuration [“IBM MPI Parallel Environment \(PE\) Applications”](#) on page 476
and session setup

Using the CLI

The chapters in this part of the book deal exclusively with the CLI. Most CLI commands must have a process/thread focus for what they do. See [Chapter 21, “Group, Process, and Thread Control,”](#) on page 513 for more information.

Chapter 16, “Using the Command Line Interface (CLI)”

You can use CLI commands without knowing much about Tcl, which is the approach taken in this chapter. This chapter tells you how to enter CLI commands and how the CLI and TotalView interact with one another when used in a nongraphical way.

Chapter 17, “Seeing the CLI at Work”

While you can use the CLI as a stand-alone debugger, using the GUI is usually easier. You will most often use the CLI when you need to debug programs using very slow communication lines or when you need to create debugging functions that are unique to your program. This chapter presents a few Tcl macros in which CLI commands are embedded.

Most of these examples are simple, designed to give you a feel for what you can do.



Chapter 16

Using the Command Line Interface (CLI)

The two components of the Command Line Interface (CLI) are the Tcl-based programming environment and the commands added to the Tcl interpreter that lets you debug your program. This chapter looks at how these components interact, and describes how you specify processes, groups, and threads.

This chapter emphasizes interactive use of the CLI rather than using the CLI as a programming language because many of its concepts are easier to understand in an interactive framework. However, everything in this chapter can be used in both environments.

This chapter contains the following sections:

- [“About the Tcl and the CLI”](#) on page 416
- [“Starting the CLI”](#) on page 418
- [“About CLI Output”](#) on page 422
- [“Using Command Arguments”](#) on page 424
- [“Using Namespaces”](#) on page 425
- [“About the CLI Prompt”](#) on page 426
- [“Using Built-in and Group Aliases”](#) on page 427
- [“How Parallelism Affects Behavior”](#) on page 428
- [“Controlling Program Execution”](#) on page 430

About the Tcl and the CLI

The CLI is built in version 8.0 of Tcl, so TotalView CLI commands are built into Tcl. This means that the CLI is *not* a library of commands that you can bring into other implementations of Tcl. Because the Tcl you are running is the standard 8.0 version, the CLI supports all libraries and operations that run using version 8.0 of Tcl.

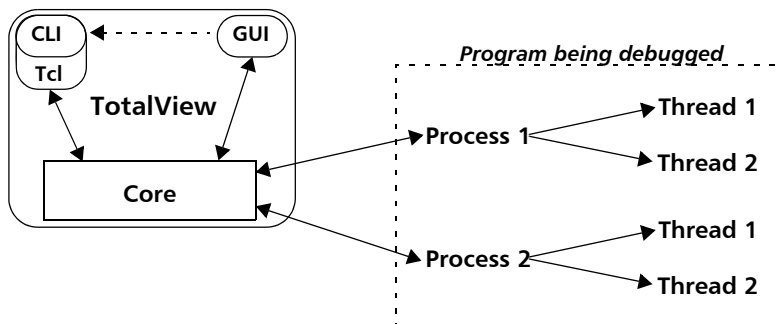
Integrating CLI commands into Tcl makes them intrinsic Tcl commands. This lets you enter and execute all CLI commands in exactly the same way as you enter and execute built-in Tcl commands. As CLI commands are also Tcl commands, you can embed Tcl primitives and functions in CLI commands, and embed CLI commands in sequences of Tcl commands.

For example, you can create a Tcl list that contains a list of threads, use Tcl commands to manipulate that list, and then use a CLI command that operates on the elements of this list. You can also create a Tcl function that dynamically builds the arguments that a process uses when it begins executing.

About The CLI and TotalView

Figure 227 illustrates the relationship between the CLI, the GUI, the TotalView core, and your program:

Figure 227 - The CLI, GUI and TotalView



The CLI and GUI are components that communicate with the TotalView core, which is what actually does the work. In this figure, the dotted arrow between the GUI and the CLI indicates that you can invoke the CLI from the GUI. The reverse is not true: you can't invoke the GUI from the CLI.

In turn, the TotalView core communicates with the processes that make up your program, receives information back from these processes, and passes information back to the component that sent the request. If the GUI is also active, the core also updates the GUI's windows. For example, stepping your program from within the CLI changes the PC in the Process Window, updates data values, and so on.

Using the CLI Interface

You interact with the CLI by entering a CLI or Tcl command. (Entering a Tcl command does exactly the same thing in the CLI as it does when interacting with a Tcl interpreter.) Typically, the effect of executing a CLI command is one or more of the following:

- The CLI displays information about your program.
- A change takes place in your program's state.
- A change takes place in the information that the CLI maintains about your program.

After the CLI executes your command, it displays a prompt. Although CLI commands are executed sequentially, commands executed by your program might not be. For example, the CLI doesn't require that your program be stopped when it prompts for and performs commands. It only requires that the last CLI command be complete before it can begin executing the next one. In many cases, the processes and threads being debugged continue to execute after the CLI has finished doing what you asked it to do.

If you need to stop an executing command or Tcl macro, press Ctrl+C while the command is executing. If the CLI is displaying its prompt, typing Ctrl+C stops any executing processes.

Because actions are occurring constantly, state information and other kinds of messages that the CLI displays are usually mixed in with the commands that you type. You might want to limit the amount of information TotalView displays by setting the **VERBOSE** variable to **WARNING** or **ERROR**. (For more information, see the "Variables" chapter in the *TotalView for HPC Reference Guide*.)

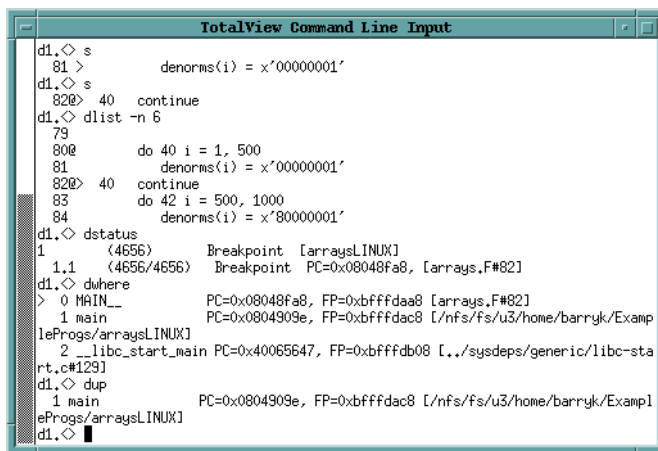
Starting the CLI

You can start the CLI in one of the following ways:

- You can start the CLI from the GUI by selecting the **Tools > Command Line** command in the Root or Process Windows. After selecting this command, TotalView opens a window into which you can enter CLI commands.
- You can start the CLI directly from a shell prompt by typing **totalviewcli**. (This assumes that the TotalView binary directory is in your path.)

Figure 228 is a snapshot of a CLI window that shows part of a program being debugged.

Figure 228 – CLI xterm Window



```
TotalView Command Line Input
d1.<> s
81 >          denorms(i) = x'00000001'
d1.<> s
82@> 40  continue
d1.<> dlist -n 6
79
80@          do 40 i = 1, 500
81          denorms(i) = x'00000001'
82@> 40  continue
83          do 42 i = 500, 1000
84          denorms(i) = x'80000001'
d1.<> dstatus
1          (4656)  Breakpoint [arraysLINUX]
1,1      (4656/4656) Breakpoint PC=0x08048fa8, [arrays.F#82]
d1.<> dwhere
> 0 MAIN__          PC=0x08048fa8, FP=0xbffffdaa8 [arrays.F#82]
1 main          PC=0x0804909e, FP=0xbffffdac8 [/nfs/fs/u3/home/barryk/Examp
leProgs/arraysLINUX]
2 __libc_start_main PC=0x40065647, FP=0xbffffb08 [../sysdeps/generic/libc-sta
rt.c#129]
d1.<> dup
1 main          PC=0x0804909e, FP=0xbffffdac8 [/nfs/fs/u3/home/barryk/Examp
leProgs/arraysLINUX]
d1.<>
```

If you have problems entering and editing commands, it might be because you invoked the CLI from a shell or process that manipulates your **stty** settings. You can eliminate these problems if you use the **stty sane** CLI command. (If the **sane** option isn't available, you have to change values individually.)

If you start the CLI with the **totalviewcli** command, you can use all of the command-line options that you can use when starting TotalView, except those that have to do with the GUI. (In some cases, TotalView displays an error message if you try. In others, it just ignores what you did.)

Information on command-line options is in the "TotalView Command Syntax" chapter of the *TotalView for HPC Reference Guide*.

RELATED TOPICS

All the ways to start TotalView

["Starting TotalView" on page 87](#)

How to perform remote debugging

["Setting Up Remote Debugging Sessions" on page 442](#)

RELATED TOPICS

Setting up for MPI debugging

[“Setting Up MPI Debugging Sessions”](#) on page 461

Setting up for non-MPI parallel debugging

[“Setting Up Parallel Debugging Sessions”](#) on page 492

Startup Example

The following is a very small CLI script:

```
#
source make_actions.tcl
#
dload fork_loop
dset ARGS_DEFAULT {0 4 -wp}
dstep
catch {make_actions fork_loop.cxx} msg
puts $msg
```

This script begins by loading and interpreting the **make_actions.tcl** file, which was described in [Chapter 17, “Seeing the CLI at Work,”](#) on page 432. It then loads the **fork_loop** executable, sets its default startup arguments, and steps one source-level statement.

If you stored this in a file named **fork_loop.tvd**, you can tell TotalView to start the CLI and execute this file by entering the following command:

```
totalviewcli -s fork_loop.tvd
```

The following example places a similar set of commands in a file that you invoke from the shell:

```
#!/bin/sh
# Next line executed by shell, but ignored by Tcl because: \
  exec totalviewcli -s "$0" "$@"
#
source make_actions.tcl
#
dload fork_loop
dset ARGS_DEFAULT {0 4 -wp}
dstep
catch {make_actions fork_loop.cxx} msg
puts $msg
```

The only real difference between the last two examples is the first few lines in the file. In this second example, the shell ignores the backslash continuation character; Tcl processes it. This means that the shell executes the **exec** command while Tcl will ignore it.

Starting Your Program

The CLI lets you start debugging operations in several ways. To execute your program from within the CLI, enter a **dload** command followed by the **drun** command.

NOTE >> If your program is launched from a starter program such as `srun` or `yod`, use the `drrun` command rather than `drun` to start your program. If you use `drun`, default arguments to the process are suppressed; `drrun` passes them on.

The following example uses the **totalviewcli** command to start the CLI. This is followed by **dload** and **drun** commands. Since this was not the first time the file was run, breakpoints exist from a previous session.

NOTE >> In this listing, the CLI prompt is "`d1.<>`". The information preceding the greater-than symbol (`>`) symbol indicates the processes and threads upon which the current command acts. The prompt is discussed in "[About the CLI Prompt](#)" on page 426.

```
%totalviewcli
d1.<> dload arraysAlpha #load the arraysAlpha program
1
d1.<> dactions          # Show the action points
No matching breakpoints were found
d1.<> dlist -n 10 75
    75      real16_array (i, j) = 4.093215 * j+2
    76 #endif
    77 26      continue
    78 27      continue
    79
    80 do 40 i = 1, 500
    81      denorms(i) = x'00000001'
    82 40 continue
    83 do 42 i = 500, 1000
    84      denorms(i) = x'80000001'
d1.<> dbreak 80          # Add two action points
1
d1.<> dbreak 83
2
d1.<> drun              # Run the program to the action point
```

This two-step operation of loading and running supports setting action points before execution begins, as well as executing a program more than once. At a later time, you can use **drrun** to restart your program, perhaps sending it new arguments. In contrast, reentering the **dload** command tells the CLI to reload the program into memory (for example, after editing and recompiling the program).

The **dload** command always creates a new process. The new process is in addition to any existing processes for the program because the CLI does not shut down older processes when starting the new one.

The **dkill** command terminates one or more processes of a program started by using a **dload**, **drun**, or **drrun** command. The following example continues where the previous example left off:

```
d1.<> dkill                # kills process
d1.<> drun                  # runs program from start
d1.<> dlist -e -n 3        # shows lines about current spot
79
80@>      do 40 i = 1, 500
81          denorms(i) = x'00000001'
d1.<> dwhat master_array # Tell me about master_array
In thread 1.1:
Name: master_array; Type: integer(100);
  Size: 400 bytes; Addr: 0x140821310
  Scope: ##arraysAlpha#arrays.F#check_fortran_arrays
  (Scope class: Any)
  Address class: proc_static_var
  (Routine static variable)
d1.<> dgo                    # Start program running
d1.<> dwhat denorms          # Tell me about denorms
In thread 1.1:
Name: denorms; Type: <void>; Size: 8 bytes;
  Addr: 0x1408214b8
  Scope: ##arraysAlpha#arrays.F#check_fortran_arrays
  (Scope class: Any)
  Address class: proc_static_var
  (Routine static variable)
d1.<> dprint denorms(0)      # Show me what is stored
denorms(0) = 0x0000000000000001 (1)
d1.<>
```

Because information is interleaved, you may not realize that the prompt has appeared. It is always safe to use the Enter key to have the CLI redisplay its prompt. If a prompt isn't displayed after you press Enter, you know that the CLI is still executing.

About CLI Output

A CLI command can either print its output to a window or return the output as a character string. If the CLI executes a command that returns a string value, it also prints the returned string. Most of the time, you won't care about the difference between *printing* and *returning-and-printing*. Either way, the CLI displays information in your window. And, in both cases, printed output is fed through a simple *more* processor. (This is discussed in more detail in the next section.)

In the following two cases, it matters whether the CLI directly prints output or returns and then prints it:

- When the Tcl interpreter executes a list of commands, the CLI only prints the information returned from the last command. It doesn't show information returned by other commands.
- You can only assign the output of a command to a variable if the CLI returns a command's output. You can't assign output that the interpreter prints directly to a variable, or otherwise manipulate it, unless you save it using the **capture** command.

For example, the **dload** command returns the ID of the process object that was just created. The ID is normally printed—unless, of course, the **dload** command appears in the middle of a list of commands; for example:

```
{dload test_program;dstatus}
```

In this example, the CLI doesn't display the ID of the loaded program, since the **dload** command was not the last command.

When information is returned, you can assign it to a variable. For example, the next command assigns the ID of a newly created process to a variable:

```
set pid [dload test_program]
```

Because you can't assign the output of the **help** command to a variable, the following doesn't work:

```
set htext [help]
```

This statement assigns an empty string to **htext** because the **help** command doesn't return text. It just prints it.

To save the output of a command that prints its output, use the **capture** command. For example, the following example writes the **help** command's output into a variable:

```
set htext [capture help]
```

NOTE >> You can capture the output only from commands. You can't capture the informational messages displayed by the CLI that describe process state. If you are using the GUI, TotalView also writes this information to the Log Window. You can display this information by using the **Tools > Event Log** command.

'more' Processing

When the CLI displays output, it sends data through a simple *more*-like process. This prevents data from scrolling off the screen before you view it. After you see the **MORE** prompt, press Enter to see the next screen of data. If you type **q** (followed by pressing the Enter key), the CLI discards any data it hasn't yet displayed.

You can control the number of lines displayed between prompts by using the **dset** command to set the **LINES_PER_SCREEN** CLI variable. (For more information, see the *TotalView for HPC Reference Guide*.)

Using Command Arguments

The default command arguments for a process are stored in the **ARGS(num)** variable, where *num* is the CLI ID for the process. If you don't set the **ARGS(num)** variable for a process, the CLI uses the value stored in the **ARGS_DEFAULT** variable. TotalView sets the **ARGS_DEFAULT** variable when you use the **-a** option when starting the CLI or the GUI.

NOTE >> The **-a** option tells TotalView to pass everything that follows on the command line to the program.

For example:

```
totalviewcli -a argument-1, argument-2, ...
```

To set (or clear) the default arguments for a process, you can use the **dset** (or **dunset**) command to modify the **ARGS()** variables directly, or you can start the process with the **drun** command. For example, the following clears the default argument list for process 2:

```
dunset ARGS(2)
```

The next time process 2 is started, the CLI uses the arguments contained in **ARGS_DEFAULT**.

You can also use the **dunset** command to clear the **ARGS_DEFAULT** variable; for example:

```
dunset ARGS_DEFAULT
```

All commands (except the **drun** command) that can create a process—including the **dgo**, **drrun**, **dcont**, **dstep**, and **dnext** commands—pass the default arguments to the new process. The **drun** command differs in that it replaces the default arguments for the process with the arguments that are passed to it.

RELATED TOPICS

The ARGS variable	ARGS in "TotalView Variables" in the <i>TotalView for HPC Reference Guide</i>
The ARGS_DEFAULT variable	ARGS_DEFAULT in "TotalView Variables" in the <i>TotalView for HPC Reference Guide</i>
The Process > Startup Parameters command	Process > Startup Parameters in the in-product Help

Using Namespaces

CLI interactive commands exist in the primary Tcl namespace (`::`). Some of the TotalView state variables also reside in this namespace. Seldom-used functions and functions that are not primarily used interactively reside in other namespaces. These namespaces also contain most TotalView state variables. (The variables that appear in other namespaces are usually related to TotalView preferences.) TotalView uses the following namespaces:

- TV::** Contains commands and variables that you use when creating functions. They can be used interactively, but this is not their primary role.
- TV::GUI::** Contains state variables that define and describe properties of the user interface, such as window placement and color.

If you discover other namespaces beginning with **TV**, you have found a namespace that contains private functions and variables. These objects can (and will) disappear, so don't use them. Also, don't create namespaces that begin with **TV**, since you can cause problems by interfering with built-in functions and variables.

The CLI **dset** command lets you set the value of these variables. You can have the CLI display a list of these variables by specifying the namespace; for example:

```
dset TV::
```

You can use wildcards with this command. For example, **dset TV::au*** displays all variables that begin with "au".

RELATED TOPICS

CLI namespace commands ["CLI Namespace Commands" in the *TotalView for HPC Reference Guide*](#)

TotalView variables ["TotalView Variables" in the *TotalView for HPC Reference Guide*](#)

About the CLI Prompt

The appearance of the CLI prompt lets you know that the CLI is ready to accept a command. This prompt lists the current focus, and then displays a greater-than symbol (>) and a blank space. (The *current focus* is the processes and threads to which the next command applies.) For example:

- d1.<>** The current focus is the default set for each command, focusing on the first user thread in process 1.
- g2.3>** The current focus is process 2, thread 3; commands act on the entire group.
- t1.7>** The current focus is thread 7 of process 1.
- gW3.>** The current focus is all worker threads in the **control group** that contains process 3.
- p3/3** The current focus is all processes in process 3, group 3.

You can change the prompt's appearance by using the **dset** command to set the **PROMPT** state variable; for example:

```
dset PROMPT "Kill this bug! > "
```

Using Built-in and Group Aliases

Many CLI commands have an alias that lets you abbreviate the command's name. (An alias is one or more characters that Tcl interprets as a command or command argument.)

NOTE >> The **alias** command, which is described in the TotalView for HPC Reference Guide, lets you create your own aliases.

For example, the following command tells the CLI to halt the current group:

```
dfocus g dhalt
```

Using an abbreviation is easier. The following command does the same thing:

```
f g h
```

You often type less-used commands in full, but some commands are almost always abbreviated. These commands include **dbreak (b)**, **ddown (d)**, **dfocus (f)**, **dgo (g)**, **dlist (l)**, **dnext (n)**, **dprint (p)**, **dstep (s)**, and **dup (u)**.

The CLI also includes uppercase group versions of aliases for a number of commands, including all stepping commands. For example, the alias for **dstep** is **s**; in contrast, **S** is the alias for **dfocus g dstep**. (The first command tells the CLI to step the process. The second steps the [control group](#).)

Group aliases differ from the group-level command that you type interactively, as follows:

- They do not work if the current focus is a list. The **g** focus specifier modifies the current focus, and can only be applied if the focus contains just one term.
- They always act on the group, no matter what width is specified in the current focus. Therefore, **dfocus t S** does a step-group command.

How Parallelism Affects Behavior

A parallel program consists of some number of processes, each involving some number of threads. Processes fall into two categories, depending on when they are created:

- **Initial process**

A pre-existing process from the normal run-time environment (that is, created outside TotalView), or one that was created as TotalView loaded the program.

- **Spawned process**

A new process created by a process executing under CLI control.

TotalView assigns an integer value to each individual process and thread under its control. This *process/thread identifier* can be the system identifier associated with the process or thread. However, it can be an arbitrary value created by the CLI. Process numbers are unique over the lifetime of a debugging session; in contrast, thread numbers are only unique while the process exists.

Process/thread notation lets you identify the component that a command targets. For example, if your program has two processes, and each has two threads, four threads exist:

Thread 1 of process 1

Thread 2 of process 1

Thread 1 of process 2

Thread 2 of process 2

You identify the four threads as follows:

1.1—Thread 1 of process 1

1.2—Thread 2 of process 1

2.1—Thread 1 of process 2

2.2—Thread 2 of process 2

RELATED TOPICS

An overview of threads and processes and how TotalView organizes them into groups

[“About Groups, Processes, and Threads”](#) on page 349

More detail on the TotalView thread/process model and how to create custom groups

[“Group, Process, and Thread Control”](#) on page 513

Types of IDs

Multi-threaded, multi-process, and distributed programs contain a variety of IDs. The following types are used in the CLI and the GUI:

System PID	This is the process ID and is generally called the <i>PID</i> .
System TID	This is the ID of the system kernel or user thread. On some systems (for example, AIX), the TIDs have no obvious meaning. On other systems, they start at 1 and are incremented by 1 for each thread.
TotalView thread ID	This is usually identical to the system TID. On some systems (such as AIX) where the threads have no obvious meaning, TotalView uses its own IDs.
pthread ID	This is the ID assigned by the Posix pthreads package. If this differs from the system TID, the TID is a pointer value that points to the pthread ID.
Debugger PID	This is an ID created by TotalView that lets it identify processes. It is a sequentially numbered value beginning at 1 that is incremented for each new process. If the target process is killed and restarted (that is, you use the ckill and drun commands), the TotalView PID does not change. The system PID changes, however, since the operating system has created a new target process.

Controlling Program Execution

Knowing what's going on and where your program is executing is simple in a serial debugging environment. Your program is either stopped or running. When it is running, an event such as arriving at a breakpoint can occur. This event tells TotalView to stop the program. Sometime later, you tell the serial program to continue executing. Multi-process and multi-threaded programs are more complicated. Each thread and each process has its own execution state. When a thread (or set of threads) triggers a breakpoint, TotalView must decide what it should do about other threads and processes because it may need to stop some and let others continue to run.

RELATED TOPICS

Tasks for working with a multi-process, multi-threaded application	“Manipulating Processes and Threads” on page 372
Stepping commands	“Using Stepping Commands” on page 166
The dload command	dload in "CLI Commands" in the <i>TotalView for HPC Reference Guide</i>
The dattach command	dattach in "CLI Commands" in the <i>TotalView for HPC Reference Guide</i>
The drun command	drun in "CLI Commands" in the <i>TotalView for HPC Reference Guide</i>
The dkill command	dkill in "CLI Commands" in the <i>TotalView for HPC Reference Guide</i>

Advancing Program Execution

Debugging begins by entering a **dload** or **dattach** command. If you use the **dload** command, you must use the **drun** (or perhaps **drun** if there's a starter program) command to start the program executing. These three commands work at the process level and you can't use them to start individual threads. (This is also true for the **dkill** command.)

To advance program execution, you enter a command that causes one or more threads to execute instructions. The commands are applied to a P/T set. (P/T sets are discussed in [Chapter 13, “About Groups, Processes, and Threads,”](#) on page 349 and [Chapter 21, “Group, Process, and Thread Control,”](#) on page 513.) Because the set doesn't have to include all processes and threads, you can cause some processes to be executed while holding others back. You can also advance program execution by increments, *stepping* the program forward, and you can define the size of the increment. For example, **dnext 3** executes the next three statements, and then pauses what you've been stepping.

Typically, debugging a program means that you have the program run, and then you stop it and examine its state. In this sense, a debugger can be thought of as a tool that lets you alter a program's state in a controlled way, and debugging is the process of stopping a process to examine its state. However, the term *stop* has a slightly differ-

ent meaning in a multi-process, multi-threaded program. In these programs, *stopping* means that the CLI holds one or more threads at a location until you enter a command that tells them to start executing again. Other threads, however, may continue executing.

For more detailed information on debugging in general, see [Part II, “Debugging Tools and Tasks,”](#) on page 82.

Using Action Points

Action points tell the CLI to stop a program’s execution. You can specify the following types of action points:

- A *breakpoint* (see **dbreak** in the *TotalView for HPC Reference Guide*) stops the process when the program reaches a location in the source code.
- A *watchpoint* (see **dwatch** in the *TotalView for HPC Reference Guide*) stops the process when the value of a variable is changed.
- A *barrier point* (see **dbarrier** in the *TotalView for HPC Reference Guide*), as its name suggests, effectively prevents processes from proceeding beyond a point until all other related processes arrive. This gives you a method for synchronizing the activities of processes. (You can only set a barrier point on processes; you can’t set them on individual threads.)
- An *eval point* (see **dbreak** in the *TotalView for HPC Reference Guide*) lets you programmatically evaluate the state of the process or variable when execution reaches a location in the source code. An eval point typically does not stop the process; instead, it performs an action. In most cases, an eval point stops the process when some condition that you specify is met.

NOTE >> For extensive information on action points, see [“Setting Action Points”](#) on page 174.

Each action point is associated with an *action point identifier*. You use these identifiers when you need to refer to the action point. Like process and thread identifiers, action point identifiers are assigned numbers as they are created. The ID of the first action point created is 1; the second ID is 2, and so on. These numbers are never reused during a debugging session.

The CLI and the GUI let you assign only one action point to a source code line, but you can make this action point as complex as you need it to be.



Chapter 17

Seeing the CLI at Work

The CLI is a command-line debugger that is completely integrated with TotalView. You can use it and never use the TotalView GUI, or you can use it and the GUI simultaneously. Because the CLI is embedded in a Tcl interpreter, you can also create debugging functions that exactly meet your needs. When you do this, you can use these functions in the same way that you use TotalView's built-in CLI commands.

This chapter contains macros that show how the CLI programmatically interacts with your program and with TotalView. Reading examples without bothering too much with details gives you an appreciation for what the CLI can do and how you can use it. With a basic knowledge of Tcl, you can make full use of all CLI features.

In each macro in this chapter, all Tcl commands that are unique to the CLI are displayed in bold. These macros perform the following tasks:

- [“Setting the CLI EXECUTABLE_PATH Variable”](#) on page 433
- [“Initializing an Array Slice”](#) on page 434
- [“Printing an Array Slice”](#) on page 435
- [“Writing an Array Variable to a File”](#) on page 437
- [“Automatically Setting Breakpoints”](#) on page 438

Setting the CLI EXECUTABLE_PATH Variable

The following macro recursively descends through all directories, starting at a location that you enter. (This is indicated by the *root* argument.) The macro ignores directories named in the *filter* argument. The result is set as the value of the CLI **EXECUTABLE_PATH** state variable.

See also the *TotalView for HPC Reference Guide's* entry for the **EXECUTABLE_PATH** variable

```
# Usage:
#
# rpath [root] [filter]
#
# If root is not specified, start at the current
# directory. filter is a regular expression that removes
# unwanted entries. If it is not specified, the macro
# automatically filters out CVS/RCS/SCCS directories.
#
# The search path is set to the result.

proc rpath {{root "."} {filter "/(CVS|RCS|SCCS)(/|$)"} } {

    # Invoke the UNIX find command to recursively obtain
    # a list of all directory names below "root".
    set find [split [exec find $root -type d -print] \n]

    set npath ""

    # Filter out unwanted directories.
    foreach path $find {
        if {![regexp $filter $path]} {
            append npath ":"
            append npath $path
        }
    }

    # Tell TotalView to use it.
    dset EXECUTABLE_PATH $npath
}
```

In this macro, the last statement sets the **EXECUTABLE_PATH** state variable. This is the only statement that is unique to the CLI. All other statements are standard Tcl.

The **dset** command, like most interactive CLI commands, begins with the letter **d**. (The **dset** command is only used in assigning values to CLI state variables. In contrast, values are assigned to Tcl variables by using the standard Tcl **set** command.)

Initializing an Array Slice

The following macro initializes an [array slice](#) to a constant value:

```
array_set (var lower_bound upper_bound val) {
    for {set i $lower_bound} {$i <= $upper_bound} {incr i}{
        dassign $var\($i) $val
    }
}
```

The CLI **dassign** command assigns a value to a variable. In this case, it is setting the value of an array element. Use this function as follows:

```
d1.<> dprint list3
list3 = {
    (1) = 1 (0x00000001)
    (2) = 2 (0x00000001)
    (3) = 3 (0x00000001)
}
d1.<> array_set list 2 3 99
d1.<> dprint list3
list3 = {
    (1) = 1 (0x00000001)
    (2) = 99 (0x00000063)
    (3) = 99 (0x00000063)
}
```

For more information on slices, see [“Displaying Array Slices”](#) on page 284.

Printing an Array Slice

The following macro prints a Fortran **array slice**. This macro, like others shown in this chapter, relies heavily on Tcl and uses unique CLI commands sparingly.

```
proc pf2Dslicing {anArray i1 i2 j1 j2 {i3 1} {j3 1} \
    {width 20}} {
    for {set i $i1} {$i <= $i2} {incr i $i3} {
        set row_out ""
        for {set j $j1} {$j <= $j2} {incr j $j3} {
            set ij [capture dprint $anArray\($i,$j\)]
            set ij [string range $ij \
                [expr [string first "=" $ij] + 1] end]
            set ij [string trimright $ij]
            if {[string first "-" $ij] == 1} {
                set ij [string range $ij 1 end]}
            append ij "          "
            append row_out " " \
                [string range $ij 0 $width] " "
        }
        puts $row_out
    }
}
```

NOTE >> The CLI's **dprint** command lets you specify a slice. For example, you can type: **dprint a(1:4,1:4)**.

After invoking this macro, the CLI prints a two-dimensional slice (**i1:i2:i3, j1:j2:j3**) of a Fortran array to a numeric field whose width is specified by the **width** argument. This width doesn't include a leading minus sign (-).

All but one line is standard Tcl. This line uses the **dprint** command to obtain the value of one array element. This element's value is then captured into a variable. The CLI **capture** command allows a value that is normally printed to be sent to a variable. For information on the difference between values being displayed and values being returned, see ["About CLI Output"](#) on page 422.

The following shows how this macro is used:

```
d1.<> pf2Dslice a 1 4 1 4
    0.841470956802 0.909297406673 0.141120001673-0.756802499294
    0.909297406673-0.756802499294-0.279415488243 0.989358246326
    0.141120001673-0.279415488243 0.412118494510-0.536572933197
    -0.756802499294 0.989358246326-0.536572933197-0.287903308868
d1.<> pf2Dslice a 1 4 1 4 1 1 17
    0.841470956802 0.909297406673 0.141120001673-0.756802499294
    0.909297406673-0.756802499294-0.279415488243 0.989358246326
    0.141120001673-0.279415488243 0.412118494510-0.536572933197
    -0.756802499294 0.989358246326-0.536572933197-0.287903308868
d1.<> pf2Dslice a 1 4 1 4 2 2 10
    0.84147095    0.14112000
    0.14112000    0.41211849
d1.<> pf2Dslice a 2 4 2 4 2 2 10
    -0.75680249    0.98935824
    0.98935824    -0.28790330
d1.<>
```

Writing an Array Variable to a File

It often occurs that you want to save the value of an array so that you can analyze its results at a later time. The following macro writes array values to a file:

```
proc save_to_file {var fname} {
    set values [capture dprint $var]
    set f [open $fname w]

    puts $f $values
    close $f
}
```

The following example shows how you might use this macro. Using the **exec** command tells the shell's **cat** command to display the file that was just written.

```
d1.<> dprint list3
list3 = {
    (1) = 1 (0x00000001)
    (2) = 2 (0x00000002)
    (3) = 3 (0x00000003)
}
d1.<> save_to_file list3 foo
d1.<> exec cat foo
list3 = {
    (1) = 1 (0x00000001)
    (2) = 2 (0x00000002)
    (3) = 3 (0x00000003)
}
d1.<>
```


Automatically Setting Breakpoints

In many cases, your knowledge of what a program is doing lets you make predictions as to where problems are occurring. The following CLI macro parses comments that you can include in a source file and, depending on the comment's text, sets a **breakpoint** or an eval point.

(For detailed information on action points, see ["Setting Action Points"](#) on page 174.)

Following this macro is an excerpt from a program that uses it.

```
# make_actions: Parse a source file, and insert
# evaluation and breakpoints according to comments.
#
proc make_actions {{filename ""}} {

    if {$filename == ""} {
        puts "You need to specify a filename"
        error "No filename"
    }

    # Open the program's source file and initialize a
    # few variables.
    set fname [set filename]
    set fsource [open $fname r]
    set lineno 0
    set incomment 0

    # Look for "signals" that indicate the type of
    # action point; they are buried in the comments.
    while {[gets $fsource line] != -1} {
        incr lineno
        set bpline $lineno

        # Look for a one-line eval point. The
        # format is ... /* EVAL: some_text */.
        # The text after EVAL and before the "*/" in
        # the comment is assigned to "code".
        if [regexp "/\\* EVAL: *(.*)\\*/" $line all code] {
            dbreak $fname\\#$bpline -e $code
            continue
        }

        # Look for a multiline eval point.
        if [regexp "/\\* EVAL: *(.*)" $line all code] {
            # Append lines to "code".
            while {[gets $fsource interiorline] != -1} {
                incr lineno
```

```

# Tabs will confuse dbreak.
regsub-all \t $interiorline \
    " " interiorline

# If "/" is found, add the text to "code",
# then leave the loop. Otherwise, add the
# text, and continue looping.
if [regexp "(.*)\\*/" $interiorline \
    all interiorcode]{
    append code \n $interiorcode
    break
} else {
    append code \n $interiorline
}
}
dbreak $fname\#$bpline -e $code
continue
}

# Look for a breakpoint.
if [regexp "/\\* STOP: .*" $line] {
dbreak $fname\#$bpline
continue
}

# Look for a command to be executed by Tcl.
if [regexp "/\\* *CMD: *(.*)\\*/" $line all cmd] {
    puts "CMD: [set cmd]"
    eval $cmd
}
}
close $fsource
}

```

The only similarity between this macro and the previous three is that almost all of the statements are Tcl. The only purely CLI commands are the instances of the **dbreak** command that set eval points and breakpoints.

The following excerpt from a larger program shows how to embed comments in a source file that is read by the **make_actions** macro:

```

...
struct struct_bit_fields_only {
    unsigned f3 : 3;
    unsigned f4 : 4;
    unsigned f5 : 5;
    unsigned f20 : 20;
    unsigned f32 : 32;
} sbfo, *sbfop = &sbfo;
...
int main()
{

```

```

    struct struct_bit_fields_only *lbfo = &sbfo;
...
    int i;
    int j;

    sbfo.f3 = 3;
    sbfo.f4 = 4;
    sbfo.f5 = 5;
    sbfo.f20 = 20;
    sbfo.f32 = 32;
...
    /* TEST: Check to see if we can access all the
       values */
    i=i;  /* STOP: */
    i=1;  /* EVAL: if (sbfo.f3 != 3) $stop; */
    i=2;  /* EVAL: if (sbfo.f4 != 4) $stop; */
    i=3;  /* EVAL: if (sbfo.f5 != 5) $stop; */
    ...
    return 0;
}

```

The **make_actions** macro reads a source file one line at a time. As it reads these lines, the regular expressions look for comments that begin with **/* STOP**, **/* EVAL**, and **/* CMD**. After parsing the comment, it sets a breakpoint at a *stop* line, an eval point at an *eval* line, or executes a command at a *cmd* line.

Using eval points can be confusing because eval point syntax differs from that of Tcl. In this example, the **\$stop** function is built into the CLI. Stated differently, you can end up with Tcl code that also contains C, C++, Fortran, and TotalView functions, variables, and statements. Fortunately, you only use this kind of mixture in a few places and you'll know what you're doing.

Advanced Tools and Customization

This part discusses tools and configurations that are either specific to a particular environment or setup, or that are used only in advanced customizations or other non-routine ways.

Chapter 18, “Setting Up Remote Debugging Sessions”

When you are debugging a program that has processes executing on a remote computer, TotalView launches server processes for these remote processes. Usually, you don't need to know much about this. The primary focus of this chapter is what to do when you have problems.

Chapter 19, “Setting Up MPI Debugging Sessions”

Setting up an MPI debugging session may require special startup or environment configuration. This chapter details any non-default configuration information for individual platforms.

Debugging other kinds of parallel programs is discussed in the next chapter.

Chapter 20, “Setting Up Parallel Debugging Sessions”

You can debug programs created using many different parallel environments, such as OpenMP, SHMEM, Global Arrays, UPC, CAF, and the like. This chapter discusses how to set up these environments.

Chapter 21, “Group, Process, and Thread Control”

In a multi-process, multi-threaded program, you may need to finely control execution. This chapter discusses the TotalView process/thread model, how to direct a command to a specific process or thread, and how to create custom groups of processes.

Chapter 22, “Scalability in HPC Computing Environments”

When working in an HPC environment, you can configure TotalView for maximum scalability, including the use of MRNet, a tree-based overlay network that supports scalable communication.



Setting Up Remote Debugging Sessions

About Remote Debugging

Debugging a remote process with TotalView is similar to debugging a native process, with these primary differences:

- The remote server hosting the processes to debug must be running the TotalView Server process **tvdsvr**, automatically launched by TotalView in most cases.
- TotalView performance depends on your network's performance. If the network is overloaded, debugging can be slow.

NOTE >> You cannot debug remote processes using TotalView Individual.

TotalView can automatically launch **tvdsvr** either:

- Independently on each remote host, called *single-process server launch*.
- As a bulk job, launching all remote processes at the same time, called *bulk server launch*.

Because TotalView can automatically launch **tvdsvr**, programs that launch remote processes rarely require any special handling. When using TotalView, it doesn't matter whether a process is local or remote.

NOTE >> When debugging programs remotely, the architecture of the remote machine must be compatible with that of the machine running TotalView. See [“Platform Issues when Remote Debugging”](#) on page 443 for more information.

This chapter explains how to set up TotalView remote debugging sessions, detailed in the following sections:

- [“Automatically Launching a Process on a Remote Server”](#) on page 445.
In most cases, you can easily perform this from the New Program dialog which launches the TotalView Server **tvdsvr** program automatically. If so, you will likely not need to read any of the following sections.
- [“Troubleshooting Server Autolaunch”](#) on page 446
Some systems have requirements that may prohibit Totalview’s default autolaunching capabilities. This section discusses various ways to customize autolaunch options and commands.
- [“Starting the TotalView Server Manually”](#) on page 449
You can also just manually launch the **tvdsvr** program, discussed in this section.
- [“TotalView Server Launch Options and Commands”](#) on page 452
The File > Preferences dialog box features several ways to cusotmize both options and commands for single and bulk server launch. This section discusses these options as well as specific commands relevant to particular platforms.
- [“Debugging Over a Serial Line”](#) on page 460
TotalView supports debugging programs over a serial line as well as TCP/IP sockets, discussed in this section.

Platform Issues when Remote Debugging

In general, when debugging programs remotely, the architecture of the remote machine must be compatible with that of the machine running TotalView. For example, you cannot perform remote debugging on a 64-bit Linux system if you launch TotalView from a 32-bit Linux system. In addition, the operating systems must also be compatible.

However, TotalView supports several forms of heterogeneous debugging in which the operating system and/or architecture differ. For example, from a Linux x86-64 session, you can debug remote processes on Linux Power.

This table shows supported combinations:

Host System	Target System
Linux x86-64	Linux x86
	Linux x86-64
	Linux Power 32
	Linux Power 64
	Cray XT
Linux x86	Linux x86
	Linux Power 32
	Linux Power 64
Linux Power 64	Linux Power 32
	Linux Power 64
	Blue Gene

You must install TotalView for each host and target platform combination being debugged.

NOTE >> The path to TotalView must be identical on the local and all remote systems so that TotalView can find the `tvdsvr` program.

TotalView assumes that you launch `tvdsvr` using `ssh -x`. If `ssh` is unavailable, set the `TVDSVRLAUNCHCMD` environment variable to the command that you use to remotely access the remote system.

NOTE >> If the default single-process server launch procedure meets your needs and you're not experiencing any problems accessing remote processes from TotalView, you probably do not need the information in this chapter. If you do experience a problem launching the server, check that the `tvdsvr` process is in your path.

Automatically Launching a Process on a Remote Server

In most cases, loading a process to debug on a remote server is no different than debugging a process on a local host. You can add or select a remote host from these debugging sessions:

- **File > Debug New Program**
- **File > Attach to a Running Program**
- **File > Debug Core File or Replay Recording File**

After you have set up a debug session, TotalView can automatically launch the process **tvdsvr** on the remote computer. For more information, see [“Adding a Remote Host”](#) on page 111. If this simple procedure does not work for you, your system may not support TotalView's default autolaunching. You can disable autolaunch or reconfigure some of your settings. See [“Troubleshooting Server Autolaunch”](#) on page 446.

Troubleshooting Server Autolaunch

Some systems do not support TotalView's default autolaunch behavior, requiring you to create your own auto-launch command or requiring special permissions or some other custom configuration.

If autolaunching of the TotalView Server is not working, you can

- Disable autolaunch and start the TotalView server manually (“[Starting the TotalView Server Manually](#)” on page 449)
- Customize either server options or commands, discussed here.

This section discusses how to edit the remote shell command as well as the arguments provided to TotalView at remote launch. For more information on the commands and options in general, see “[TotalView Server Launch Options and Commands](#)” on page 452 and **tvdsvr** in the *TotalView for HPC Reference Guide*.

Changing the Remote Shell Command

Some environments require you to create your own **autolaunching** command, for example, if your remote shell command doesn't provide the security that your site requires.

If you create your own autolaunching command, use the **tvdsvr -callback** and **-set_pw** command-line options.

If you're not sure whether **ssh** (or **rsh** on Sun SPARC computers) works at your site, try typing “**ssh -x hostname**” (or “**rsh hostname**”) from an **xterm** window, where *hostname* is the name of the host on which you want to invoke the remote process. If the process doesn't just run and instead this command prompts you for a password, add the host name of the host computer to your **.rhosts** file on the target computer.

For example, you can use the following combination of the **echo** and **telnet** commands:

```
echo %D %L %P %V; telnet %R
```

After **telnet** establishes a connection to the remote host, you can use the **cd** and **tvdsvr** commands directly, using the values of **%D**, **%L**, **%P**, and **%V** that were displayed by the **echo** command; for example:

```
cd directory
tvdsvr -callback hostname:portnumber -set_pw password
```

If your computer doesn't have a command for invoking a remote process, TotalView can't autolaunch the **tvdsvr** and you must disable both single server and bulk server launches.

For information on the **ssh** and **rsh** commands, see the manual page supplied with your operating system.

For more information on editing server launch commands, see “[Customizing Server Launch Commands](#)” on page 455.

Changing Arguments

You can also change the command-line arguments passed to **ssh** (TotalView passes **-x** by default), or whatever command you use to invoke the remote process.

For example, if the host computer doesn't mount the same file systems as your target computer, **tvdsvr** might need to use a different path to access the executable being debugged. If this is the case, you can change **%D** to the directory used on the target computer.

If the remote executable reads from standard input, you cannot use the **-n** option with your remote shell command because the remote executable receives an EOF immediately on standard input. If you omit the **-n** command-line option, the remote executable reads standard input from the **xterm** in which you started TotalView. This means that you should invoke **tvdsvr** from another **xterm** window if your remote program reads from standard input. The following is an example:

```
%C %R "xterm -display hostname:0 -e tvdsvr \  
-callback %L -working_directory %D -set_pw %P \  
-verbosity %V"
```

Each time TotalView launches **tvdsvr**, a new **xterm** opens to handle standard input and output for the remote program.

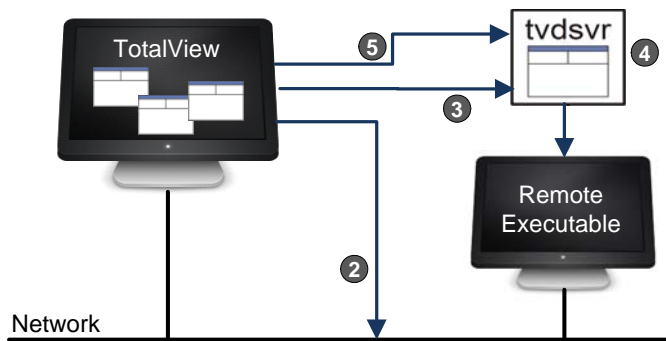
Autolaunching Sequence

This section describes the actions involved in [autolaunching](#). This information is provided to help you troubleshoot autolaunching issues.

1. With the **File > Debug New Program** or **dload** commands, specify the host name of the computer on which you want to debug a remote process, as described in ["Starting the TotalView Server Manually"](#) on page 449.
2. TotalView begins listening for incoming connections.
3. TotalView launches the **tvdsvr** process with the server launch command. (See ["Setting the Single-Process Server Launch Command"](#) on page 455.)
4. The **tvdsvr** process starts on the remote computer.
5. The **tvdsvr** process establishes a connection with TotalView.

Figure 229 illustrates a single server launch. The numbers in the diagram refer to the numbers in the preceding procedure.

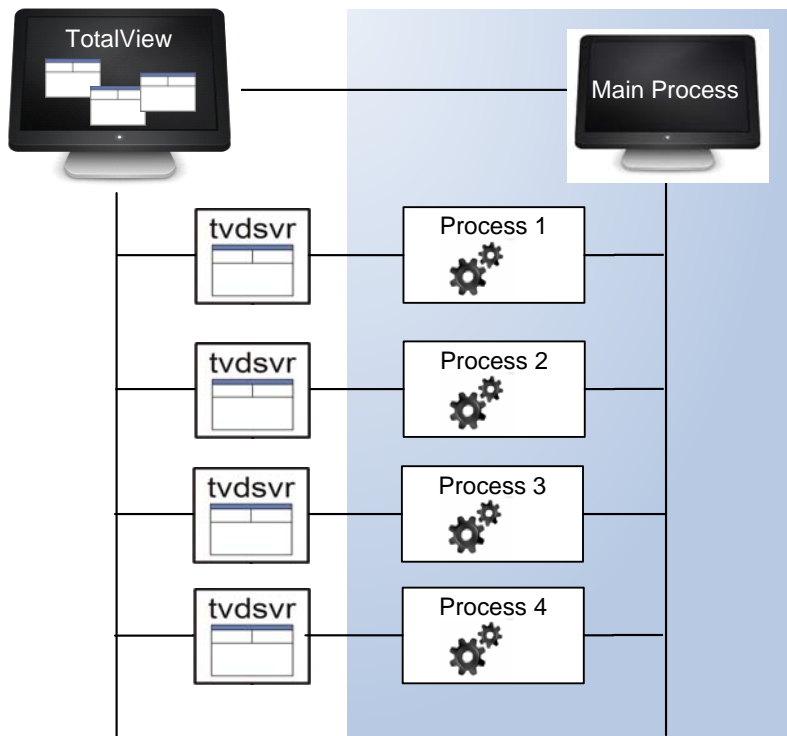
Figure 229 - Launching tvdsvr



2. Listens
3. Invokes commands
4. tvdsvr starts
5. Makes connection

If you have more than one server process, Figure 230 shows what your environment might look like:

Figure 230 - Multiple tvdsvr Processes



Starting the TotalView Server Manually

In some cases, TotalView is unable to automatically launch the TotalView Server on the remote host, and you will need to manually start the server.

NOTE >> You cannot debug remote processes using TotalView Individual.

If TotalView can't automatically launch **tvdsvr**, start it manually:

- Disable both bulk launch and single server launch, set in the **File > Preferences** dialog box
- Enter a host name and port number into the relevant Sessions Manager window (see [“Automatically Launching a Process on a Remote Server”](#) on page 445 for where this is located on the various dialogs). This disables autolaunching for the current connection.

If you disable autolaunching, you must start **tvdsvr** before you load a remote executable or attach to a remote process.

For information on all the ways to start TotalView, see [“Starting TotalView”](#) on page 87.

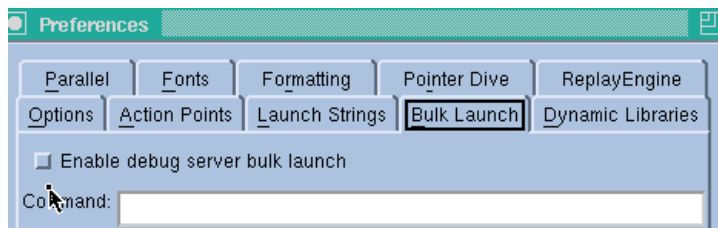
NOTE >> Some parallel programs — MPI programs, for example — make use of a starter program such as *poe* or *mpirun* to create all the parallel jobs on your nodes. TotalView lets you start these programs in two ways. One requires that the starter program be under TotalView control, and the other does not. In the first case, enter the name of the starter program on the command line. In the other, enter program information into the **File > Debug New Parallel Program or Process > Startup Parameter** dialog boxes. Programs started using these dialog boxes do not use the information you set for single-process and bulk server launching.

Here are the steps in detail to manually start **tvdsvr**:

1. Disable both bulk launch and single server launch, set in the **File > Preferences** dialog box from either the Root Window or the Process Window.

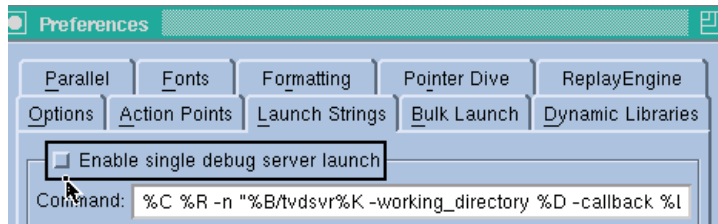
NOTE >> Bulk and single server launch options are discussed in detail in [“Server Launch Options”](#) on page 452.

- To disable bulk launch, select the Bulk Launch Tab and clear the **Enable debug server bulk launch** check box.



CLI: dset TV::bulk_launch_enabled

- To disable single server bulk launch, select the Launch Strings Tab and clear the **Enable single debug server launch** check box.



CLI: dset TV::server_launch_enabled

2. Log in to the remote computer and start **tvdsvr**:

tvdsvr -server

If you don't (or can't) use the default port number (4142), use the **-port** or **-search_port** options. For details, see "TotalView Debugger Server (tvdsvr) Command Syntax" in the *TotalView for HPC Reference Guide*.

After printing the port number and the assigned password, the server begins listening for connections. Be sure to note the password, which must be entered in [Step 3](#).

NOTE >> Using the **-server** option is not secure, as other users could connect to your *tvdsvr* process and use your UNIX UID. Consequently, this command-line option must be explicitly enabled. (Your system administrator usually does this.) For details, see **-server** in the "TotalView Command Syntax" chapter of the *TotalView for HPC Reference Guide*.

3. From the Root Window, select the **File > Debug New Program** command (or any other type of debugging session). Enter the program's name in the **File Name** field and the *hostname:portnumber* in the **Debug On Host > Add Host** dialog, and then select **OK**.

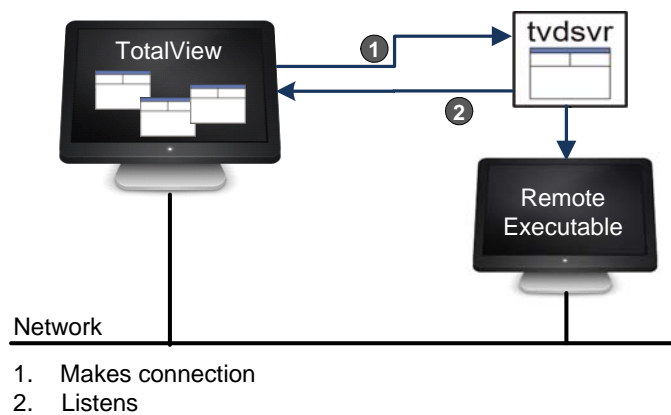
CLI: dload executable -r hostname

TotalView tries to connect to **tvdsvr**.

4. Enter the password at the prompt.

Figure 231 summarizes the steps for starting **tvdsvr** manually.

Figure 231 – Manual Launching of Debugger Server



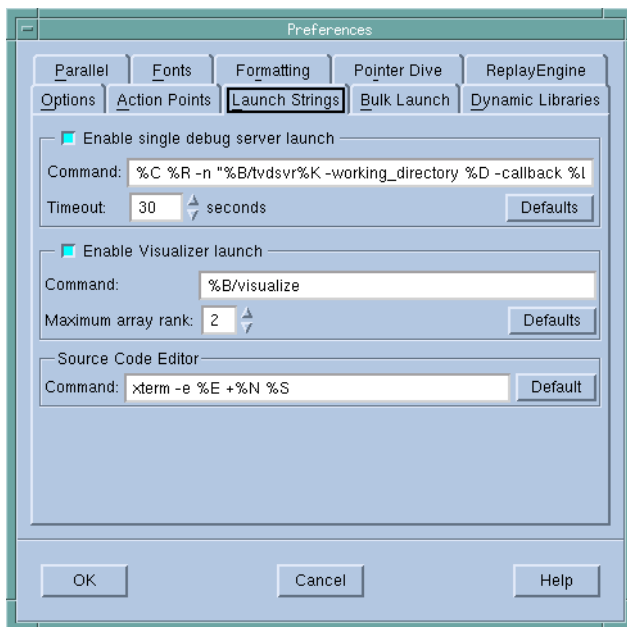
TotalView Server Launch Options and Commands

Server Launch Options

Setting Single-Process Server Launch Options

Use the **Enable single debug server launch** check box in the Launch Strings Page of the **File > Preferences** dialog box to disable **autolaunching**, change the command that TotalView uses to launch remote servers, and alter the amount of time TotalView waits when establishing connections to a **tvdsvr** process. (The **Enable Visualizer launch** and **Source Code Editor** areas are not used when setting launch options.)

Figure 232 – File > Preferences: Launch Strings Page



Enable single debug server launch

Independently launches the **tvdsvr** on each remote system.

```
CLI: dset TV::server_launch_enabled
```

NOTE >> Even if you have enabled bulk server launch, you probably also want to enable this option. TotalView uses this launch string after you start TotalView and when you name a host in the *File > Debug New Program dialog box* or have used the **-remote** command-line option. Disable single server launch only when it can't work.

Command

The command to use when independently launching **tvdsvr**. For information on this command and its options, see “[TotalView Server Launch Options and Commands](#)” on page 452.

```
CLI: dset TV::server_launch_string
```

Timeout

The time TotalView waits for a connection after automatically launching the **tvdsvr** process. The default is 30 seconds. If the connection isn't made in this time, TotalView times out. Change the length of time by entering a value from 1 to 3600 seconds (1 hour).

```
CLI: dset TV::server_launch_timeout
```

If you notice that TotalView fails to launch **tvdsvr** (as shown in the **xterm** window from which you started TotalView) before the timeout expires, click **Yes** in the **Question** dialog box that appears.

Defaults

Reverts to the default settings.

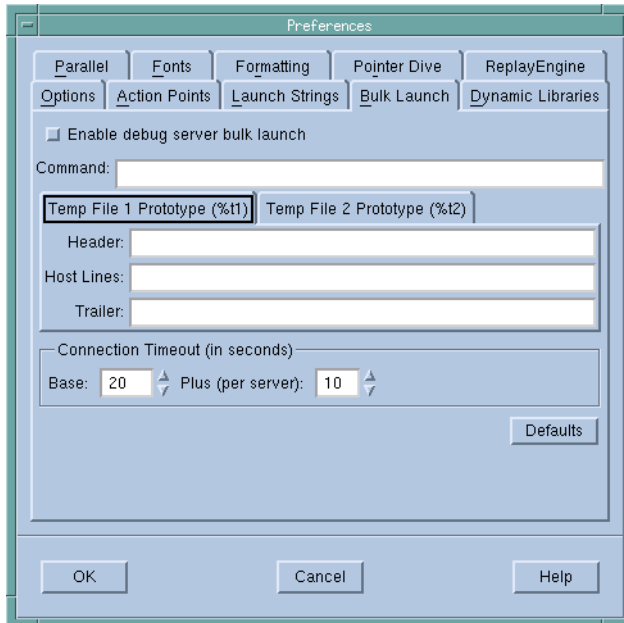
Clicking the **Defaults** button also discards all changes you made using a CLI variable. TotalView doesn't immediately change settings after you click the **Defaults** button; instead, it waits until you click the **OK** button.

Setting Bulk Launch Window Options

Use the **File > Preferences** Bulk Launch Page to change the bulk launch command, disable bulk launch, and alter connection timeouts that TotalView uses when it launches **tvdsvr** programs.

```
CLI: dset TV::bulk_launch_enabled
```


Figure 233 – File > Preferences: Bulk Launch Page



Enable debug server bulk launch

Uses the bulk launch procedure when launching the **tvdsvr**. By default, bulk launch is disabled; that is, TotalView uses its single-server launch procedure.

Command

Command used to launch **tvdsvr** if bulk launch is enabled. For information on this command and its options, see “[Setting the Bulk Server Launch Command](#)” on page 456 and “[IBM RS/6000 AIX](#)” on page 458.

```
CLI: dset TV::bulk_launch_string
```

Temp File 1 Prototype

Temp File 2 Prototype

Specifies the contents of temporary files that the bulk launch operation uses. For information on these fields, see “TotalView Debugger Server (tvdsvr) Command Syntax” in the *TotalView for HPC Reference Guide*.

```
CLI: dset TV::bulk_launch_tmpfile1_header_line
dset TV::bulk_launch_tmpfile1_host_lines
dset TV::bulk_launch_tmpfile1_trailer_line
dset TV::bulk_launch_tmpfile2_header_line
dset TV::bulk_launch_tmpfile2_host_lines
dset TV::bulk_launch_tmpfile2_trailer_line
```

Connection Timeout (in seconds)

Sets the connection timeout TotalView uses after launching **tvdsvr** processes. The default is 20 seconds for responses from the process (the **Base** time) plus 10 seconds for each server process being launched.

A **Base** timeout value can range from 1 to 3600 seconds (1 hour). The incremental **Plus** value is from 1 to 360 seconds (6 minutes). See the online Help for information on setting these values.

```
CLI: dset TV::bulk_launch_base_timeout
dset TV::bulk_launch_incr_timeout
```

If you notice that TotalView fails to launch **tvdsvr** (as shown in the **xterm** window from which you started TotalView) before the timeout expires, select **Yes** in the **Question** dialog box that appears.

Defaults

Returns to the default settings.

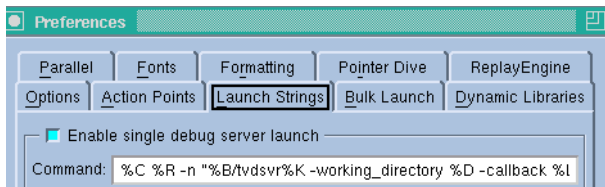
Clicking **Defaults** also discards any changes made using a CLI variable. TotalView doesn't immediately change settings after you click the **Defaults** button; instead, it waits until you click the **OK** button.

Customizing Server Launch Commands

If autolaunch is not working on your system, you may wish to check the default commands set for launching the TotalView Server on your system. You can edit customize these for both single and bulk server launch.

Setting the Single-Process Server Launch Command

You can customize the default command string that TotalView uses when it automatically launches TotalView server for a single process. This string is accessible via the **File > Preferences > Launch Strings** dialog in its Command text box:



This is the default command string:

```
%C %R -n "%B/tvdsvr -working_directory %D -callback %L \
-set_pw %P -verbosity %V %F"
```

where:

- %C** Expands to the name of the server launch command to use, which is the value of **TV::launch_command**. On most platforms, this is **ssh -x**. On Sun SPARC computers, it is **rsh**. If the **TVDSVRLAUNCHCMD** environment variable exists, **TV::launch_command** is initialized to its value.
- %R** Expands to the host name of the remote computer specified in the **File > Debug New Program** (and other Session Manager dialog boxes) or **dload** commands.
- %B** Expands to the **bin** directory in which **tvdsvr** is installed.
- n** Tells the remote shell to read standard input from **/dev/null**; that is, the process immediately receives an EOF (End-Of-File) signal.
- working_directory %D**

Makes **%D** the directory to which TotalView connects. **%D** expands to the absolute path name of the directory.

When you use this option, the host computer and the target computer must mount identical file systems. That is, the path name of the directory to which TotalView connects must be identical on host and target computers.

After changing to this directory, the shell invokes the **tvdsvr** command.

You must make sure that the **tvdsvr** directory is in your path on the remote computer.
- callback %L** Establishes a connection from **tvdsvr** to TotalView. **%L** expands to the host name and TCP/IP port number (*hostname:portnumber*) on which TotalView is listening for connections from **tvdsvr**.
- set_pw %P** Sets a 64-bit password. TotalView must supply this password when **tvdsvr** establishes a connection with it. TotalView expands **%P** to the password that it automatically generates. For more information on this password, see "TotalView Debugger Server (tvdsvr) Command Syntax" in the *TotalView for HPC Reference Guide*.
- verbosity %V** Sets the verbosity level of the **tvdsvr**. **%V** expands to the current verbosity setting. For information on verbosity, see the "Variables" chapter within the *TotalView for HPC Reference Guide*.
- %F** Contains the tracer configuration flags that need to be sent to **tvdsvr** processes. These are system-specific startup options that the **tvdsvr** process needs.

You can also use the **%H** option with this command. See "[Setting the Bulk Server Launch Command](#)" on page 456 for more information.

For information on the complete syntax of the **tvdsvr** command, see "TotalView Debugger Server (tvdsvr) Command Syntax" in the *TotalView for HPC Reference Guide*.

Setting the Bulk Server Launch Command

The commands for bulk server launch settings vary according to platform.

SGI XE and SGI ICE

The bulk server launch string is as follows:

```
array tvdsvr -working_directory %D -callback_host %H \  
            -callback_ports %L -set_pws %P -verbosity %V %F
```

where:

-working_directory %D

Specifies the directory to which TotalView connects. TotalView expands **%D** to this directory's absolute path name.

When you use this option, the host computer and the target computer must mount identical file systems. That is, the path name of the directory to which TotalView connects must be identical on the host and target computers.

After performing this operation, **tvdsvr** starts executing.

-callback_host %H

Names the host upon which TotalView makes this callback. TotalView expands **%H** to the host name of the computer on which TotalView is running.

-callback_ports %L

Names the ports on the host computers that TotalView uses for callbacks. TotalView expands **%L** to a comma-separated list of host names and TCP/IP port numbers (*hostname:portnumber,hostname:portnumber,...*) on which TotalView is listening for connections.

-set_pws %P

Sets 64-bit passwords. TotalView must supply these passwords when **tvdsvr** establishes the connection with it. **%P** expands to a comma-separated list of 64-bit passwords that TotalView automatically generates. For more information, see "TotalView Debugger Server (tvdsvr) Command Syntax" in the *TotalView for HPC Reference Guide*.

-verbosity %V

Sets the **tvdsvr** verbosity level. TotalView expands **%V** to the current verbosity setting. For information on verbosity, see the "Variables" chapter within the *TotalView for HPC Reference Guide*.

You must enable the use of the **array** command by **tvdsvr** by adding the following information to the **/usr/lib/array/arrayd.conf** file:

```
#  
# Command that allows invocation of the TotalView  
# Debugger server when performing a Bulk Server Launch.  
#  
command tvdsvr  
    invoke /opt/totalview/bin/tvdsvr %ALLARGS  
    user %USER  
    group %GROUP  
    project %PROJECT
```

If your code is not in `/opt/totalview/bin`, you will need to change this information. For information on the syntax of the `tvdsvr` command, see “TotalView Debugger Server (tvdsvr) Command Syntax” in the *TotalView for HPC Reference Guide*.

Cray XT Series

The following is the bulk server launch string for Cray XT series computers:

```
svrlaunch %B/tvdsvrmain%K -verbosity %V %F %H \  
%t1 %l %K
```

where the options unique to this command are:

%B	The bin directory where <code>tvdsvr</code> resides.
%K	The number of servers that TotalView launches.
-verbosity %V	Sets the verbosity level of the <code>tvdsvr</code> . %V expands to the current verbosity setting. For information on verbosity, see the “Variables” chapter within the <i>TotalView for HPC Reference Guide</i> .
%F	Contains the “tracer configuration flags” that need to be sent to <code>tvdsvr</code> processes. These are system-specific startup options that the <code>tvdsvr</code> process needs.
%H	Expands to the host name of the machine upon which TotalView is running.
%t1	A temporary file created by TotalView that contains a list of the hosts on which <code>tvdsvr</code> runs. This is the information you enter in the Temp File 1 Prototype field on the Bulk Launch Page.
%l	Expands to the pid of the MPI starter process. For example, it can contain <code>mpirun</code> , <code>aprun</code> , etc. It can also be the process to which you manually attach. If no pid is available, %l expands to 0.

IBM RS/6000 AIX

The following is the bulk server launch string on an IBM RS/6000 AIX computer:

```
%C %H -n "poe -pgmmodel mpm -resd no -tasks_per_node 1 \  
-procs %N -hostfile %t1 -cmdfile %t2 %F"
```

where the options unique to this command are:

%N	The number of servers that TotalView launches.
%t1	A temporary file created by TotalView that contains a list of the hosts on which <code>tvdsvr</code> runs. This is the information you enter in the Temp File 1 Prototype field on the Bulk Launch Page. TotalView generates this information by expanding the %R symbol. This is the information you enter in the Temp File 2 Prototype field on the Bulk Launch Page.
%t2	A file that contains the commands to start the <code>tvdsvr</code> processes on each computer. TotalView creates these lines by expanding the following template:

```
tvdsvr -working_directory %D \  
-callback %L -set_pw %P \  
-
```

`-verbosity %V`

Information on the options and expansion symbols is in the “TotalView Debugger Server (tvdsvr) Syntax” chapter of the *TotalView for HPC Reference Guide*.

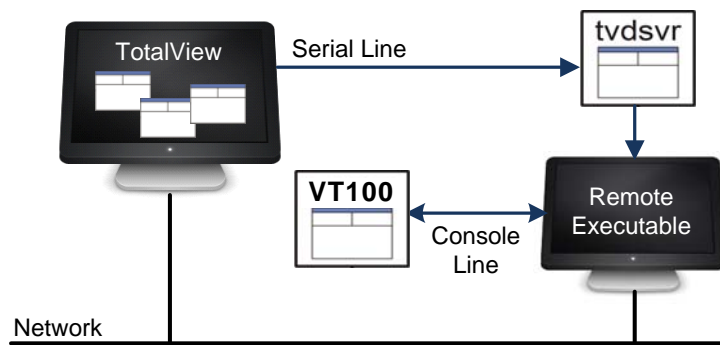
Debugging Over a Serial Line

TotalView supports debugging programs over a serial line as well as TCP/IP sockets. However, if a network connection exists, use it instead to improve performance.

You need two connections to the target computer: one for the console and the other for TotalView. TotalView cannot share a serial line with the console.

Figure 234 illustrates a TotalView session using a serial line. In this example, TotalView is communicating over a dedicated serial line with a **tvdsvr** running on the target host. A VT100 terminal is connected to the target host's console line, allowing you to type commands on the target host.

Figure 234 – Debugging Session Over a Serial Line



Starting the TotalView Debugger Server

To start a debugging session over a serial line, first start the **tvdsvr** from the command line.

Using the console connected to the target computer, start **tvdsvr** and enter the name of the serial port device on the target computer. Use the following syntax:

```
tvdsvr -serial device[:baud=num]
```

where:

device The name of the serial line device.

num The serial line's baud rate. If you omit the baud rate, TotalView uses a default value of **38400**.

For example:

```
tvdsvr -serial /dev/com1:baud=38400
```

After it starts, **tvdsvr** waits for TotalView to establish a connection.



Setting Up MPI Debugging Sessions

This chapter discusses how to set up TotalView MPI debugging sessions for various environments and special use cases, as well as some application-specific debugging tasks. In most cases, you can just use the basic procedure, discussed in [“Starting MPI Programs Using File > Debug New Parallel Program”](#) on page 463.

For information on setting up non-MPI parallel programs, see [“Setting Up Parallel Debugging Sessions”](#) on page 492.

NOTE >> For TotalView Individual, all your MPI processes must execute on the computer on which you installed TotalView. Further, you are limited to no more than 16 processes and threads.

This chapter describes the basics on setting up to debug an MPI system ([“Debugging MPI Programs”](#) on page 463), as well as the following MPI systems:

- [“MPICH Applications”](#) on page 468
- [“MPICH2 Applications”](#) on page 472
- [“Cray MPI Applications”](#) on page 475
- [“IBM MPI Parallel Environment \(PE\) Applications”](#) on page 476
- [“IBM Blue Gene Applications”](#) on page 480
- [“Open MPI Applications”](#) on page 482
- [“QSW RMS Applications”](#) on page 483

In addition, it includes these topics specific to MPI applications:

- [“Starting MPI Issues”](#) on page 489
- [“Using ReplayEngine with Infiniband MPIs”](#) on page 490

RELATED TOPICS

Tips for debugging parallel applications

[“Debugging Strategies for Parallel Applications”](#) on page 398

Tools for displaying an MPI Message Queue

[“MPI Display Tools”](#) on page 405

Creating startup profiles for environments not defined by TotalView. These definitions will appear in the Additional Starter Arguments field of the Debug New Parallel Program dialog box.

"MPI Startup" in the *TotalView for HPC Reference Guide*

Debugging MPI Programs

Starting MPI Programs

MPI programs use a starter program such as **mpirun** to start your program. You can start these MPI programs in two ways: with the starter program under TotalView control, or using the GUI, in which case the starter program is not under TotalView control. In the first case, you will enter the name of the starter program on the command line. In the latter, you will enter program information into the **File > Debug New Parallel Program** or **Process > Startup Parameters** dialog boxes.

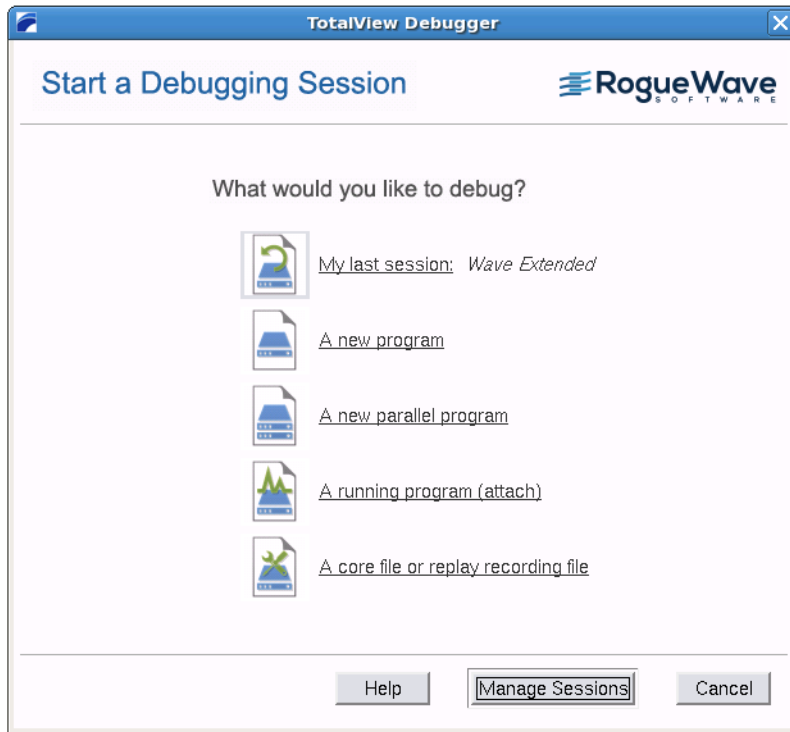
NOTE >> Programs started using GUI dialog boxes have some limitations: program launch does not use the information you set for single-process and bulk server launching, and you cannot use the Attach Subset command.

Starting MPI programs using the dialog boxes is the recommended method. This method is described in the next section. Starting using a starter program is described in various discussions throughout this chapter.

Starting MPI Programs Using File > Debug New Parallel Program

In many cases, the way in which you invoke an MPI program within TotalView control differs little from discipline to discipline. If you invoke TotalView from the command line without an argument, TotalView displays its Start a Debugging Session dialog box. This is the same as choosing **File > New Debugging Session** from either the Root or Process windows.

Figure 235 – Start a Debugging Session dialog



From here, select **A new parallel program**. Alternatively, if TotalView is already running, choose **File > Debug New Parallel Program** from the Root or Process window. Both launch the Parallel Program Session dialog.

The Parallel Program Session Dialog

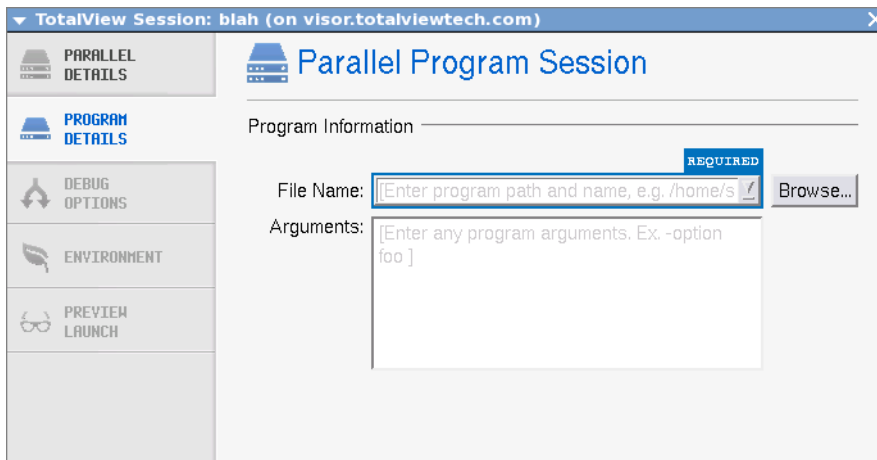
Figure 236 – Parallel Program Session dialog

The screenshot shows the 'Parallel Program Session' dialog box. The 'Session Name' field is filled with 'Parallel Session'. The 'Parallel System' dropdown is empty. The 'Name' field is filled with 'MPICH' and has a 'REQUIRED' label. The 'Parallel Settings' section includes 'Tasks (-np): 5', 'Nodes (-nodes): 2', and 'Additional Starter Arguments: [Enter starter arguments as needed]'. The 'Start Session' button is highlighted.

1. Enter a session name in the **Session Name** field.

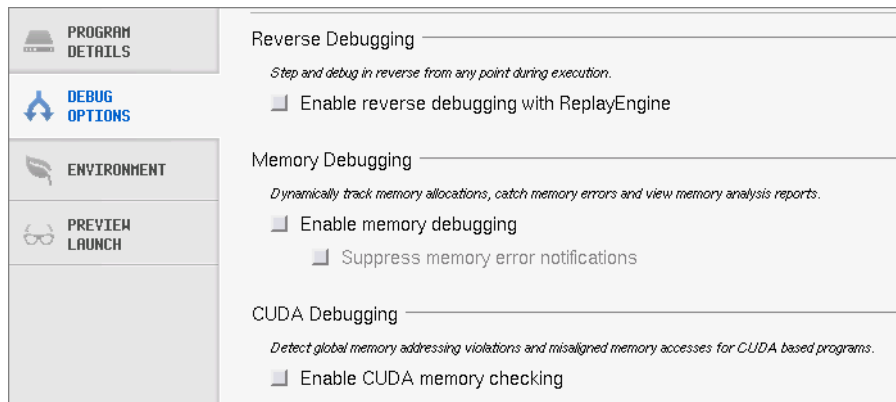
NOTE >> Any previously entered sessions of the same type are available from the Session Name dropdown box. Once selected, you can change any session properties and start your debug session. See [“Editing or Starting New Sessions in a Sessions Window”](#) on page 121.

2. Select the **Parallel** system, the number of **Tasks**, and **Nodes**.
3. (Optional) Enter any additional arguments required by the starter process into the **Arguments** area. Note that these arguments are those sent to a starter process such as **mpirun** or **poe**. They are not arguments sent to your program.
4. Select the **Program Details** tab to enter the file name of the program being debugged and any arguments to be sent to your program.

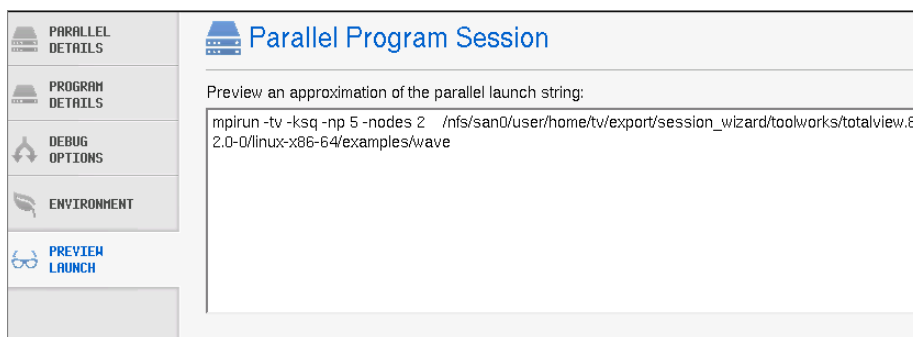


5. Select any optional settings:

- Select **Debug Options** to enable reverse, memory or CUDA debugging. See “[Options: Reverse Debugging, Memory Debugging, and CUDA](#)” on page 113.



- Select the **Environment** tab to add or initialize environment variables or customize standard I/O. See “[Setting Environment Variables and Altering Standard I/O](#)” on page 115.
- Select the **Preview Launch** tab to view the launch string TotalView will use to open your debugging session.



6. Select the **Start Session** button to launch the TotalView.

Once created, a session named `my_foo` can be quickly launched later using the `-load` command line option, like so:

```
totalview -load_session my_foo
```

MPICH Applications

NOTE >> In many cases, you can bypass the procedure described in this section. For more information, see “[Debugging MPI Programs](#)” on page 463.

To debug Message Passing Interface/Chameleon Standard (MPICH) applications, you must use MPICH version 1.2.3 or later on a homogeneous collection of computers. If you need a copy of MPICH, you can obtain it at no cost from Argonne National Laboratory at <http://www.mpich.org/downloads/>. (We strongly urge that you use a later version of MPICH. The *TotalView Platforms and Systems Requirements* document has information on versions that work with TotalView.)

The MPICH library should use the **ch_p4**, **ch_p4mpd**, **ch_shmem**, **ch_lfshmem**, or **ch_mpl** devices.

- For networks of workstations, the default MPICH library is **ch_p4**.
- For shared-memory SMP computers, use **ch_shmem**.
- On an IBM SP computer, use the **ch_mpl** device.

The MPICH source distribution includes all these devices. Choose the one that best fits your environment when you configure and build MPICH.

NOTE >> When configuring MPICH, you must ensure that the MPICH library maintains all of the information that TotalView requires. This means that you must use the **-enable-debug** option with the MPICH **configure** command. (Versions earlier than 1.2 used the **--debug** option.) In addition, the TotalView Release Notes contains information on patching your MPICH version 1.2.3 distribution.

For more information on MPICH applications, see “[MPICH Debugging Tips](#)” on page 411.

Starting TotalView on an MPICH Job

Before you can bring an MPICH job under TotalView's control, both TotalView and the **tvdsvr** must be in your path, most easily set in a login or shell startup script.

For version 1.1.2, the following command-line syntax starts a job under TotalView control:

```
mpirun [ MPICH-arguments ] -tv program [ program-arguments ]
```

For example:

```
mpirun -np 4 -tv sendrecv
```

The MPICH **mpirun** command obtains information from the **TOTALVIEW** environment variable and then uses this information when it starts the first process in the parallel job.

For Version 1.2.4, the syntax changes to the following:

```
mpirun -dbg=totalview [ other_mpitch-args ] program [ program-args ]
```

For example:

```
mpirun -dbg=totalview -np 4 sendrecv
```

In this case, **mpirun** obtains the information it needs from the **-dbg** command-line option.

In other contexts, setting this environment variable means that you can use different versions of TotalView or pass command-line options to TotalView.

For example, the following is the C shell command that sets the **TOTALVIEW** environment variable so that **mpirun** passes the **-no_stop_all** option to TotalView:

```
setenv TOTALVIEW "totalview -no_stop_all"
```

TotalView begins by starting the first process of your job, the master process, under its control. You can then set breakpoints and begin debugging your code.

On the IBM SP computer with the **ch_mpl** device, the **mpirun** command uses the **poe** command to start an MPI job. While you still must use the MPICH **mpirun** (and its **-tv** option) command to start an MPICH job, the way you start MPICH differs. For details on using TotalView with **poe**, see [“Starting TotalView on a PE Program”](#) on page 477.

Starting TotalView using the **ch_p4mpd** device is similar to starting TotalView using **poe** on an IBM computer or other methods you might use on Sun and HP platforms. In general, you start TotalView using the **totalview** command, with the following syntax;

```
totalview mpirun [ totalview_args ] -a [ mpich-args ] program [ program-args ]
```

```
CLI: totalviewcli mpirun [ totalview_args ] \  
      -a [ mpich-args ] program [ program-args ]
```

As your program executes, TotalView automatically acquires the processes that are part of your parallel job as your program creates them. Before TotalView begins to acquire them, it asks if you want to stop the spawned processes. If you click **Yes**, you can stop processes as they are initialized. This lets you check their states or set breakpoints that are unique to the process. TotalView automatically copies breakpoints from the master process to the slave processes as it acquires them. Consequently, you don't have to stop them just to set these breakpoints.

If you're using the GUI, TotalView updates the Root Window to show these newly acquired processes. For more information, see [“Attaching to Processes Tips”](#) on page 401.

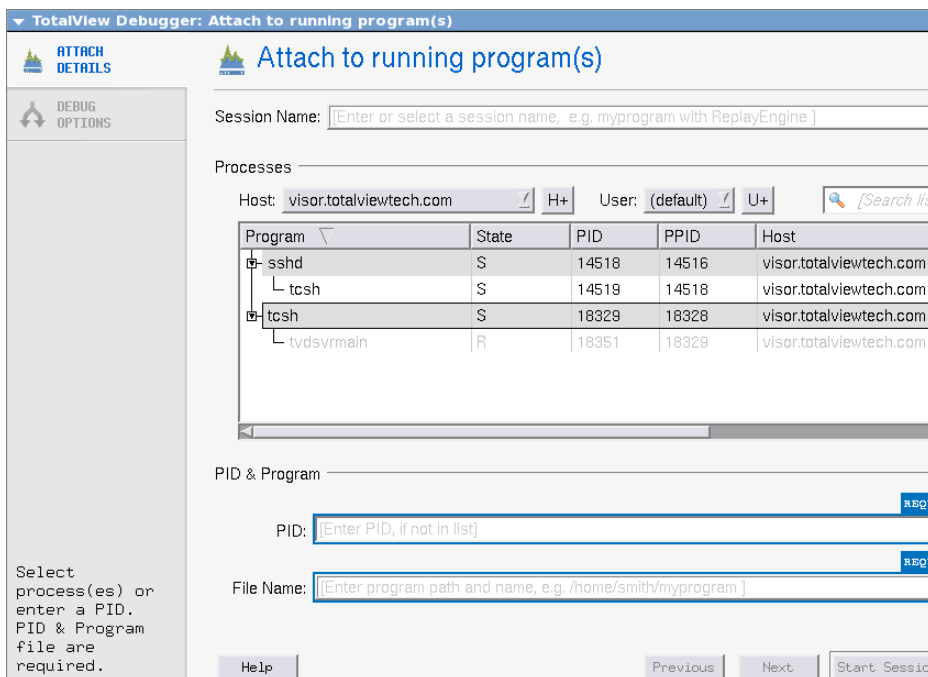
Attaching to an MPICH Job

You can attach to an MPICH application even if it was not started under TotalView control. To attach to an MPICH application:

1. Start TotalView.
Select **A running program (attach)** on the Start a Debugging Session dialog. A list of processes running on the selected host displays in the **Attach to running program(s)** dialog.
2. Attach to the first MPICH process in your workstation cluster by diving into it.

CLI: `dattach executable pid`

3. On an IBM SP with the `ch_mpi` device, attach to the `poe` process that started your job. For details, see “Starting TotalView on a PE Program” on page 477.



Normally, the first MPICH process is the highest process with the correct program name in the process list. Other instances of the same executable can be:

- The **p4** listener processes if MPICH was configured with `ch_p4`.
 - Additional slave processes if MPICH was configured with `ch_shmem` or `ch_lfshmem`.
 - Additional slave processes if MPICH was configured with `ch_p4` and has a file that places multiple processes on the same computer.
4. After attaching to your program's processes, a dialog launches where you can choose to also attach to slave MPICH processes. If you do, press **Return** or choose **Yes**. If you do not, choose **No**.

If you choose **Yes**, TotalView starts the server processes and acquires all MPICH processes.

As an alternative, you can use the **Group > Attach Subset** command to predefine what TotalView should do. For more information, see “[Attaching to Processes Tips](#)” on page 401.

NOTE >> If you are using TotalView Individual, all your MPI processes must execute on the computer on which you installed TotalView.

In some situations, the processes you expect to see might not exist (for example, they may crash or exit). TotalView acquires all the processes it can and then warns you if it cannot attach to some of them. If you attempt to dive into a process that no longer exists (for example, using a message queue display), you are alerted that the process no longer exists.

Using MPICH P4 procgroup Files

If you’re using MPICH with a P4 **procgroup** file (by using the **-p4pg** option), you must use the *same* absolute path name in your **procgroup** file and on the **mpirun** command line. For example, if your **procgroup** file contains a different path name than that used in the **mpirun** command, even though this name resolves to the same executable, TotalView assumes that it is a different executable, which causes debugging problems.

The following example uses the same absolute path name on the TotalView command line and in the **procgroup** file:

```
% cat p4group
local 1 /users/smith/mympichexe
bigiron 2 /users/smith/mympichexe
% mpirun -p4pg p4group -tv /users/smith/mympichexe
```

In this example, TotalView does the following:

1. Reads the symbols from **mympichexe** only once.
2. Places MPICH processes in the same TotalView **share group**.
3. Names the processes **mympichexe.0**, **mympichexe.1**, **mympichexe.2**, and **mympichexe.3**.

If TotalView assigns names such as **mympichexe<mympichexe>.0**, a problem occurred and you need to compare the contents of your **procgroup** file and **mpirun** command line.

MPICH2 Applications

NOTE >> You should be using MPICH2 version 1.0.5p4 or higher. Earlier versions had problems that prevented TotalView from attaching to all the processes or viewing message queue data.

Downloading and Configuring MPICH2

You can download the current MPICH2 version from:

<http://www.mpich.org/downloads/versions/>

If you wish to use all of the TotalView MPI features, you must configure MPICH2. Do this by adding one of the following to the **configure** script that is within the downloaded information:

--enable-debuginfo

or

---enable-totalview

The **configure** script looks for the following file:

python2.x/config/Makefile

It fails if the file is not there.

The next steps are:

1. Run **make**
2. Run **make install**
This places the binaries and libraries in the directory specified by the optional **--prefix** option.
3. Set the **PATH** and **LD_LIBRARY_PATH** to point to the MPICH2 **bin** and **lib** directories.

Starting TotalView Debugging on an MPICH2 Hydra Job

As of MPICH2 1.4.1, the default job type for MPICH2 is Hydra. If you are instead using MPD, see “Starting TotalView Debugging on an MPICH2 MPD Job” on page 473.

NOTE >> In many cases, you can bypass the procedure described in this section. For more information, see “Debugging MPI Programs” on page 463.

Start a Hydra job as follows:

```
totalview -args mpiexec mpiexec-args program program-args
```

You may not see sources to your program at first. If you do see the program, you can set break-points. In either case, press the **Go** button to start your process. TotalView displays a dialog box when your program goes parallel that allows you to stop execution. (This is the default behavior. You can change it using the options within **File > Preferences > Parallel** page.)

Starting TotalView Debugging on an MPICH2 MPD Job

You must start the **mpd** daemon before starting an MPICH2 MPI job.

NOTE >> As of MPICH2 1.4.1, the default job type is Hydra, rather than MPD, so if you are using the default, there is no need to start the daemon. See “Starting TotalView Debugging on an MPICH2 Hydra Job” on page 472.

Starting the MPI MPD Job with MPD Process Manager

To start the mpd daemon, use the **mpdboot** command. For example:

```
mpdboot -n 4 -f hostfile
```

where:

- n 4** The number of hosts on which you wish to run the daemon. In this example, the daemon runs on four hosts
- f hostfile** Lists the hosts on which the application will run. In this example, a file named **hostfile** contains this list.

You are now ready to start debugging your application.

Starting an MPICH2 MPD Job

NOTE >> In many cases, you can bypass the procedure described in this section. For more information, see “Debugging MPI Programs” on page 463.

Start an MPICH2 MPD job in one of the following ways:

```
mpiexec mpi-args -tv program -a program-args
```

This command tells MPI to start TotalView. You must have set the TOTALVIEW environment variable with the path to TotalView’s executable when you start a program using **mpiexec**. For example:

```
setenv TOTALVIEW \
```

`/opt/totalview/bin/totalview`

This method of starting TotalView does not let you restart your program without exiting TotalView and you will not be able to attach to a running MPI job.

**totalview python -a `which mpiexec` **
-tvsu mpiexec-args program program-args

This command lets you restart your MPICH2 job. It also lets you attach to a running MPICH2 job by using the **Attach to a Running Program** dialog box. You need to be careful that you attach to the right instance of python as it is likely that a few instances are running. The one to which you want to attach has no attached children—child processes are indented with a line showing the connection to the parent.

You may not see sources to your program at first. If you do see the program, you can set breakpoints. In either case, press the **Go** button to start your process. TotalView displays a dialog box when your program goes parallel that allows you to stop execution. (This is the default behavior. You can change it using the options within **File > Preferences > Parallel** page.)

You will also need to set the TOTALVIEW environment variable as indicated in the previous method.

Cray MPI Applications

In many cases, you can bypass the procedure described in this section. For more information, see [“Debugging MPI Programs”](#) on page 463

Specific information on debugging Cray MPI applications is located in our discussion of running TotalView on Cray platforms. See [“Debugging Cray XT Applications”](#) on page 499 for information.

IBM MPI Parallel Environment (PE) Applications

NOTE >> In many cases, you can bypass the procedure described in this section. For more information, see [“Debugging MPI Programs”](#) on page 463.

You can debug IBM MPI Parallel Environment (PE) applications on the IBM RS/6000 and SP platforms.

To take advantage of TotalView's ability to automatically acquire processes, you must be using release 3,1 or later of the Parallel Environment for AIX.

Topics in this section are:

- [“Preparing to Debug a PE Application”](#) on page 476
- [“Starting TotalView on a PE Program”](#) on page 477
- [“Setting Breakpoints”](#) on page 477
- [“Starting Parallel Tasks”](#) on page 478
- [“Attaching to a PE Job”](#) on page 478

Preparing to Debug a PE Application

The following sections describe what you must do before TotalView can debug a PE application.

Using Switch-Based Communications

If you're using switch-based communications (either *IP over the switch* or *user space*) on an SP computer, configure your PE debugging session so that TotalView can use *IP over the switch* for communicating with the TotalView Server (**tvdsvr**). Do this by setting the **-adapter_use** option to **shared** and the **-cpu_use** option to **multiple**, as follows:

- If you're using a PE host file, add **shared multiple** after all host names or pool IDs in the host file.
- Always use the following arguments on the **poe** command line:

```
-adapter_use shared -cpu_use multiple
```

If you don't want to set these arguments on the **poe** command line, set the following environment variables before starting **poe**:

```
setenv MP_ADAPTER_USE shared  
setenv MP_CPU_USE multiple
```

When using *IP over the switch*, the default is usually **shared adapter use** and **multiple cpu use**; we recommend that you set them explicitly using one of these techniques. You must run TotalView on an SP or SP2 node. Since TotalView will be using *IP over the switch* in this case, you cannot run TotalView on an RS/6000 workstation.

Performing a Remote Login

You must be able to perform a remote login using the **ssh** command. You also need to enable remote logins by adding the host name of the remote node to the **/etc/hosts.equiv** file or to your **.rhosts** file.

When the program is using switch-based communications, TotalView tries to start the TotalView Server by using the **ssh** command with the switch host name of the node.

Setting Timeouts

If you receive communications timeouts, you can set the value of the **MP_TIMEOUT** environment variable; for example:

```
setenv MP_TIMEOUT 1200
```

If this variable isn't set, TotalView uses a **timeout** value of 600 seconds.

Starting TotalView on a PE Program

The following is the syntax for running Parallel Environment (PE) programs from the command line:

```
program [ arguments ] [ pe_arguments ]
```

You can also use the **poe** command to run programs as follows:

```
poe program [ arguments ] [ pe_arguments ]
```

If, however, you start TotalView on a PE application, you must start **poe** as TotalView's target using the following syntax:

```
{ totalview | totalviewcli } poe -a program [ arguments ] [ PE_arguments ]
```

For example:

```
totalview poe -a sendrecv 500 -rmpool 1
```

Setting Breakpoints

After TotalView is running, start the **poe** process using the **Process > Go** command.

```
CLI: dfocus p dgo
```

A dialog box launches in the GUI—in the CLI, it prints a question—to determine if you want to stop the parallel tasks.

If you want to set breakpoints in your code before they begin executing, answer **Yes**. TotalView initially stops the parallel tasks, which also allows you to set breakpoints. You can now set breakpoints and control parallel tasks in the same way as any process controlled by TotalView.

If you have already set and saved breakpoints with the **Action Point > Save All** command, and you want to reload the file, answer **No**. After TotalView loads these saved breakpoints, the parallel tasks begin executing.

```
CLI: dactions -save filename
      dactions -load filename
```

Starting Parallel Tasks

After you set breakpoints, you can start all of the parallel tasks with the Process Window **Group > Go** command.

```
CLI: dfocus G dgo
      Abbreviation: G
```

NOTE >> No parallel tasks reach the first line of code in your main routine until all parallel tasks start.

Be very cautious in placing breakpoints at or before a line that calls **MPI_Init()** or **MPL_Init()** because timeouts can occur while your program is being initialized. After you allow the parallel processes to proceed into the **MPI_Init()** or **MPL_Init()** call, allow all of the parallel processes to proceed through it within a short time. For more information on this, see [“IBM PE Debugging Tips” on page 413](#) on page 398.

Attaching to a PE Job

To take full advantage of TotalView's **poe**-specific automation, you need to attach to **poe** itself, and let TotalView automatically acquire the **poe** processes on all of its nodes. In this way, TotalView acquires the processes you want to debug.

Attaching from a Node Running poe

To attach TotalView to **poe** from the node running **poe**:

1. Start TotalView in the directory of the debug target.

If you can't start TotalView in the debug target directory, you can start TotalView by editing the **tvdsvr** command line before attaching to **poe**. See [“Setting the Single-Process Server Launch Command”](#) on page 455.

2. In the **File > Attach to a Running Program**, then find the **poe** process list, and attach to it by diving into it. When necessary, TotalView launches **tvdsvrs**. TotalView also updates the Root Window and opens a Process Window for the **poe** process.

```
CLI: dattach poe pid
```

3. Locate the process you want to debug and dive on it, which launches a Process Window for it. If your source code files are not displayed in the Source Pane, invoke the **File > Search Path** command to add directories to your search path.

Attaching from a Node Not Running poe

The procedure for attaching TotalView to **poe** from a node that is not running **poe** is essentially the same as the procedure for attaching from a node that is running **poe**. Since you did not run TotalView from the node running **poe** (the startup node), you won't be able to see **poe** on the process list in the Root Window and you won't be able to start it by diving into it.

To place **poe** in this list:

1. Connect TotalView to the startup node. For details, see [“Starting the TotalView Server Manually”](#) on page 449.
2. Select the **File > Attach to a Running Program**.
3. Look for the process named **poe** and continue as if attaching from a node that is running **poe**.

```
CLI: dattach -r hostname poe poe-pid
```

IBM Blue Gene Applications

While the way in which you debug IBM Blue Gene MPI programs is very similar to debugging these programs on other platforms, starting TotalView on your program differs slightly. Unfortunately, each machine is configured differently so you'll need to find information in IBM's documentation or in documentation created at your site.

Nevertheless, the remainder of this section presents some hints based on information we have gathered at various sites.

TotalView supports debugging applications on three generations of Blue Gene systems: Blue Gene/L, Blue Gene/P, and Blue Gene/Q. While the different Blue Gene generations are similar, there are differences that affect how you start the debugger.

In general, either launch the MPI starter program under the control of the debugger, or start TotalView and attach to an already running MPI starter program. On Blue Gene/L and Blue Gene/P, the starter program is named **mpirun**. On Blue Gene/Q, the starter program is named **runjob** in most cases, or **srun** when the system is configured to use SLURM.

For example, on Blue Gene/L or Blue Gene/P:

```
{ totalview | totalviewcli } mpirun -a mpirun-command-line
```

On most Blue Gene/Q systems:

```
{ totalview | totalviewcli } runjob -a runjob-command-line
```

On Blue Gene/Q systems configured to use SLURM:

```
{ totalview | totalviewcli } srun -a srun-command-line
```

All Blue Gene systems support a scalable tool daemon launching mechanism call "co-spawning", where the tool daemons, such as TotalView's **tvdsvr**, are launched along with the parallel job. As part of the startup or attach sequence, TotalView tells the MPI starter process to launch (or co-spawn) the TotalView Debug Servers on each Blue Gene I/O node.

To support co-spawning, TotalView must pass the address of the network interface connected to the I/O node network on the front-end node to the servers on the I/O nodes. This is usually not the same network interface that is used to connect to the front-end node from the outside world. TotalView assumes that the address can be resolved by using a name that is:

```
front-end-hostname-io.
```

For example, if the hostname of the front-end is **bgqfen1**, TotalView will attempt to resolve the name **bgqfen1-io** to an IP address that the server is able to connect to.

NOTE >> Some systems follow this convention and some do not. If you are executing programs on a system that follows this convention, you will not need to set the TotalView variables described in the rest of this section. You can use the command `ping -c 1 `hostname -s`-io` on the front-end node to check whether the system is using this convention.

If the front-end cannot resolve this name, you must supply the name of the interface using the **-bluegene_io_interface** command-line option, or by setting the **bluegene_io_interface** TotalView variable. (This variable is described in the "TotalView Variables section of the *TotalView for HPC Reference Guide*.)

Because the same version of TotalView must be able to debug both Power-Linux programs (for example, **mpi-run**) and Blue Gene programs, TotalView uses a Blue Gene-specific server launch string. You can define this launch string by setting the **bluegene_server_launch_string** TotalView variable or command-line option.

NOTE >> You must set this variable in a tvdrc file. This differs from other TotalView launch strings, which you can set using the File > Preferences Dialog Box.

The default value for the **bluegene_server_launch_string** variable is:

```
-callback %L -set_pw %P -verbosity %V %F
```

In this string, **%L** is the address of the front-end node interface used by the servers. The other substitution arguments have the same meaning as in a normal server launch string. These substitution arguments are discussed in Chapter 7 of the *TotalView for HPC Reference Guide*.

Open MPI Applications

NOTE >> In many cases, you can bypass the procedure described in this section. For more information, see “[Debugging MPI Programs](#)” on page 463.

Open MPI is an open source implementation of both the MPI-1 and MPI-2 documents that combines some aspects of four different (and now no longer under active development) MPI implementations: FT-MPI from the University of Tennessee, LA-MPI from Los Alamos National Laboratory, LAM/MPI from Indiana University, and PACX-MPI from the University of Stuttgart.

For more information on Open MPI, see <http://www.open-mpi.org/>.

Debug an Open MPI program similarly to most MPI programs, using the following syntax if TotalView is in your path:

```
mpirun -tv args prog prog_args
```

As an alternative, you can invoke TotalView on **mpirun**.

```
totalview -args mpirun args ./prog
```

For example, to start TotalView on a four-process MPI program:

```
totalview -args mpirun -np 4 ./mpi_program
```

Alternatively, you can use the Session Manager or Startup Parameter window (accessed via **Process > Startup Parameters**) and choose the **Parallel** option to enter the parallel session details in the GUI.

QSW RMS Applications

NOTE >> In many cases, you can bypass the procedure described in this section. For more information, see “[Debugging MPI Programs](#)” on page 463.

TotalView supports [automatic process acquisition](#) on AlphaServer SC systems and 32-bit Red Hat Linux systems that use Quadrics RMS resource management system with the QSW switch technology.

NOTE >> Message queue display is supported only if you are running version 1, patch 2 or later, of AlphaServer SC.

Starting TotalView on an RMS Job

To start a parallel job under TotalView control, use TotalView as if you were debugging **prun**:

```
{ totalview | totalviewcli } prun -a prun-command-line
```

TotalView starts and shows you the machine code for RMS **prun**. Since you’re not usually interested in debugging this code, use the **Process > Go** command to let the program run.

```
CLI: dfocus p dgo
```

The RMS **prun** command executes and starts all MPI processes. After TotalView acquires them, it asks if you want to stop them at startup. If you answer **yes**, TotalView halts them before they enter the main program. You can then create breakpoints.

Attaching to an RMS Job

To attach to a running RMS job, attach to the RMS **prun** process that started the job.

You attach to the **prun** process the same way you attach to other processes.

After you attach to the RMS **prun** process, you have the option to attach to slave MPICH processes. If you do, press **Return** or choose **Yes**. If you do not, choose **No**.

If you choose **Yes**, TotalView starts the server processes and acquires all MPI processes.

As an alternative, you can use the **Group > Attach Subset** command to predefine what TotalView should do.

RELATED TOPICS

Attaching to processes using **prun**

[“Attaching to a Running Program”](#) on page 101

Using the **Group > Attach Subset** command to specify

[“Attaching to Processes Tips”](#) on page 401

TotalView behavior when attaching to an RMS **prun** process

SGI MPI Applications

NOTE >> In many cases, you can bypass the procedure described in this section. For more information, see [“Debugging MPI Programs”](#) on page 463.

TotalView can acquire processes started by SGI MPI applications. This MPI is part of the Message Passing Toolkit (MPT) 1.3 and 1.4 packages. TotalView can display the Message Queue Graph Window for these releases. See [“Displaying the Message Queue Graph Window”](#) on page 406 for message queue display.

Starting TotalView on an SGI MPI Job

You normally start SGI MPI programs by using the **mpirun** command. You use a similar command to start an MPI program under debugger control, as follows:

```
{ totalview | totalviewcli } mpirun -a mpirun-command-line
```

This invokes TotalView and tells it to show you the machine code for **mpirun**. Since you're not usually interested in debugging this code, use the **Process > Go** command to let the program run.

```
CLI: dfocus p dgo
```

The SGI MPI **mpirun** command runs and starts all MPI processes. After TotalView acquires them, it asks if you want to stop them at startup. If you answer **Yes**, TotalView halts them before they enter the main program. You can then create breakpoints.

If you set a verbosity level that allows informational messages, TotalView also prints a message that shows the name of the array and the value of the array services handle (**ash**) to which it is attaching.

Attaching to an SGI MPI Job

To attach to a running SGI MPI program, attach to the SGI MPI **mpirun** process that started the program. The procedure for attaching to an **mpirun** process is the same as that for attaching to any other process.

After you attach to the **mpirun** process, TotalView asks if you also want to attach to slave MPICH processes. If you do, press **Return** or choose **Yes**. If you do not, choose **No**.

If you choose **Yes**, TotalView starts the server processes and acquires all MPICH processes.

As an alternative, you can use the **Group > Attach Subset** command to predefine what to do.

RELATED TOPICS

Attaching to an **mpirun** process [“Debugging an MPI Program”](#) on page 91

Using the **Group > Attach Subset** command to specify TotalView behavior when attaching to a process [“Attaching to Processes Tips”](#) on page 401

Using ReplayEngine with SGI MPI

SGI MPI uses the **xpmem** module to map memory from one MPI process to another during job startup. Memory mapping is enabled by default. The size of this mapped memory can be quite large, and can have a negative effect on TotalView’s ReplayEngine performance. Therefore, mapped memory is limited by default for the **xpmem** module if Replay is enabled. The environment variable, **MPI_MEMMAP_OFF**, is set to 1 in the TotalView file **parallel_support.tvd** by adding the variable to the **replay_env:** specification as follows: **replay_env: MPI_MEMMAP_OFF=1.**

If full memory mapping is required, set the startup environment variable in the Arguments field of the Program Session dialog. Add the following to the environment variables: **MPI_MEMMAP_OFF=0.**

Be aware that the default mapped memory size may prove to be too large for ReplayEngine to deal with, and it could be quite slow. You can limit the size of the mapped heap area by using the **MPI_MAPPED_HEAP_SIZE** environment variable documented in the SGI documentation. After turning off **MEMMAP_OFF** as described above, you can set the size (in bytes) in the TotalView startup parameters.

For example:

```
MPI_MAPPED_HEAP_SIZE=1048576
```

NOTE >> SGI has a patch for an *MPT/XPMEM* issue. Without this patch, *XPMEM* can crash the system if ReplayEngine is turned on. To get the *XPMEM* fix for the munmap problem, either upgrade to ProPack 6 SP 4 or install SGI patch 10570 on top of ProPack 6 SP 3.

Sun MPI Applications

NOTE >> In many cases, you can bypass the procedure described in this section. For more information, see [“Debugging MPI Programs”](#) on page 463.

TotalView can debug a Sun MPI program and can display Sun MPI message queues. This section describes how to perform *job startup* and *job attach* operations.

To start a Sun MPI application:

1. Enter the following command:

```
totalview mprun [ totalview_args ] -a [ mpi_args ]
```

For example:

```
totalview mprun -g blue -a -np 4 /usr/bin/mpi/conn.x
```

```
CLI: totalviewcli mprun [ totalview_args ] -a [ mpi_args ]
```

When the TotalView Process Window appears, select the **Go** button.

```
CLI: dfocus p dgo
```

TotalView may display a dialog box with the following text:

```
Process mprun is a parallel job. Do you want to stop  
the job now?
```

2. If you compiled using the **-g** option, click **Yes** to open a Process Window that shows your source. All processes are halted.

Attaching to a Sun MPI Job

To attach to an already running **mprun** job:

1. Find the host name and process identifier (PID) of the **mprun** job by typing **mpps -b**. For more information, see the **mpps(1M)** manual page.

The following is sample output from this command:

```
JOBNAME      MPRUN_PID    MPRUN_HOST  
cre.99       12345        hpc-u2-9  
cre.100      12601        hpc-u2-8
```

2. After selecting **File > Attach to a Running Program**, type **mprun** in the **File Name** field and type the PID in the **Process ID** field.

```
CLI: dattach mprun mprun-pid
```

For example:

```
dattach mprun 12601
```

3. If TotalView is running on a different node than the **mprun** job, select the host or add a new host in the **Host** field.

```
CLI: dattach -r host-name mprun mprun-pid
```

Starting MPI Issues

NOTE >> In many cases, you can bypass the procedure described in this section. For more information, see [“Debugging MPI Programs”](#) on page 463.

If you can't successfully start TotalView on MPI programs, check the following:

- Can you successfully start MPICH programs without TotalView?
The MPICH code contains some useful scripts that verify if you can start remote processes on all of the computers in your computers file. (See **tstmachines** in **mpich/util**.)
- You won't get a message queue display if you get the following warning:

```
The symbols and types in the MPICH library used by TotalView to extract the message queues are not as expected in the image <your image name>. This is probably an MPICH version or configuration problem.
```


You need to check that you are using MPICH Version 1.1.0 or later and that you have configured it with the **-debug** option. (You can check this by looking in the **config.status** file at the root of the MPICH directory tree.)
- Does the TotalView Server (**tvdsvr**) fail to start?
tvdsvr must be in your **PATH** when you log in. Remember that TotalView uses **ssh** to start the server, and that this command doesn't pass your current environment to remotely started processes.
- Make sure you have the correct MPI version and have applied all required patches. See the *TotalView Release Notes* for up-to-date information.
- Under some circumstances, MPICH kills TotalView with the **SIGINT** signal. You can see this behavior when you use the **Group > Kill** command as the first step in restarting an MPICH job.

```
CLI: dfocus g ddelete
```

If TotalView exits and terminates abnormally with a **Killed** message, try setting the **TV::ignore_control_c** variable to true.

RELATED TOPICS

Tips for debugging MPI applications	“MPI Debugging Tips and Tools” on page 405
The TotalView server, tvdsvr	" The tvdsvr Command and Its Options" in the <i>TotalView for HPC Reference Guide</i>
MPI version information	The <i>TotalView Release Notes</i> on the TotalView documentation page

Using ReplayEngine with Infiniband MPIs

In general, using ReplayEngine with MPI versions that communicate over Infiniband is no different than using it with other MPIs, but its use requires certain environment settings, as described here. If you are launching the MPI job from within TotalView, these are set for you; if instead, you start the MPI program from outside TotalView, you must explicitly set your environment.

Required Environment Settings

When you start the MPI program from within TotalView with ReplayEngine enabled, TotalView inserts environment variable settings into the MPI processes to disable certain RDMA optimizations. (These are optimizations that hinder ReplayEngine's ability to identify the memory regions being actively used for RDMA, and their use can therefore result in unreasonably slow execution in record mode.) These variables are set for you, requiring no extra tasks compared to using a non-Infiniband MPI.

The inserted settings are:

- `VIADEV_USE_DREG_CACHE=0` (addresses MVAPICH1 versions)
- `MV2_DREG_CACHE_LIMIT=1` (addresses MVAPICH2 versions)
- `MV2_RNDV_PROTOCOL=R3` (addresses Intel MPI versions, also affects MVAPICH2)
- `OMPI_MCA_mpool_rdma_rcache_size_limit=1` (addresses Open MPI versions)

When the MPI program is started outside TotalView (for example, when using a command like `mpirun -tv`, or when you attach TotalView to an MPI program that is already running), you must set the relevant environment variable for your MPI version, as described above. Also, two additional environment variables are required to make the MPI program's use of RDMA memory visible to ReplayEngine, as follows:

- `IBV_FORK_SAFE`: Set to any value, for example `IBV_FORK_SAFE=1`
- `LD_PRELOAD`: Set to include a preload library, which can be found under the TotalView installation directory at `toolworks/totalview.<version>/linux-x86/lib/undodb_infiniband_preload_x32.so` or `toolworks/totalview.<version>/linux-x86-64/lib/undodb_infiniband_preload_x64.so`.

For example, here's how to set the environment for the MVAPICH1 implementation of MPI:

```
mpirun_rsh -np 8 -hostfile myhosts \  
VIADEV_USE_DREG_CACHE=0 IBV_FORK_SAFE=1 \  
LD_PRELOAD=/<path>/undodb_infiniband_preload_x64.so myprogram
```

For more information, consult your MPI version documentation for specifics on setting environment variables.

Cray System MPIs

On Cray XC, XK, and XC systems, although Infiniband is not used, the MPIs do use RDMA techniques. As a result, using Replay on these systems requires some particular environmental settings. Briefly, the required settings are `MPICH_SMP_SINGLE_COPY_OFF = 1`, and `LD_PRELOAD` set to the location of the Infiniband preload library described above. Refer to the “[Cray Linux Environment \(CLE\)](#)” section for details.

Possible Errors

ReplayEngine checks environment settings before it attaches to the MPI program, but in some cases, may not detect incompatible settings, reporting the following errors:

- If ReplayEngine finds that either the **IBV_FORK_SAFE** setting is absent, or that the preload library has not been loaded, it declines to attach and issues an error message citing unmet prerequisites. You can still attach TotalView to the program without ReplayEngine - for example, in the GUI by using the New Program dialog.
- If ReplayEngine cannot determine that the environment variable setting to disable an MPI optimization has been set, it continues to attach, but issues a warning message that it could not verify prerequisites. Depending on your program's use of memory for RDMA, you may find that it runs unreasonably slowly in record mode, or encounters errors that would not occur if ReplayEngine were not attached.

RELATED TOPICS

Using ReplayEngine in general

Getting Started with Replay Engine

MPI programs

“[Debugging MPI Programs](#)” on page 463



Setting Up Parallel Debugging Sessions

This chapter explains how to set up TotalView parallel debugging sessions for applications that use the parallel execution models that TotalView supports and which do not use MPI.

NOTE >> If you are using TotalView Individual, all your program's processes must execute on the computer on which you installed TotalView. In addition, TotalView Individual limits you to no more than 16 processes and threads.

This chapter discusses the following topics:

- [“Debugging OpenMP Applications”](#) on page 493
- [“Using SLURM”](#) on page 498
- [“Debugging Cray XT Applications”](#) on page 499
- [“Debugging Global Arrays Applications”](#) on page 504
- [“Debugging Shared Memory \(SHMEM\) Code”](#) on page 506
- [“Debugging UPC Programs”](#) on page 507
- [“Debugging CoArray Fortran \(CAF\) Programs”](#) on page 511

This chapter also describes TotalView features that you can use with most parallel models:

- Define the process you want TotalView to attach to. See [“Attaching to Processes Tips”](#) on page 401.
- See [“Debugging Strategies for Parallel Applications”](#) on page 398 for general hints on how to approach debugging parallel programs.

Debugging OpenMP Applications

TotalView supports many OpenMP compilers for the C, C++, and Fortran languages. Supported compilers and architectures are listed in the *TotalView Platforms and Systems Requirements* document.

The following are some features that TotalView supports:

- Source-level debugging of the original OpenMP code.
- The ability to plant breakpoints throughout the OpenMP code, including lines that are executed in parallel.
- Visibility of OpenMP worker threads.
- Access to **SHARED** and **PRIVATE** variables in OpenMP PARALLEL code.
- A stack-back link token in worker threads' stacks so that you can find their master stack.
- Access to OMP THREADPRIVATE data in code compiled by supported compilers.

Topics in this section are:

- [“Debugging OpenMP Programs”](#) on page 493
- [“Viewing OpenMP Private and Shared Variables”](#) on page 494
- [“Viewing OpenMP THREADPRIVATE Common Blocks”](#) on page 496
- [“Viewing the OpenMP Stack Parent Token Line”](#) on page 497

Debugging OpenMP Programs

Debugging OpenMP code is similar to debugging multi-threaded code. The major differences are in the way the OpenMP compiler alters your code. These alterations include:

- *Outlining*. The compiler pulls the body of a parallel region out of the original routine and places it in an *outlined routine*. In some cases, the compiler generates multiple outlined routines from a single parallel region. This allows multiple threads to execute the parallel region.

The outlined routine's name is based on the original routine's name. In most cases, the compiler adds a numeric suffix.

- The compiler inserts calls to the OpenMP runtime library.
- The compiler splits variables between the original routine and the outlined routine. Normally, shared variables reside in the master thread's original routine, and private variables reside in the outlined routine.

- The master thread creates threads to share the workload. As the master thread begins to execute a parallel region in the OpenMP code, it creates the worker threads, dispatches them to the outlined routine, and then calls the outlined routine itself.

About TotalView OpenMP Features

TotalView interprets the changes that the OpenMP compiler makes to your code so that it can display your program in a coherent way. Here are some things you should know:

- The compiler can generate multiple outlined routines from a single parallel region. This means that a single line of source code can generate multiple blocks of machine code inside different functions.
- You can't single step into or out of a parallel region. Instead, set a breakpoint inside the parallel region and let the process run to it. After execution reaches the parallel region, you can single step in it.
- OpenMP programs are multi-threaded programs, so the rules for debugging multi-threaded programs apply.

About OpenMP Platform Differences

In general, TotalView smooths out the differences that occur when you execute OpenMP platforms on different platforms. The following list discusses these differences:

- The OpenMP master thread has logical thread ID number 1. The OpenMP worker threads have a logical thread ID number greater than 1.
- Select or dive on the stack parent token line to view the original routine's stack **frame** in the OpenMP master thread.
- When you stop the OpenMP worker threads in a **PARALLEL DO** outlined routine, the stack backtrace shows the following call sequence:
 - Outlined routine called from the special stack parent token line.
 - The OpenMP runtime library called from.
 - The original routine (containing the parallel region).

Viewing OpenMP Private and Shared Variables

You can view both OpenMP private and shared variables.

The compiler maintains OpenMP private variables in the outlined routine, and treats them like local variables. See [“Displaying Local Variables and Registers”](#) on page 232. In contrast, the compiler maintains OpenMP shared variables in the master thread's original routine stack **frame**.

You can display shared variables through a Process Window focused on the OpenMP master thread, or through one of the OpenMP worker threads.

To see these variables:

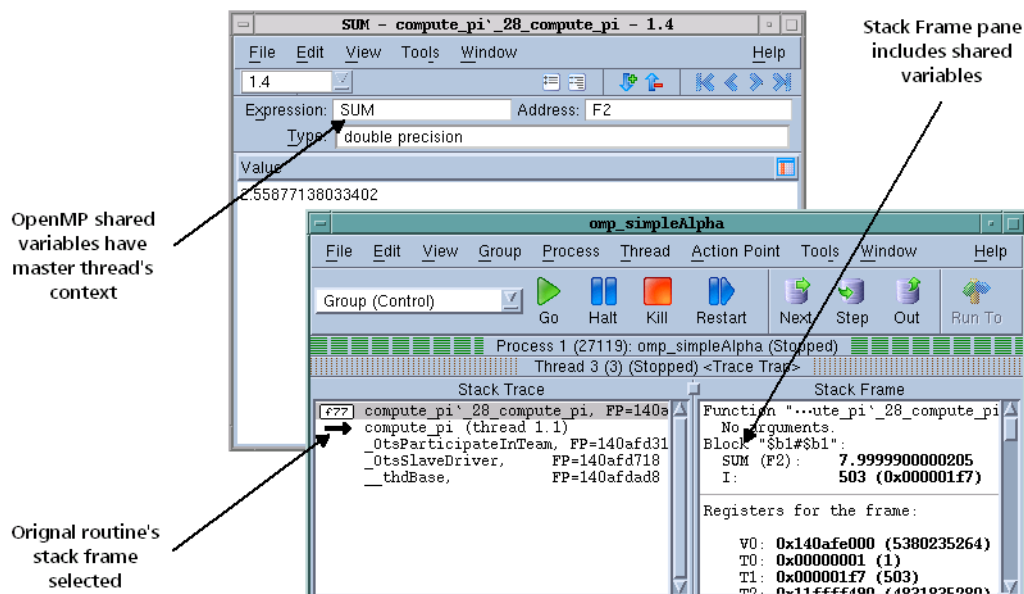
1. Select the outlined routine in the Stack Trace Pane, or select the original routine stack frame in the OpenMP master thread.
2. Dive on the variable name, or select the **View > Lookup Variable** command. When prompted, enter the variable name.

CLI: dprint

You need to first set your focus to the OpenMP master thread.

A Variable Window is launched that displays the value of the OpenMP shared variable, as shown in [Figure 237](#).

Figure 237 – OpenMP Shared Variable



Shared variables reside in the OpenMP master thread's stack. When displaying shared variables in OpenMP worker threads, TotalView uses the stack context of the OpenMP master thread to find the shared variable. TotalView uses the OpenMP master thread's context when displaying the shared variable in a Variable Window.

You can also view OpenMP shared variables in the Stack Frame Pane by selecting either of the following:

- Original routine stack frame in the OpenMP master thread.
- Stack parent token line in the Stack Trace Pane of OpenMP worker threads.

Viewing OpenMP THREADPRIVATE Common Blocks

Some compilers implement OpenMP **THREADPRIVATE** common blocks by using the thread local storage system facility. This facility stores a variable declared in OpenMP **THREADPRIVATE** common blocks at different memory locations in each thread in an OpenMP process. This allows the variable to have different values in each thread. In contrast, IBM and other compilers use the pthread key facility.

To view a variable in an OpenMP **THREADPRIVATE** common block or the OpenMP **THREADPRIVATE** common block:

1. In the Threads Tab of the Process Window, select the thread that contains the private copy of the variable or common block you want to view.
2. In the Stack Trace Pane of the Process Window, select the stack **frame** that lets you access the OpenMP **THREADPRIVATE** common block variable. You can select either the outlined routine or the original routine for an OpenMP master thread. You must, however, select the outlined routine for an OpenMP worker thread.
3. From the Process Window, dive on the variable name or common block name, or select the **View > Lookup Variable** command. When prompted, enter the name of the variable or common block. You may need to append an underscore character (`_`) after the common block name.

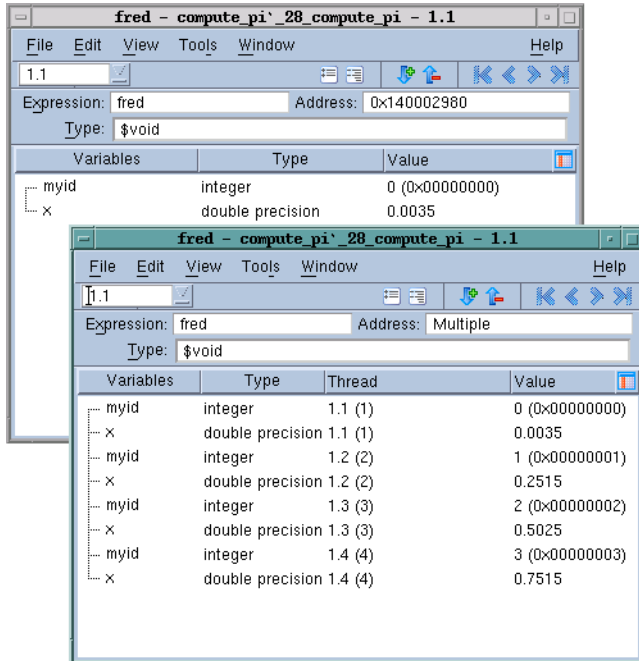
CLI: dprint

A Variable Window opens that displays the value of the variable or common block for the selected thread. See [“Displaying Variables”](#) on page 220 for more information on displaying variables.

4. To view OpenMP **THREADPRIVATE** common blocks or variables across all threads, use the Variable Window's **Show across > Threads** command. See [“Displaying a Variable in all Processes or Threads”](#) on page 300.

Figure 238 shows Variable Windows displaying OpenMP **THREADPRIVATE** common blocks. Because the Variable Window has the same thread context as the Process Window from which it was created, the title bar patterns for the same thread match. TotalView displays the values of the common block across all threads when you use the **View > Show Across > Threads** command.

Figure 238 – OpenMP THREADPRIVATE Common Block Variables

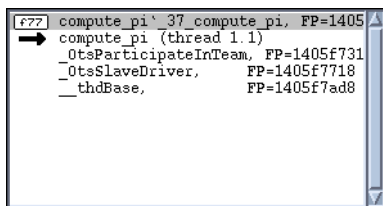


Viewing the OpenMP Stack Parent Token Line

TotalView inserts a special stack parent token line in the Stack Trace Pane of OpenMP worker threads when they are stopped in an outlined routine.

When you select or dive on the stack parent token line, the Process Window switches to the OpenMP master thread, allowing you to see the stack context of the OpenMP worker thread's routine.

Figure 239 – OpenMP Stack Parent Token Line



This stack context includes the OpenMP shared variables.

Using SLURM

TotalView supports the SLURM resource manager. Here is some information copied from the SLURM website (<http://www.llnl.gov/linux/slurm>).

SLURM is an open-source resource manager designed for Linux clusters of all sizes. It provides three key functions. First it allocates exclusive and/or non-exclusive access to resources (computer nodes) to users for some duration of time so they can perform work. Second, it provides a framework for starting, executing, and monitoring work (typically a parallel job) on a set of allocated nodes. Finally, it arbitrates conflicting requests for resources by managing a queue of pending work.

SLURM is not a sophisticated batch system, but it does provide an Applications Programming Interface (API) for integration with external schedulers such as the Maui Scheduler. While other resource managers do exist, SLURM is unique in several respects:

- Its source code is freely available under the GNU General Public License.
- It is designed to operate in a heterogeneous cluster with up to thousands of nodes.
- It is portable; written in C with a GNU autoconf configuration engine. While initially written for Linux, other UNIX-like operating systems should be easy porting targets. A plugin mechanism exists to support various interconnects, authentication mechanisms, schedulers, etc.
- SLURM is highly tolerant of system failures, including failure of the node executing its control functions.
- It is simple enough for the motivated end user to understand its source and add functionality.

Debugging Cray XT Applications

The Cray XT Series is supported by the TotalView x86_64 distribution. The discussion here is based on running applications on Cray XT Catamount, some of which is also applicable to using Cray Linux Environment (CLE). The primary difference between the two, and it is a big difference, is that CLE uses **aprun** to launch programs rather than **yod** (See “[Cray Linux Environment \(CLE\)](#)” on page 502 for details).

RELATED TOPICS

Setting up an MPI debugging session “[Setting Up MPI Debugging Sessions](#)” on page 461

Tips for parallel debugging “[General Parallel Debugging Tips](#)” on page 399

Cray XT Catamount

On the Cray XT Catamount, all jobs running on compute nodes are started with the **yod** starter program. These jobs do not have to be MPI jobs. Debugging a program started with **yod** is similar to debugging any program using a starter program. In general, you would type:

```
totalview totalview_args yod -a yod_args
```

For example:

```
totalview yod -a -np 4 ./my_prog
```

Here are some things you should know:

- **tvdsvr_rs** processes are started for your compute nodes. (This is a process started by TotalView on a remote node that communicates back with TotalView. For more information on this server, see [Chapter 18, “Setting Up Remote Debugging Sessions,”](#) on page 442.) **yod** then passes information to TotalView, which then starts the servers. If this does not occur, consult your **yod** documentation.
- There may be more than one **tvdsvr_rs** process. TotalView creates one **tvdsvr_rs** process for each **RS_DBG_CLIENTS_PER_SERVER** or 64 compute nodes.
- To attach to a running program, attach to the instance of **yod** that is controlling it, using normal TotalView mechanisms. TotalView automatically attaches to all compute node tasks that are part of the job.
- TotalView cannot know how many compute nodes are available, so each server assumes that it will be serving 64 compute nodes, and asks for a 64-node license.

If you wish to use a small license (less than 64 processors), override this default using the **-nodes_allowed tvdsvr** command-line option. The argument to this option specifies how many nodes the server supports and how many licenses it needs. Because this is a **tvdsvr_rs** command-line option, you must add it into the server launch string.

You can also use the **-nodes_allowed** server launch string option along with the **RS_DBG_CLIENTS_PER_SERVER** environment variable to increase the number of compute nodes each server will serve (and the number of Cray licences it asks for). However, we do not recommend that you set this server launch string option to a value greater than 256. (Note that you need only set this variable if **RS_DBG_CLIENTS_PER_SERVER** is greater than 64.)

For information on setting server launch strings, see “[Customizing Server Launch Commands](#)” on page 455.

NOTE >> While debugging, you must also have the FlexLM license server running. TotalView uses this server to verify that you are using licensed software. However, this server is not related to the servers that TotalView launches when you are debugging your program.

Configuring Cray XT for TotalView

When configuring your Cray XT system for use with the TotalView, you must:

- Mount user home directories on all service nodes that you will use while debugging.
- (Optional) Enable passwordless **ssh** on all service nodes that you will use while debugging. In most cases, your system administrator will have enabled your system so that it uses **ssh** instead of **rsh**. If passwordless ssh is not enabled, you will be asked to enter a password each time a process is launched on a node.
- (Optional) Automatically set **RS_DBG_CLIENTS_PER_SERVER** and **-nodes_allowed**.

On Cray XT systems, setting a **-nodes_allowed** command-line option to 64 will not work. Instead, configure TotalView to use **RS_DBG_CLIENTS_PER_SERVER** and **-nodes_allowed** to make best use of the cluster and TotalView licenses.

TotalView administrators can set installation preferences by editing (or creating) the **\$TVROOT/linux-x86-64/lib/.tvrc** file. Here are two simple scenarios:

- If you have only one TotalView license, and that license is for less than 64 processors, then a server launch string like this would be best:

```
dset -set_as_default TV::server_launch_string \  
    {%C %R -n "%B/tvdsvr%K -working_directory %D \  
    -callback %L \  
    -nodes_allowed maximum_processor_license \  
    -set_pw %P -verbosity %V %F"}
```

where *maximum_processor_license* is the processor count for your TotalView license.

- If you are running TotalView on a cluster where the ratio of service nodes to compute nodes is less than 1:64, use a server launch string. For example:

```
dset -set_as_default TV::server_launch_string \  
    {%C %R -n "%B/tvdsvr%K -working_directory %D \  
    -callback %L \  
    -nodes_allowed ${RS_DBG_CLIENTS_PER_SERVER-64} \  
    -set_pw %P -verbosity %V %F"}
```

You need to set the **RS_DBG_CLIENTS_PER_SERVER** environment variable before submitting all jobs where a service node-to-compute node ratio of 1:64 is not possible. You should also set **RS_DBG_CLIENTS_PER_SERVER** to the number of compute nodes served by each service node. For example, if you have a service-to-node ratio of 1:128, set this variable to 128.

NOTE >> The `TV::server_launch_string` variable is used for both Cray XT3 and Linux x86-64. This means that if you will also be using this TotalView installation on other linux-x86-64 machines, do not set the `TV::server_launch_string` variable in your global `.tvdr`.

Using TotalView with your Cray XT System

As part of launching an application on a compute node, TotalView launches a server program on your login node using **ssh**. As with any **ssh** session, authentication is required. We recommend that you enable **ssh** without a pass phrase.

TotalView typically runs interactively. If your site has not designated any compute nodes for interactive processing, use the **PBS Pro qsub -I** interactive mode. This mode is described in the *Cray XT3 Programming Environment User's Guide*.

If TotalView is installed on your system, use the following command to load it into your user environment:

```
module load xt-totalview
```

You can now use the following command to start the CLI:

```
totalviewcli yod [-a argument_list] application_name
```

Here's the command that starts the GUI:

```
totalviewcli yod [-a argument_list] application_name
```

The following example shows how you can debug a program named **a.out**:

```
% qsub -I -l size=4  
qsub: waiting for job 14448.nid00003 to start  
qsub: job 14448.nid00003 ready  
  
DISPLAY is user1:0.0  
Linux perch 2.4.21-0-sles9-ss-lustre #2 Fri Apr 29  
17:14:15 PDT 2005 x86_64 x86_64 x86_64 GNU/Linux  
/ufs/home/users/user1  
  
% module load xt-totalview  
% cd working_directory
```



```
% totalview yod -a -sz 4 a.out
```

Cray Linux Environment (CLE)

CLE applications are similar to those on Cray XT Catamount. The primary difference is that CLE applications are launched using **aprun** rather than **yod**.

Most — perhaps all — programs are launched using a batch queueing system such as PBS, Moab, and so on. While this is independent from TotalView, you will need to do queue up for an interactive session. For example:

```
qsub -I -sz=size
```

Here is an example of how you would start a CLE debugging session:

```
totalview aprun -a -n4 a.out
```

TotalView is not able to stop your program before it calls **MPI_Init()**. While this is typically at the beginning of **main()**, the actual location depends on how you've written the program. This means that if you set a breakpoint before the **MPI_Init()** call, TotalView ignores it because the statement upon which you set the breakpoint will have already executed.

Support for Cray Abnormal Termination Processing (ATP)

Cray's ATP module stops a running job at the moment it crashes. This allows you to attach TotalView to the held job and begin debugging it. To hold a job as it is crashing you must set the **ATP_HOLD_TIME** environment variable before launching your job with **aprun**.

When your job crashes, **aprun** outputs a message stating that your job has crashed and that ATP is holding it. You can now attach TotalView to **aprun** using the normal attach procedure (see “[Attaching to a Running Program](#)” on page 101).

For more information on ATP, see the Cray [intro_atp](#) man page.

Special Requirements for Using ReplayEngine

On Cray XC, XK, and XC systems, the MPIs use RDMA techniques, similar to Infiniband MPIs. When using ReplayEngine on MPI programs, certain environment variable settings must be in effect for the MPI rank processes. These settings ensure that memory mapping operations are visible to ReplayEngine. The required settings are:

- **MPICH_SMP_SINGLE_COPY_OFF = 1**
- **LD_PRELOAD**: Set to include a preload library, which can be found under the TotalView installation directory at `toolworks/totalview.<version>/linux-x86/lib/undodb_infiniband_preload_x32.so` or `toolworks/totalview.<version>/linux-x86-64/lib/undodb_infiniband_preload_x64.so`.

These settings may be applied with the **aprun -e** option. For example, to have TotalView launch an MPI program with ReplayEngine enabled, use a command similar to this:

```
totalview -replay -args aprun -n 8 \  
-e MPICH_SMP_SINGLE_COPY_OFF=1 \  
-e LD_PRELOAD=/<path>/undodb_infiniband_preload_x64.so \  
myprogram
```

Debugging Global Arrays Applications

The following paragraphs, which are copied from the Global Arrays home site (<http://hpc.pnl.gov/globalarrays>), describe the global arrays environment:

The Global Arrays (GA) toolkit provides a shared memory style programming environment in the context of distributed array data structures (called “global arrays”). From the user perspective, a global array can be used as if it was stored in shared memory. All details of the data distribution, addressing, and data access are encapsulated in the global array objects. Information about the actual data distribution and locality can be easily obtained and taken advantage of whenever data locality is important. The primary target architectures for which GA was developed are massively-parallel distributed-memory and scalable shared-memory systems.

GA divides logically shared data structures into “local” and “remote” portions. It recognizes variable data transfer costs required to access the data depending on the proximity attributes. A local portion of the shared memory is assumed to be faster to access and the remainder (remote portion) is considered slower to access. These differences do not hinder the ease-of-use since the library provides uniform access mechanisms for all the shared data regardless where the referenced data is located. In addition, any processes can access a local portion of the shared data directly/in-place like any other data in process local memory. Access to other portions of the shared data must be done through the GA library calls.

GA was designed to complement rather than substitute for the message-passing model, and it allows the user to combine shared-memory and message-passing styles of programming in the same program. GA inherits an execution environment from a message-passing library (w.r.t. processes, file descriptors etc.) that started the parallel program.

TotalView supports Global Arrays on the Intel IA-64 platform. Debug a Global Arrays program in basically the same way that you debug any other multi-process program. The one difference is that you use the **Tools > Global Arrays** command to display information about your global data.

The global arrays environment has a few unique attributes. Using TotalView, you can:

- Display a list of a program's global arrays.
- Dive from this list of global variables to see the contents of a global array in C or Fortran format.
- Cast the data so that TotalView interprets data as a global array handle. This means that TotalView displays the information as a global array. Specifically, casting to **\$GA** forces the Fortran interpretation; casting to **\$ga** forces the C interpretation; and casting to **\$Ga** uses the language in the current context.

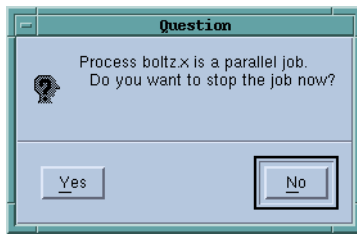
Within a Variable Window, the commands that operate on a local array, such as slicing, filtering, obtaining statistics, and visualization, also operate on global arrays.

The command used to start TotalView depends on your operating system. For example, the following command starts TotalView on a program invoked using **prun** using three processes:

```
totalview prun -a -N 3 boltz.x
```

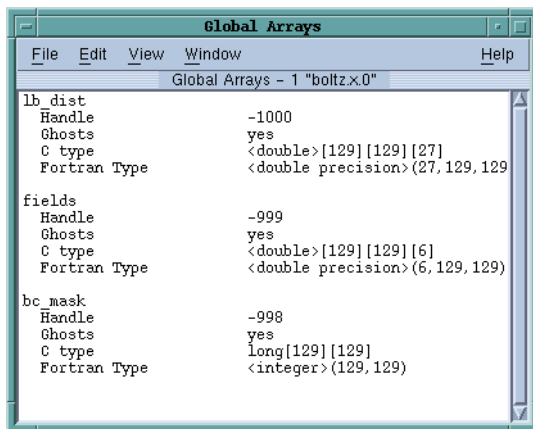
Before your program starts parallel execution, a Question dialog launches so you can stop the job to set breakpoints or inspect the program before it begins execution

Figure 240 – Question Window for Global Arrays Program



After your program hits a breakpoint, use the **Tools > Global Arrays** command to begin inspecting your program's global arrays. TotalView displays the following window.

Figure 241 – Tools > Global Arrays Window



CLI: dga

The arrays named in this window are displayed using their C and Fortran type names. Diving on the line that contains the type definition displays Variable Windows that contain information about that array.

After TotalView displays this information, you can use other standard commands and operations on the array. For example, you can use the slice and filter operations and the commands that visualize, obtain statistics, and show the nodes from which the data was obtained.

If you inadvertently dive on a global array variable from the Process Window, TotalView does not know that it is a component of a global array. If, however, you do dive on the variable, you can cast the variable into a global array using either **\$ga** for a C Language cast or **\$GA** for a Fortran cast.

Debugging Shared Memory (SHMEM) Code

TotalView supports programs using the distributed memory access Shared Memory (SHMEM) library on Quadrics RMS systems and SGI Altix systems. The SHMEM library allows processes to read and write data stored in the memory of other processes. This library also provides collective operations.

Debugging a SHMEM RMS or SGI Altix program is no different than debugging any other program that uses a starter program. For example:

```
totalview srun -a my_program
```

Debugging UPC Programs

TotalView supports debugging UPC programs on Linux x86 platforms. This section discusses only the UPC-specific features of TotalView. It is not an introduction to the UPC Language. For an introduction to the UPC language, see <http://www.gwu.edu/~upc/>.

NOTE >> When debugging UPC code, TotalView requires help from a UPC assistant library that your compiler vendor provides. You need to include the location of this library in your **LD_LIBRARY_PATH** environment variable. TotalView also provides assistants that you can use.

Topics in this section are:

- “Invoking TotalView” on page 507
- “Viewing Shared Objects” on page 507
- “Displaying Pointer to Shared Variables” on page 509

Invoking TotalView

The way in which you invoke TotalView on a UPC program is straight-forward. However, this procedure depends on the parallel technology you are using. Here are a couple of examples:

- For Quadrics RMS:

```
totalview prun -a prog_upc_args
```
- For MPICH and LAM

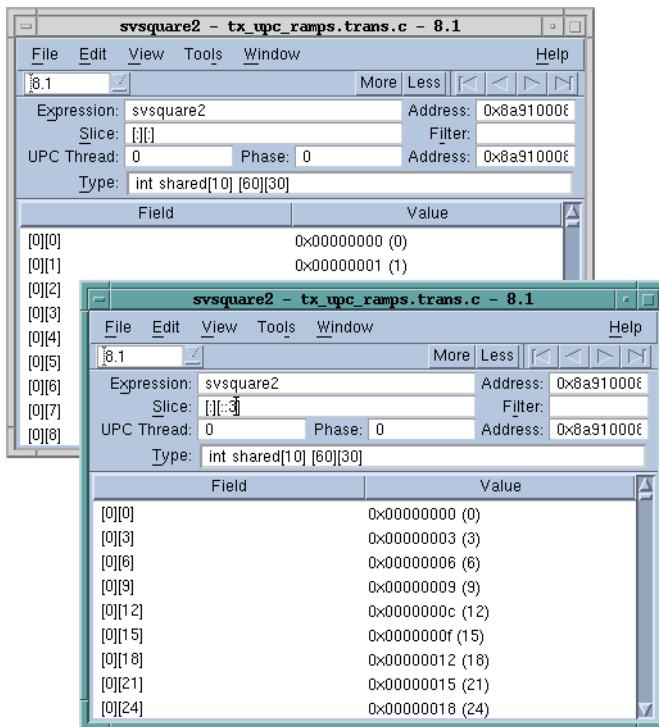
```
totalview mpirun -a -np 2 prog_upc_args
```

Viewing Shared Objects

TotalView displays UPC shared objects, and fetches data from the UPC thread with which it has an affinity. For example, TotalView always fetches shared scalar variables from thread 0.

The upper-left screen in [Figure 242](#) displays elements of a large shared array. You can manipulate and examine shared arrays the same as any other array. For example, you can slice, filter, obtain statistical information, and so on. (For more information on displaying array data, see [Chapter 10, “Examining Arrays,”](#) on page 283.) The lower-right screen shows a slice of this array.

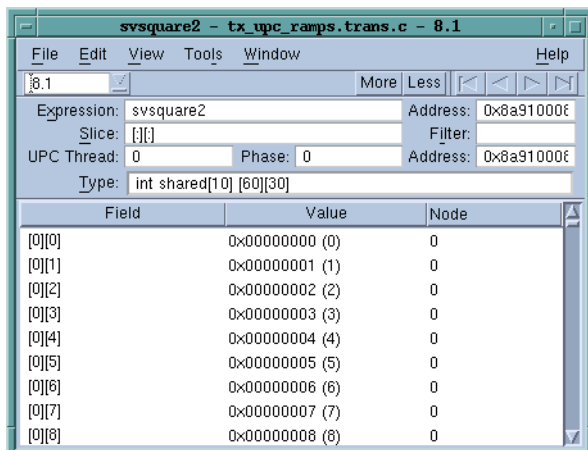
Figure 242 – A Sliced UPC Array



In this figure, TotalView displays the value of a pointer-to-shared variable whose target is the array in the **Shared Address** area. As usual, the address in the process appears in the top left of the display.

Since the array is shared, it has an additional property: the element's affinity. You can display this information if you right-click your mouse on the header and tell TotalView to display Nodes.

Figure 243 – UPC Variable Window Showing Nodes

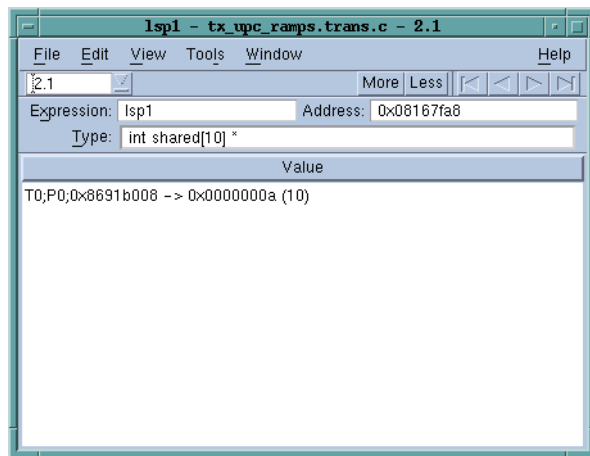


You can also use the **Tools > Visualize Distribution** command to visualize this array. For more information on visualization, see “[Array Visualizer](#)” on page 309.

Displaying Pointer to Shared Variables

TotalView understands pointer-to-shared data and displays the components of the data, as well as the target of the pointer to shared variables. For example, [Figure 244](#) shows this data being displayed:

Figure 244 – A Pointer to a Shared Variable



In this figure, notice the following:

- Because the **Type** field displays the full type name, this is a pointer to a shared **int** with a block size of 10.
- TotalView also displays the **upc_threadof ("T0")**, the **upc_phaseof ("P0")**, and the **upc_addrfield (0x0x10010ec4)** components of this variable.

In the same way that TotalView normally shows the target of a pointer variable, it also shows the target of a UPC pointer variable. When dereferencing a UPC pointer, TotalView fetches the target of the pointer from the UPC thread with which the pointer has affinity.

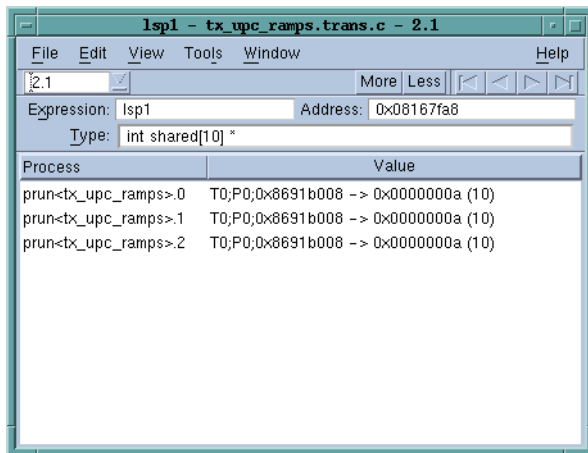
You can update the pointer by selecting the pointer value and editing the thread, phase, or address values. If the phase is corrupt, you'll see something like the following in the **Value** area:

```
T0;P6;0x3ffc0003b00 <Bad phase [max 4]> ->
                                0xc0003c80 (-1073726336)
```

In this example, the pointer is invalid because the phase is outside the legal range. TotalView displays a similar message if the thread is invalid.

Since the pointer itself is not shared, you can use the **TView > Show Across** commands to display the value from each of the UPC threads.

Figure 245 – Pointer to a Shared Variable



Debugging CoArray Fortran (CAF) Programs

TotalView has partial support for debugging CoArray Fortran (CAF) programs on Cray platforms. This section discusses the parts of TotalView that support CAF-specific features. CoArray Fortran allows a programmer to distribute parts of an array over a set of processes using an augmented Fortran array syntax. The processes in a CAF job share the same executable. The processes are assigned "image ids" starting at image one.

NOTE >> When debugging CAF code, TotalView requires help from a CAF assistant library that your compiler vendor provides. You need to include the location of this library in your LD_LIBRARY_PATH environment variable. TotalView also provides assistants that you can use.

Because currently TotalView support is partial, expressions that attempt to re-cast CAF types or change the visible slices of CAF types are likely to fail.

Invoking TotalView

CAF programs commonly rely on an underlying parallel protocol such as MPI. They are started the same way as other programs using the same parallel technology.

On Cray machines that use `aprun`, invoking a four-image job on TotalView may look like this:

```
totalview aprun -a -n 4 caf_program caf_program_args
```

Viewing CAF Programs

For a CAF program, the process id in the TotalView process window shows the CAF image id. TotalView shows the correct dimensions and co-dimensions of arrays and the co-dimensions of scalars.

When diving on a CAF array or scalar, TotalView shows the data local to the current image. Diving across processes shows the entire distributed array.

Figure 246 – Diving on CAF array y

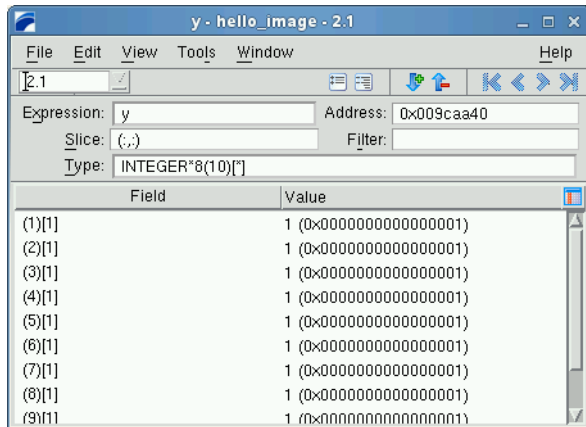
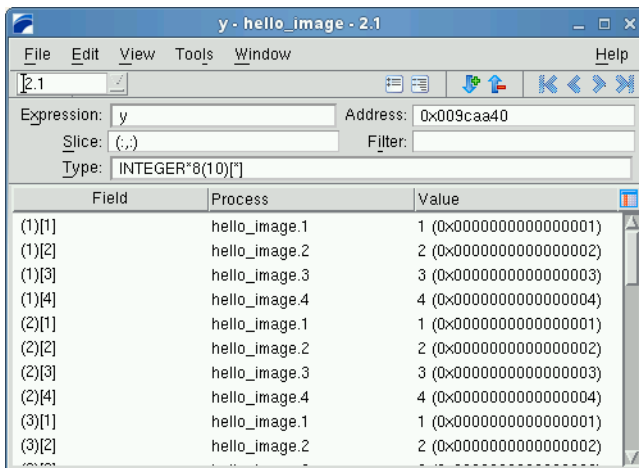


Figure 247 – Diving on CAF array y across processes



If you use the **array viewer**, **statistics**, and **visualizer** commands from the Tools menu when viewing a CAF array across processes, the commands treat the co-array dimensions much like standard array dimensions.

Using CLI with CAF

The **dprint** command in the CLI displays the data in CAF arrays in a similar way to the above. When the focus is a process, **dprint** lists the local values. When the focus is the shared group containing the CAF images, **dprint** lists the entire co-array.



Chapter 21

Group, Process, and Thread Control

The specifics of how multi-process, multi-threaded programs execute differ greatly from platform to platform and environment to environment, but all share some general characteristics. This chapter discusses the TotalView process/thread model. It also describes how you tell the GUI and the CLI what processes and threads to direct a command to.

This chapter contains the following sections:

- [“Defining the GOI, POI, and TOI”](#) on page 514
- [“Recap on Setting a Breakpoint”](#) on page 515
- [“Stepping \(Part I\)”](#) on page 516
- [“Setting Process and Thread Focus”](#) on page 520
- [“Setting Group Focus”](#) on page 526
- [“Stepping \(Part II\): Examples”](#) on page 538
- [“Using P/T Set Operators”](#) on page 540
- [“Creating Custom Groups”](#) on page 542

Defining the GOI, POI, and TOI

This chapter consistently uses the following three related acronyms:

- GOI—Group of Interest
- POI—Process of Interest
- TOI—Thread of Interest

These terms are important in the TotalView process/thread model because TotalView must determine the scope of what it does when it executes a command. For example, [Chapter 13, “About Groups, Processes, and Threads”](#) introduced the types of groups TotalView defines. That chapter ignored what happens when you execute a TotalView command on a group. For example, what does “stepping a group” actually mean? What happens to processes and threads that aren't in this group?

Associated with these three terms is a fourth term: *arena*. The *arena* is the collection of processes, threads, and groups that are affected by a debugging command. This collection is called an *arena list*.

In the GUI, the arena is most often set using the pulldown list in the toolbar. You can also set the arena using commands in the menubar. For example, there are eight *next* commands. The difference between them is the arena; that is, the difference between the *next* commands is the processes and threads that are the target of what the *next* command runs.

When TotalView executes any action command, the arena decides the scope of what can run. It doesn't, however, determine what does run. Depending on the command, TotalView determines the TOI, POI, or GOI, and then executes the command's action on that thread, process, or group. For example, suppose TotalView steps the current **control group**:

- TotalView needs to know what the TOI is so that it can determine what threads are in the **lockstep group**—TotalView only lets you step a lockstep group.
- The lockstep group is part of a share group.
- This share group in turn is part of a **control group**.

By knowing what the TOI is, the GUI also knows what the GOI is. This is important because, while TotalView knows what it will step (the threads in the lockstep group), it also knows what it will allow to run freely while it is stepping these threads. In the CLI, the P/T set determines the TOI.

RELATED TOPICS

Concept information on threads and processes and [“About Groups, Processes, and Threads”](#) on page 349
how TotalView organizes them into groups

Selecting a focus [“Using the Toolbar to Select a Target”](#) on page 377

Recap on Setting a Breakpoint

You can set breakpoints in your program by selecting the boxed line numbers in the Source Code pane of a Process window. A boxed line number indicates that the line generates executable code. A **STOP** icon masking a line number indicates that a breakpoint is set on the line. Selecting the **STOP** icon clears the breakpoint.

When a program reaches a breakpoint, it stops. You can let the program resume execution in any of the following ways:

- Use the single-step commands described in [“Using Stepping Commands”](#) on page 166.
- Use the set program counter command to resume program execution at a specific source line, machine instruction, or absolute hexadecimal value. See [“Setting the Program Counter”](#) on page 173.
- Set breakpoints at lines you choose, and let your program execute to that breakpoint. See [“Setting Breakpoints and Barriers”](#) on page 179.
- Set conditional breakpoints that cause a program to stop after it evaluates a condition that you define, for example, “stop when a value is less than eight.” See [“Setting Eval Points”](#) on page 198.

TotalView provides additional features for working with breakpoints, process barrier breakpoints, and eval points. For more information, see [Chapter 8, “Setting Action Points,”](#) on page 174.

Stepping (Part I)

You can use TotalView stepping commands to:

- Execute one source line or machine instruction at a time; for example, **Process > Step** in the GUI and **dstep** in the CLI.

```
CLI: dstep
```

- Run to a selected line, which acts like a temporary breakpoint; for example, **Process > Run To**.

```
CLI: duntil
```

- Run until a function call returns; for example, **Process > Out**.

```
CLI: dout
```

In all cases, stepping commands operate on the Thread of Interest (TOI). In the GUI, the TOI is the selected thread in the current Process Window. In the CLI, the TOI is the thread that TotalView uses to determine the scope of the stepping operation.

On all platforms except SPARC Solaris, TotalView uses *smart* single-stepping to speed up stepping of one-line statements that contain loops and conditions, such as Fortran 90 array assignment statements. *Smart stepping* occurs when TotalView realizes that it doesn't need to step through an instruction. For example, assume that you have the following statements:

```
integer iarray (1000,1000,1000)
iarray = 0
```

These two statements define one billion scalar assignments. If your computer steps every instruction, you will probably never get past this statement. *Smart stepping* means that TotalView single-steps through the assignment statement at a speed that is very close to your computer's native speed.

Other topics in this section are:

- [“Understanding Group Widths”](#) on page 517
- [“Understanding Process Width”](#) on page 517
- [“Understanding Thread Width”](#) on page 517
- [“Using Run To and duntil Commands”](#) on page 518

RELATED TOPICS

Stepping through your program [“Using Stepping Commands”](#) on page 166

Stepping examples [“Stepping \(Part II\): Examples”](#) on page 538

Understanding Group Widths

TotalView behavior when stepping at group width depends on whether the Group of Interest (GOI) is a process group or a thread group. In the following lists, *goal* means the place at which things should stop executing. For example, if you selected a *step* command, the goal is the next line. If you selected a *run to* command, the goal is the selected line.

The actions that TotalView performs on the GOI are dependent on the type of process group that is the focus, as follows:

- *Process group*—TotalView examines the group, and identifies which of its processes has a thread stopped at the same location as the TOI (a *matching* process). TotalView runs these matching processes until one of its threads arrives at the goal. When this happens, TotalView stops the thread's process. The command finishes when it has stopped all of these *matching* processes.
- *Thread group*—TotalView runs all processes in the **control group**. However, as each thread arrives at the goal, TotalView only stops that thread; the rest of the threads in the same process continue executing. The command finishes when all threads in the GOI arrive at the goal. When the command finishes, TotalView stops all processes in the control group.

TotalView doesn't wait for threads that are not in the same share group as the TOI, since they are executing different code and can never arrive at the goal.

Understanding Process Width

TotalView behavior when stepping at process width (which is the default) depends on whether the Group of Interest (GOI) is a process group or a thread group.

The actions that TotalView performs on the GOI are dependent on the type of process group that is the focus, as follows:

- *Process group*—TotalView runs all threads in the process, and execution continues until the TOI arrives at its goal, which can be the next statement, the next instruction, and so on. Only when the TOI reaches the goal does TotalView stop the other threads in the process.
- *Thread group*—TotalView lets all threads in the GOI and all manager threads run. As each member of the GOI arrives at the goal, TotalView stops it; the rest of the threads continue executing. The command finishes when all members of the GOI arrive at the goal. At that point, TotalView stops the whole process.

Understanding Thread Width

When TotalView performs a stepping command, it decides what it steps based on the *width*. Using the toolbar, you specify width using the left-most pulldown. This pulldown has three items: **Group**, **Process**, and **Thread**.

Stepping at thread width tells TotalView to only run that thread. It does not step other threads. In contrast, process width tells TotalView to run all threads in the process that are allowed to run while the TOI is stepped. While TotalView is stepping the thread, manager threads run freely.

Stepping a thread isn't the same as stepping a thread's process, because a process can have more than one thread.

NOTE >> Thread-stepping is not implemented on Sun platforms. On SGI platforms, thread-stepping is not available with pthread programs. If, however, your program's parallelism is based on SGI's sprocs, thread-stepping is available.

Thread-level single-step operations can fail to complete if the TOI needs to synchronize with a thread that isn't running. For example, if the TOI requires a lock that another held thread owns, and steps over a call that tries to acquire the lock, the primary thread can't continue successfully. You must allow the other thread to run in order to release the lock. In this case, you should use process-width stepping instead.

Using Run To and duntil Commands

The **duntil** and **Run To** commands differ from other step commands when you apply them to a process group. (These commands tell TotalView to execute program statements *until* it reaches the selected statement.) When used with a process group, TotalView identifies all processes in the group that already have a thread stopped at the goal. These are the *matching* processes. TotalView then runs only nonmatching processes. Whenever a thread arrives at the goal, TotalView stops its process. The command finishes when it has stopped all members of the group. This lets you synchronize all the processes in a group in preparation for group-stepping them.

You need to know the following if you're running at process width:

- | | |
|---------------|---|
| Process group | If the Thread of Interest (TOI) is already at the goal location, TotalView steps the TOI past the line before the process runs. This lets you use the Run To command repeatedly in loops. |
| Thread group | If any thread in the process is already at the goal, TotalView temporarily holds it while other threads in the process run. After all threads in the thread group reach the goal, TotalView stops the process. This lets you synchronize the threads in the POI at a source line. |

If you're running at group width:

- | | |
|---------------|--|
| Process group | TotalView examines each process in the process and share group to determine whether at least one thread is already at the goal. If a thread is at the goal, TotalView holds its process. Other processes are allowed to run. When at least one thread from each of these processes is held, the command completes. This lets you synchronize at least one thread in each of these processes at a source line. If you're running a control group, this synchronizes all processes in the share group. |
|---------------|--|

Thread group TotalView examines all the threads in the thread group that are in the same share group as the TOI to determine whether a thread is already at the goal. If it is, TotalView holds it. Other threads are allowed to run. When all of the threads in the TOI's share group reach the goal, TotalView stops the TOI's *control* group and the command completes. This lets you synchronize thread group members. If you're running a **workers group**, this synchronizes all worker threads in the share group.

The process stops when the TOI and at least one thread from each process in the group or process being run reach the command stopping point. This lets you synchronize a group of processes and bring them to one location.

You can also run to a selected line in a nested stack **frame**, as follows:

1. Select a nested frame in the Stack Trace Pane.
2. Select a source line or instruction in the function.
3. Enter a **Run To** command.

TotalView executes the primary thread until it reaches the selected line in the selected stack frame.

RELATED TOPICS

Stepping commands	"Using Stepping Commands" on page 166
Running to a specific line	"Executing to a Selected Line" on page 169
The duntil command	duntil in "CLI Commands" in the <i>TotalView for HPC Reference Guide</i>
The Group > Run To command	Group > Run To in the in-product Help
The Process > Run To command	Process > Run To in the in-product Help
The Thread > Run To command	Thread > Run To in the in-product Help

Setting Process and Thread Focus

NOTE >> The previous sections emphasize the GUI; this section and the ones that follow emphasize the CLI. Here you will find information on how to have full [asynchronous](#) debugging control over your program. Fortunately, having this level of control is seldom necessary. In other words, don't read the rest of this chapter unless you have to.

When TotalView executes a command, it must decide which processes and threads to act on. Most commands have a default set of threads and processes and, in most cases, you won't want to change the default. In the GUI, the default is the process and thread in the current Process Window. In the CLI, this default is indicated by the focus, which is shown in the CLI prompt.

There are times, however, when you need to change this default. This section begins a rather intensive look at how you tell TotalView what processes and threads to use as the target of a command.

Topics in this section are:

- [“Understanding Process/Thread Sets”](#) on page 520
- [“Specifying Arenas”](#) on page 521
- [“Specifying Processes and Threads”](#) on page 522

Understanding Process/Thread Sets

All TotalView commands operate on a set of processes and threads. This set is called a *Process/Thread (P/T) set*. The right-hand text box in windows that contain P/T set controls lets you construct these sets. In the CLI, you specify a P/T set as an argument to a command such as **dfocus**. If you're using the GUI, TotalView creates this list for you based on which Process Window has focus.

Unlike a serial debugger in which each command clearly applies to the only executing thread, TotalView can control and monitor many threads with their PCs at many different locations. The P/T set indicates the groups, processes, and threads that are the target of the CLI command. No limitation exists on the number of groups, processes, and threads in a set.

A P/T set is a list that contains one or more P/T identifiers. (The next section, [“Specifying Arenas”](#) on page 521, explains what a P/T identifier is.) Tcl lets you create lists in the following ways:

- You can enter these identifiers within braces (**{ }**).
- You can use Tcl commands that create and manipulate lists.

These lists are then used as arguments to a command. If you're entering one element, you usually do not have to use the Tcl list syntax.

For example, the following list contains specifiers for process 2, thread 1, and process 3, thread 2:

```
{p2.1 p3.2}
```

If you do not explicitly specify a P/T set in the CLI, TotalView defines a target set for you. (In the GUI, the default set is determined by the current Process Window.) This set is displayed as the default CLI prompt. (For information on this prompt, see [“About the CLI Prompt”](#) on page 426.)

You can change the focus on which a command acts by using the **dfocus** command. If the CLI executes the **dfocus** command as a unique command, it changes the default P/T set. For example, if the default focus is process 1, the following command changes the default focus to process 2:

```
dfocus p2
```

After TotalView executes this command, all commands that follow focus on process 2.

NOTE >> In the GUI, you set the focus by displaying a Process Window that contains this process. Do this by either using the P+, Px and P- buttons in the tab bar at the bottom, by making a selection in the Processes/Ranks Tab, or by clicking on a process in the Root Window. Note that the **Px** button launches a dialog box that enables you to enter a specific Process or Thread to focus on.

If you begin a command with **dfocus**, TotalView changes the target only for the command that follows. After the command executes, TotalView restores the *former* default. The following example shows both of these ways to use the **dfocus** command. Assume that the current focus is process 1, thread 1. The following commands change the default focus to group 2 and then step the threads in this group twice:

```
dfocus g2
dstep
dstep
```

In contrast, if the current focus is process 1, thread 1, the following commands step group 2 and then step process 1, thread 1:

```
dfocus g2 dstep
dstep
```

Some commands only operate at the process level; that is, you cannot apply them to a single thread (or group of threads) in the process, but must apply them to all or to none.

Specifying Arenas

A P/T identifier often indicates a number of groups, processes, and threads. For example, assume that two threads executing in process 2 are stopped at the same statement. This means that TotalView places the two stopped threads into **lockstep groups**. If the default focus is process 2, stepping this process actually steps both of these threads.

TotalView uses the term *arena* to define the processes and threads that are the target of an action. In this case, the arena has two threads. Many CLI commands can act on one or more arenas. For example, the following command has two arenas:

```
dfocus {p1 p2}
```

The two arenas are process 1 and process 2.

When there is an arena list, each arena in the list has its own GOI, POI, and TOI.

Specifying Processes and Threads

The previous sections described P/T sets as being lists; however, these discussions ignored what the individual elements of the list are. A better definition is that a P/T set is a list of arenas, where an *arena* consists of the processes, threads, and groups that are affected by a debugging command. Each *arena specifier* describes a single arena in which a command acts; the *list* is just a collection of arenas. Most commands iterate over the list, acting individually on an arena. Some CLI output commands, however, combine arenas and act on them as a single target.

An arena specifier includes a *width* and a TOI. (Widths are discussed later in this section.) In the P/T set, the TOI specifies a target thread, while the width specifies how many threads surrounding the thread of interest are affected.

Defining the Thread of Interest (TOI)

The TOI is specified as **p.t**, where **p** is the TotalView process ID (PID) and **t** is the TotalView thread ID (TID). The **p.t** combination identifies the POI (Process of Interest) and TOI. The TOI is the primary thread affected by a command. This means that it is the primary focus for a TotalView command. For example, while the **dstep** command always steps the TOI, it may also run the rest of the threads in the POI and step other processes in the group.

In addition to using numerical values, you can also use two special symbols:

- The less-than character (<) indicates the *lowest numbered worker thread* in a process, and is used instead of the TID value. If, however, the arena explicitly names a thread group, the < symbol means the lowest numbered member of the thread group. This symbol lets TotalView select the first user thread, which is not necessarily thread 1.
- A dot (.) indicates the current set. Although you seldom use this symbol interactively, it can be useful in scripts.

About Process and Thread Widths

You can enter a P/T set in two ways. If you're not manipulating groups, the format is as follows:

```
[width_letter][pid][.tid]
```

NOTE >> [“Specifying Groups in P/T Sets”](#) on page 527 extends this format to include groups. When using P/T sets, you can create sets with just width indicators or just group indicators, or both.

For example, **p2.3** indicates process 2, thread 3.

Although the syntax seems to indicate that you do not need to enter any element, TotalView requires that you enter at least one. Because TotalView tries to determine what it can do based on what you type, it tries to fill in what you omit. The only requirement is that when you use more than one element, you use them in the order shown here.

You can leave out parts of the P/T set if what you do enter is unambiguous. A missing width or PID is filled in from the current focus. A missing TID is always assumed to be <. For more information, see [“Naming Incomplete Arenas”](#) on page 536.

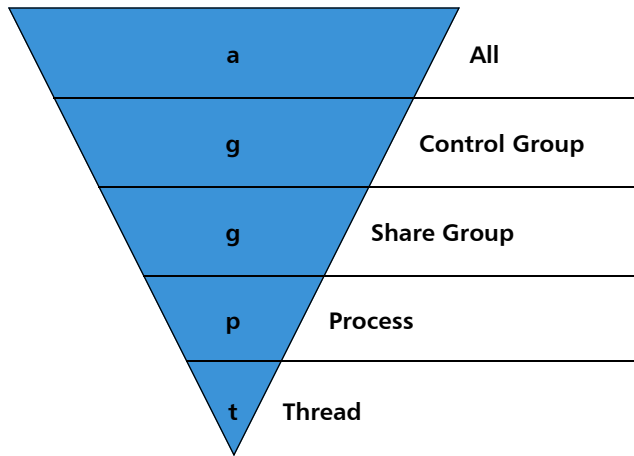
The *width_letter* indicates which processes and threads are part of the arena. You can use the following letters:

- | | | |
|----------|----------------------|--|
| t | <i>Thread width</i> | A command's target is the indicated thread. |
| p | <i>Process width</i> | A command's target is the process that contains the TOI. |
| g | <i>Group width</i> | A command's target is the group that contains the POI. This indicates control and share groups. |
| a | <i>All processes</i> | A command's target is all threads in the GOI that are in the POI. |
| d | <i>Default width</i> | A command's target depends on the default for each command. This is also the width to which the default focus is set. For example, the dstep command defaults to process width (run the process while stepping one thread), and the dwhere command defaults to thread width. |

You must use lowercase letters to enter these widths.

Figure 248 The following figure illustrates how these specifiers relate to one another.

Figure 248 – Width Specifiers



The **g** specifier indicates control and share groups. This inverted triangle indicates that the arena focuses on a greater number of entities as you move from **Thread** level at the bottom to **All** level at the top.

As mentioned previously, the TOI specifies a target thread, while the width specifies how many threads surrounding the TOI are also affected. For example, the **dstep** command always requires a TOI, but entering this command can do the following:

- Step just the TOI during the step operation (thread-level single-step).
- Step the TOI and step all threads in the process that contain the TOI (process-level single-step).
- Step all processes in the group that have threads at the same PC as the TOI (group-level single-step).

This list doesn't indicate what happens to other threads in your program when TotalView steps your thread. For more information, see "[Stepping \(Part II\): Examples](#)" on page 538.

To save a P/T set definition for later use, assign the specifiers to a Tcl variable; for example:

```
set myset {g2.3 t3.1}
dfocus $myset dgo
```

As the **dfocus** command returns its focus set, you can save this value for later use; for example:

```
set save_set [dfocus]
```

Specifier Examples

The following are some sample specifiers:

g2.3 Select process 2, thread 3, and set the width to *group*.

t1.7

Commands act only on thread 7 or process 1.

d1.<

Use the default set for each command, focusing on the first user thread in process 1. The less-than symbol (<) sets the TID to the first user thread.

Setting Group Focus

TotalView has two types of groups: process groups and thread groups. Process groups only contain processes, and thread groups only contain threads. The threads in a thread group can be drawn from more than one process.

Topics in this section are:

- [“Specifying Groups in P/T Sets”](#) on page 527
- [“About Arena Specifier Combinations”](#) on page 528
- [“‘All’ Does Not Always Mean ‘All’”](#) on page 531
- [“Setting Groups”](#) on page 532
- [“Using the g Specifier: An Extended Example”](#) on page 533
- [“Merging Focuses”](#) on page 535
- [“Naming Incomplete Arenas”](#) on page 536
- [“Naming Lists with Inconsistent Widths”](#) on page 537

For a general discussion on how TotalView organizes threads and processes into groups, see [“About Groups, Processes, and Threads”](#) on page 349.

TotalView has four predefined groups. Two of these only contain processes, while the other two only contain threads. TotalView also lets you create your own groups, and these groups can have elements that are processes and threads. The following are the predefined process groups:

- **Control Group**
Contains the parent process and all related processes. A control group includes children that were forked (processes that share the same source code as the parent) and children that were forked but subsequently called the **execve()** function.
Assigning a new value to the **CGROUP (dpid)** variable for a process changes that process's control group. In addition, the **dgroups -add** command lets you add members to a group in the CLI. In the GUI, you use the **Group > Custom Groups** command.
- **Share Group**
Contains all members of a **control group** that share the same executable. TotalView automatically places processes in share groups based on their control group and their executable.

NOTE >> You can't change a share group's members. However, the dynamically loaded libraries used by group members can be different.

In general, if you're debugging a multi-process program, the control group and share group differ only when the program has children that it forked by calling the **execve()** function.

The following are the predefined thread groups:

- **Workers Group**

Contains all worker threads from all processes in the control group. The only threads not contained in a workers group are your operating system's manager threads.

- **Lockstep Group**

Contains every stopped thread in a share group that has the same PC. TotalView creates one lockstep group for every thread. For example, suppose two threads are stopped at the same PC. TotalView creates two lockstep groups. While each lockstep group has the same two members, they differ in that each has a different TOI. While there are some circumstances where this is important, you can usually ignore this distinction. That is, while two lockstep groups exist if two threads are stopped at the same PC, ignoring the second lockstep group is almost never harmful.

The group ID value for a lockstep group differs from the ID of other groups. Instead of having an automatic and transient integer ID, the lockstep group ID is **pid.tid**, where **pid.tid** identifies the thread with which it is associated. For example, the lockstep group for thread 2 in process 1 is **1.2**.

Specifying Groups in P/T Sets

This section extends the arena specifier syntax to include groups.

If you do not include a group specifier, the default is the **control group**. The CLI only displays a target group in the focus string if you set it to something other than the default value.

NOTE >> You most often use target group specifiers with the stepping commands, as they give these commands more control over what's being stepped.

Use the following format to add groups to an arena specifier:

[width_letter][group_indicator][pid][.tid]

This format adds the *group_indicator* to what was discussed in "[Specifying Processes and Threads](#)" on page 522.

In the description of this syntax, everything appears to be optional. But, while no single element is required, you must enter at least one element. TotalView determines other values based on the current focus.

TotalView lets you identify a group by using a letter, number, or name.

A Group Letter

You can name one of TotalView's predefined sets. Each set is identified by a letter. For example, the following command sets the focus to the workers group:

```
dfocus W
```

The following are the group letters. These letters are in uppercase:

C	<i>Control group</i> All processes in the control group.
D	<i>Default control group</i> All processes in the control group. The only difference between this specifier and the C specifier is that this letter tells the CLI not to display a group letter in the CLI prompt.
S	<i>Share group</i> The set of processes in the control group that have the same executable as the arena's TOI.
W	<i>Workers group</i> The set of all worker threads in the control group.
L	<i>Lockstep group</i> A set that contains all threads in the share group that have the same PC as the arena's TOI. If you step these threads as a group, they proceed in lockstep.

A Group Number

You can identify a group by the number TotalView assigns to it. The following example sets the focus to group 3:

```
dfocus 3/
```

The trailing slash tells TotalView that you are specifying a group number instead of a PID. The slash character is optional if you're using a *group_letter*. However, you must use it as a separator when entering a numeric group ID and a **pid.tid** pair. For example, the following example identifies process 2 in group 3:

```
p3/2
```

A Group Name

You can name a set that you define. You enter this name with slashes. The following example sets the focus to the set of threads contained in process 3 that are also contained in a group called **my_group**:

```
dfocus p/my_group/3
```

About Arena Specifier Combinations

The following table lists what's selected when you use arena and group specifiers to step your program:

Specifier	Specifies
aC	All threads.
aS	All threads.
aW	All threads in all workers groups.
aL	All threads. Every thread is a member of a control group and a member of a share group and a member of a lockstep group. Consequently, three of these definitions mean "all threads."
gC	All threads in the Thread of Interest (TOI) control group.
gS	All threads in the TOI share group.
gW	All worker threads in the control group that contains the TOI.
gL	All threads in the same share group within the process that contains the TOI that have the same PC as the TOI.
pC	All threads in the control group of the Process of Interest (POI). This is the same as gC .
pS	All threads in the process that participate in the same share group as the TOI.
pW	All worker threads in the POI.
pL	All threads in the POI whose PC is the same as the TOI.
tC	Just the TOI. The t specifier overrides the group specifier, so all of
tS	these specifiers resolve to the current thread.
tW	
tL	

NOTE >> Stepping commands behave differently if the group being stepped is a process group rather than a thread group. For example, **aC** and **aS** perform the same action, but **aL** is different.

If you don't add a PID or TID to your arena specifier, TotalView does it for you, taking the PID and TID from the current or default focus.

The following are some additional examples. These examples add PIDs and TIDs numbers to the raw specifier combinations listed in the previous table:

pW3 All worker threads in process 3.

pW3.< All worker threads in process 3. The focus of this specifier is the same as the focus in the previous example.

gW3	All worker threads in the control group that contains process 3. The difference between this and pW3 is that pW3 restricts the focus to just one of the processes in the control group.
gL3.2	All threads in the same <i>share</i> group as process 3 that are executing at the same PC as thread 2 in process 3. The reason this is a share group and not a control group is that different share groups can reside only in one control group.
/3	Specifies processes and threads in process 3. The arena width, POI, and TOI are inherited from the existing P/T set, so the exact meaning of this specifier depends on the previous context. While the slash is unnecessary because no group is indicated, it is syntactically correct.
g3.2/3	The 3.2 group ID is the name of the lockstep group for thread 3.2. This group includes all threads in the process 3 share group that are executing at the same PC as thread 2.
p3/3	Sets the process to process 3. The Group of Interest (GOI) is set to group 3. If group 3 is a process group, most commands ignore the group setting. If group 3 is a thread group, most commands act on all threads in process 3 that are also in group 3. When you set the process using an explicit group, you might not be including all the threads you expect to be included. This is because commands must look at the TOI, POI, and GOI.

NOTE >> It is redundant to specify a thread width with an explicit group ID as this width means that the focus is on one thread.

In the following examples, the first argument to the **dfocus** command defines a temporary P/T set that the CLI command (the last term) operates on. The **dstatus** command lists information about processes and threads. These examples assume that the global focus was **d1.<** initially.

dfocus g dstatus

Displays the status of all threads in the control group.

dfocus gW dstatus

Displays the status of all worker threads in the control group.

dfocus p dstatus

Displays the status of all worker threads in the current focus process. The width here, as in the previous example, is process, and the (default) group is the control group. The intersection of this width and the default group creates a focus that is the same as in the previous example.

dfocus pW dstatus

Displays the status of all worker threads in the current focus process. The width is process level, and the target is the workers group.

The following example shows how the prompt changes as you change the focus. In particular, notice how the prompt changes when you use the **C** and the **D** group specifiers.

```
d1.<> f C
dC1.<
dC1.<> f D
```

```
d1.<
d1.<>
```

Two of these lines end with the less-than symbol (<). These lines are not prompts. Instead, they are the value returned by TotalView when it executes the **dfocus** command.

'All' Does Not Always Mean 'All'

When you use stepping commands, TotalView determines the scope of what runs and what stops by looking at the TOI. This section looks at the differences in behavior when you use the **a** (all) arena specifier. The following table describes what runs when you use this arena:

Specifier	Specifies
aC	All threads.
aS	All threads.
aW	All threads in all workers groups.
aL	All threads. Every thread is a member of a control group and a member of a share group and a member of a lockstep group. Consequently, three of these definitions mean "all threads."

The following are some combinations:

- f aC dgo** Runs everything. If you're using the **dgo** command, everything after the **a** is ignored: **a/aPizza/17.2, ac, aS,** and **aL** do the same thing. TotalView runs everything.
- f aC duntil** While everything runs, TotalView must wait until something reaches a goal. It really isn't obvious what this focus is. Since **C** is a process group, you might guess that all processes run until at least one thread in every participating process arrives at a goal. The reality is that since this goal must reside in the current share group, this command completes as soon as all processes in the TOI share group have at least one thread at the goal. Processes in other control groups run freely until this happens.
The TOI determines the goal. If there are other control groups, they do not participate in the goal.
- f aS duntil** This command does the same thing as the **f aC duntil** command because the goals for **f aC duntil** and **f aS duntil** are the same, and the processes that are in this scope are identical.
Although more than one share group can exist in a control group, these other share groups do not participate in the goal.
- f aL duntil** Although everything will run, it is not clear what should occur. **L** is a thread group, so you might expect that the **duntil** command will wait until all threads in all lockstep groups arrive at the goal. Instead, TotalView defines the set of threads that it allows to run to a goal as just those

threads in the TOI's lockstep group. Although there are other lockstep groups, these lockstep groups do not participate in the goal. So, while the TOI's lockstep threads are progressing towards their goal, all threads that were previously stopped run freely.

f aW duntil Everything runs. TotalView waits until all members of the TOI workers group arrive at the goal.

Two broad distinctions between process and thread group behavior exist:

- When the focus is on a process group, TotalView waits until just one thread from each participating process arrives at the goal. The other threads just run.
When focus is on a thread group, every participating thread must arrive at the goal.
- When the focus is on a process group, TotalView steps a thread over the goal breakpoint and continues the process if it isn't the right thread.
When the focus is on a thread group, TotalView holds a thread even if it isn't the right thread. It also continues the rest of the process.
If your system does not support **asynchronous** thread control, TotalView treats thread specifiers as if they were process specifiers.

With this in mind, **f aL dstep** does not step all threads. Instead, it steps only the threads in the TOI's lockstep group. All other threads run freely until the stepping process for these lockstep threads completes.

Setting Groups

This section presents a series of examples that set and create groups.

You can use the following methods to indicate that thread 3 in process 2 is a worker thread:

```
dset WGROUP(2.3) $WGROUP(2)
```

Assigns the group ID of the thread group of worker threads associated with process 2 to the **WGROUP** variable. (Assigning a nonzero value to **WGROUP** indicates that this is a worker group.)

```
dset WGROUP(2.3) 1
```

This is a simpler way of doing the same thing as the previous example.

```
dfocus 2.3 dworker 1
```

Adds the groups in the indicated focus to a workers group.

```
dset CGROUP(2) $CGROUP(1)  
dgroups -add -g $CGROUP(1) 2  
dfocus 1 dgroups -add 2
```

These three commands insert process 2 into the same control group as process 1.

```
dgroups -add -g $WGROUP(2) 2.3
```

Adds process 2, thread 3 to the workers group associated with process 2.

```
dfocus tW2.3 dgroups -add
```

This is a simpler way of doing the same thing as the previous example.

Following are some additional examples:

```
dfocus g1 dgroups -add -new thread
```

Creates a new thread group that contains all the threads in all the processes in the control group associated with process 1.

```
set mygroup [dgroups -add -new thread $GROUP($SGROUP(2))]  
dgroups -remove -g $mygroup 2.3  
dfocus g$mygroup/2 dgo
```

The first command creates a new group that contains all the threads from the process 2 share group; the second removes thread 2.3; and the third runs the remaining threads.

RELATED TOPICS

The **dfocus** command **dfocus** in "CLI Commands" in the *TotalView for HPC Reference Guide*

The **dgroup** command **dgroup** in "CLI Commands" in the *TotalView for HPC Reference Guide*

The **dset** command **dset** in "CLI Commands" in the *TotalView for HPC Reference Guide*

Using the g Specifier: An Extended Example

The meaning of the **g** width specifier is sometimes not clear when it is coupled with a group scope specifier. Why have a **g** specifier when you have four other group specifiers? Stated in another way, isn't something like **gL** redundant?

The simplest answer, and the reason you most often use the **g** specifier, is that it forces the group when the default focus indicates something different from what you want it to be.

The following example shows this. The first step sets a breakpoint in a multi-threaded OMP program and executes the program until it hits the breakpoint.

```
d1.<> dbreak 35  
Loaded OpenMP support library libguidedb_3_8.so :  
          KAP/Pro Toolset 3.8  
  
1  
d1.<> dcont  
Thread 1.1 has appeared  
Created process 1/37258, named "omp_prog"  
Thread 1.1 has exited  
Thread 1.1 has appeared  
Thread 1.2 has appeared  
Thread 1.3 has appeared  
Thread 1.1 hit breakpoint 1 at line 35 in ".breakpoint_here"
```


The default focus is **d1.<**, which means that the CLI is at its default width, the POI is 1, and the TOI is the lowest numbered nonmanager thread. Because the default width for the **dstatus** command is process, the CLI displays the status of all processes. Typing **dfocus p dstatus** produces the same output.

```
d1.<> dstatus
1:          37258  Breakpoint  [omp_prog]
  1.1: 37258.1 Breakpoint  PC=0x1000acd0,
        [./omp_prog.f#35]
  1.2: 37258.2 Stopped    PC=0xfffffffffffffffffff
  1.3: 37258.3 Stopped    PC=0xd042c944
d1.<> dfocus p dstatus
1:          37258  Breakpoint  [omp_prog]
  1.1: 37258.1 Breakpoint  PC=0x1000acd0,
        [./omp_prog.f#35]
  1.2: 37258.2 Stopped    PC=0xfffffffffffffffffff
  1.3: 37258.3 Stopped    PC=0xd042c944
```

The CLI displays the following when you ask for the status of the lockstep group. (The rest of this example uses the **f** abbreviation for **dfocus**, and **st** for **dstatus**.)

```
d1.<> f L st
1:          37258  Breakpoint  [omp_prog]
  1.1: 37258.1 Breakpoint  PC=0x1000acd0,
        [./omp_prog.f#35]
```

This command tells the CLI to display the status of the threads in thread, which is the 1.1 lockstep group since this thread is the TOI. The **f L focus** command narrows the set so that the display only includes the threads in the process that are at the same PC as the TOI.

NOTE >> By default, the **dstatus** command displays information at process width. This means that you don't need to type **f pL dstatus**.

The **duntil** command runs thread 1.3 to the same line as thread 1.1. The **dstatus** command then displays the status of all the threads in the process:

```
d1.<> f t1.3 duntil 35
35@>          write(*,*)"i= ",i,
               "thread= ",omp_get_thread_num()
d1.<> f p dstatus
1:          37258  Breakpoint  [omp_prog]
  1.1: 37258.1 Breakpoint  PC=0x1000acd0,
        [./omp_prog.f#35]
  1.2: 37258.2 Stopped    PC=0xfffffffffffffffffff
  1.3: 37258.3 Breakpoint  PC=0x1000acd0,
        [./omp_prog.f#35]
```

As expected, the CLI adds a thread to the lockstep group:

```
d1.<> f L dstatus
1:          37258  Breakpoint  [omp_prog]
```

```
1.1: 37258.1 Breakpoint PC=0x1000acd0,  
      [./omp_prog.f#35]  
1.3: 37258.3 Breakpoint PC=0x1000acd0,  
      [./omp_prog.f#35]
```

The next set of commands begins by narrowing the width of the default focus to thread width—notice that the prompt changes—and then displays the contents of the lockstep group:

```
d1.<> f t  
t1.<> f L dstatus  
1:      37258 Breakpoint [omp_prog]  
      1.1: 37258.1 Breakpoint PC=0x1000acd0,  
          [./omp_prog.f#35]
```

Although the lockstep group of the TOI has two threads, the current focus has only one thread, and that thread is, of course, part of the lockstep group. Consequently, the lockstep group *in the current focus* is just the one thread, even though this thread's lockstep group has two threads.

If you ask for a wider width (**p** or **g**) with **L**, the CLI displays more threads from the lockstep group of thread 1.1. as follows:

```
t1.<> f pL dstatus  
1:      37258 Breakpoint [omp_prog]  
      1.1: 37258.1 Breakpoint PC=0x1000acd0,  
          [./omp_prog.f#35]  
      1.3: 37258.3 Breakpoint PC=0x1000acd0,  
          [./omp_prog.f#35]  
  
t1.<> f gL dstatus  
1:      37258 Breakpoint [omp_prog]  
      1.1: 37258.1 Breakpoint PC=0x1000acd0,  
          [./omp_prog.f#35]  
      1.3: 37258.3 Breakpoint PC=0x1000acd0,  
          [./omp_prog.f#35]
```

NOTE >> If the TOI is 1.1, **L** refers to group number 1.1, which is the lockstep group of thread 1.1.

Because this example only contains one process, the **pL** and **gL** specifiers produce the same result when used with the **dstatus** command. If, however, there were additional processes in the group, you only see them when you use the **gL** specifier.

Merging Focuses

When you specify more than one focus for a command, the CLI merges them. In the following example, the focus indicated by the prompt—this focus is called the *outer* focus—controls the display. This example shows what happens when **dfocus** commands are strung together:

```
t1.<> f d  
d1.<
```

```

dl.<> f tL dstatus
1:      37258  Breakpoint  [omp_prog]
    1.1: 37258.1 Breakpoint  PC=0x1000acd0,
        [./omp_prog.f#35]
dl.<> f tL f p dstatus
1:      37258  Breakpoint  [omp_prog]
    1.1: 37258.1 Breakpoint  PC=0x1000acd0,
        [./omp_prog.f#35]
    1.3: 37258.3 Breakpoint  PC=0x1000acd0,
        [./omp_prog.f#35]
dl.<> f tL f p f D dstatus
1:      37258  Breakpoint  [omp_prog]
    1.1: 37258.1 Breakpoint  PC=0x1000acd0,
        [./omp_prog.f#35]
    1.2: 37258.2 Stopped     PC=0xfffffffffffffffffff
    1.3: 37258.3 Breakpoint  PC=0x1000acd0,
        [./omp_prog.f#35]
dl.<> f tL f p f D f L dstatus
1:      37258  Breakpoint  [omp_prog]
    1.1: 37258.1 Breakpoint  PC=0x1000acd0,
        [./omp_prog.f#35]
    1.3: 37258.3 Breakpoint  PC=0x1000acd0,
        [./omp_prog.f#35]

```

Stringing multiple focuses together might not produce the most readable result. In this case, it shows how one **dfocus** command can modify what another sees and acts on. The ultimate result is an arena that a command acts on. In these examples, the **dfocus** command tells the **dstatus** command what to display.

Naming Incomplete Arenas

In general, you do not need to completely specify an arena. TotalView provides values for any missing elements. TotalView either uses built-in default values or obtains them from the current focus. The following explains how TotalView fills in missing pieces:

- If you don't use a width, TotalView uses the width from the current focus.
- If you don't use a PID, TotalView uses the PID from the current focus.
- If you set the focus to a list, there is no longer a default arena. This means that you must explicitly name a width and a PID. You can, however, omit the TID. (If you omit the TID, TotalView defaults to the less-than symbol <.)

You can type a PID without typing a TID. If you omit the TID, TotalView uses the default <, where < indicates the lowest numbered worker thread in the process. If, however, the arena explicitly names a thread group, < means the lowest numbered member of the thread group.

TotalView does not use the TID from the current focus, since the TID is a process-relative value.

- A dot before or after the number specifies a process or a thread. For example, **1.** is clearly a PID, while **.7** is clearly a TID.

If you type a number without typing a dot, the CLI most often interprets the number as being a PID.

- If the width is **t**, you can omit the dot. For instance, **t7** refers to thread 7.
- If you enter a width and don't specify a PID or TID, TotalView uses the PID and TID from the current focus.

If you use a letter as a group specifier, TotalView obtains the rest of the arena specifier from the default focus.

- You can use a group ID or tag followed by a **/**. TotalView obtains the rest of the arena from the default focus.

Focus merging can also influence how TotalView fills in missing specifiers. For more information, see “[Merging Focuses](#)” on page 535.

Naming Lists with Inconsistent Widths

TotalView lets you create lists that contain more than one width specifier. This can be very useful, but it can be confusing. Consider the following:

```
{p2 t7 g3.4}
```

This list is quite explicit: all of process 2, thread 7, and all processes in the same group as process 3, thread 4. However, how should TotalView use this set of processes, groups, and threads?

In most cases, TotalView does what you would expect it to do: it iterates over the list and acts on each arena. If TotalView cannot interpret an inconsistent focus, it prints an error message.

Some commands work differently. Some use each arena's width to determine the number of threads on which it acts. This is exactly what the **dgo** command does. In contrast, the **dwhere** command creates a call graph for process-level arenas, and the **dstep** command runs all threads in the arena while stepping the TOI. TotalView may wait for threads in multiple processes for group-level arenas. The command description in the *TotalView for HPC Reference Guide* points out anything that you need to watch out for.

Stepping (Part II): Examples

The following are examples that use the CLI stepping commands:

- **Step a single thread**
While the thread runs, no other threads run (except kernel manager threads).
Example: `dfocus t dstep`
- **Step a single thread while the process runs**
A single thread runs into or through a critical region.
Example: `dfocus p dstep`
- **Step one thread in each process in the group**
While one thread in each process in the share group runs to a goal, the rest of the threads run freely.
Example: `dfocus g dstep`
- **Step all worker threads in the process while nonworker threads run**
Worker threads run through a parallel region in lockstep.
Example: `dfocus pW dstep`
- **Step all workers in the share group**
All processes in the share group participate. The nonworker threads run.
Example: `dfocus gW dstep`
- **Step all threads that are at the same PC as the TOI**
TotalView selects threads from one process or the entire share group. This differs from the previous two items in that TotalView uses the set of threads that are in lockstep with the TOI rather than using the workers group.
Example: `dfocus L dstep`

In the following examples, the default focus is set to **d1.<**

- | | |
|---------------------------|---|
| dstep | Steps the TOI while running all other threads in the process. |
| dfocus W dnext | Runs the TOI and all other worker threads in the process to the next statement. Other threads in the process run freely. |
| dfocus W duntil 37 | Runs all worker threads in the process to line 37. |
| dfocus L dnext | Runs the TOI and all other stopped threads at the same PC to the next statement. Other threads in the process run freely. Threads that encounter a temporary breakpoint in the course of running to the next statement usually join the lockstep group. |

dfocus gW duntil 37

Runs all worker threads in the share group to line 37. Other threads in the control group run freely.

UNW 37

Performs the same action as the previous command: runs all worker threads in the share group to line 37. This example uses the predefined **UNW** alias instead of the individual commands. That is, **UNW** is an alias for **dfocus gW duntil**.

SL

Finds all threads in the share group that are at the same PC as the TOI and steps them all in one statement. This command is the built-in alias for **dfocus gL dstep**.

sl

Finds all threads in the current process that are at the same PC as the TOI, and steps them all in one statement. This command is the built-in alias for **dfocus L dstep**.

RELATED TOPICS

Stepping through your program

["Using Stepping Commands"](#) on page 166

Stepping (Part 1)

["Stepping \(Part I\)"](#) on page 516

Using P/T Set Operators

At times, you do not want all of one type of group or process to be in the focus set. TotalView lets you use the following three operators to manage your P/T sets:

- | Creates a union; that is, all members of two sets.
- Creates a difference; that is, all members of the first set that are not also members of the second set.
- & Creates an intersection; that is, all members of the first set that are also members of the second set.

For example, the following creates a union of two P/T sets:

```
p3 | L2
```

You can, apply these operations repeatedly; for example:

```
p2 | p3 & L2
```

This statement creates an intersection between p3 and L2, and then creates a union between **p2** and the results of the intersection operation. You can directly specify the order by using parentheses; for example:

```
p2 | (p3 & pL2)
```

Typically, these three operators are used with the following P/T set functions:

- breakpoint(*ptset*)** Returns a list of all threads that are stopped at a breakpoint.
- comm(*process*, "*comm_name*")** Returns a list containing the first thread in each process associated within a communicator within the named process. While *process* is a P/T set it is not expanded into a list of threads.
- error(*ptset*)** Returns a list of all threads stopped due to an error.
- existent(*ptset*)** Returns a list of all threads.
- held(*ptset*)** Returns a list of all threads that are held.
- nonexistent(*ptset*)** Returns a list of all processes that have exited or which, while loaded, have not yet been created.
- running(*ptset*)** Returns a list of all running threads.
- stopped(*ptset*)** Returns a list of all stopped threads.
- unheld(*ptset*)** Returns a list of all threads that are not held.
- watchpoint(*ptset*)** Returns a list of all threads that are stopped at a watchpoint.

The way in which you specify the P/T set argument is the same as the way that you specify a P/T set for the **dfocus** command. For example, **watchpoint(L)** returns all threads in the current lockstep group. The only operator that differs is **comm**, whose argument is a process.

The dot operator (**.**), which indicates the current set, can be helpful when you are editing an existing set.

The following examples clarify how you use these operators and functions. The P/T set **a** (all) is the argument to these operators.

f {breakpoint(a) | watchpoint(a)} dstatus

Shows information about all threads that are stopped at breakpoints and watchpoints. The **a** argument is the standard P/T set indicator for **all**.

f {stopped(a) - breakpoint(a)} dstatus

Shows information about all stopped threads that are not stopped at breakpoints.

f {. | breakpoint(a)} dstatus

Shows information about all threads in the current set, as well as all threads stopped at a breakpoint.

f {g.3 - p6} duntil 577

Runs thread 3 along with all other processes in the group to line 577. However, it does not run anything in process 6.

f {(\$PTSET) & p123}

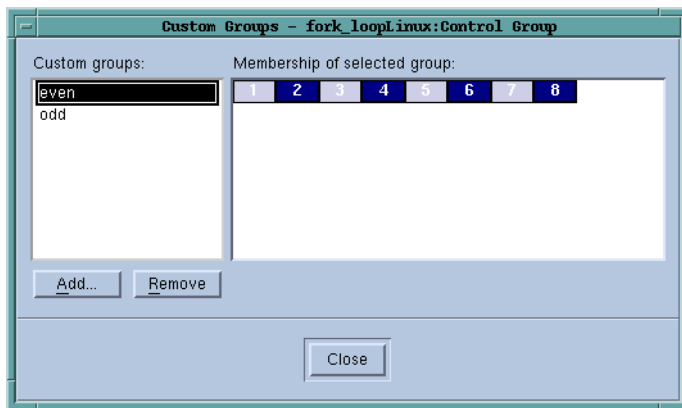
Uses just process 123 in the current P/T set.

Creating Custom Groups

Debugging a multi-process or multi-threaded program most often focuses on running the program in one of two ways: either you run everything or run one or two things. Figuring out what you should be running, however, is a substantial part of the art of debugging. You can make things easier on yourself if you divide your program into groups, and then control these groups separately. When you need to do this, use the **Groups > Custom Groups** Dialog Box. (See [Figure 249](#).) This dialog box also lets you alter a group's contents as well as delete the group.

NOTE >> You can manage only process groups with this dialog box. Thread groups can only be managed using the CLI. In addition, the groups you create must reside within one control group.

Figure 249 – Group > Custom Groups Dialog Box



When you first display this dialog box, TotalView also displays a second, used to enter the group's name.

The dialog's right side contains a set of boxes. Each represents one of your processes. The initial color represents the process's state. (This just helps you coordinate within the display in the Process Window's Processes/Ranks Tab.) You can now create a group using your mouse by clicking on blocks as follows:

- **Left-click on a box:** Selects a box. No other box is selected. If other boxes are selected, they are deselected.
- **Shift-left-click and drag:** select a group of contiguous boxes.
- **Control-left-click on a box:** Adds a box to the current selection.

Edit an existing group in the same way. After making the group active by clicking on its name on the left, click within the right to make changes. (In most cases, you'll be using a control-left-click.)

If you've changed a group and then select **Add** or **Close**, TotalView asks if you want to save the changed group.

If you click **Add** when a group is selected, TotalView creates a group with the same members as that group.

Finally, you can delete a group by selecting its name and clicking **Remove**.



Scalability in HPC Computing Environments

Overview

TotalView provides features and performance enhancements for scalable debugging in today's HPC computing environments, and no special configuration or action is necessary on your part to take advantage of TotalView's scalability abilities.

This chapter details TotalView's features and configurations related to scalability, as follows:

- **Root Window.** The Root Window aggregates program state so that it can display quickly and is easy to understand.
- **Scalability Configuration Settings.** Depending on your needs, you might want to set specific configuration variables that enable scalable debugging operations.
- **MRNet Configuration Settings.** TotalView uses MRNet, a tree-based overlay network, for scalable communication. TotalView is preconfigured for scalability, but in some situations you may want to change MRNet's configuration.
- **dstatus and dwhere command options.** These options provide aggregated views of various process and thread properties. (See the **-group_by** option in the Reference Guide entries for these commands.)
- **Compressed process/thread list.** The **ptlist** compactly displays the set of processes and threads that have been aggregated together.

RELATED TOPICS

Compressed List Syntax (**ptlist**)

“Compressed List Syntax (ptlist)” in the **dstatus** entry of the *Reference Guide*

the **Px** “Jump to Process/Thread” button

[Using the Processes/Ranks and Threads Tabs](#) on page 379

dstatus -group_by and **dwhere-group_by** options

dstatus and **dwhere** in the *Reference Guide*

Configuring TotalView for Scalability

To take advantage of TotalView's features that support better scalability, disable user-thread debugging. User thread debugging is an area of the debugger that has not yet been parallelized, and can therefore slow down job launch and attach time. However, disabling user thread debugging also disables support for displaying thread local storage (e.g., via the `__thread` compiler keyword. This limitation will be fixed in a future release.

To configure TotalView with these settings, create a TotalView startup file in `<totalviewInstallDir>/<PLATFORM>/lib/.tvdrc` and add the following lines:

```
# If TLS is not required, disable user threads for faster launch
# and attach times
dset -set_as_default TV::user_threads false
```

Process Window's Process Tab

By default, TotalView 8.15.0 and later suppress the display of the process grid in the Processes tab, because it can have a negative impact when scaling to a large number of processes. If debugger scalability is not a concern and you prefer to display the Processes tab in the Process Window, specify the `-process_grid` option or set the `TV::GUI:process_grid_wanted` state variable to `true` in the startup file.

To display the Process Window's Processes tab when you start TotalView, pass TotalView the `-process_grid` command option:

```
totalview -process_grid
```

To always display the Processes tab in the Process Window by default, set the state variable `TV::GUI:process_grid_wanted` to `true` for use when initializing TotalView:

```
dset TV::GUI:process_grid_wanted true
```

dlopen Options

When a target process calls `dlopen()`, a **dlopen** event is generated in TotalView. Handling **dlopen** events heavily impacts startup time for dynamically linked executables, specifically after launch and attach, but before the user hits the first breakpoint. TotalView provides two ways to configure **dlopen** for better performance:

- Filtering **dlopen** events to avoid stopping a process for each event.
- Handling **dlopen** events in parallel, reducing client/server communication overhead to fetch library information. **Note:** Both this option and MRNet must be enabled for TotalView to fetch libraries in parallel.

RELATED TOPICS

A more detailed comparison of **dlopen** event filtering modes

"Filtering dlopen Events" in the *TotalView for HPC Reference Guide*

More on setting **dlopen** for parallel library handling

"Handling dlopen Events in Parallel" in the *TotalView for HPC Reference Guide*

The **TV::dlopen_always_recalculate** state variable and command line options

TV::dlopen_always_recalculate and **-dlopen_always_recalculate** in the *TotalView for HPC Reference Guide*

The **TV::dlopen_recalculate_on_match** state variable and command line options

TV::dlopen_recalculate_on_match and **dlopen_recalculate_on_match** in the *TotalView for HPC Reference Guide*

The **TV::dlopen_read_libraries_in_parallel** state variable and command line options

TV::dlopen_read_libraries_in_parallel and **dlopen_read_libraries_in_parallel** in the *TotalView for HPC Reference Guide*

dlopen Event Filtering

You can filter **dlopen** events to plant breakpoints in the *dlopened* libraries only when the process stops for some other reason.

When so configured, the process never stops for a **dlopen** event, not even "null" **dlopen** events. Using this option can result in significant performance gains — but note that an application may execute past the point at which you want to start debugging inside the *dlopened* library, so this setting may be impractical for some applications.

dlopen event filtering is controlled by the settings on two state variables, **TV::dlopen_always_recalculate** and **TV::dlopen_recalculate_on_match**. Three possible **dlopen** filtering modes are made possible by these variables:

- **Slow Mode:** Reloads libraries on every **dlopen** event. This is the default.
- **Medium Mode:** Reports only libraries that match defined patterns on a **dlopen** event.

- **Fast Mode:** Does not stop for **dlopen** events. This mode provides the best performance and is recommended when scalability is important.

You can set **dlopen** to use the **Fast** mode for all invocations of TotalView by putting the following in your **tvdrvc** file:

```
dset dlopen_always_recalculate==false
dset dlopen_recalculate_on_match=="
```

Or, you can just launch an individual instance of TotalView with these settings by entering:

```
totalview -no_dlopen_always_recalculate -dlopen_recalculate_on_match ""
```

Handling dlopen Events in Parallel

TotalView's default behavior is to handle *dlopened* libraries serially, creating multiple, single-cast client-server communications. This can degrade performance, depending on the number of libraries a process *dlopes*, and the number of processes in the job.

To handle *dlopened* libraries in parallel using MRNet, enter the following in your **tvdrvc** file so that all future invocations of TotalView will have this set:

```
dset TV::dlopen_read_libraries_in_parallel true
```

Or for a single invocation of TotalView, simply launch TotalView using the command parameter:

```
totalview -dlopen_read_libraries_in_parallel
```

NOTE >> Enabling this option does not guarantee that **dlopen** performance will improve on all systems in all scenarios. Be sure to test the impact of this setting on your system and debugging environments.

Remember that MRNet must also be enabled for this to work.

MRNet

MRNet stands for “Multicast/Reduction Network.” MRNet uses a tree-based front-end to back-end communication model to significantly improve the efficiency of data multicast and aggregation for front-end tools running on massively parallel systems.

The following description is from the MRNet web site (<http://www.paradyn.org/mrnet/>):

MRNet is a software overlay network that provides efficient multicast and reduction communications for parallel and distributed tools and systems. MRNet uses a tree of processes between the tool's front-end and back-ends to improve group communication performance. These internal processes are also used to distribute many important tool activities, reducing data analysis time and keeping tool front-end loads manageable.

MRNet-based tool components communicate across logical channels called streams. At MRNet internal processes, filters are bound to these streams to synchronize and aggregate dataflows. Using filters, MRNet can efficiently compute averages, sums, and other more complex aggregations and analyses on tool data. MRNet also supports facilities that allow tool developers to dynamically load new tool-specific filters into the system.

Rogue Wave's use of MRNet is part of a larger strategy to improve the scalability of TotalView as high-end computers grow into very high process and thread counts.

TotalView supports MRNet on Linux x86_64 and Linux Power clusters, IBM Blue Gene, and Cray XT, XE, and XK.

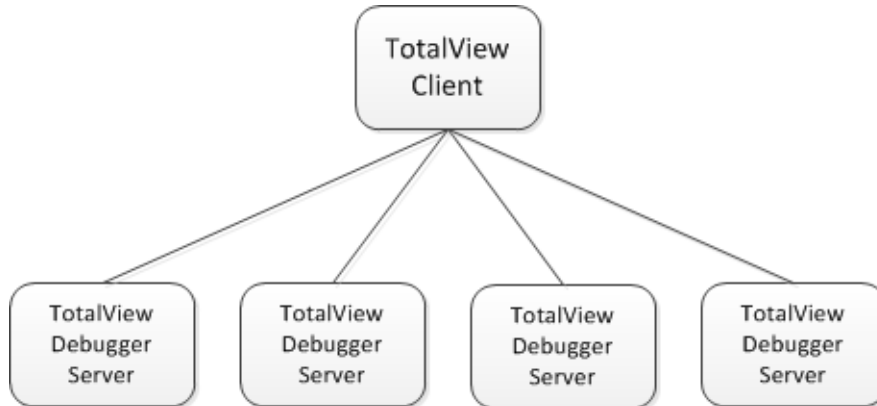
TotalView Infrastructure Models

Starting with TotalView 8.11.0, the TotalView debugger supported two infrastructure models that control the way the debugger organizes its TotalView debugger server processes when debugging a parallel job involving multiple compute nodes. Starting with TotalView 8.15, TotalView uses the tree-based infrastructure described below by default.

The first model uses a “flat vector” of TotalView debugger server processes. The TotalView debugger has always supported this model, and still does. Under the flat vector model, the debugger server processes have a direct (usually socket) connection to the TotalView front-end client. This model works well at low process scales, but begins to degrade as the target application scales beyond a few thousand nodes or processes. This is the default infrastructure model.

Figure 250 shows the TotalView client connected to four TotalView debugger servers (`tvdsvr`). In this example, four separate socket channels directly connect the client to the debugger servers.

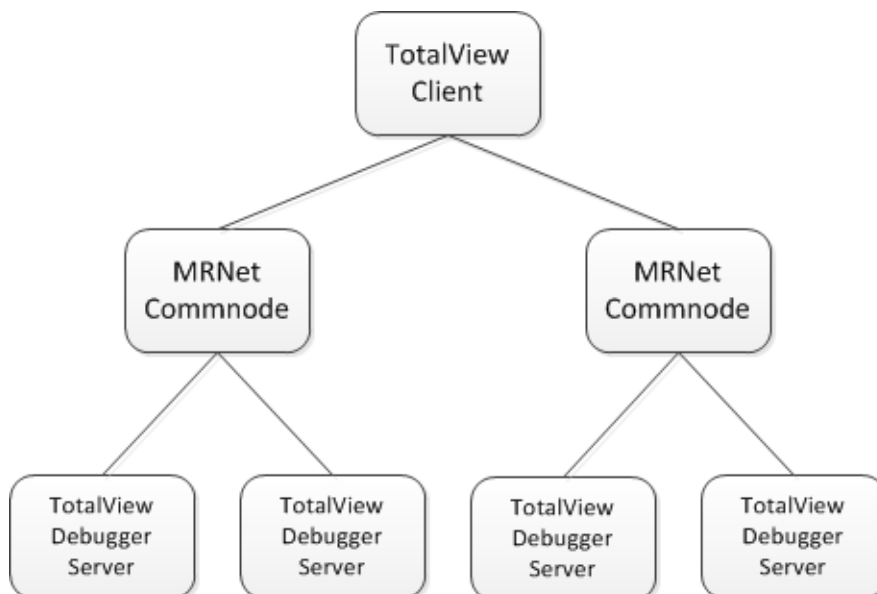
Figure 250 – Flat Vector of Servers Infrastructure Model



The second model uses MRNet to form a tree of debugger server and MRNet communication processes connected to the TotalView front-end client, which forms the root of the tree. MRNet supports building many different shapes of trees, but note that the shape of the tree (for example, depth and fan-out) can greatly affect the performance of the debugger. The following sections describe how to control the shape of the MRNet tree in TotalView.

Figure 251 shows an MRNet tree in which the TotalView client is connected to four TotalView debugger servers through two MRNet commnode processes using a tree fan-out value of 2.

Figure 251 – MRNet Infrastructure Model



Using MRNet with TotalView

TotalView is already preconfigured for maximum scalability, so no further customization is necessary. This section is for advanced users and describes TotalView options and state variables related to the use of MRNet with TotalView, as follows:

- [General Use](#)
- [Using MRNet on Blue Gene](#)
- [Using MRNet on Cray Computers](#)

Please refer to the TotalView documentation for a general description of how options and state variables can be used with TotalView.

General Use

This section discusses basic configuration options of MRNet with TotalView. If you are working on a Blue Gene or Cray computer, you will need to look at the sections specific to those systems as well.

Disabling MRNet Before Startup

By default, TotalView uses the MRNet infrastructure on the platforms where it is supported (Linux-x86_64, Linux-Power, Blue Gene/Q, and Cray). On platforms where MRNet is not supported, TotalView uses its standard vector-of-servers infrastructure.

If for some reason you do not want to use the MRNet infrastructure to debug an MPI job, you must first disable MRNet in TotalView before launching the MPI job. MRNet can be disabled by:

- Starting TotalView with the **-nomrnet** option:

```
prompt> totalview -nomrnet
```
- With TotalView running, use the command line interface (CLI) to set the **TV::mrnet_enabled** state variable:

```
prompt> dset TV::mrnet_enabled false
```

MRNet Server Launch String

Option: `-mrnet_server_launch_string` *string*

State variable: `TV::mrnet_server_launch_string` *string*

Default string: `%B/tvdsvr%K -working_directory %D -set_pw %P -verbosity %V %F`

The server launch string defines configuration options when launching a debugging server. TotalView has a default string it uses when launching a server using the vector-of-servers architecture, and an option and state variable that allow you to modify the default string. The MRNet usage of TotalView also has a default launch string and corresponding option and state variables.

The MRNet launch string differs from the standard launch string in two ways: it does not contain a remote shell command expansion (e.g., `rsh` or `ssh`), and it has no `-callback` option.

TotalView always appends the following string to the expanded MRNet launch string:

```
-mrnet_launch node_id
```

where `node_id` is an integer that specifies the server's TotalView node ID within the job. If `node_id` is `0`, the server assigns itself a node ID equal to its MRNet rank plus 1.

Controlling the Shape of an MRNet Tree

The shape of the MRNet tree calculated by TotalView can be controlled through a collection of options and state variables. Given the list of hosts, which is typically extracted from the MPIR proctable, TotalView calculates an MRNet topology string to create various shapes of trees.

There are three basic controls:

- Tree fan-out: specifies the maximum number of children a node can have. If the number of leaves in the tree is not a power of the fan-out, some of the tree nodes will have fewer children.
- Tree depth: specifies the maximum depth of the tree (that is, the number of levels below the root). If the number of leaves is not greater than the square of the tree depth value, a shallower tree is built.
- Whether to allocate an extra communications node below the root.

MRNet Tree Fan-Out

Option: `-mrnet_fanout` *integer*

State variable: `TV::mrnet_fanout` *integer*

Default value: 32

If you change the default value, the new value must be greater than or equal to **2** and less than or equal to **32768**.

MRNet Tree Depth

Option: `-mrnet_levels` *integer*

State variable: `TV::mrnet_levels` *integer*

Default value: 2

The MRNet tree depth can be specified in terms of the number of levels below the root. If you change the default value, the new value must be greater than or equal to **-2** and less than or equal to **32**.

- If the tree depth is **0**, the MRNet tree fan-out value is used, and TotalView attempts to honor the fan-out value near the bottom of the tree (the leaves).

- If the tree depth is set to a value that is greater than **0** (which includes the default value of **2**), the fan-out value is ignored and a balanced tree is built with at most the specified number of levels.
- If the tree depth is **-1**, the fan-out value is used, and TotalView attempts to honor the fan-out value near the top (the root) of the tree, rather than near the bottom of the tree (the leaves).
- If the tree depth is **-2**, TotalView builds a tree similar to the one created when the tree depth is **-1**, except that the tree is unbalanced from side-to-side.

As an example, consider a tree with a root node and eight leaf nodes. If the fan-out value is **4** and the tree depth value is **0**, a tree that is “bushy” near the leaves is built because TotalView honors fan-out at the leaf end of the tree.

```
root:1 => n1:2 n5:2 ;
  n1:2 => n1:1 n2:1 n3:1 n4:1 ;
  n5:2 => n5:1 n6:1 n7:1 n8:1 ;
```

However, for the same tree when the tree depth setting is **-1**, a tree that is “bushy” near the root is built because TotalView honors fan-out at the root end of the tree.

```
root:1 => n1:2 n3:2 n5:2 n7:2 ;
  n1:2 => n1:1 n2:1 ;
  n3:2 => n3:1 n4:1 ;
  n5:2 => n5:1 n6:1 ;
  n7:2 => n7:1 n8:1 ;
```

Allocate an Extra Root Node

Option: `-mrnet_extra_root` *boolean*

State variable: `TV::mrnet_extra_root` *boolean*

Default value: `false`

For example, for a tree with a root and eight leaf nodes, using a fan-out value of **4**, a tree depth value of **0**, and requesting an extra root node, the following topology string will be calculated:

```
root:3 => root:1 ;
  root:1 => n1:2 n5:2 ;
    n1:2 => n1:1 n2:1 n3:1 n4:1 ;
    n5:2 => n5:1 n6:1 n7:1 n8:1 ;
```

Path to MRNet Components

Option: `-mrnet_commnnode_path` *path-to-mrnet_commnnode*

State variable: `TV::mrnet_commnnode_path` *path-to-mrnet_commnnode*

Default value: `tv-installation-root/platform/bin/mrnet_commnnode`

In a TotalView distribution, this is a path to a shell script that sets environment variables and execs the proper executable for the platform.

Path to the MRNet shared library directory

Option: `-mrnet_filterlib_dir` *path-to-mrnet-shlib-directory*

State variable: `TV::mrnet_filterlib_dir` *path-to-mrnet-shlib-directory*

Default value: `tv-installation-root/platform/shlib/mrnet/obj`

The TotalView server tree filters library `libservertree_filters.so.1` and the MRNet `libxplat.so` and `libmrnet.so` libraries are stored in this directory.

Performance Notes

Rogue Wave has conducted performance tests on some specific systems, and based on this testing we here provide a couple of tips. These tips should be considered as guidelines. The only way to know how performance is affected by different tree configurations on your system is by trying out alternatives with your own jobs.

- In general, higher fan-outs seem to perform better than deeper trees. Specifically, trees deeper than two levels consistently performed worse than a two-level tree.
- In our testing, a one-level tree failed due to resource shortages at around 512 nodes, so this is not a viable option at higher scales.

MRNet and ssh/rsh

Controlling MRNet's Use of rsh vs ssh

When MRNet is used as the infrastructure in a Linux cluster or on Blue Gene front-end nodes, MRNet's built-in support is used to instantiate the tree of debugger servers and communications processes. Tree instantiation is based on a remote shell startup mechanism. By default, MRNet uses `ssh` as the remote shell program, but some environments require that `rsh` be used instead. TotalView controls the remote shell used by MRNet using the `TV::xplat_rsh` state variable or the `-xplat_rsh` TotalView command option to set this state variable. If this variable isn't explicitly set and the `XPLAT_RSH` environment variable is not set or is empty, TotalView uses the value of `TV::launch_command` when instantiating an MRNet tree.

On Cray XT, XE, and XK systems, MRNet uses the ALPS Tool Helper library to instantiate the tree, which does not require the use of a separate remote shell program.

Tips on Using ssh/rsh with MRNet

The use of `rsh` / `ssh` differs in every system environment, therefore you should consult your system's documentation to know whether `rsh` or `ssh` should be used for your system. The `rsh` and `ssh` man pages are also a useful resource. Regardless, we offer the following tips as a guideline for how to configure `rsh` and `ssh`:

- Configure `rsh` or `ssh` to allow accessing the remote nodes without a password. `rsh` typically uses a file named `$HOME/.rhosts` (see `man 5 rhost` on a Linux system). `ssh` typically uses a pair of private/public keys stored in files under your `$HOME/.ssh` directory (see `man 1 ssh` on a Linux system).

- Disable X11 forwarding in `ssh` in your `$HOME/.ssh/config` file (see `man 5 ssh_config` on a Linux system).
- Set `StrictHostKeyChecking` to `no` in `ssh` in your `$HOME/.ssh/config` file (see `man 5 ssh_config` on a Linux system). If the `ssh` host keys change for a remote host, you may need to delete the lines for the host from the `$HOME/.ssh/known_hosts` file, or remove the file.

Using MRNet on Blue Gene

The following sections describe the options and state variables that were added to TotalView to control the configuration and use of MRNet on Blue Gene. Please refer to the TotalView documentation for a general description of how options and state variables can be used with TotalView.

Blue Gene Server Command String

State variable: `TV::bluegene_server_command_string` *string*

Default string: `%B/tvdsvr%K`

This is a read-only state variable. It is expanded to the path of the TotalView Blue Gene debugger server command. TotalView expands the launch string using the normal launch string expansion rules.

Blue Gene/MRNet Server Launch String

Option: `-bluegene_mrnet_server_launch_string` *string*

State variable: `TV::bluegene_mrnet_server_launch_string` *string*

Default value: `-set_pw %P -verbosity %V %F`

Analogous to the standard Blue Gene server launch string, the Blue Gene MRNet server launch string is used when MRNet is used to launch the TotalView debugger servers on Blue Gene. TotalView expands the launch string using the normal launch string expansion rules.

The expanded string is written into the MPIR Process Acquisition Interface `MPIR_server_arguments` variable in the MPI starter process, such as `mpirun`, `-runjob`, or `srun`. The arguments are passed to the server command that is executed on the Blue Gene IO nodes. The MRNet launch string differs from the standard launch string in that the MRNet launch string does not contain the `-callback` option.

TotalView always appends the following string to the expanded Blue Gene MRNet launch string:

```
-mrnet_commnode temp-db-file
```

where `temp-db-file` is the path to the IO-to-FE node assignments database temporary file.

Blue Gene/MRNet Front-End Topology String

Option: `-bluegene_mrnet_fe_topology` *string*

State variable: `TV::bluegene_mrnet_fe_topology` *string*

Default value: `" "` (the empty string)

If set to a non-empty string, this string is used as the MRNet topology string for instantiating the Blue Gene communications tree on the front-end nodes. This string must be a well-formed MRNet topology string usable directly by MRNet.

For example, if TotalView is running on the front-end host **dawndev4**, this option can be used to instantiate two additional `mrnet_commnnode` processes on that front-end host:

```
totalview -bluegene_mrnet_fe_topology \  
    "dawndev4:0 => dawndev4-io:1 dawndev4-io:2 ;" \  
-mrnet -stdin /dev/null -args mpirun ./ALLc
```

The servers on the IO node will connect back to the two `mrnet_commnnode` processes on the front-end using the `dawndev4-io` network interface, and the two `mrnet_commnnode` processes on the front-end will connect to the TotalView process (the root of the MRNet tree) using the `dawndev4` network interface.

Blue Gene/MRNet Front-End Host List

Option: `-bluegene_mrnet_fe_host_list` *string*

State variable: `TV::bluegene_mrnet_fe_host_list` *string*

Default value: `" "` (the empty string)

This list specifies Blue Gene front-end nodes on which to run MRNet `mrnet_commnnode` processes. If set to a non-empty string, this variable is used as the list of front-end nodes for instantiating the Blue Gene communications tree. The list must contain a unique set of host names or IP addresses.

This string is used only if `TV::bluegene_mrnet_fe_topology` is set to a non-empty string.

For example, if TotalView is running on the front-end host **dawndev4**, this option can be used to instantiate two additional `mrnet_commnnode` processes on two other front-end nodes, **dawndev1** and **dawndev2**:

```
totalview \  
-xplat_rsh ssh \  
-bluegene_mrnet_fe_host_list "dawndev1-io dawndev2-io" \  
-mrnet -stdin /dev/null -args mpirun ./ALLc
```

The servers on the IO node will connect back to the two `mrnet_commnnode` processes on the front-end nodes using the `dawndev1-io` and `dawndev2-io` network interfaces, and the two `mrnet_commnnode` processes on the front-end will connect to the TotalView process (the root of the MRNet tree) using the `dawndev4-io` network interface.

Blue Gene/MRNet Back-End Servers per IO Node

Blue Gene/P

Option: `-bluegene_p_mrnet_back_end_servers_per_io_node` *integer*

State variable: `TV::bluegene_p_mrnet_back_end_servers_per_io_node` *integer*

Default value: **1**

Blue Gene/Q

Option: `-bluegene_q_mrnet_back_end_servers_per_io_node` *integer*

State variable: `TV::bluegene_q_mrnet_back_end_servers_per_io_node` *integer*

Default value: **16**

These state variables control the number of back-end server processes created on the IO nodes.

- On Blue Gene/P, the value must be set to **1** due to constraints in the IBM debugging interface.
- On Blue Gene/Q the value must be greater than or equal to **1** and less than or equal to **64**.

If the value is **1**, no `mrnet_commnode` processes are created on the IO nodes. If the value is greater than **1**, a single `mrnet_commnode` process is created on the IO nodes and the back-end server processes connect to that communications process. On Blue Gene/Q, the default is to create 16 back-end server processes per IO node, which evenly share the workload of debugging the target processes running on the compute node.

MRNet IO to FE Database Temporary File Directory

Option: `-mrnet_io_to_fe_db_temp_dir` *string*

State variable: `TV::mrnet_io_to_fe_db_temp_dir` *string*

Default value: `.` (dot)

This state variable specifies the directory in which to create the MRNet IO-to-FE node association database temporary file. The directory must be on a file system that is shared between the front-end and IO nodes. By default, the TotalView client process's current working directory is used. TotalView creates a temporary file using the `mks-temp()` Posix.1-2001 function with the pattern `tvdsvr_cp_db.#####`, where `#####` is replaced with a string that makes the filename unique. After the MRNet tree is fully instantiated, TotalView deletes this temporary file.

Blue Gene Front-End Tree Considerations

As described above, TotalView has several options and state variables that allow for alternate front-end trees. TotalView decides which front-end tree to create as follows:

- If `TV::bluegene_mrnet_fe_topology` is a non-empty string, it is used as-is and fed directly into MRNet to instantiate the front-end tree; otherwise,

- If **TV::bluegene_mrnet_fe_host_list** is a non-empty string, it must be a unique list of front-end host names or IP addresses that is used to calculate the MRNet front-end tree; otherwise,
- A single root node on the front-end host is used.

A Single Root Node on the Front-End

By default, TotalView creates a single root node on the front-end host, and the server or **mrnet_commnnode** processes running on the IO nodes connect back to the root using the IO network interface on the front-end host.

Consider an example where the IO network interface on a front-end node has the string **-io** appended to the primary host name. For example, **dawndev4-io** is the name for the IO network interface on **dawndev4**.

```
dawndev4> hostname
dawndev4
dawndev4> grep dawndev4 /etc/hosts
192.168.10.14    edawndev4 dawndev4-eth2 e4
134.9.39.52    dawndev4.llnl.gov dawndev4 dawndev4-eth3
134.9.8.5      dawndev4-nfs.llnl.gov dawndev4-nfs dawndev4-eth0
172.16.126.164 dawndev4-io dawndev4-eth1
dawndev4> /sbin/ifconfig | grep addr
eth0      Link encap:Ethernet  HWaddr 00:1A:64:DD:B8:A6
          inet addr:134.9.8.5  Bcast:134.9.8.255  Mask:255.255.255.0
eth1      Link encap:Ethernet  HWaddr 00:1A:64:DD:B8:A7
          inet addr:172.16.126.164  Bcast:172.16.126.255  Mask:255.255.255.0
eth2      Link encap:Ethernet  HWaddr 00:1A:64:47:E3:5A
          inet addr:192.168.10.14  Bcast:192.168.10.255  Mask:255.255.255.0
eth3      Link encap:Ethernet  HWaddr 00:1A:64:47:E3:5B
          inet addr:134.9.39.52  Bcast:134.9.39.255  Mask:255.255.255.0
```

Above, we can see that **dawndev4** has four network interfaces (not including the **127.0.0.1** loopback address), and **eth1** is the network interface connected to the IO node network.

On systems that do not use this naming convention, the TotalView state variable **TV::bluegene_io_interface** must be set to the interface name, host name or IP address of an IO network connected interface on the front-end node. For more information, see “[IBM Blue Gene Applications](#)” on page 480.

Explicit Front-End Topology String

If an explicit front-end topology string is specified with **TV::bluegene_mrnet_fe_topology**, it is used as-is and fed directly into MRNet to instantiate the front-end tree. The topology string must be a valid MRNet topology string. MRNet attempts to instantiate the front-end tree using its built-in launch support. If this fails, no tree is built and TotalView does not gain control of the job.

When specifying a front-end topology string, the following must be considered:

- The root of the tree must be a network interface on the same node where TotalView is running. For example, on dawndev4, the root must be dawndev4 or dawndev4-io, or even localhost if there are additional sub-nodes.
- The network interface specified at a leaf must be accessible via the IO network. For example, on dawndev4, specifying dawndev4-io as a leaf will work, specifying localhost as a leaf will not work, and specifying dawndev4 may or may not work depending on the connectivity between an IO node and the network interface associated with dawndev4.
- If a single front-end host is specified to run multiple processes (e.g., `fe4:0=>fe4:1 fe4:2;`), MRNet uses `fork()` and `exec()` to spawn the `mrnet_commmnode` processes.
- If multiple front-end hosts are specified to run multiple processes (e.g., `fe4:0=>fe1:0 fe2:0;`), `rsh/ssh` is used to spawn the `mrnet_commmnode` processes. In this case, the user must be able to `rsh` or `ssh` to the front-end nodes, and may need to set `XPLAT_RSH` using the `TV::xplat_rsh` state variable or `-xplat_rsh` command option described above.

Explicit List of Front-End Nodes

If an explicit list of front-end nodes is specified with `TV::bluegene_mrnet_fe_host_list`, it is used to calculate a topology string, which is then fed into MRNet to instantiate the front-end tree. The MRNet tree calculation controls for tree fan-out, tree depth, and an extra root node are used in the calculation. MRNet attempts to instantiate the front-end tree using its built-in launch support.

When specifying a list of front-end nodes, the following must be considered:

- The root of the tree used by TotalView is the same as the host name or IP address that is used in the single root node case (see above). For example, on dawndev4, dawndev4-io is used.
- The list of hosts specifies the leaves of the front-end tree. Therefore, the list of hosts must specify a network interface accessible via the IO network. For example, on dawndev4, specifying `"dawndev1-io dawndev2-io"` as the list will work, but specifying `"dawndev1 dawndev2"` may or may not work depending on the connectivity between an IO node and the network interface associated with dawndev1 and dawndev2.
- Depending on the setting of the MRNet tree calculation controls for tree fan-out, tree depth, and an extra root node, additional interior `mrnet_commmnode` processes may be run on the front-end nodes specified by the list.
- The hosts on the list must be able to connect back to the root of the tree, and depending on the calculated topology may need to be able connect back to each other.
- The list of hosts can include the root host, but a host name must not appear more than once on the list.
- If a single front-end host is used to run multiple processes, MRNet uses `fork()` and `exec()` to spawn the `mrnet_commmnode` processes.

- If multiple front-end hosts are specified to run multiple processes, `rsh/ssh` is used to spawn the `mrnet_commmnode` processes. In this case, the user must be able to `rsh` or `ssh` to the front-end nodes, and may need to set `XPLAT_RSH`.

Using MRNet on Cray Computers

The following sections describe the options and state variables that were added to TotalView to control the configuration and use of MRNet on Cray. Please refer to the TotalView documentation for a general description of how options and state variables can be used with TotalView.

Is Cray XT Flag

State variable: `TV::is_cray_xt` *boolean*

Default value: Set to `true` if TotalView is running on Linux-x86_64 and `/proc/cray_xt/nid` exists; otherwise set to `false`.

Note that some Cray front-end (login) nodes do not have a `/proc/cray_xt/nid` file, in which case a job must be submitted to start TotalView on a Cray XT, XE, or XK node.

Cray XT MRNet Server Launch String

Option: `-cray_xt_mrnet_server_launch_string` *string*

State variable: `TV::cray_xt_mrnet_server_launch_string` *string*

Default value: `/var/spool/alps/%A/toolhelper%A/tvdsvr%K \`
`-working_directory %D -set_pw %P -verbosity %V %F`

Analogous to the standard MRNet server launch string, the Cray XT MRNet server launch string is used when MRNet launches the TotalView debugger servers on Cray XT, XE, or XK. TotalView expands the launch string using the normal launch string expansion rules.

Cray XT MRNet Transfer File List

Option: `-cray_xt_mrnet_xfer_file_list` *stringlist*

State variable: `TV::cray_xt_mrnet_xfer_file_list` *stringlist*

Default value:

The default value is calculated. at TotalView startup time, as follows. The following is used as a "base" list of files needed by TotalView on the Cray compute nodes when MRNet is in use.

```
TVROOT/bin/mrnet_commmnode_main_cray_xt
TVROOT/bin/tvdsvr_mrnet
TVROOT/bin/tvdsvrmain_mrnet
TVROOT/shlib/mpa/obj_cray_xt/libmpattr.so.1
TVROOT/shlib/unwind/obj/libunwind-x86_64.so.8
```

```

TVROOT/shlib/unwind/obj/libunwind.so.8
TVROOT/shlib/mrnet/obj_cray_xt/libmrnet.so
TVROOT/shlib/mrnet/obj_cray_xt/libxplat.so
TVROOT/shlib/mrnet/obj_cray_xt/libservertree_filters.so.1
TVROOT/shlib/mrnet/obj_cray_xt/libtvwrapalps.so.1
/lib64/libthread_db.so.1
/usr/bin/ld
/usr/bin/objcopy
TVROOT/lib/libundodb_debugger_x64.so
TVROOT/lib/undodb_a_x64.o
TVROOT/lib/undodb_a_x32.o
TVROOT/lib/undodb_x64.so
TVROOT/lib/undodb_x32.so
TVROOT/lib/undodb_infiniband_preload_x64.so
TVROOT/lib/undodb_infiniband_preload_x32.so
TVROOT/lib/libtvheap_mic.so
TVROOT/lib/mic/libtvheap_64.so

```

The above list is then passed to the shell script named "cray_sysdso_deps.sh" to calculate the system shared libraries needed by the executables and shared libraries on the base list. The actual list of system libraries can vary from system to system, but typically consists of the following files:

```

/lib64/libdl.so.2
/lib64/libgcc_s.so.1
/lib64/libm.so.6
/lib64/libpthread.so.0
/usr/lib64/libbfd-<version>.so
/usr/lib64/libstdc++.so.5

```

The version of `libbfd`, which is needed by `ld` and `objcopy`, varies from system to system.

The default value is a space-separated string-list of file names that are transferred (staged) to the compute nodes. These files are the shell script, executable and shared library files required to run the MRNet commnode and TotalView debugger server processes on the compute nodes. When instantiating the MRNet tree on Cray XT, XE, or XK, the ALPS Tool Helper library is used to broadcast these files into the compute nodes' ramdisk under the `/var/spool/alps/apid` directory. `TVROOT` is the path to the platform-specific files in the TotalView installation.



Chapter 23

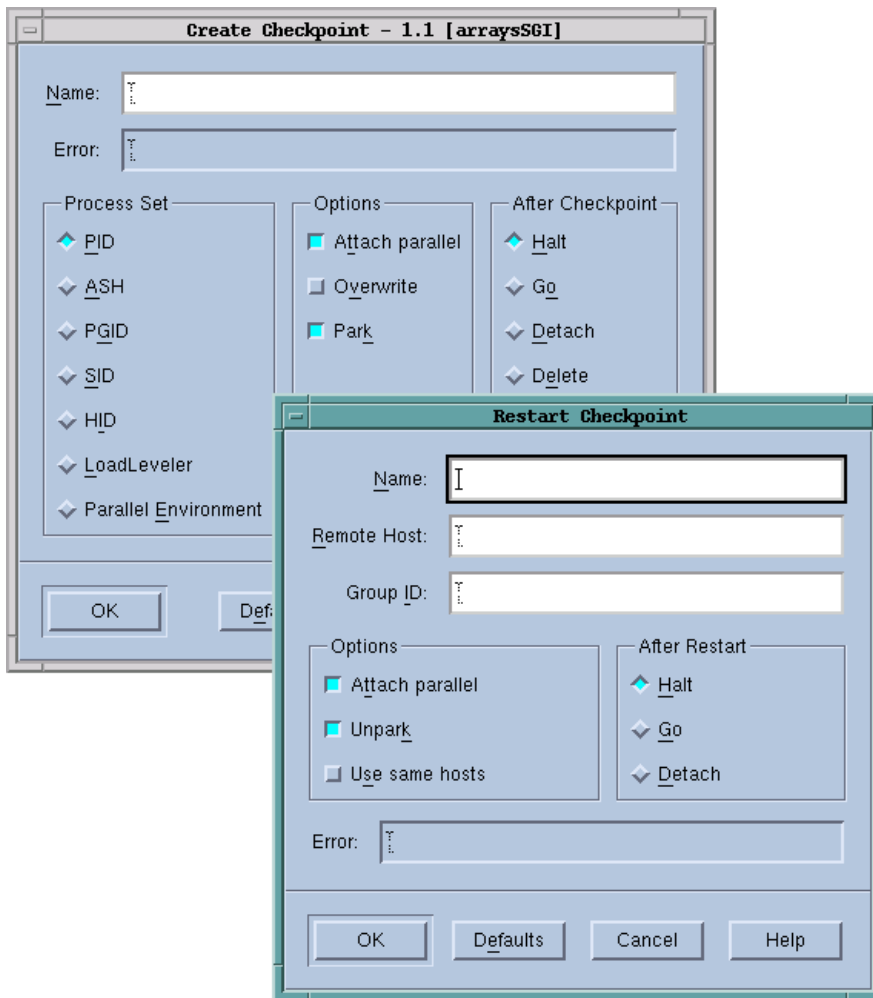
Checkpointing

You can save the state of selected processes and then use this saved information to restart the processes from the position where they were saved. For more information, see the Process Window **Tools > Create Checkpoint** and **Tools > Restart Checkpoint** commands in the online Help, [Figure 252](#).

This feature is currently available only on IBM RS/6000 platforms.

```
CLI: dcheckpoint  
     drestart
```

Figure 252 – Create Checkpoint and Restart Checkpoint Dialog Boxes





Fine-Tuning Shared Library Use

When TotalView encounters a reference to a shared library, it normally reads all of that library's symbols. In some cases, you might need to explicitly read in this library's information before TotalView automatically reads it.

On the other hand, you may not want TotalView to read and process a library's loader and debugging symbols. In most cases, reading these symbols occurs quickly. However, if your program uses large libraries, you can increase performance by telling TotalView not to read these symbols.

Preloading Shared Libraries

As your program executes, it can call the **dlopen()** function to access code contained in shared libraries. In some cases, you might need to do something from within TotalView that requires you to preload library information. For example, you might need to refer to one of a library's functions in an eval point or in a **Tools > Evaluate** command. If you use the function's name before TotalView reads the dynamic library, TotalView displays an error message.

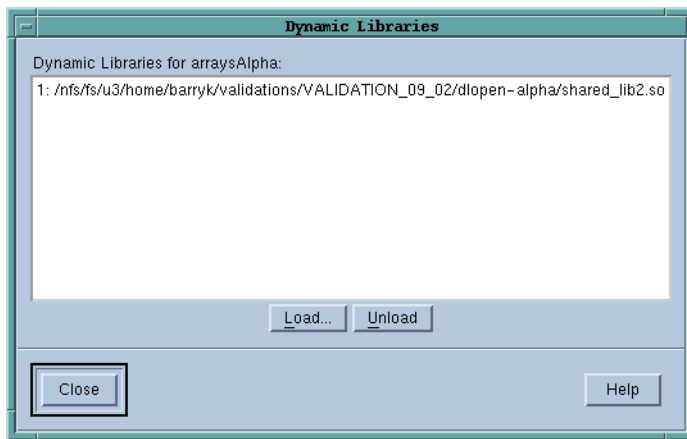
Use the **Tools > Debugger Loaded Libraries** command to tell the debugger to open a library.

CLI: ddlopen

This CLI command gives you additional ways to control how a library's symbols are used.

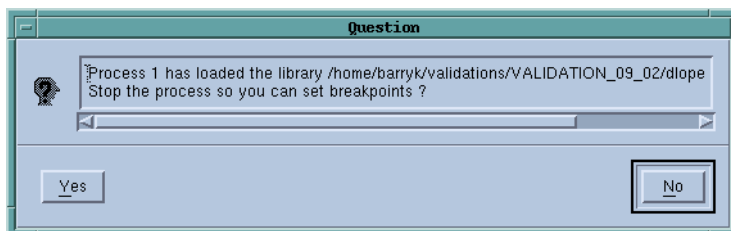
After selecting this command, TotalView displays the following dialog box:

Figure 253 – Tools > Debugger Loaded Libraries Dialog Box



Selecting the **Load** button tells TotalView to display a file explorer dialog box that lets you navigate through your computer's file system to locate the library. After selecting a library, TotalView reads it and displays a question box that lets you stop execution to set a breakpoint:

Figure 254 – Stopping to Set a Breakpoint Question Box



NOTE >> TotalView might not read in symbol and debugging information when you use this command. See [“Controlling Which Symbols TotalView Reads”](#) on page 567 for more information.

RELATED TOPICS

TV:dll **TV::dll** in the *TotalView for HPC Reference Guide*

The **ddlopen** command **ddlopen** in the *TotalView for HPC Reference Guide*

Controlling Which Symbols TotalView Reads

When debugging large programs with large libraries, reading and parsing symbols can impact performance. This section describes how you can minimize the impact that reading this information has on your debugging session.

NOTE >> Using the preference settings and variables described in this section, you can control the time it takes to read in the symbol table. For most programs, even large ones, changing the settings is often inconsequential, but if you are debugging a very large program with large libraries, you can achieve significant performance improvements.

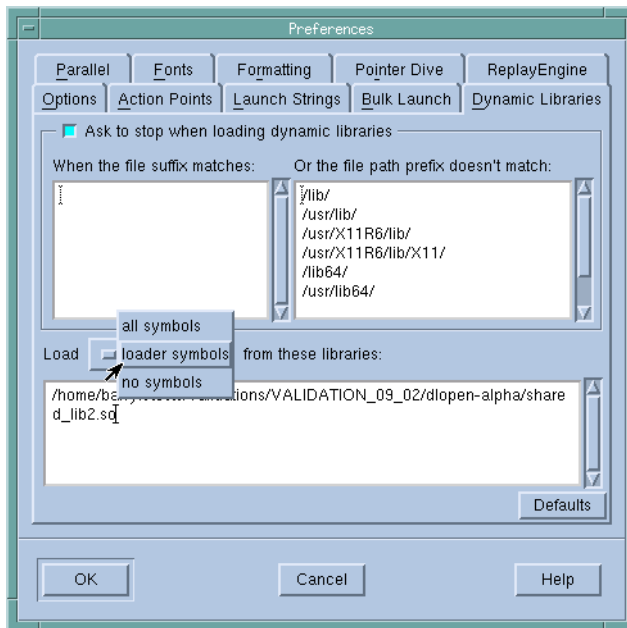
A shared library contains, among other things, loader and debugging symbols. Typically, loader symbols are read quite quickly. Debugging symbols can require considerable processing. The default behavior is to read all symbols. You can change this behavior by telling TotalView to only read in loader symbols or even that it should not read in any symbols.

NOTE >> Saying “TotalView reads all symbols” isn’t quite true as TotalView often just reads in loader symbols for some libraries. For example, it only reads in loader symbols if the library resides in the `/usr/lib` directory. (These libraries are typically those provided with the operating system.) You can override this behavior by adding a library name to the **All Symbols** list that is described in the next section.

Specifying Which Libraries are Read

After invoking the **File > Preferences** command, select the Dynamic Libraries Page.

Figure 255 – File > Preferences: Dynamic Libraries Page



The lower portion of this page lets you enter the names of libraries for which you need to manage the information that TotalView reads.

When you enter a library name, you can use the ***** (asterisk) and **?** (question mark) wildcard characters. These characters have their standard meaning. Placing entries into these areas does the following:

- all symbols This is the default operation. You only need to enter a library name here if it would be excluded by a wildcard in the **loader symbols** and **no symbols** areas.
- loader symbols TotalView reads loader symbols from these libraries. If your program uses a number of large shared libraries that you will not be debugging, you might set this to asterisk (*). You then enter the names of DLLs that you need to debug in the **all symbols** area.
- no symbols Normally, you wouldn't put anything on this list since TotalView might not be able to create a backtrace through a library if it doesn't have these symbols. However, you can increase performance if you place the names of your largest libraries here.

When reading a library, TotalView looks at these lists in the following order:

1. **all symbols**
2. **loader symbols**
3. **no symbols**

If a library is found in more than one area, TotalView does the first thing it is told to do and ignores any other requests. For example, after TotalView reads a library's symbols, it cannot honor a request to not load in symbols, so it ignores a request to not read them.

```
CLI: dset TV::dll_read_all_symbols
      dset TV::dll_read_loader_symbols_only
      dset TV::dll_read_no_symbols
```

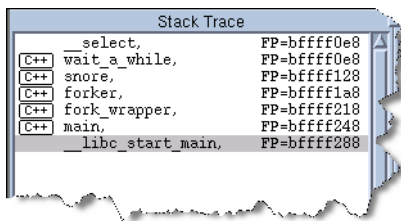
See the online Help for additional information.

If your program stops in a library that has not already had its symbols read, TotalView reads the library's symbols. For example, if your program SEGVs in a library, TotalView reads the symbols from that library before it reports the error. In all cases, however, TotalView always reads the loader symbols for shared system libraries.

Reading Excluded Information

While you are debugging your program, you might find that you do need the symbol information that you told TotalView it shouldn't read. Tell TotalView to read them by right-clicking your mouse in the Stack Trace Pane and then selecting the **Load All Symbols in Stack** command from the context menu.

Figure 256 – Load All Symbols in Stack Context menu



After selecting this command, TotalView examines all active stack frames and, if it finds unread libraries in any frame, reads them.

```
CLI: TV::read_symbols
```

This CLI command also gives you finer control over how TotalView reads in library information.



Using the CUDA Debugger

This part introduces the TotalView CUDA debugger and includes the following chapters:

Chapter 25, “About the TotalView CUDA Debugger”

Introduces the CUDA debugger, including features, requirements, installation and drivers.

Chapter 26, “CUDA Debugging Tutorial”

Discusses how to build and debug a simple CUDA program, including compiling, controlling execution, and analyzing data.

Chapter 27, “CUDA Problems and Limitations”

Issues related to limitations in the NVIDIA environment.

Chapter 28, “Sample CUDA Program”

Compilable sample CUDA program.



About the TotalView CUDA Debugger

The TotalView CUDA debugger is an integrated debugging tool capable of simultaneously debugging CUDA code that is running on the host Linux-x86_64 and the NVIDIA® GPU. CUDA support is an extension to the standard version of Linux-x86_64 TotalView, and is capable of debugging 64-bit CUDA programs on Linux-x86_64. Debugging 32-bit CUDA programs is currently not supported.

Supported major features:

- Debug CUDA application running directly on GPU hardware
- Set breakpoints, pause execution, and single step in GPU code
- View GPU variables in PTX registers, local, parameter, global, or shared memory
- Access runtime variables, such as threadIdx, blockIdx, blockDim, etc.
- Debug multiple GPU devices per process
- Support for the CUDA MemoryChecker
- Debug remote, distributed and clustered systems
- Support for directive-based programming languages
- Support for Linux-x86_64 host debugging features

Requirements:

- CUDA SDK 7.0, 7.5, or 8.0
 - With SDK 6.0 or 6.5, TotalView 8.15
 - With SDK 7.0, TotalView 8.15.4

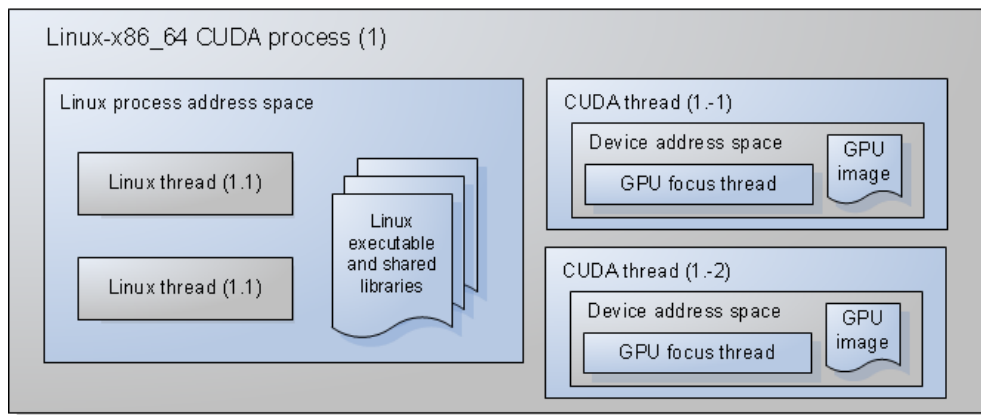
— With SDK 7.5, TotalView 8.15.10

- Tesla, Fermi or Kepler hardware supported by NVIDIA
- A linux-x86_64 distribution supported by NVIDIA

TotalView CUDA Debugging Model

Figure 257 shows the TotalView CUDA debugging model for a Linux process consisting of two Linux pthreads and two CUDA threads. A CUDA thread is a CUDA kernel invocation that is running on a device.

Figure 257 – TotalView CUDA debugging model



A Linux-x86_64 CUDA process consists of:

- A Linux process address space, containing a Linux executable and a list of Linux shared libraries.
- A collection of Linux threads, where a Linux thread:
 - Is assigned a positive debugger thread ID.
 - Shares the Linux process address space with other Linux threads.
- A collection of CUDA threads, where a CUDA thread:
 - Is assigned a negative debugger thread ID.
 - Has its own address space, separate from the Linux process address space, and separate from the address spaces of other CUDA threads.
 - Has a "GPU focus thread", which is focused on a specific hardware thread (also known as a core or "lane" in CUDA lingo).

The above TotalView CUDA debugging model is reflected in the TotalView user interface and command line interface. In addition, CUDA-specific CLI commands allow you to inspect CUDA threads, change the focus, and display their status. See the **dcuda** entry in the *TotalView for HPC Reference Guide* for more information.

Installing the CUDA SDK Tool Chain

Before you can debug a CUDA program, you must download and install the CUDA SDK software from NVIDIA using the following steps:

- Visit the NVIDIA CUDA Zone download page:
<https://developer.nvidia.com/cuda-downloads>
- Select Linux as your operating system
- Download and install the CUDA SDK Toolkit for your Linux distribution (64-bit)

By default, the CUDA SDK Toolkit is installed under `/usr/local/cuda/`. The `nvcc` compiler driver is installed in `/usr/local/cuda/bin`, and the CUDA 64-bit runtime libraries are installed in `/usr/local/cuda/lib64`.

You may wish to:

- Add `/usr/local/cuda/bin` to your `PATH` environment variable.
- Add `/usr/local/cuda/lib64` to your `LD_LIBRARY_PATH` environment variable.

Backward Compatibility with CUDA Device Drivers

The table below shows, for each version of TotalView, the SDK tool chain versions that are supported, and the minimum version of the NVIDIA driver needed for each SDK tool chain.

It is important to understand that it is the installed driver that ultimately determines the level of support. That is:

- NVidia provides backwards compatibility in its driver versions. For a given SDK, you can use a driver version that is newer than the minimum shown in the table below. In other words, newer NVidia drivers support older SDK versions. For example, using TotalView 8.15.10, you can debug programs built with the CUDA SDK 6.5 tool chain on systems that are running driver version 352.29 from the CUDA 7.5 SDK, or any driver version that is 340.21 or newer.
- NVidia does not provide upwards compatibility in its driver versions. For a given SDK, you cannot use a driver version that is older than the minimum shown in the table below. In other words, older NVidia drivers do not support newer SDK versions. For example, using TotalView 8.15.10, you cannot debug programs built with the CUDA SDK 7.5 tool chain on systems that are running driver version 340.21 from the CUDA SDK 6.5 or any driver version that is older than 352.29.

SDK Tool Chain Version	Minimum Driver Version	TotalView Version			
		8.15.0	8.15.4	8.15.7	8.15.10
6.0	331.62	Y	Y	Y	D
6.5	340.21	Y	Y	Y	Y
7.0	346.29	-	Y	Y	Y
7.5	352.29	-	-	-	Y

Y — TotalView supports programs for this driver/SDK version

D — TotalView support for this driver/SDK version is deprecated

- — Driver/SDK version unsupported

Directive-Based Accelerator Programming Languages

Converting C or Fortran code into CUDA code can take some time and effort. To simplify this process, a number of directive-based accelerator programming languages have emerged. These languages work by placing compiler directives in the user's code. Instead of writing CUDA code, the user can write standard C or Fortran code, and the compiler converts it to CUDA at compile time.

TotalView currently supports Cray's OpenMP Accelerator Directives and Cray's OpenACC Directives. TotalView uses the normal CUDA Debugging Model when debugging programs that have been compiled using these directives.



CUDA Debugging Tutorial

This chapter discusses how to build and debug a simple CUDA program using TotalView.

Compiling for Debugging

When compiling an NVIDIA CUDA program for debugging, it is necessary to pass the **-g -G** options to the **nvcc** compiler driver. These options disable most compiler optimization and include symbolic debugging information in the driver executable file, making it possible to debug the application. For example, to compile the sample CUDA program named **tx_cuda_matmul.cu** for debugging, use the following commands to compile and execute the application:

```
% /usr/local/bin/nvcc -g -G -c tx_cuda_matmul.cu -o tx_cuda_matmul.o
% /usr/local/bin/nvcc -g -G -Xlinker=-R/usr/local/cuda/lib64 \
tx_cuda_matmul.o -o tx_cuda_matmul
% ./tx_cuda_matmul
A:
[  0][  0] 0.000000
...output deleted for brevity...
[  1][  1] 131.000000
%
```

Access the source code for this CUDA program `tx_cuda_matmul.cu` program at [“Sample CUDA Program”](#) on page 599.

Compiling for Fermi

To compile for Fermi, use the following compiler option:

```
-gencode arch=compute_20,code=sm_20
```

Compiling for Fermi and Tesla

To compile for both Fermi and Tesla GPUs, use the following compiler options:

```
-gencode arch=compute_20,code=sm_20 -gencode arch=compute_10,code=sm_10
```

See the NVIDIA documentation for complete instructions on compiling your CUDA code.

Compiling for Kepler

To compile for Kepler GPUs, use the following compiler options:

```
-gencode arch=compute_35,code=sm_35
```

See the NVIDIA documentation for complete instructions on compiling your CUDA code.

Starting a TotalView CUDA Session

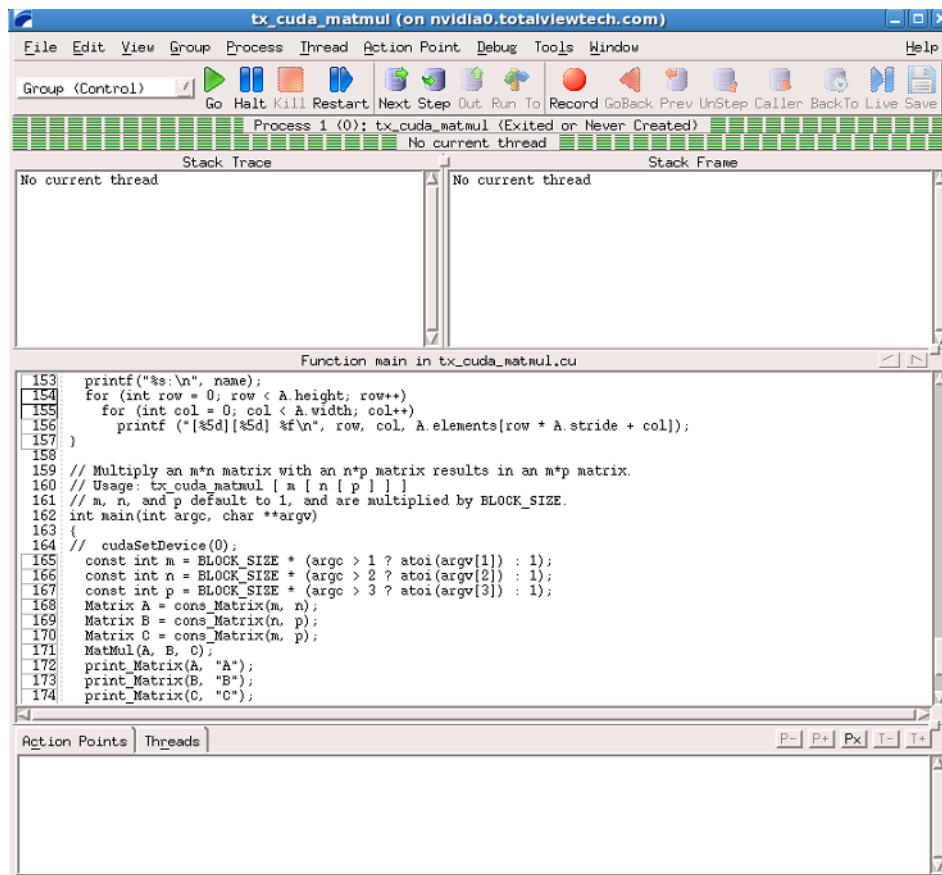
A standard Linux-x86_64 TotalView installation supports debugging CUDA applications running on both the host and GPU processors. TotalView dynamically detects a CUDA install on your system. To start the TotalView GUI or CLI, provide the name of your CUDA host executable to the **totalview** or **totalviewcli** command. For example, to start the TotalView GUI on the sample program, use the following command:

```
% totalview tx_cuda_matmul
CUDA library loaded: Current API is 3.0 rev 17
...
```

If TotalView successfully loads the CUDA debugging library, it prints the current API version and revision as shown above.

After reading the symbol table information for the CUDA host executable, TotalView opens the initial process window focused on main in the host code, as shown in Figure 258.

Figure 258 – Initial process window opened on CUDA host code



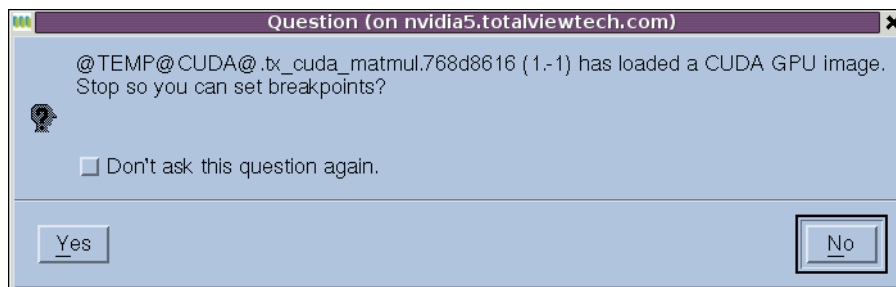
You can debug the CUDA host code using the normal TotalView commands and procedures.

Loading the CUDA Kernel

The executable that runs on the GPU is not available to the debugger until the CUDA kernel is launched. Therefore, you have to allow the host code to launch the CUDA kernel before you can plant breakpoints in CUDA GPU code.

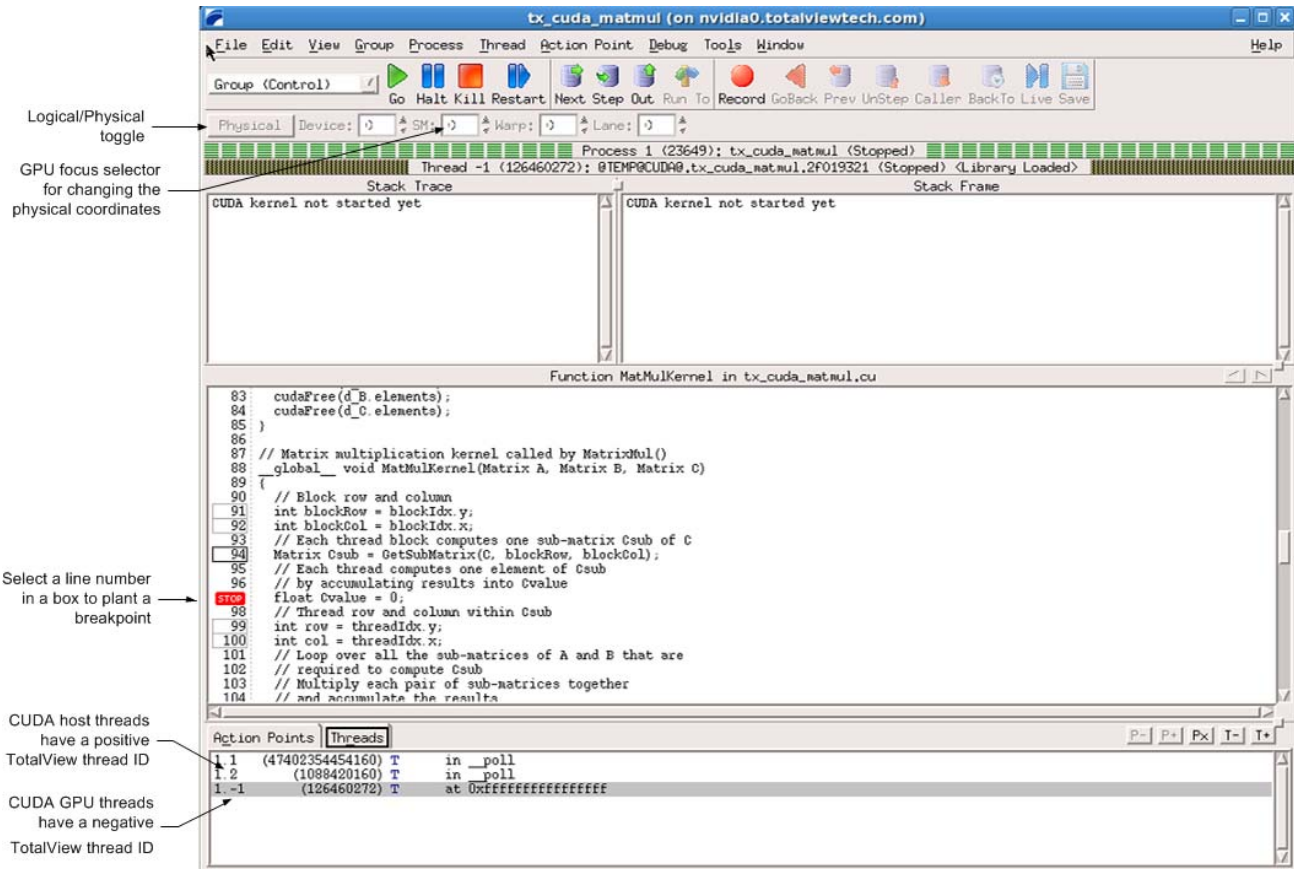
To debug the CUDA GPU code, continue running the CUDA host code so that it executes the CUDA kernel invocation. For example, select "Go" on the process window to start running the CUDA host process. When the process executes the CUDA kernel invocation and loads the GPU executable onto the device, TotalView posts a dialog box as shown in [Figure 259](#).

Figure 259 – CUDA GPU image load dialog box



Select "**Yes**" to plant breakpoints in the CUDA GPU code. The TotalView process window automatically refocuses on the CUDA thread showing the CUDA kernel ready to be executed, [Figure 260](#).

Figure 260 – TotalView process window focused on a newly loaded CUDA thread



TotalView gives host threads a positive debugger thread ID and CUDA threads a negative thread ID. In the above example, the initial host thread in process "1" is labeled "1.1" and the CUDA thread is labeled "1.-1". In TotalView, a "CUDA thread" is a CUDA kernel invocation consisting of registers and memory, as well as a "GPU focus thread". Use the "GPU focus selector" to change the physical coordinates of the GPU focus thread.

There are two coordinate spaces. One is the logical coordinate space that is in CUDA terms grid and block indices: <<<(Bx,By,Bz),(Tx,Ty,Tz)>>>. The other is the physical coordinate space that is in hardware terms the device number, streaming multiprocessor (SM) number on the device, warp (WP) number on the SM, and lane (LN) number on the warp.

Any given thread has both a thread index in this 4D physical coordinate space, and a different thread index in the 6D logical coordinate space. These indices are shown in a series of spin boxes in the process window. If the button says “Physical” (Figure 260), the physical thread number is displayed; if “Logical” (Figure 262), the logical number. Pressing this button switches between the two numbering systems, but does not change the actual thread.

Figure 261 – Logical / physical toggle in the process window



To view a CUDA host thread, select a thread with a positive thread ID in the Threads tab of the process window. To view a CUDA GPU thread, select a thread with a negative thread ID, then use the GPU thread selector to focus on a specific GPU thread. There is one GPU focus thread per CUDA thread, and changing the GPU focus thread affects all windows displaying information for a CUDA thread and all command line interface commands targeting a CUDA thread. In other words, changing the GPU focus thread can change data displayed for a CUDA thread and affect other commands, such as single-stepping.

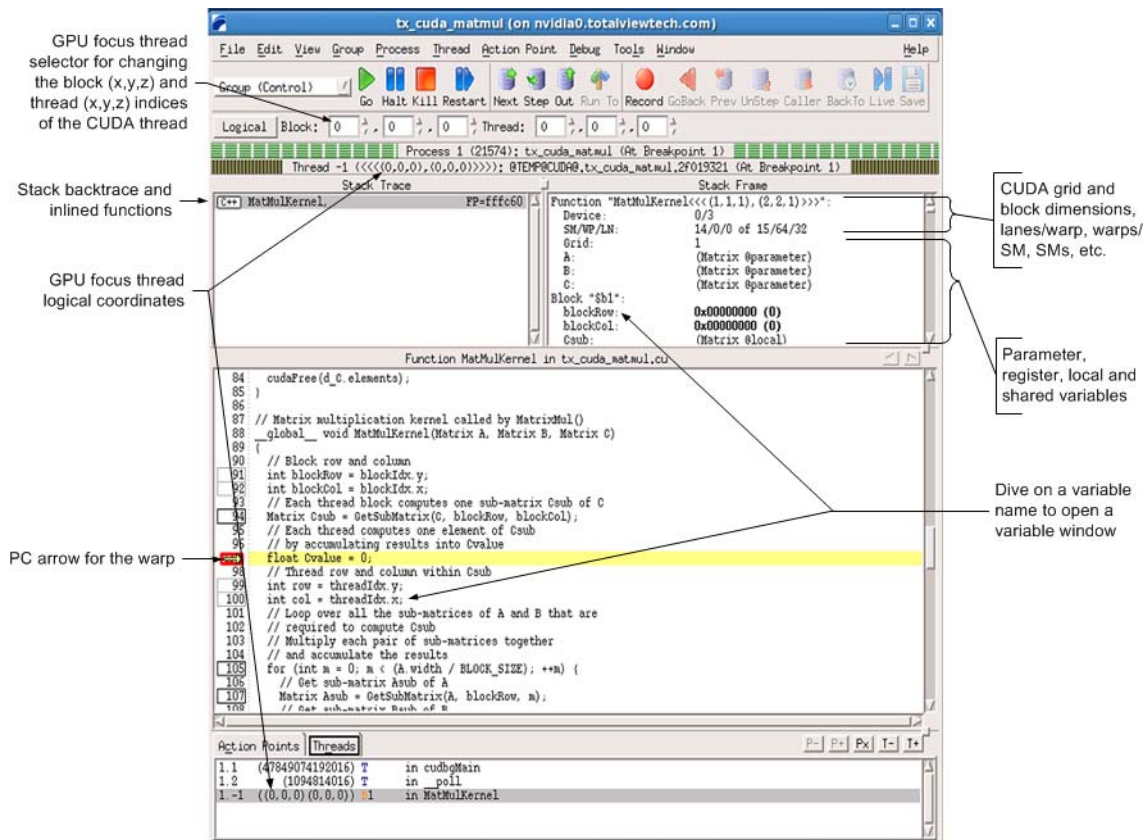
Note that in all cases, when you select a thread, TotalView automatically switches the stack trace, stack frame and source panes, and Action Points tab to match the selected thread.

Controlling Execution

Running to a Breakpoint in the GPU code

Select a line number inside a box to plant a breakpoint in the GPU code, and select "Go" to continue the process, which will start the execution of the CUDA kernel. Once the CUDA kernel starts executing, it will hit the breakpoint planted in the GPU code, as shown in Figure 262.

Figure 262 – CUDA thread stopped at a breakpoint, focused on GPU thread <<<(0,0,0),(0,0,0)>>>



The logical coordinates of the GPU focus threads are shown in the thread status title bar and the Threads pane. You can use the GPU focus thread selector to change the GPU focus thread. When you change the GPU focus thread, the logical coordinates displayed also change, and the stack trace, stack frame, and source panes are updated to reflect the state of the new GPU focus thread.

The yellow PC arrow in the source pane shows the execution location of the GPU focus thread. The GPU hardware threads, also known as "lanes", execute in parallel so multiple lanes may have the same PC value. The lanes may be part of the same warp, or in different warps.

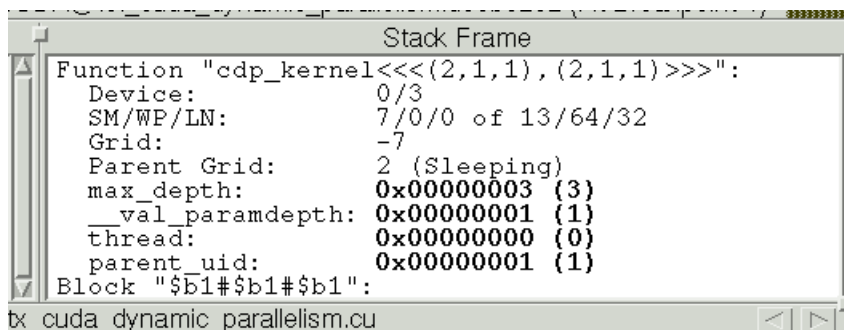
The stack trace pane shows the stack backtrace and inlined functions. Each stack frame in the stack backtrace represents either the PC location of GPU kernel code, or the expansion of an inlined function. Inlined functions can be nested. The "return PC" of an inlined function is the address of the first instruction following the inline expansion, which is normally within the function containing the inlined-function expansion.

The stack frame pane shows the parameter, register and local variables for the function in the selected stack frame. The variables for the selected GPU kernel code or inlined function expansion are shown.

Viewing the Kernel's Grid Identifier

TotalView 8.13 adds support for showing the grid identification in the stack frame information when a CUDA thread stops, [Figure 263](#).

Figure 263 – Viewing the Grid and Parent Grid Identifiers



The grid is a unique identifier for a kernel running on a device. With CUDA SDK 5.5, kernels can launch parallel kernels on the same device. The parent grid is the identifier of the grid that launched the kernel currently in focus.

Single-Stepping GPU Code

TotalView allows you to single-step GPU code just like normal host code, but note that a single-step operation steps the entire warp associated with the GPU focus thread. So, when focused on a CUDA thread, a single-step operation advances all of the GPU hardware threads in the same warp as the GPU focus thread.

To advance the execution of more than one warp, you may either:

- set a breakpoint and continue the process
- select a line number in the source pane and select "Run To".

Execution of more than one warp also happens when single-stepping a **`__syncthreads()`** thread barrier call. Any source-level single-stepping operation runs all of the GPU hardware threads to the location following the thread barrier call.

Single-stepping an inlined function (nested or not) in GPU code behaves the same as single-stepping a non-inlined function. You can:

- step into an inlined function,
- step over an inlined function,
- run to a location inside an inlined function,
- single-step within an inlined function, and
- return out of an inlined function.

Halting a Running Application

You can temporarily halt a running application at any time by selecting "Halt", which halts the host and CUDA threads. This can be useful if you suspect the kernel might be hung or stuck in an infinite loop. You can resume execution at any time by selecting "Go" or by selecting one of the single-stepping buttons.

Displaying CUDA Program Elements

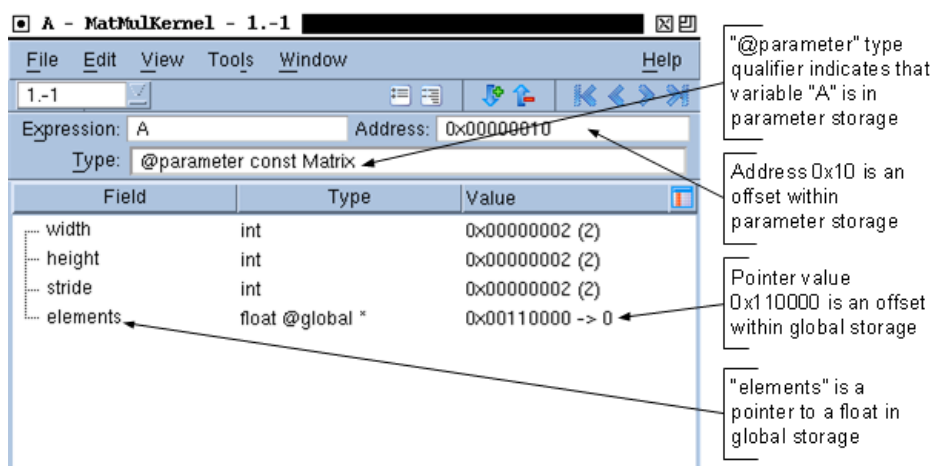
GPU Assembler Display

Due to limitations imposed by NVIDIA, assembler display is not supported. All GPU instructions are currently displayed as 32-bit hexadecimal words.

GPU Variable and Data Display

TotalView can display variables and data from a CUDA thread. The stack frame pane of the process window contains parameter, register, local, and shared variables, as shown in [Figure 264](#). The variables are contained within the lexical blocks in which they are defined. The type of the variable determines its storage kind (register, or local, shared, constant or global memory). The address is a PTX register name or an offset within the storage kind.

Figure 264 – A variable window displaying a parameter



Dive on a variable in the stack frame pane or source pane in the process window to open a variable window. [Figure 264](#) shows a parameter named **A** with type `@parameter const Matrix`.

The identifier `@parameter` is a TotalView built-in type storage qualifier that tells the debugger the storage kind of "A" is parameter storage. The debugger uses the storage qualifier to determine how to locate **A** in device memory. The supported type storage qualifiers are shown in [Table 2](#).

Table 2: Supported Type Storage Qualifiers

Storage Qualifier	Meaning
<code>@parameter</code>	Address is an offset within parameter storage.
<code>@local</code>	Address is an offset within local storage.

Table 2: Supported Type Storage Qualifiers

Storage Qualifier	Meaning
@shared	Address is an offset within shared storage.
@constant	Address is an offset within constant storage.
@global	Address is an offset within global storage.
@register	Address is a PTX register name (see below).

The type storage qualifier is a necessary part of the type for correct addressing in the debugger. When you edit a type or a type cast, make sure that you specify the correct type storage qualifier for the address offset.

CUDA Built-In Runtime Variables

TotalView allows access to the CUDA built-in runtime variables, which are handled by TotalView like any other variables, except that you cannot change their values.

The supported CUDA built-in runtime variables are as follows:

- `struct dim3_16 threadIdx;`
- `struct dim3_16 blockIdx;`
- `struct dim3_16 blockDim;`
- `struct dim3_16 gridDim;`
- `int warpSize;`

The types of the built-in variables are defined as follows:

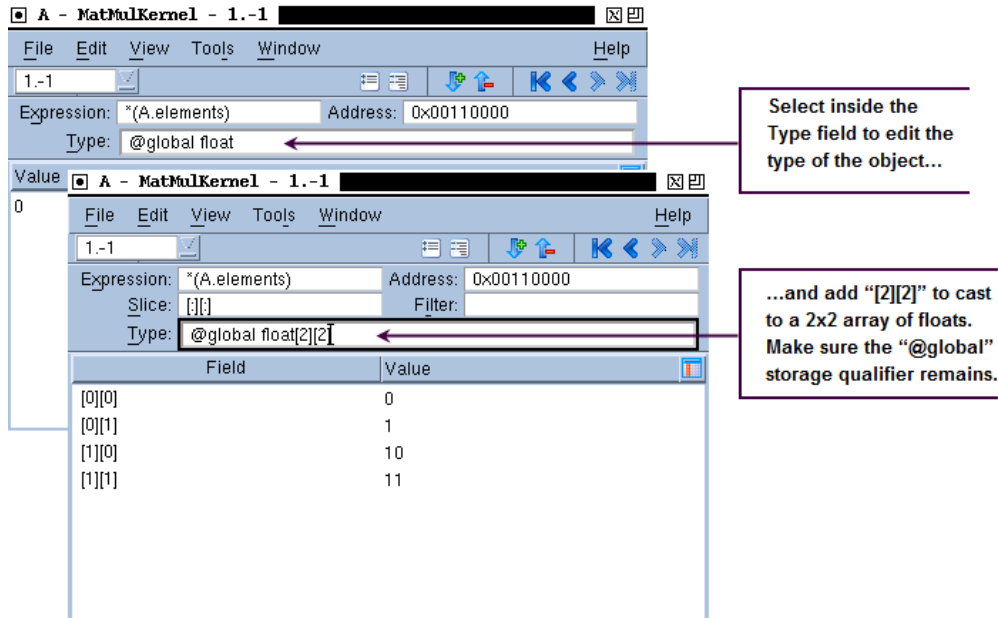
- `struct dim3_16 { unsigned short x, y, z; };`
- `struct dim2_16 { unsigned short x, y; };`

You can dive on the name of a runtime variable in the source pane of the process window, or input its name into the **View > Lookup Variable... (v)** menu command dialog box. Built-in variables can also be used in the TotalView expression system.

Type Casting

The variable window allows you to edit the types of variables. This is useful for viewing an address as a different type. For example, [Figure 265](#) shows the result of casting a float in global storage to a 2x2 array of floats in global storage.

Figure 265 – Casting to a 2x2 array of float in global storage



You can determine the storage kind of a variable by diving on the variable to open a variable window in the graphical user interface (GUI), or by using the **dwhat** command in the command line interface (CLI).

Here are some examples of using the CLI to determine variable types and to perform type casts. **Use Tools > Command Line** from the process window menu to open a CLI window from the GUI.

The following examples use the CLI for ease of illustration, but you can instead use the GUI by entering the cast expression (**dprint argument**) in the Expression field of the variable window.

When you are using the CLI and want to operate on a CUDA thread, you must first focus on the CUDA thread. The GPU focus thread in the CLI is the same as in the GUI:

```
d1.<> dfocus .-1
d1.-1
d1.-1>
```

The **dwhat** command prints the type and address offset or PTX register name of a variable. The **dwhat** command prints additional lines that have been omitted here for clarity:

```
d1.-1> dwhat A
In thread 1.-1:
Name: A; Type: @parameter const Matrix; Size: 24 bytes; Addr: 0x00000010
...
d1.-1> dwhat blockRow
In thread 1.-1:
Name: blockRow; Type: @register int; Size: 4 bytes; Addr: %r2
...
d1.-1> dwhat Csub
```

```

In thread 1.-1:
Name: Csub; Type: @local Matrix; Size: 24 bytes; Addr: 0x00000060
...
dl.-1>

```

You can use **dprint** in the CLI to cast and print an address offset as a particular type. Note that the CLI is a Tcl interpreter, so we wrap the expression argument to **dprint** in curly braces {} for Tcl to treat it as a literal string to pass into the debugger. For example, below we take the address of "A", which is at 0x10 in parameter storage. Then, we can cast 0x10 to a "pointer to a Matrix in parameter storage", as follows:

```

dl.-1> dprint {&A}
&A = 0x00000010 -> (Matrix const @parameter)
dl.-1> dprint {*(@parameter Matrix*)0x10}
*(@parameter Matrix*)0x10 = {
  width = 0x00000002 (2)
  height = 0x00000002 (2)
  stride = 0x00000002 (2)
  elements = 0x00110000 -> 0
}
dl.-1>

```

The above "@parameter" type qualifier is an important part of the cast, because without it the debugger cannot determine the storage kind of the address offset. Casting without the proper type storage qualifier usually results in "Bad address" being displayed, as follows:

```

dl.-1> dprint {*(Matrix*)0x10}
*(Matrix*)0x10 = <Bad address: 0x00000010> (struct Matrix)
dl.-1>

```

You can perform similar casts for global storage addresses. We know that "A.elements" is a pointer to a 2x2 array in global storage. The value of the pointer is 0x110000 in global storage. You can use C/C++ cast syntax:

```

dl.-1> dprint {A.elements}
A.elements = 0x00110000 -> 0
dl.-1> dprint {*(@global float(*)[2][2])0x00110000}
*(@global float(*)[2][2])0x00110000 = {
  [0][0] = 0
  [0][1] = 1
  [1][0] = 10
  [1][1] = 11
}
dl.-1>

```

Or you can use TotalView cast syntax, which is an extension to C/C++ cast syntax that allows you to simply read the type from right to left to understand what it is:

```

dl.-1> dprint {*(@global float[2][2]*)0x00110000}
*(@global float[2][2]*)0x00110000 = {
  [0][0] = 0
  [0][1] = 1
  [1][0] = 10

```



```

    [1][1] = 11
}
d1.-1>

```

If you know the address of a pointer and you want to print out the target of the pointer, you must specify a storage qualifier on both the pointer itself and the target type of the pointer. For example, if we take the address of "A.elements", we see that it is at address offset 0x20 in parameter storage, and we know that the pointer points into global storage. Consider this example:

```

d1.-1> dprint {*(@global float[2][2]*@parameter)0x20}
*(@global float[2][2]*@parameter)0x20 = 0x00110000 -> (@global float[2][2])
d1.-1> dprint {**(@global float[2][2]*@parameter)0x20}
**(@global float[2][2]*@parameter)0x20 = {
    [0][0] = 0
    [0][1] = 1
    [1][0] = 10
    [1][1] = 11
}
d1.-1>

```

Above, using the TotalView cast syntax and reading right to left, we cast 0x20 to a pointer in parameter storage to a pointer to a 2x2 array of floats in global storage. Dereferencing it once gives the value of the pointer to global storage. Dereferencing it twice gives the array in global storage. The following is the same as above, but this time in C/C++ cast syntax:

```

d1.-1> dprint {*(@global float(*@parameter)[2][2])0x20}
*(@global float(*@parameter)[2][2])0x20 = 0x00110000 -> (@global float[2][2])
d1.-1> dprint {**(@global float(*@parameter)[2][2])0x20}
**(@global float(*@parameter)[2][2])0x20 = {
    [0][0] = 0
    [0][1] = 1
    [1][0] = 10
    [1][1] = 11
}
d1.-1>

```

PTX Registers

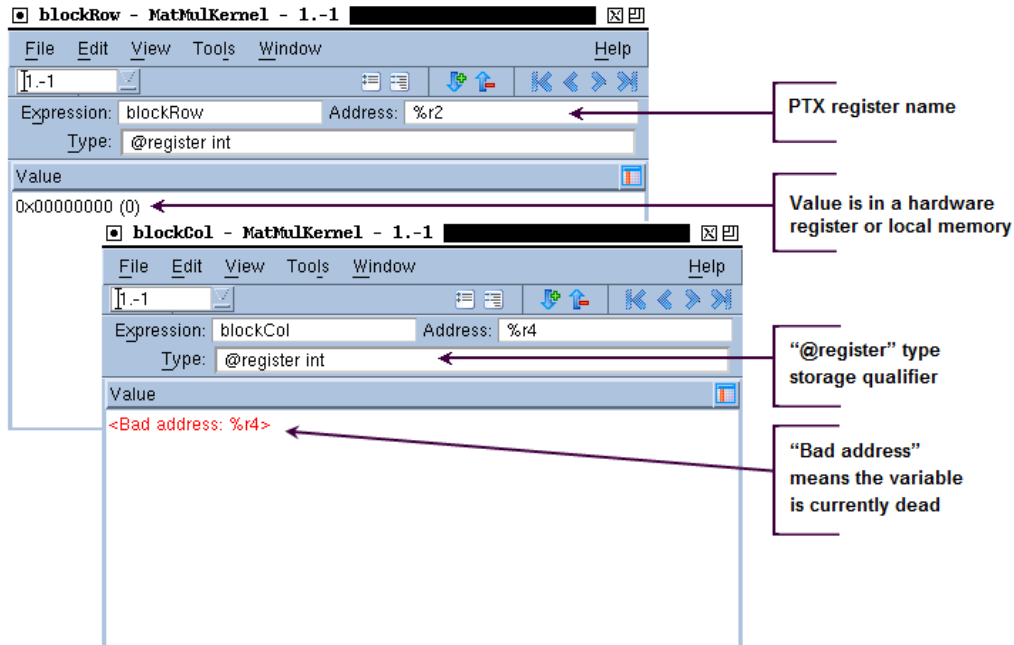
In CUDA, PTX registers are more like symbolic virtual locations than hardware registers in the classic sense. At any given point during the execution of CUDA device code, a variable that has been assigned to a PTX register may live in one of three places:

- A hardware (SAS) register
- Local storage
- Nowhere (its value is dead)

Variables that are assigned to PTX registers are qualified with the "@register" type storage qualifier, and their locations are PTX register names. The name of a PTX register can be anything, but the compiler usually assigns a name in one of the following formats: %rN, %rdN, or %fN, where N is a decimal number.

Using compiler-generated location information, TotalView maps a PTX register name to the SASS hardware register or local memory address where the PTX register is currently allocated. If the PTX register value is "live", then TotalView shows you the SASS hardware register name or local memory address. If the PTX register value is "dead", then TotalView displays **Bad address** and the PTX register name as show in [Figure 266](#).

Figure 266 – PTX register variables: one live, one dead



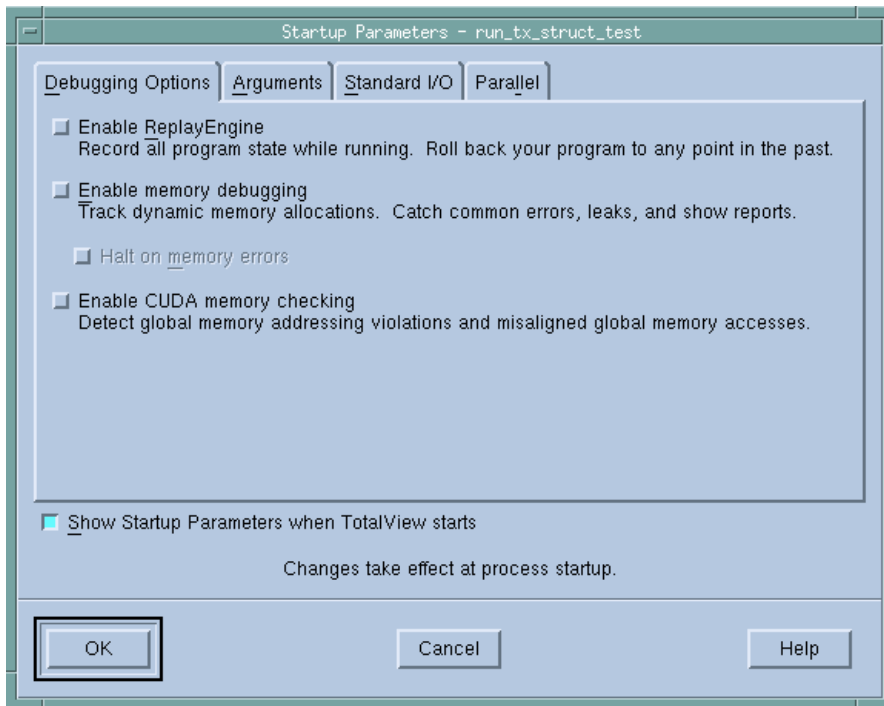
Enabling CUDA MemoryChecker Feature

You can detect global memory addressing violations and misaligned global memory accesses by enabling the CUDA MemoryChecker feature.

To enable the feature, use one of the following:

- Select "Enable CUDA memory checking" from the Startup Parameters dialog box in TotalView, as shown in [Figure 267](#).

Figure 267 – Enabling CUDA memory checking from TotalView Startup Parameters



- Pass the `-cuda_memcheck` option to the `totalview` command.
- Set the `TV::cuda_memcheck` CLI state variable to `true`. For example:
`dset TV::cuda_memcheck true`

Note that global memory violations and misaligned global memory accesses will be detected only while the CUDA thread is running. Detection will not happen when single-stepping the CUDA thread.

GPU Core Dump Support

CUDA GPU core dumps can be debugged just as you debug any other core dump. To obtain a GPU core dump, you must first set the `CUDA_ENABLE_COREDUMP_ON_EXCEPTION` environment variable to `1` to enable generation of a GPU core dump when a GPU exception is encountered. This option is disabled by default.

To change the default core dump file name, set the `CUDA_COREDUMP_FILE` environment variable to a specific file name. The default core dump file name is in the following format: `core.cuda.<hostname>.<pid>` where `<hostname>` is the host name of machine running the CUDA application and `<pid>` is the process identifier of the CUDA application.

To debug a GPU core dump, TotalView must be running on a machine with the CUDA SDK installed.

As with any core dump, you must also supply the name of the executable that produced the core dump:

```
totalview <executable> <core-dump-file>
```

GPU Error Reporting

By default, TotalView reports GPU exception errors as "signals". Continuing the application after these errors can lead to application termination or unpredictable results.

Table 3 lists reported errors, according to these platforms and settings:

- Exception codes **Lane Illegal Address** and **Lane Misaligned Address** are detected using all supported SDK versions when CUDA memcheck is enabled, on supported Tesla and Fermi hardware.
- All other CUDA errors are detected only for GPUs with sm_20 or higher (for example Fermi) running SDK 3.1 or higher. It is not necessary to enable CUDA memcheck to detect these errors.

Table 3: CUDA Exception Codes

Exception code	Error Precision	Error Scope	Description
CUDA_EXCEPTION_0: "Device Unknown Exception"	Not precise	Global error on the GPU	An application-caused global GPU error that does not match any of the listed error codes below.
CUDA_EXCEPTION_1: "Lane Illegal Address"	Precise (Requires memcheck on)	Per lane/thread error	A thread has accessed an illegal (out of bounds) global address.
CUDA_EXCEPTION_2: "Lane User Stack Overflow"	Precise	Per lane/thread error	A thread has exceeded its stack memory limit.
CUDA_EXCEPTION_3: "Device Hardware Stack Overflow"	Not precise	Global error on the GPU	The application has triggered a global hardware stack overflow, usually caused by large amounts of divergence in the presence of function calls.
CUDA_EXCEPTION_4: "Warp Illegal Instruction"	Not precise	Warp error	A thread within a warp has executed an illegal instruction.
CUDA_EXCEPTION_5: "Warp Out-of-range Address"	Not precise	Warp error	A thread within a warp has accessed an address that is outside the valid range of local or shared memory regions.
CUDA_EXCEPTION_6: "Warp Misaligned Address"	Not precise	Warp error	A thread within a warp has accessed an incorrectly aligned address in the local or shared memory segments.
CUDA_EXCEPTION_7: "Warp Invalid Address Space"	Not precise	Warp error	A thread within a warp has executed an instruction that attempts to access a memory space not permitted for that instruction.

Table 3: CUDA Exception Codes

Exception code	Error Precision	Error Scope	Description
CUDA_EXCEPTION_8: "Warp Invalid PC"	Not precise	Warp error	A thread within a warp has advanced its PC beyond the 40-bit address space.
CUDA_EXCEPTION_9: "Warp Hardware Stack Overflow"	Not precise	Warp error	A thread within a warp has triggered a hardware stack overflow.
CUDA_EXCEPTION_10: "Device Illegal Address"	Not precise	Global error	A thread has accessed an illegal (out of bounds) global address. For increased precision, enable memcheck.
CUDA_EXCEPTION_11: "Lane Misaligned Address"	Precise (Requires memcheck on)	Per lane/thread error	A thread has accessed an incorrectly aligned global address.

Displaying Device Information

TotalView can display each device installed on the system, along with the properties of each SM, warp, and lane on that device. Together, these four attributes form the physical coordinates of a CUDA thread. To view the window, select **Tools > CUDA Devices**.

Figure 268 – CUDA Devices when no CUDA threads are present

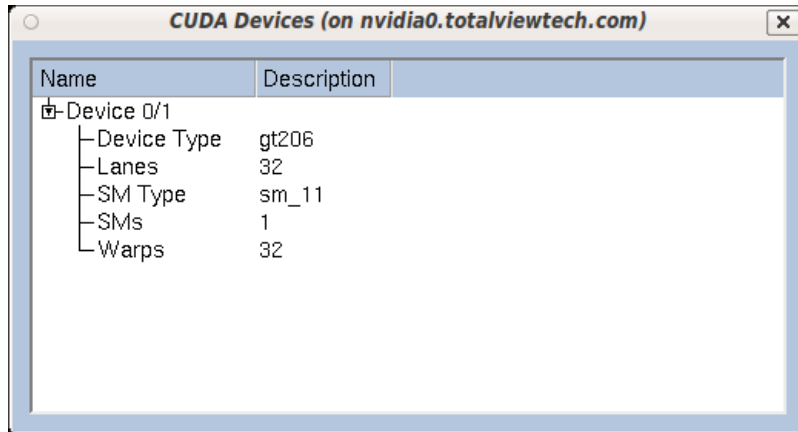
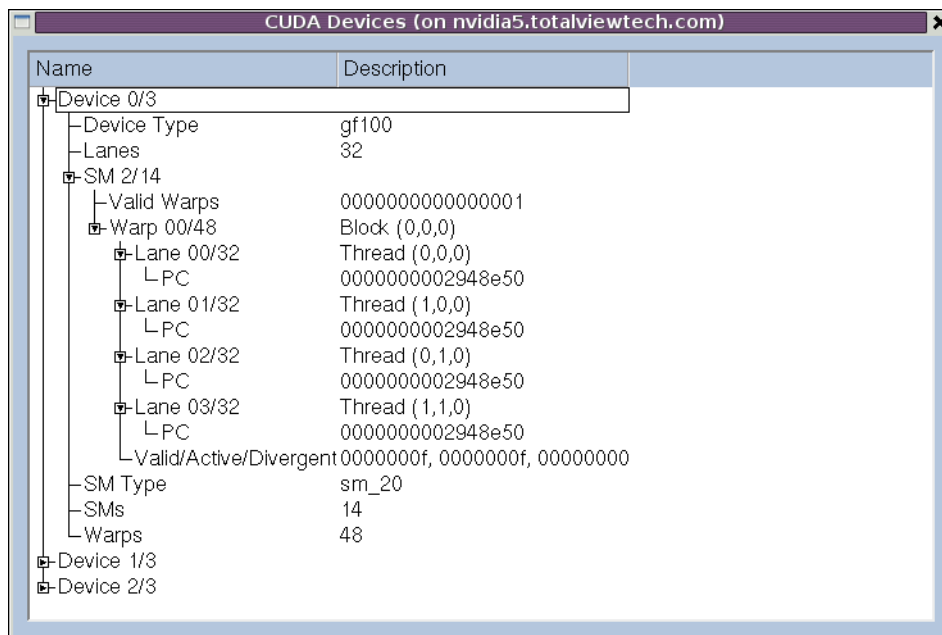


Figure 269 – CUDA Devices when CUDA threads are present





CUDA Problems and Limitations

CUDA TotalView sits directly on top of the CUDA debugging environment provided by NVIDIA, which is still evolving and maturing. This environment contains certain problems and limitations, discussed in this chapter.

Hangs or Initialization Failures

When starting a CUDA debugging session, you may encounter hangs in the debugger or target application, initialization failures, or failure to launch a kernel. Use the following checklist to diagnose the problem:

Serialized Access There may be at most one CUDA debugging session active per node at a time. A node cannot be shared for debugging CUDA code simultaneously by multiple user sessions, or multiple sessions by the same user. Use `ps` or other system utilities to determine if your session is conflicting with another debugging session.

Leaky Pipes The CUDA debugging environment uses FIFOs (named pipes) located in `/tmp` and named matching the pattern `"cudagdb_pipe.N.N"`, where `N` is a decimal number. Occasionally, a debugging session might accidentally leave a set of pipes lying around. You may need to manually delete these pipes in order to start your CUDA debugging session:

```
rm /tmp/cudagdb_pipe.*
```

If the pipes were leaked by another user, that user will own the pipes and you may not be able to delete them. In this case, ask the user or system administrator to remove them for you.

Orphaned Processes Occasionally, a debugging session might accidentally orphan a process. Orphaned processes might go compute bound or prevent you or other users from starting a debugging

session. You may need to manually kill orphaned CUDA processes in order to start your CUDA debugging session or stop a compute-bound process. Use system tools such as ps or top to find the processes and kill them using the shell kill command. If the process were orphaned by another user, that user will own the processes and you may not be able to kill them. In this case, ask the user or system administrator to kill them for you.

Multi-threaded Programs on Fermi

We have seen problems debugging some multi-threaded CUDA programs on Fermi, where the CUDA debugging environment kills the debugger with an internal error (SIGSEGV). We are working with NVIDIA to resolve this problem.

CUDA and ReplayEngine

You can enable ReplayEngine while debugging CUDA code; that is, ReplayEngine record mode will work. However, ReplayEngine does not support replay operations when focused on a CUDA thread. If you attempt this, you will receive a Not Supported error.



Chapter 28

Sample CUDA Program

```
/*
 * NVIDIA CUDA matrix multiply example straight out of the CUDA
 * programming manual, more or less.
 */

#include <cuda.h>
#include <stdio.h>

// Matrices are stored in row-major order:
// M(row, col) = *(M.elements + row * M.stride + col)
typedef struct {
    int width; /* number of columns */
    int height; /* number of rows */
    int stride;
    float* elements;
} Matrix;

// Get a matrix element
__device__ float GetElement(const Matrix A, int row, int col)
{
    return A.elements[row * A.stride + col];
}

// Set a matrix element
__device__ void SetElement(Matrix A, int row, int col, float value)
{
    A.elements[row * A.stride + col] = value;
}
```

```

}

// Thread block size
#define BLOCK_SIZE 2

// Get the BLOCK_SIZExBLOCK_SIZE sub-matrix Asub of A that is
// located col sub-matrices to the right and row sub-matrices down
// from the upper-left corner of A
__device__ Matrix GetSubMatrix(Matrix A, int row, int col)
{
    Matrix Asub;
    Asub.width = BLOCK_SIZE;
    Asub.height = BLOCK_SIZE;
    Asub.stride = A.stride;
    Asub.elements = &A.elements[A.stride * BLOCK_SIZE * row
        + BLOCK_SIZE * col];
    return Asub;
}

// Forward declaration of the matrix multiplication kernel
__global__ void MatMulKernel(const Matrix, const Matrix, Matrix);

// Matrix multiplication - Host code
// Matrix dimensions are assumed to be multiples of BLOCK_SIZE
void MatMul(const Matrix A, const Matrix B, Matrix C)
{
    // Load A and B to device memory
    Matrix d_A;
    d_A.width = d_A.stride = A.width; d_A.height = A.height;
    size_t size = A.width * A.height * sizeof(float);
    cudaMalloc((void**)&d_A.elements, size);
    cudaMemcpy(d_A.elements, A.elements, size,
        cudaMemcpyHostToDevice);
    Matrix d_B;
    d_B.width = d_B.stride = B.width; d_B.height = B.height;
    size = B.width * B.height * sizeof(float);
    cudaMalloc((void**)&d_B.elements, size);
    cudaMemcpy(d_B.elements, B.elements, size,
        cudaMemcpyHostToDevice);
    // Allocate C in device memory
    Matrix d_C;
    d_C.width = d_C.stride = C.width; d_C.height = C.height;
    size = C.width * C.height * sizeof(float);
    cudaMalloc((void**)&d_C.elements, size);
    // Invoke kernel
    dim3 dimBlock(BLOCK_SIZE, BLOCK_SIZE);
    dim3 dimGrid(B.width / dimBlock.x, A.height / dimBlock.y);
    MatMulKernel<<<dimGrid, dimBlock>>>(d_A, d_B, d_C);
}

```

```

// Read C from device memory
cudaMemcpy(C.elements, d_C.elements, size,
           cudaMemcpyDeviceToHost);
// Free device memory
cudaFree(d_A.elements);
cudaFree(d_B.elements);
cudaFree(d_C.elements);
}

// Matrix multiplication kernel called by MatrixMul()
__global__ void MatMulKernel(Matrix A, Matrix B, Matrix C)
{
// Block row and column
int blockRow = blockIdx.y;
int blockCol = blockIdx.x;
// Each thread block computes one sub-matrix Csub of C
Matrix Csub = GetSubMatrix(C, blockRow, blockCol);
// Each thread computes one element of Csub
// by accumulating results into Cvalue
float Cvalue = 0;
// Thread row and column within Csub
int row = threadIdx.y;
int col = threadIdx.x;
// Loop over all the sub-matrices of A and B that are
// required to compute Csub
// Multiply each pair of sub-matrices together
// and accumulate the results
for (int m = 0; m < (A.width / BLOCK_SIZE); ++m) {
// Get sub-matrix Asub of A
Matrix Asub = GetSubMatrix(A, blockRow, m);
// Get sub-matrix Bsub of B
Matrix Bsub = GetSubMatrix(B, m, blockCol);
// Shared memory used to store Asub and Bsub respectively
__shared__ float As[BLOCK_SIZE][BLOCK_SIZE];
__shared__ float Bs[BLOCK_SIZE][BLOCK_SIZE];
// Load Asub and Bsub from device memory to shared memory
// Each thread loads one element of each sub-matrix
As[row][col] = GetElement(Asub, row, col);
Bs[row][col] = GetElement(Bsub, row, col);
// Synchronize to make sure the sub-matrices are loaded
// before starting the computation
__syncthreads();
// Multiply Asub and Bsub together
for (int e = 0; e < BLOCK_SIZE; ++e)
Cvalue += As[row][e] * Bs[e][col];
// Synchronize to make sure that the preceding
// computation is done before loading two new
// sub-matrices of A and B in the next iteration
}
}

```

```

    __syncthreads();
}
// Write Csub to device memory
// Each thread writes one element
SetElement(Csub, row, col, Cvalue);
// Just a place to set a breakpoint in the debugger
__syncthreads();
__syncthreads();/* STOP: Csub should be fully updated */
}

static Matrix
cons_Matrix (int height_, int width_)
{
    Matrix A;
    A.height = height_;
    A.width = width_;
    A.stride = width_;
    A.elements = (float*) malloc(sizeof(*A.elements) * width_ * height_);
    for (int row = 0; row < height_; row++)
        for (int col = 0; col < width_; col++)
            A.elements[row * width_ + col] = row * 10.0 + col;
    return A;
}

static void
print_Matrix (Matrix A, char *name)
{
    printf("%s:\n", name);
    for (int row = 0; row < A.height; row++)
        for (int col = 0; col < A.width; col++)
            printf ("[%5d][%5d] %f\n", row, col, A.elements[row * A.stride + col]);
}

// Multiply an m*n matrix with an n*p matrix results in an m*p matrix.
// Usage: tx_cuda_matmul [ m [ n [ p ] ] ]
// m, n, and p default to 1, and are multiplied by BLOCK_SIZE.
int main(int argc, char **argv)
{
    // cudaSetDevice(0);
    const int m = BLOCK_SIZE * (argc > 1 ? atoi(argv[1]) : 1);
    const int n = BLOCK_SIZE * (argc > 2 ? atoi(argv[2]) : 1);
    const int p = BLOCK_SIZE * (argc > 3 ? atoi(argv[3]) : 1);
    Matrix A = cons_Matrix(m, n);
    Matrix B = cons_Matrix(n, p);
    Matrix C = cons_Matrix(m, p);
    MatMul(A, B, C);
}

```

```
print_Matrix(A, "A");  
print_Matrix(B, "B");  
print_Matrix(C, "C");  
return 0;  
}
```



PART VI

Appendices

This part contains appendices that are essentially reference material:

Appendix A, "Glossary," on page 605

Definitions for technical terms used in this documentation.

Appendix B, "Licenses," on page 623

Licenses for 3rd-party software.

Appendix C, "Resources," on page 627

General information on resources available to you.

Glossary

ACTION POINT: A debugger feature that lets a user request that program execution stop under certain conditions. Action points include breakpoints, watchpoints, eval points, and barriers.

ACTION POINT IDENTIFIER:

A unique integer ID associated with an action point.

ACTIVATION RECORD:

See [stack frame](#) on page 618.

ADDRESS SPACE:

A region of memory that contains code and data from a program. One or more threads can run in an address space. A process normally contains an address space.

ADDRESSING EXPRESSION:

A set of instructions that tell TotalView where to find information. These expressions are only used within the [type transformation facility](#).

AFFECTED P/T SET:

The set of process and threads that are affected by the command. For most commands, this is identical to the target P/T set, but in some cases it might include additional threads. (See "[p/t \(process/thread\) set](#)" on page 616 for more information.)

AGGREGATE DATA:

A collection of data elements. For example, a structure or an array is an aggregate.

AGGREGATED OUTPUT:

The CLI compresses output from multiple threads when they would be identical except for the P/T identifier.

API:

Application Program Interface. The formal interface by which programs communicate with libraries.

ARENA:

A specifier that indicates the processes, threads, and groups upon which a command executes. Arena specifiers are **p** (process), **t** (thread), **g** (group), **d** (default), and **a** (all).

ARRAY SECTION:

In Fortran, a portion of an array that is also an array. The elements of this array is a new unnamed array object with its own indices. Compare this with a TotalView [array slice](#) on page 606.

ARRAY SLICE:

A subsection of an array, which is expressed in terms of a [lower bound](#) on page 613, [upper bound](#) on page 621, and [stride](#) on page 619. Displaying a slice of an array can be useful when you are working with very large arrays. Compare this with a TotalView [array section](#) on page 606.

ASYNCHRONOUS:

When processes communicate with one another, they send messages. If a process decides that it doesn't want to wait for an answer, it is said to run "asynchronously." For example, in most client/server programs, one program sends an RPC request to a second program and then waits to receive a response from the second program. This is the normal *synchronous* mode of operation. If, however, the first program sends a message and then continues executing, not waiting for a reply, the first mode of operation is said to be *asynchronous*.

ATTACH:

The ability for TotalView to gain control of an already running process on the same machine or a remote machine.

AUTOLAUNCHING:

When a process begins executing on a remote computer, TotalView can also launch a **tvdsvr** (TotalView Debugger Server) process on the computer that will send debugging information back to the TotalView process that you are interacting with.

AUTOMATIC PROCESS ACQUISITION:

TotalView automatically detects the many processes that parallel and distributed programs run in, and attaches to them automatically so you don't have to attach to them manually. If the process is on a remote computer, automatic process acquisition automatically starts the TotalView Debugger Server (**tvdsvr**).

BARRIER POINT:

An action point specifying that processes reaching a particular location in the source code should stop and wait for other processes to catch up.

BASE WINDOW:

The original Process Window or Variable Window before you dive into routines or variables. After diving, you can use a **Reset** or **Undive** command to restore this original window.

BLOCKED:

A thread state in which the thread is no longer executing because it is waiting for an event to occur. In most cases, the thread is blocked because it is waiting for a mutex or condition state.

BREAKPOINT:

A point in a program where execution can be suspended to permit examination and manipulation of data.

BUG:

A programming error. Finding them is why you're using TotalView.

BULK LAUNCH:

A TotalView procedure that launches multiple tvdsrv processes simultaneously.

CAF:

See CoArray Fortran.

CALL FRAME:

The memory area that contains the variables belonging to a function, subroutine, or other scope division, such as a block.

CALL STACK:

A higher-level view of stack memory, interpreted in terms of source program variables and locations. This is where your program places stack frames.

CALLBACK:

A function reference stored as a pointer. By using the function reference, this function can be invoked. For example, a program can hand off the function reference to an event processor. When the event occurs, the function can be called.

CHILD PROCESS:

A process created by another process (see "parent process" on page 615) when that other process calls the **fork()** function.

CLOSED LOOP:

See closed loop on page 607.

CLUSTER DEBUGGING:

The action of debugging a program that is running on a cluster of hosts in a network. Typically, the hosts are of the same type and have the same operating system version.

COARRAY FORTRAN (CAF):

A variation of Fortran with array syntax augmented to depict arrays distributed across processes.

COMMAND HISTORY LIST:

A debugger-maintained list that stores copies of the most recent commands issued by the user.

CONDITION SYNCHRONIZATION:

A process that delays thread execution until a condition is satisfied.

CONDITIONAL BREAKPOINT:

A breakpoint containing an expression. If the expression evaluates to true, program stops. TotalView does not have conditional breakpoints. Instead, you must explicitly tell TotalView to end execution by using the `$stop` directive.

CONTEXT SWITCHING:

In a multitasking operating system, the ability of the CPU to move from one task to another. As a switch is made, the operating system must save and restore task states.

CONTEXTUALLY QUALIFIED (SYMBOL):

A symbol that is described in terms of its dynamic context, rather than its static scope. This includes process identifier, thread identifier, frame number, and variable or subprocedure name.

CONTROL GROUP:

All the processes that a program creates. These processes can be local or remote. If your program uses processes that it did not create, TotalView places them in separate control groups. For example, a client/server program has two distinct executables that run independently of one another. Each would be in a separate control group. In contrast, processes created by the `fork()` function are in the same control group.

CORE FILE:

A file that contains the contents of memory and a list of thread registers. The operating system dumps (creates) a core file whenever a program exits because of a severe error (such as an attempt to store into an invalid address).

CORE-FILE DEBUGGING:

A debugging session that examines a core file image. Commands that modify program state are not permitted in this mode.

CPU:

Central Processing Unit. The component within the computer that most people think of as “the computer”. This is where computation and activities related to computing occur.

CROSS-DEBUGGING:

A special case of remote debugging where the host platform and the target platform are different types of machines.

CURRENT FRAME:

The current portion of stack memory, in the sense that it contains information about the subprocedure invocation that is currently executing.

CURRENT LANGUAGE:

The source code language used by the file that contains the current source location.

CURRENT LIST LOCATION:

The location governing what source code appears in response to a list command.

DATASET:

A set of array elements generated by TotalView and sent to the Visualizer. (See [visualizer process](#) on page 621.)

DBELOG LIBRARY:

A library of routines for creating event points and generating event logs from TotalView. To use event points, you must link your program with both the **dbelog** and **elog** libraries.

DBFORK LIBRARY:

A library of special versions of the **fork()** and **execve()** calls used by TotalView to debug multi-process programs. If you link your program with the TotalView **dbfork** library, TotalView can automatically attach to newly spawned processes.

DEADLOCK:

A condition where two or more processes are simultaneously waiting for a resource such that none of the waiting processes can execute.

DEBUGGING INFORMATION:

Information relating an executable to the source code from which it was generated.

DEBUGGER PROMPT:

A string printed by the CLI that indicates that it is ready to receive another user command.

DEBUGGER SERVER:

See [tvdsvr process](#) on page 621.

DEBUGGER STATE:

Information that TotalView or the CLI maintains to interpret and respond to user commands. This includes debugger modes, user-defined commands, and debugger variables.

DEPRECATED:

A feature that is still available but might be eliminated in a future release.

DISASSEMBLED CODE:

A symbolic translation of binary code into assembler language.

DISTRIBUTED DEBUGGING:

The action of debugging a program that is running on more than one host in a network. The hosts can be homogeneous or heterogeneous. For example, programs written with message-passing libraries such as Parallel Macros (PARMACS), run on more than one host.

DIVING:

The action of displaying more information about an item. For example, if you dive into a variable in TotalView, a window appears with more information about the variable.

DLL:

Dynamic Link Library. A shared library whose functions can be dynamically added to a process when a function with the library is needed. In contrast, a statically linked library is brought into the program when it is created.

DOPE VECTOR:

This is a run time descriptor that contains all information about an object that requires more information than is available as a single pointer or value. For example, you might declare a Fortran 90 pointer variable that is a pointer to some other object, but which has its own upper bound, as follows:

```
integer, pointer, dimension (:) :: iptr
```

Suppose that you initialize it as follows:

```
iptr => iarray (20:1:-2)
```

iptr is a synonym for every other element in the first twenty elements of **iarray**, and this pointer array is in reverse order. For example, **iptr(1)** maps to **iarray(20)**, **iptr(2)** maps to **iarray(18)**, and so on.

A compiler represents an **iptr** object using a run time descriptor that contains (at least) elements such as a pointer to the first element of the actual data, a stride value, and a count of the number of elements (or equivalently, an upper bound).

DPID:

Debugger ID. This is the ID TotalView uses for processes.

DYNAMIC LIBRARY:

A library that uses dynamic loading to load information in an external file at runtime. Dynamic loading implies dynamic linking, which is a process that does not copy a program and its data into the executable at compile time.

EDITING CURSOR:

A black line that appears when you select a TotalView GUI field for editing. You use field editor commands to move the editing cursor.

EVAL POINT:

A point in the program where TotalView evaluates a code fragment without stopping the execution of the program.

EVENT LOG:

A file that contains a record of events for each process in a program.

EVENT POINT:

A point in the program where TotalView writes an event to the event log for later analysis with TimeScan.

EXCEPTION:

A condition generated at runtime that indicates that a non-standard event has occurred. The program usually creates a method to handle the event. If the event is not handled, either the program's result will be inaccurate or the program will stop executing.

EXECUTABLE:

A compiled and linked version of source files

EXPRESSION SYSTEM:

A part of TotalView that evaluates C, C++, and Fortran expressions. An expression consists of symbols (possibly qualified), constants, and operators, arranged in the syntax of a source language. Not all Fortran 90, C, and C++ operators are supported.

EXTENT:

The number of elements in the dimension of an array. For example, a Fortran array of integer(7,8) has an extent of 7 in one dimension (7 rows) and an extent of 8 in the other dimension (8 columns).

FIELD EDITOR:

A basic text editor that is part of TotalView. The field editor supports a subset of GNU Emacs commands.

FOCUS:

The set of groups, processes, and threads upon which a CLI command acts. The current focus is indicated in the CLI prompt (if you're using the default prompt).

FRAME:

An area in stack memory that contains the information corresponding to a single invocation of a subprocedure. See [stack frame](#) on page 618.

FRAME POINTER:

See [stack pointer](#) on page 618.

FULLY QUALIFIED (SYMBOL):

A symbol is fully qualified when each level of source code organization is included. For variables, those levels are executable or library, file, procedure or line number, and variable name.

GARBAGE COLLECTION:

Examining memory to determine if it is still be referenced. If it is not, it sent back to the program's memory manager so that it can be reused.

GID:

The TotalView group ID.

GLOBAL ARRAYS:

(from a definition on the Global Arrays web site) The Global Arrays (GA) toolkit provides an efficient and portable "shared-memory" programming interface for distributed-memory computers. Each process in a MIMD parallel program can asynchronously access logical blocks of physically distributed dense multi-dimensional arrays, without need for explicit cooperation by other processes. For more information, see <http://hpc.pnl.gov/globalarrays/>.

GRID:

A collection of distributed computing resources available over a local or wide area network that appears as if it were one large virtual computing system.

GOI:

The group of interest. This is the group that TotalView uses when it is trying to determine what to step, stop, and so on.

GROUP:

When TotalView starts processes, it places related processes in families. These families are called “groups.”

GROUP OF INTEREST:

The primary group that is affected by a command. This is the group that TotalView uses when it is trying to determine what to step, stop, and so on.

HEAP:

An area of memory that your program uses when it dynamically allocates blocks of memory. It is also how people describe my car.

HOST COMPUTER:

The computer on which TotalView is running.

IMAGE:

All of the programs, libraries, and other components that make up your executable.

INFINITE LOOP:

See [loop](#), [infinite](#) on page 613.

INSTRUCTION POINTER:

See program counter.

INITIAL PROCESS:

The process created as part of a load operation, or that already existed in the runtime environment and was attached by TotalView or the CLI.

INITIALIZATION FILE:

An optional file that establishes initial settings for debugger state variables, user-defined commands, and any commands that should be executed whenever TotalView or the CLI is invoked. Must be called **.tvdrc**.

INTERPRETER:

A program that reads programming language statements and translates the statements into machine code, then executes this code.

LAMINATE:

A process that combines variables contained in separate processes or threads into a unified array for display purposes.

LHS EXPRESSION:

This is a synonym for **lvalue**.

LINKER:

A program that takes all the object files created by the compiler and combines them and libraries required by the program into the executable program.

LOCKSTEP GROUP:

All threads that are at the same PC (program counter). This group is a subset of a workers group. A lockstep group only exists for stopped threads. All threads in the lockstep group are also in a workers group. By definition, all members of a lockstep group are in the same workers group. That is, a lockstep group cannot have members in more than one workers group or more than one control group.

LOOP, INFINITE:

See [infinite loop](#) on page 612.

LOWER BOUND:

The first element in the dimension of an array or the slice of an array. By default, the lower bound of an array is 0 in C and 1 in Fortran, but the lower bound can be any number, including negative numbers.

LVALUE:

A symbol name or expression suitable for use on the left-hand side of an assignment statement in the corresponding source language. That is, the expression must be appropriate as the target of an assignment.

MACHINE STATE:

Convention for describing the changes in memory, registers, and other machine elements as execution proceeds.

MANAGER THREAD:

A thread created by the operating system. In most cases, you do not want to manage or examine manager threads.

MESSAGE QUEUE:

A list of messages sent and received by message-passing programs.

MIMD:

An acronym for Multiple Instruction, Multiple Data, which describes a type of parallel computing.

MISD:

An acronym for Multiple Instruction, Single Data, which describes a type of parallel computing.

MPI:

An acronym for "Message Passing Interface."

MPICH:

MPI/Chameleon (Message Passing Interface/Chameleon) is a freely available and portable MPI implementation. MPICH was written as a collaboration between Argonne National Lab and Mississippi State University. For more information, see <http://www.mcs.anl.gov/research/projects/mpi/>.

MPMD PROGRAMS:

An acronym for Multiple Program, Multiple Data, which describes programs that involve multiple executables, executed by multiple threads and processes.

MULTITASK:

In the context of high performance computing, this is the ability to divide a program into smaller pieces or tasks that execute separately.

MULTI-PROCESS:

The ability of a program to spawn off separate programs, each having its own context and memory. multi-process programs can (and most often do) run processes on more than one computer. They can also run multiple processes on one computer. In this case, memory can be shared

MULTI-THREADED:

The ability of a program to spawn off separate tasks that use the same memory. Switching from task to task is controlled by the operating system.

MUTEX (MUTUAL EXCLUSION):

Techniques for sharing resources so that different users do not conflict and cause unwanted interactions.

NATIVE DEBUGGING:

The action of debugging a program that is running on the same machine as TotalView.

NESTED DIVE:

TotalView lets you dive into pointers, structures, or arrays in a variable. When you dive into one of these elements, TotalView updates the display so that the new element appears. A nested dive is a *dive* within a dive. You can return to the previous display by selecting the left arrow in the top-right corner of the window.

NODE:

A machine on a network. Each machine has a unique network name and address.

OFF-BY-ONE:

An error usually caused by forgetting that arrays begin with element 0 in C and C++.

OPENMP:

(from a definition on the OpenMP web site) OpenMP is a specification for a set of compiler directives, library routines, and environment variables that can be used to specify shared memory parallelism in Fortran and C/C++ programs. The MP in OpenMP stands for Multi Processing. We provide Open specifications for Multi Processing via collaborative work with interested parties from the hardware and software industry, government and academia. For more information, see <http://openmp.org/wp/>.

OUT-OF-SCOPE:

When symbol lookup is performed for a particular symbol name and it isn't found in the current scope or any that contains scopes, the symbol is said to be out-of-scope.

PAGE PROTECTION:

The ability to segregate memory pages so that one process cannot access pages owned by another process. It can also be used to generate an exception when a process tries to access the page.

PARALLEL PROGRAM:

A program whose execution involves multiple threads and processes.

PARALLEL TASKS:

Tasks whose computations are independent of each other, so that all such tasks can be performed simultaneously with correct results.

PARALLELIZABLE PROBLEM:

A problem that can be divided into parallel tasks. This type of program might require changes in the code and/or the underlying algorithm.

PARCEL: The number of bytes required to hold the shortest instruction for the target architecture.

PARENT PROCESS:

A process that calls the **fork()** function to spawn other processes (usually called child processes).

PARMACS LIBRARY:

A message-passing library for creating distributed programs that was developed by the German National Research Centre for Computer Science.

PARTIALLY QUALIFIED (SYMBOL):

A symbol name that includes only some of the levels of source code organization (for example, file name and procedure, but not executable). This is permitted as long as the resulting name can be associated unambiguously with a single entity.

PATCHING:

Inserting code in a breakpoint that is executed immediately preceding the breakpoint's line. The patch can contain a GOTO command to branch around incorrect code.

PC:

An abbreviation for *Program Counter*.

PID:

Depending on the context, this is either the process ID or the program ID. In most cases, this is the process ID.

POI:

The process of interest. This is the process that TotalView uses when it is trying to determine what to step, stop, and so on.

/PROC:

An interface that allows debuggers and other programs to control or obtain information from running processes. ptrace also does this, but /proc is more general.

PROCESS:

An executable that is loaded into memory and is running (or capable of running).

PROCESS GROUP:

A group of processes associated with a multi-process program. A process group includes program control groups and share groups.

PROCESS/THREAD IDENTIFIER:

A unique integer ID associated with a particular process and thread.

PROCESS OF INTEREST:

The primary process that TotalView uses when it is trying to determine what to step, stop, and so on.

PROGRAM CONTROL GROUP:

A group of processes that includes the parent process and all related processes. A program control group includes children that were forked (processes that share the same source code as the parent), and children that were forked with a subsequent call to the **execve()** function (processes that don't share the same source code as the parent). Contrast this with **share group** on page 617.

PROGRAM EVENT:

A program occurrence that is being monitored by TotalView or the CLI, such as a **breakpoint**.

PROGRAM STATE:

A higher-level view of the machine state, where addresses, instructions, registers, and such are interpreted in terms of source program variables and statements.

P/T (PROCESS/THREAD) SET:

The set of threads drawn from all threads in all processes of the target program.

PTHREAD ID:

This is the ID assigned by the Posix pthreads package. If this differs from the system TID, it is a pointer value that points to the pthread ID.

QUEUE:

A data structure whose data is accessed in the order in which it was entered. This is like a line at a tollbooth where the first in is the first out.

RACE CONDITION:

A problem that occurs when threads try to simultaneously access a resource. The result can be a deadlock, data corruption, or a program fault.

REMOTE DEBUGGING:

The action of debugging a program that is running on a different machine than TotalView. The machine on which the program is running can be located many miles away from the machine on which TotalView is running.

RESUME COMMANDS:

Commands that cause execution to restart from a stopped state: **dstep**, **dgo**, **dcont**, **dwait**.

RHS EXPRESSION:

This is a synonym for **rvalue**.

RVALUE:

An expression suitable for inclusion on the right-hand side of an assignment statement in the corresponding source language. In other words, an expression that evaluates to a value or collection of values.

SATISFACTION SET:

The set of processes and threads that must be held before a barrier can be satisfied.

SATISFIED:

A condition that indicates that all processes or threads in a group have reached a barrier. Prior to this event, all executing processes and threads are either running because they have not yet hit the barrier, or are being held at the barrier because not all of the processes or threads have reached it. After the barrier is *satisfied*, the held processes or threads are released, which means they can be run. Prior to this event, they could not run.

SCOPE:

The region in your program in which a variable or a function exists or is defined. This region begins with its declaration and extends to the end of the current block.

SEARCH PATH:

A list that contains places that software looks to locate files contained within the file system. In TotalView, the search path contains locations containing your program's source code.

SERIAL EXECUTION:

Execution of a program sequentially, one statement at a time.

SERIAL LINE DEBUGGING:

A form of remote debugging where TotalView and the **tvdsvr** communicate over a serial line.

SERVICE THREAD:

A thread whose purpose is to *service* or manage other threads. For example, queue managers and print spoolers are service threads. There are two kinds of service threads: those created by the operating system or runtime system and those created by your program.

SHARE GROUP:

All the processes in a control group that share the same code. In most cases, your program has more than one share group. Share groups, like control groups, can be local or remote.

SHARED LIBRARY:

A compiled and linked set of source files that are dynamically loaded by other executables.

SIGNALS:

Messages informing processes of asynchronous events, such as serious errors. The action that the process takes in response to the signal depends on the type of signal and whether the program includes a signal handler routine, a routine that traps certain signals and determines appropriate actions to be taken by the program.

SIMD:

An acronym for Single Instruction, Multiple Data, which describes a type of parallel computing.

SINGLE PROCESS SERVER LAUNCH:

A TotalView procedure that individually launches tvdsvr processes.

SINGLE STEP:

The action of executing a single statement and stopping (as if at a breakpoint).

SISD:

An acronym for Single Instruction, Single Data, which describes a type of parallel computing.

SLICE:

A subsection of an array, which is expressed in terms of a [lower bound](#) on page 613, [upper bound](#) on page 621, and [stride](#) on page 619. Displaying a slice of an array can be useful when you are working with very large arrays. Compare this with a TotalView [array section](#) on page 606.

SOID:

An acronym for symbol object ID. A SOID uniquely identifies all TotalView information. It also represents a handle by which you can access this information.

SOURCE FILE:

Program file that contains source language statements. TotalView lets you debug FORTRAN 77, Fortran 90, Fortran 95, C, C++, and assembler files.

SOURCE LOCATION: For each thread, the source code line it executes next. This is a static location, indicating the file and line number; it does not, however, indicate which invocation of the subprocedure is involved.

SPAWNED PROCESS:

The process created by a user process executing under debugger control.

SPMD PROGRAMS:

An acronym for Single Program, Multiple Data, which describe a type of parallel computing that involves just one executable, executed by multiple threads and processes.

STACK:

A portion of computer memory and registers used to hold information temporarily. The stack consists of a linked list of stack frames that holds return locations for called routines, routine arguments, local variables, and saved registers.

STACK FRAME:

Whenever your program calls a function, it creates a set of information that includes the local variables, arguments, contents of the registers used by an individual routine, a frame pointer pointing to the previous stack frame, and the value of the program counter (PC) at the time the routine was called. The information for one function is called a “stack frame” as it is placed on your program’s stack.

When your program begins executing, it has only one frame: the one allocated for function **main()**. As your program calls functions, new frames are allocated. When a function returns to the function from which it is called, the frame is deallocated.

STACK POINTER:

A pointer to the area of memory where subprocedure arguments, return addresses, and similar information is stored. This is also called a frame pointer.

STACK TRACE:

A sequential list of each currently active routine called by a program, and the frame pointer that points to its stack frame.

STATIC (SYMBOL) SCOPE:

A region of a program's source code that has a set of symbols associated with it. A scope can be nested inside another scope.

STEPPING:

Advancing program execution by fixed increments, such as by source code statements.

STL:

An acronym for Standard Template Library.

STOP SET:

A set of threads that TotalView stops after an action point triggers.

STOPPED/HELD STATE:

The state of a process whose execution has paused in such a way that another program event (for example, arrival of other threads at the same barrier) is required before it is capable of continuing execution.

STOPPED/RUNNABLE STATE:

The state of a process whose execution has been paused (for example, when a breakpoint triggered or due to some user command) but can continue executing as soon as a resume command is issued.

STOPPED STATE:

The state of a process that is no longer executing, but will eventually execute again. This is subdivided into stopped/runnable and stopped/held.

STRIDE:

The interval between array elements in a slice and the order in which TotalView displays these elements. If the stride is 1, TotalView displays every element between the lower bound and upper bound of the slice. If the stride is 2, TotalView displays every other element. If the stride is -1, TotalView displays every element between the upper bound and lower bound (reverse order).

SYMBOL:

Entities within program state, machine state, or debugger state.

SYMBOL LOOKUP:

Process whereby TotalView consults its debugging information to discover what entity a symbol name refers to. Search starts with a particular static scope and occurs recursively so that contains scopes are searched in an outward progression.

SYMBOL NAME:

The name associated with a symbol known to TotalView (for example, function, variable, data type, and so on).

SYMBOL TABLE:

A table of symbolic names used in a program (such as variables or functions) and their memory locations. The symbol table is part of the executable object generated by the compiler (with the **-g** option) and is used by debuggers to analyze the program.

SYNCHRONIZATION:

A mechanism that prevents problems caused by concurrent threads manipulating shared resources. The two most common mechanisms for synchronizing threads are *mutual exclusion* and *condition synchronization*.

TARGET COMPUTER:

The computer on which the process to be debugged is running.

TARGET PROCESS SET:

The target set for those occasions when operations can only be applied to entire processes, not to individual threads in a process.

TARGET PROGRAM:

The executing program that is the target of debugger operations.

TARGET P/T SET:

The set of processes and threads that a CLI command acts on.

TASK:

A logically discrete section of computational work. (This is an informal definition.)

THREAD:

An execution context that normally contains a set of private registers and a region of memory reserved for an execution stack. A thread runs in an address space.

THREAD EXECUTION STATE:

The convention of describing the operations available for a thread, and the effects of the operation, in terms of a set of predefined states.

THREAD OF INTEREST:

The primary thread affected by a command. This is abbreviated as TOI.

TID:

The thread ID. On some systems (such as AIX where the threads have no obvious meaning), TotalView uses its own IDs.

TLA:

An acronym for Three-Letter Acronym. So many things from computer hardware and software vendors are referred to by a three-letter acronym that yet another acronym was created to describe these terms.

TOI:

The thread of interest. This is the primary thread affected by a command.

TRIGGER SET:

The set of threads that can trigger an action point (that is, the threads upon which the action point was defined).

TRIGGERS:

The effect during execution when program operations cause an event to occur (such as arriving at a breakpoint).

TTF:

See [type transformation facility](#) on page 621.

TRAP:

An instruction that stops program execution and which allows a debugger to gain control over your program.

TVDSVR PROCESS:

The TotalView Debugger Server process, which facilitates remote debugging by running on the same machine as the executable and communicating with TotalView over a TCP/IP port or serial line.

TYPE TRANSFORMATION FACILITY:

This is abbreviated as TTF. A TotalView subsystem that allows you to change the way information appears. For example, an STL vector can appear as an array.

UNDISCOVERED SYMBOL:

A symbol that is referred to by another symbol. For example, a **typedef** is a reference to the aliased type.

UNDIVING:

The action of displaying the previous contents of a window, instead of the contents displayed for the current dive. To undo, you click the **undo** icon in the upper-right corner of the window.

UPC:

(from a definition on the UPC web site) The Unified Parallel C language, which is an extension to the C programming language that is designed for high performance computing on large-scale parallel machines. The language provides a uniform programming model for both shared and distributed memory hardware. The programmer is presented with a single shared, partitioned address space, where variables may be directly read and written by any processor, but each variable is physically associated with a single processor. See <http://upc.lbl.gov/> for more information.

UPPER BOUND:

The last element in the dimension of an array or the slice of an array.

USER THREAD:

A thread created by your program.

USER INTERRUPT KEY:

A keystroke used to interrupt commands, most commonly defined as Ctrl+C.

VARIABLE WINDOW:

A TotalView window that displays the name, address, data type, and value of a particular variable.

VISUALIZATION:

In TotalView, visualization means graphically displaying an array's values.

VISUALIZER PROCESS:

A process that works with TotalView in a separate window, allowing you to see a graphic representation of program array data.

WATCHPOINT:

An action point that tells TotalView to stop execution when the value of a memory location changes.

WORKER THREAD:

A thread in a workers group. These are threads created by your program that performs the task for which you've written the program.

WORKERS GROUP:

All the worker threads in a control group. Worker threads can reside in more than one share group.



Licenses

3rd-Party Licenses

TotalView uses the following 3rd-party software:

3rd-party software	Use
CUDA header files	CUDA debugging support

CUDA License Information

To support CUDA debugging, TotalView ships with certain NVIDIA header files. These header files contain license information, and not always the same information. Below we detail the different versions of the license information correlated with the files they occur in.

License information in the files `common.h`, `elfutil.h`, `libcudacore.h`, and `tls.h`:

```
/*
 * Copyright (c) 2014-2016 NVIDIA CORPORATION. All rights reserved.
 *
 * Redistribution and use in source and binary forms, with or without
 * modification, are permitted provided that the following conditions
 * are met:
 * * Redistributions of source code must retain the above copyright
 *   notice, this list of conditions and the following disclaimer.
 * * Redistributions in binary form must reproduce the above copyright
 *   notice, this list of conditions and the following disclaimer in the
```

```
* documentation and/or other materials provided with the distribution.
* * Neither the name of NVIDIA CORPORATION nor the names of its
* contributors may be used to endorse or promote products derived
* from this software without specific prior written permission.
*
* THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS ``AS IS'' AND ANY
* EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE
* IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR
* PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER OR
* CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL,
* EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO,
* PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR
* PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY
* OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT
* (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE
* OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.
*/
```

License information in the files `cuda_stdint.h`, `cudacoredump1.h`, and `cuda debugger.h`:

```
/*
 * Copyright 2009-2015 NVIDIA Corporation. All rights reserved.
 *
 * NOTICE TO LICENSEE:
 *
 * This source code and/or documentation ("Licensed Deliverables") are
 * subject to NVIDIA intellectual property rights under U.S. and
 * international Copyright laws.
 *
 * These Licensed Deliverables contained herein is PROPRIETARY and
 * CONFIDENTIAL to NVIDIA and is being provided under the terms and
 * conditions of a form of NVIDIA software license agreement by and
 * between NVIDIA and Licensee ("License Agreement") or electronically
 * accepted by Licensee. Notwithstanding any terms or conditions to
 * the contrary in the License Agreement, reproduction or disclosure
 * of the Licensed Deliverables to any third party without the express
 * written consent of NVIDIA is prohibited.
 *
 * NOTWITHSTANDING ANY TERMS OR CONDITIONS TO THE CONTRARY IN THE
 * LICENSE AGREEMENT, NVIDIA MAKES NO REPRESENTATION ABOUT THE
 * SUITABILITY OF THESE LICENSED DELIVERABLES FOR ANY PURPOSE. IT IS
 * PROVIDED "AS IS" WITHOUT EXPRESS OR IMPLIED WARRANTY OF ANY KIND.
 * NVIDIA DISCLAIMS ALL WARRANTIES WITH REGARD TO THESE LICENSED
 * DELIVERABLES, INCLUDING ALL IMPLIED WARRANTIES OF MERCHANTABILITY,
 * NONINFRINGEMENT, AND FITNESS FOR A PARTICULAR PURPOSE.
 * NOTWITHSTANDING ANY TERMS OR CONDITIONS TO THE CONTRARY IN THE
 * LICENSE AGREEMENT, IN NO EVENT SHALL NVIDIA BE LIABLE FOR ANY
 * SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, OR ANY
 * DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS,
```

```
* WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS
* ACTION, ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE
* OF THESE LICENSED DELIVERABLES.
*
* U.S. Government End Users. These Licensed Deliverables are a
* "commercial item" as that term is defined at 48 C.F.R. 2.101 (OCT
* 1995), consisting of "commercial computer software" and "commercial
* computer software documentation" as such terms are used in 48
* C.F.R. 12.212 (SEPT 1995) and is provided to the U.S. Government
* only as a commercial end item. Consistent with 48 C.F.R.12.212 and
* 48 C.F.R. 227.7202-1 through 227.7202-4 (JUNE 1995), all
* U.S. Government End Users acquire the Licensed Deliverables with
* only those rights set forth herein.
*
* Any use of the Licensed Deliverables in individual and commercial
* software must include, in the user documentation and internal
* comments to the code, the above Disclaimer and U.S. Government End
* Users Notice.
*/
```

License information in the files `utarray.h` and `uthash.h`:

```
/*
Copyright (c) 2008-2014, Troy D. Hanson http://troydhanson.github.com/uthash/
All rights reserved.
```

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

- * Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.

```
THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS
IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED
TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A
PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER
OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL,
EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO,
PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR
PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF
LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING
NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS
SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.
*/
```

License information in the file `elfdefinitions.h`:

```
/*-
* Copyright (c) 2010 Joseph Koshy
* All rights reserved.
*/
```

```
* Redistribution and use in source and binary forms, with or without
* modification, are permitted provided that the following conditions
* are met:
* 1. Redistributions of source code must retain the above copyright
*   notice, this list of conditions and the following disclaimer.
* 2. Redistributions in binary form must reproduce the above copyright
*   notice, this list of conditions and the following disclaimer in the
*   documentation and/or other materials provided with the distribution.
*
* THIS SOFTWARE IS PROVIDED BY THE AUTHOR AND CONTRIBUTORS ``AS IS'' AND
* ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE
* IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE
* ARE DISCLAIMED.  IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE
* FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL
* DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS
* OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION)
* HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT
* LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY
* OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF
* SUCH DAMAGE.
*
* $Id: elfdefinitions.h 3078 2014-07-26 08:22:03Z jkoshy $
*/
```

```
/*
```

```
* These definitions are based on:
* - The public specification of the ELF format as defined in the
*   October 2009 draft of System V ABI.
*   See: http://www.sco.com/developers/gabi/latest/ch4.intro.html
* - The May 1998 (version 1.5) draft of "The ELF-64 object format".
* - Processor-specific ELF ABI definitions for sparc, i386, amd64, mips,
*   ia64, and powerpc processors.
* - The "Linkers and Libraries Guide", from Sun Microsystems.
*/
```

Resources

TotalView Family Differences

This manual describes the TotalView Enterprise, TotalView Team, and TotalView Individual debuggers. Each of these supports the use of the CLI debugger as well. In all cases, TotalView Enterprise and TotalView Team have the same features, differing only in the way they are licensed. TotalView Individual differs in its feature set.

NOTE >> The most fundamental differences between TotalView Team and TotalView Enterprise are the way resources are shared and used. When you purchase TotalView Team, you are purchasing “tokens.” These tokens represent debugging capabilities. For example, if you have 64 tokens available, 64 programmers could be active, each debugging a one-process job; or two programmers, each debugging a 32-process job. In contrast, a TotalView Enterprise license is based on the number of users and the number of licensed processors. You’ll find more precise information on our web site.

The basic differences are:

TotalView Team & Enterprise	TotalView Individual	Comment
Execute on any licensed computer of the same architecture	Node locked.	You can execute TotalView Individual only on the computer you install it on.
Number of users is determined by license	Only one user	The TotalView Enterprise license limits the number of users. TotalView Team does not.

TotalView Team & Enterprise	TotalView Individual	Comment
Number of processes limited by license. No limit on threads	No more than 32 processes and threads.	
Your license determines the number of processors upon which your program can run.	A program can execute on no more than 16 cores.	TotalView Enterprise licenses the full capabilities of all machines upon which it runs. TotalView Team can acquire part of your machine.
Processes can execute on any computers in the same network.	Remote processes are not allowed.	Processes must execute on the installed computer.
Remote X Server connections allowed.	No remote X Server connections are allowed.	Programmers cannot remotely log into a computer and then execute TotalView Individual.
Memory debugging is bundled.	No memory debugging	

TotalView Documentation

The following table describes all available TotalView documentation:

Product	Title	Description	HTML	PDF	Print
General TotalView Documentation					
	<i>Getting Started with TotalView Products</i>	Introduces the basic features of TotalView, MemoryScape, and Replay-Engine, with links for more detailed information	✓	✓	
	<i>TotalView Platforms Guide</i>	Specifies supported platforms for TotalView, MemoryScape, and ReplayEngine	✓	✓	
	<i>TotalView Evaluation Guide</i>	Brochure that introduces basic TotalView features		✓	✓
User Guides					
	<i>TotalView User Guide</i>	Primary resource for information on using the TotalView GUI and the CLI	✓	✓	

Product	Title	Description	HTML	PDF	Print
	<i>Debugging Memory Problems with MemoryScape</i>	How to debug memory issues, relevant to both TotalView and the MemoryScape standalone product	✓	✓	
	<i>Reverse Debugging with Replay Engine</i>	How to perform reverse debugging using the embedded add-on ReplayEngine	✓	✓	
Reference Guides					
	<i>TotalView Reference Guide</i>	A reference of CLI commands, how to run TotalView, and platform-specific detail	✓	✓	
New Features					
	What's new in this release	On the landing page of the HTML documentation, lists new features for the documented release	✓		
	<i>TotalView Change Log</i>	Details the changes to the product from release to release	✓	✓	
Installation Guides					
	<i>TotalView Install Guide</i>	Installing TotalView and the FLEX/m license manager	✓	✓	
	<i>MemoryScape Install Guide</i>	Installing MemoryScape as a standalone product	✓	✓	
In-Product Help					
	<i>TotalView Help</i>	Context-sensitive help launched from TotalView	✓		
	<i>MemoryScape Help</i>	Context-sensitive help launched from MemoryScape	✓		

Conventions

The following table describes the conventions used in this book:

Convention	Meaning
[]	Brackets are used when describing optional parts of a command.
<i>arguments</i>	In a command description, text in italics represents information you enter. Elsewhere, italics is used for emphasis.
Bold text	In a command description, bold text represents keywords or options that must be entered exactly as displayed. Elsewhere, it represents words that are used in a programmatic way rather than their normal way.
<i>Example text</i>	In program listings, this represents a program or something you'd enter in response to a shell or CLI prompt. Bold text here indicates exactly what you should type. If you're viewing this information online, example text is in color.

Contacting Us

Please contact us if you have problems installing TotalView, questions that are not answered in the product documentation or on our Web site, or suggestions for new features or improvements.

By Email

- For technical support: support@roguewave.com
- For documentation issues: rwonlinedocs@roguewave.com

By Phone

800-856-3766 in the United States

(+1) 508-652-7700 worldwide

If you are reporting a problem, please include the following information:

- The *version* of TotalView and the *platform* on which you are running TotalView.
- An *example* that illustrates the problem.
- A *record* of the sequence of events that led to the problem.

Index

Symbols

- : (colon), in array type strings 259
- : as array separator 284
- . (dot) current set indicator 522, 541
- . (period), in suffix of process names 389
- .dmg installer 89
- .rhosts file 446, 477
- .totalview subdirectory 93
- .tvdr initialization files 93
- .Xdefaults file 94, 134
 - autoLoadBreakpoints 134
 - deprecated resources 134
- ' module separator 274
- @ action point marker, in CLI 179
- / slash in group specifier 528
- /usr/lib/array/arrayd.conf file 457
- & intersection operator 540
- # scope separator character 281
- #string data type 257
- %B bulk server launch command 458
- %C server launch replacement characters 455, 456
- %D bulk server launch command 457
- %D single process server launch command 456
- %F bulk server launch command 458
- %H bulk server launch command 457
- %H hostname replacement character 458
- %I bulk server launch command 458
- %K bulk server launch command 458
- %L bulk server launch command 457
- %L single process server launch command 456
- %N bulk server launch command 458
- %P bulk server launch command 457
- %P single process server launch command 456
- %R single process server launch command 456
- %t1 bulk server launch command 458
- %t2 bulk server launch command 458
- %V bulk server launch command 457
- < first thread indicator (CLI) 522
- > (right angle bracket), indicating nested dives 241
- difference operator 540
- | union operator 540
- \$address data type 261
- \$char data type 261
- \$character data type 261
- \$clid built-in variable 344
- \$code data type 238, 261, 265
- \$complex data type 261
- \$complex_16 data type 261
- \$complex_8 data type 261
- \$count built-in function 178, 199, 203, 345
- \$countall built-in function 345
- \$countthread built-in function 346
- \$debug assembler pseudo op 341
- \$denorm filter 293
- \$double data type 261
- \$double_precision data type 261
- \$duid built-in variable 344
- \$extended data type 261
- \$float data type 261
- \$hold assembler pseudo op 341
- \$hold built-in function 346
- \$holdprocess assembler pseudo op 341
- \$holdprocess built-in function 346
- \$holdprocessall built-in function 346
- \$holdprocessstopall assembler pseudo op 341
- \$holdstopall assembler pseudo op 341
- \$holdstopall built-in function 346
- \$holdthread assembler pseudo op 341
- \$holdthread built-in function 346
- \$holdthreadstop assembler pseudo op 341
- \$holdthreadstop built-in function 346
- \$holdthreadstopall assembler pseudo op 341
- \$holdthreadstopall built-in function 346
- \$holdthreadstopprocess assembler pseudo op 341
- \$holdthreadstopprocess built-in function 346
- \$inf filter 293
- \$int data type 261
- \$integer data type 261
- \$integer_1 data type 261
- \$integer_2 data type 262
- \$integer_4 data type 262
- \$integer_8 data type 262
- \$is_denorm intrinsic function 294
- \$is_finite intrinsic function 294
- \$is_inf intrinsic function 294
- \$is_nan intrinsic function 294
- \$is_ndenorm intrinsic function 294

- \$is_ninf intrinsic function 294
 - \$is_norm intrinsic function 294
 - \$is_pdenorm intrinsic function 294
 - \$is_pinf intrinsic function 294
 - \$is_pnorm intrinsic function 294
 - \$is_pzero intrinsic function 294
 - \$is_qnan intrinsic function 294
 - \$is_snan intrinsic function 294
 - \$is_zero intrinsic function 294
 - \$logical data type 262
 - \$logical_1 data type 262
 - \$logical_2 data type 262
 - \$logical_4 data type 262
 - \$logical_8 data type 262
 - \$long data type 262
 - \$long_branch assembler pseudo op 341
 - \$long_long data type 262
 - \$nan filter 292
 - \$nanq filter 292
 - \$nans filter 293
 - \$ndenorm filter 293
 - \$newval built-in function 211
 - \$newval built-in variable 344
 - \$nid built-in variable 344
 - \$ninf filter 293
 - \$oldval built-in function 211
 - \$oldval built-in variable 344
 - \$oldval watchpoint variable 211
 - \$pdenorm filter 293
 - \$pid built-in variable 344
 - \$pinf filter 293
 - \$processduid built-in variable 344
 - \$ptree assembler pseudo op 342
 - \$real data type 262
 - \$real_16 data type 262
 - \$real_4 data type 262
 - \$real_8 data type 262
 - \$short data type 262
 - \$stop assembler pseudo op 342
 - \$stop built-in function 178, 203, 212, 346
 - \$stopall assembler pseudo op 342
 - \$stopall built-in function 346
 - \$stopprocess assembler pseudo op 342
 - \$stopprocess built-in function 346
 - \$stopthread assembler pseudo op 342
 - \$stopthread built-in function 347
 - \$string data type 256, 262, 263
 - \$systid built-in variable 344
 - \$tid built-in variable 344
 - \$visualize built-in function 322, 347
 - in animations 322
 - using casts 322
 - \$void data type 262, 265
 - \$wchar data type 262, 264
 - \$wchar_s16 data type 262
 - \$wchar_s32 data type 262
 - \$wchar_u16 data type 262
 - \$wchar_u32 data type 262
 - \$wstring data type 262, 264
 - \$wstring_s16 data type 262
 - \$wstring_s32 data type 263
 - \$wstring_u16 data type 262
 - \$wstring_u32 data type 263
- A**
- a command-line option 90, 424
 - passing arguments to program 90
 - a width specifier 529
 - general discussion 531
 - absolute addresses, display assembler as 161
 - acquiring processes 478
 - action
 - points tab 185, 186
 - Action Point > At Location command 182, 186
 - Action Point > At Location Dialog Box figure 182, 186
 - Action Point > Delete All command 185
 - Action Point > Properties
 - command 175, 177, 184, 185, 189, 191, 194, 196, 198, 395, 413
 - deleting barrier points 196
 - Action Point > Properties dialog box 184, 189, 190, 194
 - Action Point > Save All command 213, 478
 - Action Point > Save As command 213
 - Action Point > Set Barrier command 194
 - Action Point > Suppress All command 185, 186
 - action point identifiers
 - never reused in a session 431
 - action points 190
 - common properties 175
 - definition 42, 175
 - deleting 185
 - disabling 185
 - enabling 185
 - evaluation points 177
 - files 94
 - identifiers 431
 - ignoring 185
 - list of 149
 - multiple addresses 179
 - saving 213
 - suppressing 185
 - symbols 176
 - unsuppressing 186
 - watchpoint 16
 - Action Points Page 149, 399
 - actor mode, Visualizer 310
 - adapter_use option 476
 - Add host option 111
 - Add to Expression List command 247, 250
 - Add to Expression List context menu command 247
 - Add username dialog 103
 - adding a user to an Attach to a Program debug session 103
 - adding command-line arguments 116
 - adding environment

- variables 116
- adding members to a group 526
- adding program arguments 90
- \$address 261
- address range conflicts 204
- addresses
 - changing 267
 - editing 267
 - specifying in variable window 236
 - tracking in variable window 222
- advancing
 - and holding processes 430
 - program execution 430
- aggregates, in Expression List window 249
- aliases
 - built-in 427
 - group 427
 - group, limitations 427
- align assembler pseudo op 342
- all width specifier 523
- allocated arrays, displaying 266
- altering standard I/O 116
- Ambiguous Function dialog 157, 183, 186
- ambiguous function names 157
- Ambiguous Line dialog 181
- ambiguous names 158
- ambiguous source lines 395
- angle brackets, in windows 241
- animation using \$visualize 322
- areas of memory, data type 265
- arena specifiers 522
 - defined 522
 - incomplete 536
 - inconsistent widths 537
- arenas
 - and scope 514
 - defined 514, 521
 - iterating over 522
- ARGS variable 424
 - modifying 424
- ARGS_DEFAULT variable 90, 424
 - clearing 424
- arguments
 - in server launch
 - command 447, 455
 - passing to program 90
 - replacing 424
 - Arguments area of new program session 465
 - argv, displaying 266
 - array data
 - filtering by comparison 290
 - filtering by range of values 294
 - filtering for IEEE values 292
 - updating the view in the Array Viewer 289
 - array of structures
 - about 240
 - displaying 242
 - in Expression List window 249
 - array pointers 234
 - array rank 324
 - array services handle (ash) 485
 - array slice
 - defined 287
 - Array Statistics Window
 - figure 297
 - array structure
 - viewing limitations 225
 - Array Viewer
 - dialog for viewing array data 288
- arrays
 - array data filtering 290
 - bounds 258
 - casting 259
 - character 263
 - checksum statistic 297
 - colon separators 284
 - count statistic 298
 - deferred shape 276, 284
 - denormalized count
 - statistic 298
 - display subsection 259
 - displaying 284, 322
 - displaying allocated 266
 - displaying argv 266
 - displaying contents 153
 - displaying declared 266
 - displaying multiple 322
 - displaying slices 284
 - diving into 240
 - editing dimension of 259
 - extent 259
 - filter conversion rules 291
 - filtering 259, 290, 291, 292
 - filtering expressions 295
 - filtering options 290
 - in C 259
 - in Fortran 259
 - infinity count statistic 298
 - limiting display 286
 - lower adjacent statistic 298
 - lower bound of slices 285
 - lower bounds 258, 259
 - maximum statistic 298
 - mean statistic 298
 - median statistic 298
 - minimum statistic 298
 - multi-dimensional array data, viewing 288
 - NaN statistic 298
 - non-default lower bounds 259
 - overlapping nonexistent memory 284
 - pointers to 258
 - quartiles statistic 298
 - skipping elements 286
 - slice example 285
 - slice, initializing 434
 - slice, printing 435
 - slice, refining 322
 - slices with the variable
 - command 287
 - slices, defined 287
 - sorting 296
 - standard deviation
 - statistic 298
 - statistics 297
 - stride 285
 - stride elements 285
 - subsections 284
 - sum statistic 299
 - type strings for 258
 - upper adjacent statistic 299
 - upper bound 258
 - upper bound of slices 285
 - viewing across
 - elements 301
 - visualizing 311, 322

- writing to file 437
- zero count statistic 299
- arrow over line number 149
- ascii assembler pseudo op 342
- asciz assembler pseudo op 342
- ash (array services handle) 485
- ash (array services handle) 485
- ASM icon 103, 112, 120, 176, 188
- assembler
 - absolute addresses 161
 - and -g compiler option 153
 - constructs 339
 - displaying 161
 - expressions 340
 - in code fragment 197
 - symbolic addresses 161
- Assembler > By Address
 - command 161
- Assembler > Symbolically
 - command 161
- Assembler command 161
- assigning output to variable 422
- assigning p/t set to variable 524
- asynchronous processing 351
- At Location command 182, 186
- attach options
 - in Attach to a Program dialog 104
- Attach Page 479
- Attach Subset command 401, 402
- Attach to a Running Program
 - command 101
- Attach to a Running Program dialog 101
- Attach to a running program
 - dialog 375
 - possible errors 104
- attaching
 - commands 110
 - configuring a debug session 101
 - restricting 401
 - restricting by
 - communicator 402
 - selective 401
 - to all 403
 - to job 478
 - to MPI tasks 404
 - to MPICH application 470
 - to MPICH job 470
 - to none 403
 - to PE 478
 - to poe 479
 - to processes 101, 401, 479
 - to RMS processes 483
 - to SGI MPI job 485, 486
- attaching to a program
 - adding a new user 103
- attaching to processes
 - preference 404
- Auto Visualize command 312
- Auto Visualize, in Dataset Window 314
- auto_array_cast_bounds
 - variable 234
- auto_deref_in_all_c
 - variable 234
- auto_deref_in_all_fortran
 - variable 234
- auto_deref_initial_c
 - variable 234
- auto_deref_initial_fortran
 - variable 234
- auto_deref_nested_c
 - variable 234
- auto_deref_nested_fortran
 - variable 234
- auto_save_breakpoints
 - variable 213
- autolaunch 442, 452
 - defined 91
 - disabling 91, 452, 453
 - launch problems 449
- autolaunching 447
- autoLoadBreakpoints
 - .Xdefault 134
- automatic dereferencing 234
- automatic process
 - acquisition 469, 476
- averaging data points 319
- averaging surface display 319
- axis, transposing 316

B

- backtick separator 274
- backward icon 154
- barrier points 193, 194, 370, 383
 - clearing 185
 - defined 431
 - defined (again) 193
 - deleting 196
 - satisfying 195
 - states 193
 - stopped process 196
- baud rate, for serial line 460
- bit fields 254
- block scoping 280
- Block Status command 236
- blocking send operations 411
- blocks
 - displaying 225
 - naming 281
- Blue Gene
 - starting a debugging session 480
- bluegene_io_interface
 - variable 481
- bluegene_server_launch
 - variable 481
- bold data 10
- Both command 161, 173
- bounds for arrays 258
- boxed line number 149, 179, 515
- branching around code 200
- Breakpoint at Assembler Instruction figure 188
- breakpoint files 94
- breakpoint operator 540
- breakpoints
 - and MPI_Init() 478
 - apply to all threads 175
 - automatically copied from master process 469
 - behavior when reached 188
 - changing for
 - parallelization 399
 - clearing 139, 185, 515
 - conditional 197, 199, 345
 - copy, master to slave 469
 - countdown 199, 345, 346
 - default stopping action 399
 - defined 175, 431
 - deleting 185
 - disabling 185
 - enabling 185
 - entering 485
 - example setting in multipro-

- cess program 192
 - fork() 191
 - hitting within eval point 338
 - ignoring 185
 - in child process 189
 - in parent process 189
 - listing 149
 - machine-level 188
 - multiple processes 189
 - not shared in separated
 - children 191
 - placing 149
 - reloading 478
 - removed when
 - detaching 105
 - removing 139, 177
 - saving 213
 - set while a process is
 - running 179
 - set while running parallel
 - tasks 478
 - setting 139, 176, 179, 189, 438, 477, 515
 - shared by default in
 - processes 191
 - sharing 190, 191
 - stop all related
 - processes 190
 - suppressing 185
 - thread-specific 344
 - toggling 182
 - while stepping over 167
- bss assembler pseudo op 342
- built-in aliases 427
- built-in functions
 - \$count 178, 199, 203, 345
 - \$countall 345
 - \$countthread 346
 - \$hold 346
 - \$holdprocess 346
 - \$holdprocessall 346
 - \$holdstopall 346
 - \$holdthread 346
 - \$holdthreadstop 346
 - \$holdthreadstopall 346
 - \$holdthreadstopprocess 346
 - \$stop 178, 203, 212, 346
 - \$stopall 346
 - \$stopprocess 346
- \$stopthread 347
- \$visualize 322, 347
- forcing interpretation 202
- built-in variables 344
 - \$clid 344
 - \$duid 344
 - \$newval 344
 - \$nid 344
 - \$oldval 344
 - \$pid 344
 - \$processduid 344
 - \$string 261
 - \$systid 344
 - \$tid 344
- forcing interpretation 345
- Bulk Launch page 449
- bulk server launch 442, 453
 - command 454
 - connection timeout 455
 - on IBM RS/6000 458
 - on Cray 458
- bulk server launch command
 - %B 458
 - %D 457
 - %F 458
 - %H 457
 - %I 458
 - %K 458
 - %L 457
 - %N 458
 - %P 457
 - %t1 458
 - %t2 458
 - %V 457
 - callback_host 457
 - callback_ports 457
 - set_pws 457
 - verbosity 457
 - working_directory 457
- bulk_incr_timeout variable 455
- bulk_launch_base_timeout
 - variable 455
- bulk_launch_enabled
 - variable 450, 453, 454
- bulk_launch_incr_timeout
 - variable 455
- bulk_launch_string variable 454
- bulk_launch_tmpfile1_header_
 - line variable 454
- bulk_launch_tmpfile1_header_
 - line variable 454
- bulk_launch_tmpfile1_host_line
 - variable 454
- bulk_launch_tmp-
 - file1_host_lines variable 454
- bulk_launch_tmpfile1_trailer_
 - line variable 454
- bulk_launch_tmpfile1_trailer_
 - line variable 454
- bulk_launch_tmpfile2_header_
 - line variable 454
- bulk_launch_tmpfile2_header_
 - line variable 454
- bulk_launch_tmpfile2_host_
 - lines variable 454
- bulk_launch_tmpfile2_host_line
 - variable 454
- bulk_launch_tmpfile2_trailer_
 - line variable 454
- bulk_launch_tmpfile2_trailer_
 - line variable 454
- By Address command 161
- byte assembler pseudo op 342

C

- C casting for Global Arrays 504, 505
- C control group specifier 528, 529
- C/C++
 - array bounds 259
 - arrays 259
 - filter expression 295
 - how data types are
 - displayed 256
 - in code fragment 197
 - type strings supported 256
- C/C++ statements
 - expression system 333
- C++
 - changing class types 269
 - display classes 268
- C++/C++
 - in expression system 331
- CAF (CoArray Fortran) 511
- Call Graph command 304

- call graph, updating display 304
- call stack 149
- call_graph group 306
- callback command-line option 446
- callback_host bulk server launch command 457
- callback_option single process server launch command 456
- callback_ports bulk server launch command 457
- camera mode, Visualizer 309
- capture command 422
- casting 244, 256, 257, 258
 - examples 266
 - to type \$code 238
 - types of variable 256
- casting arrays 259
- casting Global Arrays 504, 505
- CGROUP variable 526, 532
- ch_lfshmem device 468
- ch_mpl device 468
- ch_p4 device 412, 468, 470
- ch_shmem device 468, 470
- Change Value command 254
- changing autolaunch options 452
- changing command-line arguments 116
- changing expressions 244
- changing precision 218
- changing process thread set 521
- changing processes 380
- changing program state 417
- changing remote shell 446
- changing size 218
- changing threads 381
- changing threads in Variable Window 238
- changing variables 254
- \$char data type 261
- \$character data type 261
- character arrays 263
- chasing pointers 234, 240
- checksum array statistic 297
- child process names 389
- classes, displaying 268
- Clear All STOP and EVAL command 185
- clearing
 - breakpoints 139, 185, 189, 515
 - continuation signal 171
 - evaluation points 139
- CLI
 - components 415
 - in startup file 419
 - initialization 419
 - introduced 8
 - invoking program from shell example 419
 - launching from GUI 588
 - not a library 416
 - output 422
 - prompt 420
 - relationship to TotalView 416
 - starting 87, 89, 418
 - starting a new session 89
 - starting from command prompt 418
 - starting from TotalView GUI 418
- CLI commands
 - assigning output to variable 422
 - capture 422
 - dactions 176
 - dactions -load 213, 478
 - dactions -save 213, 478
 - dassign 254
 - dattach 90, 102, 110, 430, 470, 479, 488
 - dattach mprun 488
 - dbarrier 193, 195
 - dbarrier -e 199
 - dbarrier -stop_when_hit 413
 - dbreak 179, 182, 190, 439
 - dbreak -e 199
 - dcheckpoint 562
 - ddelete 182, 185, 196, 489
 - ddetach 105
 - ddisable 184, 185, 196
 - ddlopen 565
 - ddown 169
 - default focus 521
- denable 185, 186
- dfocus 166, 520, 521
- dga 505
- dgo 392, 399, 477, 478, 485, 537
- dgroups -add 526, 532
- dhalt 166, 378, 399
- dhold 193, 383
- dhold -thread 384
- dkill 172, 401, 421, 430
- dload 109, 420, 430, 450
- dnnext 168, 394, 400
- dnnexti 168, 394
- dout 170, 516
- dprint 157, 221, 222, 232, 233, 236, 237, 260, 266, 271, 273, 275, 284, 285, 287, 435, 495, 496
- dptsets 374, 379
- drerun 172, 420
- drestart 562
- drun 420, 424
- dsession 109
- dsession -load 89
- dset 424, 426
- dstatus 195, 374
- dstep 167, 394, 400, 516, 522, 524, 537
- dstepi 167, 393, 394
- dunhold 193, 383
- dunhold -thread 384
- dunset 424
- duntil 169, 516, 518
- dup 169, 222
- dwhere 222, 523, 537
- exit 95
- read_symbols 569
- run when starting TotalView 93

CLI variables

- ARGS 424
- ARGS_DEFAULT 90, 424
 - clearing 424
- ARGS, modifying 424
- auto_array_cast_bounds 234
- auto_deref_in_all_c 234
- auto_deref_in_all_fortran 234
- auto_deref_initial_c 234
- auto_deref_initial_fortran 234

- auto_deref_nested_c 234
- auto_deref_nested_fortran 234
- auto_save_breakpoints 213
- bulk_incr_timeout 455
- bulk_launch_base_timeout 455
- bulk_launch_enabled 449, 450, 453, 454
- bulk_launch_incr_timeout 455
- bulk_launch_string 454
- bulk_launch_tmpefile1_trailer_line 454
- bulk_launch_tmpefile2_trailer_line 454
- bulk_launch_tmpfile1_header_line 454
- bulk_launch_tmpfile1_header_line 454
- bulk_launch_tmpfile1_host_lines 454
- bulk_launch_tmpfile1_host_line 454
- bulk_launch_tmpfile1_trailer_line 454
- bulk_launch_tmpfile2_header_line 454
- bulk_launch_tmpfile2_header_line 454
- bulk_launch_tmpfile2_host_line 454
- bulk_launch_tmpfile2_host_lines 454
- bulk_launch_tmpfile2_trailer_line 454
- data format 219
- dll_read_all_symbols 569
- dll_read_loader_symbols_only 569
- dll_read_no_symbols 569
- EXECUTABLE_PATH 100, 125, 127, 433
- LINES_PER_SCREEN 423
- parallel_attach 404
- parallel_stop 404
- pop_at_breakpoint 124
- pop_on_error 123
- process_load_callbacks 94
- PROMPT 426
- server_launch_enabled 450, 452
- server_launch_string 453
- server_launch_timeout 453
- SHARE_ACTION_POINT 184, 190, 191
- signal_handling_mode 123
- STOP_ALL 184, 190
- suffixes 86
- ttf 218
- ttf_max_length 218
- VERBOSE 417
- warn_step_throw 123
- \$clid built-in variable 344
- Close command 154, 239
- Close command (Visualizer) 314
- Close Relatives command 154
- Close Similar command 154, 239
- Close, in dataset window 314
- closing similar windows 154
- closing variable windows 239
- closing windows 154
- cluster ID 344
- CoArray Fortran (CAF) 511
- \$code data type 261
- code constructs supported
 - assembler 339
 - C/C++ 333
 - Fortran 334
- \$code data type 265
- code fragments 197, 338, 344
 - modifying instruction path 198
 - when executed 198
 - which programming languages 197
- code, branching around 200
- collapsing structures 225
- colons as array separators 284
- colors used 379
- columns, displaying 251
- comm assembler pseudo op 342
- command arguments 424
 - clearing example 424
 - passing defaults 424
 - setting 424
- Command Line command 87, 418
- Command Line Interpreter 8
- command prompts 426
 - default 426
 - format 426
 - setting 426
 - starting the CLI from 418
- command scope 280
- command-line options 420
 - a 424
 - a 90
 - launch Visualizer 323
 - no_startup_scripts 93
 - nodes_allowed 499
 - passing to TotalView 90
 - remote 453
 - remote 90
 - s startup 418
- commands 87
 - Action Point > At Location 182
 - Action Point > Delete All 185
 - Action Point > Properties 185, 189, 191, 194, 196, 413
 - Action Point > Save All 213, 478
 - Action Point > Save As 213
 - Action Point > Set Barrier 194
 - Action Point > Suppress All 185
 - Add to Expression List 250
 - Auto Visualize (Visualizer) 314
 - change Visualizer launch 325
 - Clear All STOP and EVAL 185
 - Custom Groups 542
 - Edit > Delete All Expressions 253
 - Edit > Delete Expression 253
 - Edit > Duplicate Expression 253
 - Edit > Find 156
 - Edit > Find Again 156
 - Edit > Reset Defaults 252, 253
 - File > Attach to a Running

- Program 101
- File > Close 154, 239
- File > Close (Visualizer) 314
- File > Close Similar 154, 239
- File > Debug Core File 106
- File > Debug New Parallel Program 463
- File > Debug New Program 99, 127, 450, 453
- File > Delete (Visualizer) 313, 314
- File > Edit Source 164
- File > Exit (Visualizer) 313
- File -> Manage Sessions 119
- File > New Debugging Session 98, 463
- File > Options (Visualizer) 314, 316
- File > Preferences 128
 - Formatting page 218
 - Launch Strings page 324
 - Options page 218
 - Pointer Dive page 234
- File > Save Pane 155
- File > Search Path 100, 125, 126, 479
- File > Signals 123
- Group > Attach 483, 484, 485, 486
- Group > Attach Subset 401
- Group > Control > Go 383
- Group > Detach 105
- Group > Edit 526
- Group > Go 191, 392, 399, 478
- Group > Halt 166, 378, 399
- Group > Hold 383
- Group > Kill 172, 489
- Group > Next 400
- Group > Release 383
- Group > Restart 172
- Group > Run To 399
- Group > Step 400
- group or process 399
- interrupting 417
- Load All Symbols in Stack 569
- mpirun 480, 485
- Options > Auto Visualize 312

- poe 469, 476
- Process > Create 393
- Process > Detach 105
- Process > Go 172, 392, 399, 477, 483, 485
- Process > Halt 166, 378, 399
- Process > Hold 383
- Process > Next 394
- Process > Next Instruction 394
- Process > Out 516
- Process > Run To 516
- Process > Startup 90
- Process > Step 394
- Process > Step Instruction 394
- Process Startup Parameters 127
- prun 483
- remsh 446
- rsh 477
- server launch, arguments 455
- single-stepping 166
- ssh 446
- Startup 90
- Thread > Continuation Signal 105, 171
- Thread > Go 392
- Thread > Hold 383
- Thread > Set PC 173
- Tools > Attach Subset 402
- Tools > Call Graph 304
- Tools > Command Line 418
- Tools > Create Checkpoint 562
- Tools > Evaluate 245, 322, 323, 337, 565
- Tools > Global Arrays 504, 505
- Tools > Manage Shared Libraries 565
- Tools > Message Queue 407, 408, 409
- Tools > Message Queue Graph 406
- Tools > Program Browser 221
- Tools > Restart 562
- Tools > Statistics 297
- Tools > Thread Objects 278
- Tools > Variable

- Browser 230
- Tools > View Across 510
- Tools > Visualize 17, 312
- Tools > Visualize Distribution 509
- Tools > Watchpoint 211
- totalview
 - core files 87
- totalview command 87, 480, 485
- totalviewcli command 87, 89, 480, 485
- tvdsrv 442
 - launching 455
- View > Add to Expression List 247
- View > Assembler > By Address 161
- View > Assembler > Symbolically 161
- View > Block Status 236
- View > Collapse All 225
- View > Compilation Scope 226
- View > Dive 253
- View > Dive In All 242
- View > Dive in New Window 12
- View > Dive Thread 279
- View > Dive Thread New 279
- View > Examine Format > Raw 235
- View > Examine Format > Structured 235
- View > Expand All 225
- View > Graph (Visualizer) 313
- View > Lookup Function 157, 159, 160
- View > Lookup Variable 221, 232, 236, 275, 287
- View > Reset 158, 160
- View > Reset (Visualizer) 320
- View > Source As > Assembler 161
- View > Source As > Both 161, 173
- View > Source As > Source 161
- View > Surface (Visualizer) 313
- View > Variable 495

- View > View Across >
 - None 300
- View > View Across >
 - Process 300
- View > View Across >
 - Thread 300
- Visualize 17
- visualize 323, 325
- Window > Duplicate 153, 154, 241
- Window > Duplicate Base Window (Visualizer) 314
- Window > Memorize 151
- Window > Memorize All 151
- Window > Update 382
- common block
 - displaying 271
 - diving on 272
 - members have function scope 271
- comparing variable values 228
- comparisons in filters 295
- Compilation Scope > Floating command 247
- Compilation Scope command 226
- compiled expressions 202
 - allocating patch space for 203
 - performance 202
- compiled in scope list 280
- compiling
 - CUDA programs. See CUDA, compiling.
 - g compiler option 85
 - multiprocess programs 85
 - O option 85
 - optimization 85
 - programs 32, 85, 372
- completion rules for arena specifiers 536
- \$complex data type 261
- \$complex_8 data type 261
- \$complex_16 data type 261
- compound objects 258
- conditional breakpoints 197, 199, 345
- conf file 457
- configure command 468
- configuring the Visualizer 323
- connection for serial line 460
- connection timeout 453, 455
 - altering 452
- connection timeout, bulk server launch 455
- contained functions 275
 - displaying 275
- context menus 139
- continuation signal 171
 - clearing 171
- Continuation Signal command 105, 171
- continuing with a signal 171
- continuous execution 417
- Control Group and Share Groups Examples figure 390
- control groups 361, 389
 - adding an Attach to Program debug session 104
 - defined 360
 - discussion 389
 - overview 526
 - specifier for 528
- control in parallel environments 430
- control in serial environments 430
- control registers
 - interpreting 233
- controlling program execution 430
- conversion rules for filters 291
- core dump, naming the signal that caused 107
- core files
 - debug session in the Debug Core File dialog 106
 - debugging 90
 - examining 109
 - in totalview command 87
 - multi-threaded 107
 - opening 110
- correcting programs 201
- count array statistic 298
- \$count built-in function 345
- \$countall built-in function 345
- countdown breakpoints 199, 345
- counter, loop 199
- \$countthread built-in function 346
- CPU registers 233
- cpu_use option 476
- Cray
 - configuring TotalView for 500
 - loading TotalView 501
 - qsub 501
 - starting the CLI 501
 - starting TotalView 501
- Cray Linux Environment (CLE) using TotalView 502
- Cray XT, XE, and XK debugging 499
- Cray XT3 debugging tvdsvr 499
- Create Checkpoint command 562
- creating custom groups 542
- creating groups 364, 392
- creating new processes 420
- creating processes 392
 - and starting them 392
 - using Step 394
 - without starting it 393
 - without starting them 393
- creating threads 353
- creating type transformations 217
- Ctrl+C 417
- CUDA
 - @parameter qualifier 589
 - @register storage qualifier 591
 - assigned thread IDs 581
 - breakpoints, running 583
 - CLI and operating on CUDA threads 588
 - compiling a program for debugging 577

- compiling options 577
- compilingTesla GPU 578
- coordinate spaces, 4D and 5D 581
- CUDA thread defined 581
- data from CUDA thread, displaying 586
- debugging model, defined 573
- devices, displaying 596
- execution, viewing 583
- features 28, 571
- g -G compiling option 577
- GPU and breakpoints 583
- GPU focus thread 581
- GPU thread selector 581
- host thread, viewing 582
- installing 574
- kernel, launching 580
- Linux-x86_64, supported platform 571
- logical coordinate space 581
- MemoryChecker 592
- nvcc compiler 577
- physical coordinate space 581
- process, defined 573
- PTX register, locations 590
- ReplayEngine
 - limitations 598
- requirements 571
- running a GPU code
 - breakpoint 583
- runtime variables, supported 587
- sample program 599
- single-stepping GPU code 584
- starting TotalView for CUDA applications 579
- storage qualifier, supported types 586
- thread's four attributes 596
- troubleshooting 597
- type casting 587
- variables from CUDA thread, displaying 586
- variables, editing 587

CUDA Debugging option in Program Session dialog 114

current location of program

- counter 149
- current set indicator 522
- current stack frame 160
- current working directory 125, 126
- Custom Groups command 542
- Cycle Detection tab 407

D

- D control group specifier 528
- dactions command 176
 - load 213, 478
 - save 213, 478
- daemons 350, 353
- dassign command 254
- data
 - editing 10
 - viewing, from Visualizer 311
- data assembler pseudo op 342
- data dumping 235
- data in arrays
 - viewing using Array Viewer 288
- data precision, changing display 132
- data types 261
 - C++ 268
 - changing 256
 - changing class types in C++ 269
 - for visualization 311
 - int 257
 - int[] 257
 - int* 257
 - opaque data 266
 - pointers to arrays 258
 - predefined 261
 - to visualize 311
- data_format variables 219
- dataset
 - defined for Visualizer 311
 - visualizing 322
 - window (Visualizer) 314
 - window (Visualizer), display commands 315
 - window, menu
- commands 313
- deleting 313
- dimensions 325
- header fields 325
- ID 326
 - vh_axis_order field 325
- dattach command 90, 102, 110, 430, 470, 479, 488
 - mprun command 488
- dbarrier command 193, 195
 - e 199
 - stop_when_hit 413
- dbfork library 85, 191
 - linking with 85
- dbreak command 179, 182, 190, 439
 - e 199
- dcheckpoint command 562
- ddelete command 182, 185, 196, 489
- ddetach command 105
- ddisable command 184, 185, 196
- ddlopen command 565
- ddown command 169
- deadlocks 518
 - message passing 408
- \$debug assembler pseudo op 341
- Debug New Parallel Program command 463
- Debug New Program command 127, 450
- Debug Options
 - in Debug New Program dialog 101
- debug, using with MPICH 489
- debugger initialization 419
- debugger PID 429
- debugger server
 - starting manually 449
- Debugger Unique ID (DUID) 344
- debugging
 - core file 90
 - executable file 87
 - multiprocess programs 85
 - not compiled with -g 85
 - OpenMP applications 493
 - over a serial line 460

- PE applications 476
- programs that call
 - execve 85
 - programs that call fork 85
 - QSW RMS 483
 - SHMEM library code 506
 - UPC programs 507
- debugging Blue Gene
 - applications 480
- debugging core files
 - in the Debug Core File dialog 106
- debugging Fortran modules 274
- debugging MPI programs 91
- debugging session 430
- debugging symbols, reading 567
- debugging techniques 370, 398, 489
- declared arrays, displaying 266
- def assembler pseudo op 342
- default address range
 - conflicts 204
- default control group
 - specifier 528
- default focus 534
- default process/thread set 521
- default programming
 - language 86
- default text editor 164
- default width specifier 523
- deferred shape array
 - definition 284
 - types 276
- deferred symbols
 - force loading 569
 - reading 567
- deferring order for shared
 - libraries 568
- Delete All command 185
- Delete command
 - (Visualizer) 313, 314
- Delete, in dataset window 314
- deleting
 - action points 185
 - datasets 313
 - programs 172
- denable command 185, 186
- denorm filter 293
- denormalized count array
 - statistic 298
- DENORMs 290
- deprecated X defaults 134
- deprecated, defined 134
- dereferencing 12
 - automatic 234
 - pointers 234
- Detach command 105
- Detach from processes
 - command 106
- detaching from processes 105
- detaching removes all
 - breakpoints 105
- detecting cycles 407
- determining scope 227, 514
- dfocus command 166, 520, 521
 - example 521
- dga command 505
- dgo command 392, 399, 477, 478, 485, 537
- dgroups command
 - add 526, 532, 533
 - remove 370
- dhalt command 166, 378, 399
- dhold command 193, 383
 - process 384
 - thread 384
- difference operator 540
- directories, setting order of
 - search 125
- disabling
 - action points 185
 - autolaunch 452
 - autolaunch feature 453
- disassembled machine
 - code 158
 - in variable window 238
- discard dive stack 158
- discard mode for signals 124
- discarding signal problem 124
- disconnected processing 351
- displaying 153
 - areas of memory 236
 - argv array 266
- array data 153
- arrays 284
- blocks 225
- columns 251
- common blocks 271
- declared and allocated
 - arrays 266
- Fortran data types 271
- Fortran module data 273
- global variables 221, 230
- long variable names 222
- machine instructions 237
- memory 236
- pointer 153
- pointer data 153
- registers 232
- remote hostnames 146
- stack trace pane 153
- STL variables 215
- structs 259
- subroutines 153
- thread objects 278
- typedefs 259
- unions 260
- variable 152
- Variable Windows 220
- dive icon 154, 240
- Dive In All command 242, 244
- Dive In New Window
 - command 12
- Dive Thread command 279
- Dive Thread New command 279
- dividing work up 351
- diving 139, 152, 407, 479
 - creating call_graph group 306
- defined 10
- in a "view acrosss" pane 301
- in a variable window 240
- in source code 158
- into a pointer 153, 240
- into a process 152
- into a stack frame 153
- into a structure 240
- into a thread 152
- into a variable 152
- into an array 240
- into formal parameters 232
- into Fortran common
 - blocks 272

- into function name 158
- into global variables 221, 230
- into local variables 232
- into MPI buffer 410
- into MPI processes 410
- into parameters 232
- into pointer 153
- into processes 152
- into registers 232
- into routines 153
- into the PC 237
- into threads 149, 152
- into variables 152, 153
- nested 153
- nested dive defined 240
- program browser 230
- registers 220
- scoping issue 227
- variables 220

dkill command 172, 401, 421, 430
 dll_read_all_symbols variable 569
 dll_read_loader_symbols variable 569
 dll_read_loader_symbols_only variable 569
 dll_read_no_symbols variable 569
 dload command 109, 420, 430, 450
 returning process ID 422
 dlopen(), using 565
 dmg installer 89
 dnext command 168, 394, 400
 dnexti command 168, 394
 double assembler pseudo op 342
 \$double_precision data type 261
 dout command 170, 516
 dpid 429
 dprint command 157, 221, 222, 232, 233, 236, 237, 260, 266, 271, 273, 275, 284, 285, 287, 435, 495, 496
 using with CAF 512
 dptsets command 374, 379
 drerun command 172, 420
 drestart command 562
 drun command 420, 424
 dsession command 109
 dset command 424, 426
 dstatus command 195, 374
 dstep command 167, 394, 516, 522, 524, 537
 dstep commands 400
 dstepi command 167, 393, 394
 DUID 344
 of process 344
 \$duid built-in variable 344
 dunhold command 193, 383
 -thread 384
 dunset command 424
 duntil command 169, 516, 518
 dup command 169
 dup commands 222
 Duplicate Base Window in Visualizer dataset window 314
 Duplicate command 153, 154, 241
 dwhere command 222, 523, 537
 dynamic call graph 304
 Dynamic Libraries page 568
 dynamic patch space allocation 203, 204

E

Edit > Delete All Expressions command 253
 Edit > Delete Expression command 253
 Edit > Duplicate Expression command 253
 Edit > Find Again command 156
 Edit > Find command 156
 Edit > Reset Defaults command 252, 253
 edit mode 139
 Edit Source command 164
 editing
 addresses 267
 compound objects or arrays 258
 source text 164
 type strings 256
 view across data 301
 editing groups 542
 EDITOR environment variable 164
 editor launch string 164
 effects of parallelism on debugger behavior 428
 Enable action point 185
 Enable memory debugging checkbox 114
 Enable Visualizer Launch checkbox 324
 enabling
 action points 185
 Environment tab of Program Sessions dialog 115
 environment variables
 adding 116
 before starting poe 476
 EDITOR 164
 how to enter 116
 LC_LIBRARY_PATH 94
 LM_LICENSE_FILE 94
 MP_ADAPTER_USE 476
 MP_CPU_USE 476
 MP_EUIDEVELOP 411
 PATH 125, 126
 setting in of Program Sessions dialog 115
 SHLIB_PATH 94
 TOTALVIEW 91, 411, 469
 TVDSVRLAUNCHCMD 456
 environment variables in Debug New Program dialog 101
 equiv assembler pseudo op 342
 errors
 returned in Attach to a Running Program dialog 104
 using ReplayEngine with Infiniband MPis 491
 errors, in multiprocess program 123
 EVAL icon 139, 177
 for evaluation points 139
 eval points
 and expression system 329

- Evaluate command 322, 323, 337, 344
- Evaluate Window
 - expression system 330
- Evaluate window 329
- evaluating an expression in a watchpoint 206
- evaluating expressions 337
- evaluating state 431
- evaluation points 177, 197
 - assembler constructs 339
 - C constructs 333
 - clearing 139
 - defined 175, 431
 - defining 197
 - examples 199
 - Fortran constructs 334
 - hitting breakpoint while evaluating 338
 - listing 149
 - lists of 149
 - machine level 197
 - patching programs 200
 - printing from 177
 - saving 198
 - setting 139, 198, 438
 - using \$stop 178
 - where generated 197
- evaluation system
 - limitations 330
- event points listing 149
- Examine Format > Raw Format command 235
- Examine Format > Structured command 235
- examining
 - core files 109
 - memory 235
 - processes 389
 - stack trace and stack frame 232
- exception enable modes 233
- excluded information, reading 569
- exclusion list, shared library 568
- EXECUTABLE_PATH tab 126
- EXECUTABLE_PATH variable 100, 125, 127, 433
 - setting 433
- executables
 - debugging 87
 - specifying name in scope 281
- execution
 - controlling 430
 - halting 378
 - out of function 170
 - resuming 383
 - startup file 93
 - to completion of function 170
- execve() 85, 191, 389
 - debugging programs that call 85
 - setting breakpoints with 191
- existent operator 540
- exit CLI command 95
- Exit command 95
- Exit command (Visualizer) 313
- expanding structures 225
- expression evaluation window
 - compiled and interpreted expressions 202
 - discussion 337
- Expression List window 16, 221, 238, 246
 - Add to Expression List command 247
 - aggregates 249
 - and expression system 329
 - array of structures 249
 - diving 249
 - editing contents 252
 - editing the value 253
 - editing type field 253
 - entering variables 246
 - expressions 249
 - highlighting changes 248
 - multiple windows 250
 - multiprocess/multithreaded behavior 250
 - rebinding 251
 - reevaluating 251
 - reopening 251
 - reordering rows 252
 - restarting your program 251
 - selecting before sending 247
 - sorting columns 252
- Expression List window, 329
- expression system
 - accessing array elements 328
 - C/C++ declarations 333
 - C/C++ statements 333
 - defined 328
 - eval points 329
 - Expression List Window 329
 - Fortran 334
 - Fortran intrinsics 335
 - functions and their issues 329
 - methods 329
 - structures 328
 - templates and limitations 333
 - Tools > Evaluate Window 330
 - using C++ 331
 - Variable Window 329
- expressions 190, 540
 - can contain loops 337
 - changing in Variable Window 244
 - compiled 202
 - evaluating 337
 - in Expression List window 249
 - performance of 202
 - side effects 245
- expressions and variables 244
- \$extended data type 261
- extent of arrays 259

F

- features of CUDA debugger. See CUDA, features.
- Fermi GPU, compiling for. See CUDA, compiling for Fermi
- figures
 - Action Point > At Location Dialog Box 182, 186
 - Action Point > Properties Dialog Box 184, 189, 194

- Action Point Symbol 176
- Ambiguous Function Dialog Box 157, 183
- Ambiguous Line Dialog Box 181
- Array Data Filter by Range of Values 295
- Array Data Filtering by Comparison 292
- Array Data Filtering for IEEE Values 293
- Array Statistics Window 297
- Breakpoint at Assembler Instruction Dialog Box 188
- Control and Share Groups Example 390
- File > Preferences: Action Points Page 190
- Five Processes and Their Groups on Two Computers 363
- Fortran Array with Inverse Order and Limited Extent 286
- PC Arrow Over a Stop Icon 189
- Sorted Variable Window 296
- Stopped Execution of Compiled Expressions 203
- Stride Displaying the Four Corners of an Array 286
- Tools > Evaluate Dialog Box 339
- Tools > Watchpoint Dialog Box 209
- Undive/Redive Buttons 240
- Using Assembler 340
- Viewing Across an Array of Structures 301
- Viewing Across Threads 300
- Waiting to Complete Message Box 338
- File > Attach to a Running Program 101
- File > Close command 154, 239
- File > Close command (Visualizer) 314
- File > Close Relatives command 154
- File > Close Similar command 154, 239
- File > Debug New Parallel Program command 463
- File > Debug New Program command 127, 450
- File > Debug New Program dialog 99
- File > Delete command (Visualizer) 313, 314
- File > Edit Source command 164
- File > Exit command 95
- File > Exit command (Visualizer) 313
- File -> Manage Sessions command 119
- File > New Debugging Session dialog 98
- File > Options command (Visualizer) 314, 316
- File > Preferences Bulk Launch page 449 Options page 151
- File > Preferences > Launch Strings saving remote server launch string 113
- File > Preferences command Action Points page 124, 399 Bulk Launch page 449, 453 different values between platforms 128 Dynamic Libraries page 568 Formatting page 218 Launch Strings page 324, 452 Options page 123, 218 overview 128 Parallel page 403 Pointer Dive page 234
- File > Preferences: Action Points Page figure 190
- File > Save Pane command 155
- File > Search Path command 100, 125, 126, 479 search order 125, 126
- File > Signals command 123
- file command-line option to Visualizer 323, 325
- file extensions 86
- file, start up 93
- files
 - .rhosts 477
 - hosts.equiv 477
 - visualize.h 325
- fill assembler pseudo op 342
- filter expression, matching 290
- filtering
 - array data 290, 291
 - array expressions 295
 - by comparison 291
 - comparison operators 291
 - conversion rules 291
 - example 292
 - IEEE values 292
 - options 290
 - ranges of values 294
 - unsigned comparisons 292
- filters 295
 - \$denorm 293
 - \$inf 293
 - \$nan 292
 - \$nanq 292
 - \$nans 293
 - \$ninf 293
 - \$pdenorm 293
 - \$pinf 293
 - comparisons 295
- Find Again command 156
- Find command 156
- finding
 - functions 157
 - source code 157, 159
 - source code for functions 157
- first thread indicator of < 522
- Five Processes and Their Groups on Two Computers figure 363
- \$float data type 261
- float assembler pseudo op 342
- floating scope 247
- focus
 - as list 536
 - changing 521
 - jump to thread or process 380
 - pushing 521
 - restoring 521

- setting 520
- for loop 337
- Force window positions (disables window manager placement modes) check box 151
- fork_loop.tvd example program 419
- fork() 85, 191, 389
 - debugging programs that call 85
 - setting breakpoints with 191
- Formatting page 218
- Fortran
 - array bounds 259
 - arrays 259
 - CoArray support 511
 - common blocks 271
 - contained functions 275
 - data types, displaying 271
 - debugging modules 274
 - deferred shape array types 276
 - expression system 334
 - filter expression 295
 - in code fragment 197
 - in evaluation points 334
 - intrinsic in expression system 335
 - module data, displaying 273
 - modules 273, 274
 - pointer types 276
 - type strings supported by TotalView 256
 - user defined types 275
- Fortran Array with Inverse Order and Limited Extent figure 286
- Fortran casting for Global Arrays 504, 505
- Fortran modules 277
 - command 273
- Fortran parameters 277
- forward icon 154
- four linked processors 355
- 4142 default port 450
- frame pointer 169

- freezing window display 227
- function calls, in eval points 201
- function visualization 304
- functions
 - finding 157
 - IEEE 294
 - in expression system 329
 - locating 157
 - returning from 170

G

- g compiler option 153
- g compiler option 85
- g -G option, for compiling CUDA program. See CUDA, -g -G option.
- g width specifier 529, 533
- \$GA cast 504, 505, 504
- \$ga cast 504, 505
- generating a symbol table 85
- Global Arrays 504
 - casting 504, 505
 - debugging 504
 - diving on type information 505
 - Intel IA-64 504
- global assembler pseudo op 342
- global variables
 - changing 393
 - displaying 393
 - diving into 221, 230
- gnu_debuglink file 91
- Go command 392, 399, 477, 478, 483, 485
- GOI defined 514
- going parallel 404
- goto statements 198
- GPU. See CUDA.
- Graph command (Visualizer) 313
- Graph Data Window 315
- graph points 316
- Graph visualization menu 313
- graph window, creating 313
- Graph, in Dataset Window 313

- graphs, two dimensional 315
- group
 - process 518
 - thread 519
- Group > Attach Subset
 - command 401, 483, 484, 485, 486
- Group > Control > Go
 - command 383
- Group > Custom Group
 - command 370
- Group > Detach command 105
- Group > Edit command 526
- Group > Go command 191, 386, 392, 399, 478
- Group > Halt command 166, 378, 399
- Group > Hold command 383
- Group > Kill command 172, 401, 489
- Group > Next command 400
- Group > Release command 383
- Group > Restart command 172
- Group > Run To command 399
- Group > Step command 400
- group aliases 427
 - limitations 427
- group commands 399
- group indicator
 - defined 527
- group name 528
- group number 528
- group stepping 517
- group syntax 527
 - group number 528
 - naming names 528
 - predefined groups 528
- GROUP variable 533
- group width specifier 523
- groups
 - adding an Attach to Program debug session 104
 - behavior 517
 - creating 364, 392, 542
 - defined 360
 - editing 542

- examining 389
- holding processes 383
- overview 360
- process 518
- relationships 524
- releasing processes 383
- running 403
- selecting processes for 542
- starting 392
- stopping 403
- thread 518
- Groups > Custom Groups
 - command 306, 542
- GUI namespace 425

H

- h held indicator 383
- half assembler pseudo op 342
- Halt command 166, 378, 399
- halt commands 378
- halting 378
 - groups 378
 - processes 378
 - threads 378
- handler routine 122
- handling signals 122, 123
- header fields for datasets 325
- held indicator 383
- held operator 540
- held processes, defined 193
- hexadecimal address, specifying
 - in variable window 236
- hi16 assembler operator 341
- hi32 assembler operator 341
- highlighted variables 223, 225
- highlighting changes in Expression List window 248
- hold and release 383
- \$hold assembler pseudo op 341
- \$hold built-in function 346
- Hold command 383
- hold state 383
 - toggling 194
- Hold Threads command 384
- holding and advancing
 - processes 430
- holding problems 387
- holding threads 519

- \$holdprocess assembler pseudo op 341
- \$holdprocess built-in function 346
- \$holdprocessall built-in function 346
- \$holdprocessstopall assembler pseudo op 341
- \$holdstopall assembler pseudo op 341
- \$holdstopall built-in function 346
- \$holdthread assembler pseudo op 341
- \$holdthread built-in function 346
- \$holdthreadstop assembler pseudo op 341
- \$holdthreadstop built-in function 346
- \$holdthreadstopall assembler pseudo op 341
- \$holdthreadstopall built-in function 346
- \$holdthreadstopprocess assembler pseudo op 341
- \$holdthreadstopprocess built-in function 346
- hostname
 - expansion 458
 - for tvdsvr 90
 - in square brackets 146
- hosts.equiv file 477
- how TotalView determines
 - share group 391
- hung processes 101

I

- I state 376
- IBM Blue Gene
 - bluegene_io_interface 481
 - bluegene_server_launch 481
 - starting TotalView 480
- IBM MPI 476
- IBM SP machine 468, 469
- idle state 376
- IEEE functions 294

- Ignore mode warning 124
- ignoring action points 185
- implicitly defined process/thread set 521
- incomplete arena specifier 536
- inconsistent widths 537
- inf filter 293
- Infiniband MPIs
 - possible errors 491
 - settings 490
 - with ReplayEngine 490
- infinity count array statistic 298
- INFs 290
- inheritance hierarchy 332
- initial process 428
- initialization search paths 93
- initialization subdirectory 93
- initializing an array slice 434
- initializing debugging state 93
- initializing the CLI 419
- initializing TotalView 93
- instructions
 - data type for 265
 - displaying 237
- \$int data type 261
- int data type 257
- int[] data type 257
- int* data type 257
- \$integer_2 data type 262
- \$integer_4 data type 262
- \$integer_8 data type 262
- interactive CLI 415
- internal counter 199
- interpreted expressions 202
 - performance 202
- interrupting commands 417
- intersection operator 540
- intrinsic functions
 - \$is_Inf 294
 - \$is_inf 294
 - \$is_nan 294
 - \$is_ndenorm 294
 - \$is_ninf 294
 - \$is_nnorm 294
 - \$is_norm 294
 - \$is_pdenorm 294
 - \$is_pinf 294

- \$is_pnom 294
- \$is_pzero 294
- \$is_qnan 294
- \$is_snan 294
- \$is_zero 294
- inverting array order 286
- inverting axis 316
- invoking CLI program from shell example 419
- invoking TotalView on UPC 507
- IP over the switch 476
- iterating
 - over a list 537
 - over arenas 522

J

- joystick mode, Visualizer 310
- jump to dialog 380

K

- KeepSendQueue command-line option 411
- kernel, CUDA. See CUDA, kernel.
- Kill command 172, 401
- killing programs 172
- ksq command-line option 411

L

- L lockstep group specifier 528, 529
- labels, for machine instructions 238
- Last Value column 224, 248
- launch
 - configuring Visualizer 323
 - options for Visualizer 324
 - TotalView Visualizer from command line 323
- launch strings
 - saving as a preference 113
- Launch Strings page 324, 452
- lcomm assembler pseudo op 342
- LD_LIBRARY_PATH environment variable 94, 507
- left margin area 149
- left mouse button 139

- libraries
 - dbfork 85
 - debugging SHMEM library code 506
 - naming 568
 - see alsoshared libraries
- limitations
 - CUDA and ReplayEngine 598
- limitations in evaluation system 330
- limiting array display 286
- line number area 139, 176
- line numbers 149
 - for specifying blocks 281
- LINES_PER_SCREEN variable 423
- linked lists, following pointers 240
- Linux-PowerLE 208
- Linux-x86_64, supported CUDA platform. See CUDA, Linux-x86_64.
- list transformation, STL 217
- lists of variables, seeing 16
- lists with inconsistent widths 537
- lists, iterating over 537
- LM_LICENSE_FILE environment variable 94
- lo16 assembler operator 341
- lo32 assembler operator 341
- Load All Symbols in Stack command 569
- load_session flag 89
- loader symbols, reading 567
- loading
 - file into TotalView 89
 - new executables 98
 - remote executables 91
 - shared library symbols 568
- loading loader symbols 568
- loading no symbols 568
- local hosts 90
- locations, toggling breakpoints at 182
- lockstep group 362, 514, 521

- defined 360
- L specifier 528
- number of 527
- overview 527
- \$logical data type 262
- \$logical_1 data type 262
- \$logical_2 data type 262
- \$logical_4 data type 262
- \$logical_8 data type 262
- \$long data type 262
- long variable names, displaying 222
- \$long_branch assembler pseudo op 341
- \$long_long data type 262
- Lookup Function
 - command 157, 159, 160
- Lookup Variable command 157, 221, 232, 236, 275, 496
 - specifying slices 287
- loop counter 199
- lower adjacent array statistic 298
- lower bounds 258
 - non default 259
 - of array slices 285
- lysm TotalView pseudo op 342

M

- Mac OS X
 - procmod permission 89
 - starting execution 89
 - starting from an xterm 89
- machine instructions
 - data type 265
 - data type for 265
 - displaying 237
- make_actions.tcl sample macro 419, 438
- Manage Debugging Sessions window
 - accessing 119
- manager threads 358, 362
- managing sessions
 - accessing dialog 119
 - editing, deleting, duplicating 120

- launching your last session 109
- manual hold and release 383
- map templates 215
- map transformation, STL 215
- master process, recreating slave processes 401
- master thread 494
 - OpenMP 494, 497
 - stack 495
- matching processes 518
- matching stack frames 300
- maximum array statistic 298
- mean array statistic 298
- median array statistic 298
- Memorize All command 151
- Memorize command 151
- memory contents, raw 236
- Memory Debugging option in Program Session dialog 114
- memory information 236
- memory locations, changing values of 254
- memory, displaying areas of 236
- memory, examining 235
- menus, context 139
- message passing deadlocks 408
- Message Queue command 407, 408, 409
- message queue display 485, 489
- Message Queue Graph 407
 - diving 407
 - rearranging shape 408
 - updating 407
- Message Queue Graph command 406
- message-passing programs 399
- messages
 - envelope information 411
 - unexpected 411
- messages from TotalView, saving 422
- methods, in expression system 329
- middle mouse button 139
- minimum array statistic 298
- missing TID 523

- mixing arena specifiers 537
- modifying code behavior 198
- module data definition 273
- modules 273, 274
 - debugging
 - Fortran 274
 - displaying Fortran data 273
- modules in Fortran 277
- more processing 423
- more prompt 423
- mouse button
 - diving 139
 - left 139
 - middle 139
 - right 139
 - selecting 139
- mouse buttons, using 139
- MP_ADAPTER_USE environment variable 476
- MP_CPU_USE environment variable 476
- MP_EUIDEVELOP environment variable 411
- MP_TIMEOUT 477
- MPI
 - attaching to 485, 486
 - buffer diving 410
 - communicators 409
 - debugging 91
 - Infiniband, using with ReplayEngine 490
 - library state 409
 - on IBM 476
 - on SGI 485
 - on Sun 487
 - Open 482
 - process diving 410
 - rank display 405
 - starting 463
 - starting on Cray 475
 - starting on SGI 485
 - starting processes 483
 - starting processes, SGI 485
 - troubleshooting 489
- mpi tasks, attaching to 404
- MPI_Init() 409, 478
 - breakpoints and timeouts 413
- MPI_lprobe() 411

- MPI_Recv() 411
- MPICH 468, 469
 - and SIGINT 489
 - and the TOTALVIEW environment variable 469
 - attach from TotalView 470
 - attaching to 470
 - ch_lfshmem device 468, 470
 - ch_mpl device 468
 - ch_p4 device 468, 470
 - ch_shmem device 470
 - ch_smem device 468
 - configuring 468
 - debugging tips 411
 - diving into process 470
 - MPICH/ch_p4 412
 - mpirun command 468, 469
 - naming processes 471
 - obtaining 468
 - P4 471
 - p4pg files 471
 - starting TotalView using 468
 - tv command-line option 468
 - using -debug 489
- mpirun command 411, 468, 469, 480, 485
 - options to TotalView through 411
 - passing options to 411
- mpirun process 485, 486
- MPL_Init() 478
 - and breakpoints 478
- mprun command 487
- multiple classes, resolving 158
- Multiple indicator 301
- multi-process programming library 85
- multi-process programs and signals 123
 - compiling 85
 - process groups 389
 - setting and clearing breakpoints 189
- multiprocessing 355
- multi-threaded core files 107
- multi-threaded signals 171

N

- n option, of rsh command 447

- n single process server launch command 456
- names of processes in process groups 389
- namespaces 425
 - TV:: 425
 - TV::GUI:: 425
- naming libraries 568
- naming MPICH processes 471
- naming rules
 - for control groups 389
 - for share groups 389
- nan filter 292
- nanq filter 292
- NaNs 290, 292
 - array statistic 298
- nans filter 293
- navigating, source code 160
- ndenorm filter 293
- nested dive 153
 - defined 240
 - window 241
- nested stack frame, running to 519
- Next command 166, 394, 400
- "next" commands 168
- Next Instruction command 394
- \$nid built-in variable 344
- ninf filter 293
- no_startup_scripts command line option 93
- no_stop_all command-line option 411
- node ID 344
- nodes_allowed command-line option 499
 - Cray 500
- nodes_allowed tvdsrv command-line option 499
- nodes_allowed, tvdsrv command-line option 499
- nodes, attaching from to poe 478
- None (IView Across) command 300
- nonexistent operators 540

- non-sequential program execution 417
- nvcc compiler, and CUDA. See CUDA, nvcc compiler.
- NVIDIA. See CUDA.

O

- O option 85
- offsets, for machine instructions 238
- \$oldval built-in variable 344
- omitting array stride 285
- omitting period in specifier 537
- omitting width specifier 536, 537
- opaque data 265
- opaque type definitions 266
- Open MPI
 - starting 482
- Open process window at breakpoint check box 124
- Open process window on signal check box 123
- opening a core file 110
- opening shared libraries 565
- OpenMP 493, 494
 - debugging 493
 - debugging applications 493
 - master thread 494, 495, 497
 - master thread stack context 495
 - private variables 494
 - runtime library 493
 - shared variables 494, 497
 - stack parent token 497
 - THREADPRIVATE variables 497
 - TotalView-supported features 493
 - viewing shared variables 495
 - worker threads 494
- operators
 - difference 540
 - & intersection 540
 - | union 540
 - breakpoint 540
 - existent 540
 - held 540

- nonexistent 540
- running 540
- stopped 540
- unheld 540
- watchpoint 540
- optimizations, compiling for 85
- options
 - for visualize 323
 - in dataset window 314
 - patch_area 204
 - patch_area_length 204
 - sb 213
 - setting 134
- Options > Auto Visualize command (Visualizer) 312, 314
- Options command (Visualizer) 314, 316
- Options page 151, 218
- options, for compiling CUDA. See CUDA, compiling options
- org assembler pseudo op 343
- Out command 166
- "out" commands 170
- out command, goal 170
- outliers 298, 299
- outlined routine 493, 496, 497
- outlining, defined 493
- output
 - assigning output to variable 422
 - from CLI 422
 - only last command executed returned 422
 - printing 422
 - returning 422
 - when not displayed 422

P

- p width specifier 529
- p.t notation 522
- p/t sets
 - arguments to Tcl 520
 - expressions 540
 - set of arenas 522
 - syntax 522
- p/t syntax, group syntax 527
- P+/P- buttons 380

- p4 listener process 470
- p4pg files 471
- p4pg option 471
- panes, saving 155
- parallel debugging tips 401
- PARALLEL DO outlined routine 494
- parallel environments, execution control of 430
- Parallel page 403
- parallel program, defined 428
- parallel program, restarting 401
- parallel region 494
- parallel tasks, starting 478
- parallel_attach variable 404
- parallel_stop variables 404
- parameters, displaying in Fortran 277
- parsing comments example 438
- passing arguments 90
- passing default arguments 424
- pasting
 - with middle mouse 139
- patch space size, different than 1MB 204
- patch space, allocating 203
- patch_area_base option 204
- patch_area_length option 204
- patching
 - function calls 201
 - programs 200
- PATH environment variable 100, 125, 126
- pathnames, setting in proc-group file 471
- PC Arrow Over a Stop Icon figure 189
- PC icon 173
- pdenorm filter 293
- PE 478
 - adapter_use option 476
 - and slow processes 413
 - applications 476
 - cpu_use option 476
 - debugging tips 413
 - from command line 477
 - from poe 477
 - options to use 476
 - switch-based communication 476
- PE applications 476
- pending messages 408
- pending receive operations 409, 410
- pending send operations 409, 411
 - configuring for 411
- pending unexpected messages 409
- performance
 - and shared library use 564
- performance of interpreted, and compiled expressions 202
- performance of remote debugging 442
- Performance, improving in the Program Browser 231
- persist command-line option to Visualizer 323, 325
- phase, UPC 509
- pick, Visualizer 309
- picking a dataset point value 317
- \$pid built-in variable 344
- pid specifier, omitting 536
- pid.tid to identify thread 149
- pinf filter 293
- piping information 155
- plant in share group 190
- Plant in share group check box 191, 199
- poe
 - and mpirun 469
 - and TotalView 477
 - arguments 476
 - attaching to 478, 479
 - interacting with 413
 - on IBM SP 470
 - placing on process list 479
 - required options to 476
 - running PE 477
 - TotalView acquires poe processes 478
- poe, and bulk server launch 458
- POI defined 514
- point of execution for multiprocess or multithreaded program 149
- pointer data 153
- Pointer Dive page 234
- pointers 153
 - as arrays 234
 - chasing 234, 240
 - dereferencing 234
 - diving on 153
 - in Fortran 276
 - to arrays 258
- pointer-to-shared UPC data 509
- points, in graphs 316
- pop_at_breakpoint variable 124
- pop_on_error variable 123
- popping a window 153
- port 4142 450
- port command-line option 450
- port number for tvdsrv 90
- precision 218
 - changing 218
 - changing display 132
- predefined data types 261
- preference file 93
- preferences
 - Bulk Launch page 449, 453
 - Launch Strings page 452
 - Options page 123
 - saving remote server launch string 113
 - setting 134
- preloading shared libraries 565
- primary thread, stepping failure 518
- print statements, using 177
- printing an array slice 435
- printing in an eval point 177
- private variables 493
 - in OpenMP 494
- procedures
 - debugging over a serial line 460
 - displaying 266
 - displaying declared and allocated arrays 266
- process
 - detaching 105

- holding 518
- ID 344
- numbers are unique 428
- selecting in processes/rank tab 379
- state 374
- states 149
- stepping 517
- synchronization 399, 518
- width specifier 523
- width specifier, omitting 537
- Process > Create command 393
- Process > Detach command 105
- Process > Enable Memory Debugging command 114
- Process > Go command 172, 386, 392, 399, 477, 483, 485
- Process > Halt command 166, 378, 399
- Process > Hold command 383
- Process > Hold Threads command 384
- Process > Next command 394
- Process > Next Instruction command 394
- Process > Out command 516
- Process > Release Threads command 384
- Process > Run To command 516
- Process > Startup Parameters command 90, 127
 - entering standard I/O information 117
- Process > Step command 394
- Process > Step Instruction command 394
- process as dimension in Visualizer 312
- process barrier breakpoint
 - changes when clearing 196
 - changes when setting 196
 - defined 175
 - deleting 196
 - setting 194
- process DUID 344
- process focus 520
- process groups 360, 518, 526
 - behavior 532
 - behavior at goal 518
 - stepping 517
 - synchronizing 518
- Process Window 148
 - host name in title 146
 - raising 123
- process_id.thread_id 522
- process_load_callbacks variable 94
- process/set threads saving 524
- process/thread identifier 428
- process/thread notation 428
- process/thread sets 428
 - as arguments 520
 - changing focus 521
 - default 521
 - implicitly defined 521
 - inconsistent widths 537
 - structure of 522
 - target 520
 - widths inconsistent 537
- \$processduid built-in variable 344
- processes
 - acquiring 469, 471
 - acquisition in poe 478
 - apparently hung 400
 - attaching to 101, 479
 - barrier point behavior 196
 - behavior 517
 - breakpoints shared 190
 - call graph 304
 - changing 380
 - copy breakpoints from master process 469
 - creating 392, 394
 - creating by single-stepping 394
 - creating new 420
 - creating using Go 392
 - creating without starting 393
 - deleting 172
 - deleting related 172
 - detaching from 105
 - displaying data 152
 - diving into 479
 - diving on 152
 - groups 389
 - held defined 193
 - holding 193, 346, 383
 - hung 101
 - initial 428
 - loading programs using the Sessions Manager 98
 - master restart 401
 - MPI 410
 - names 389
 - refreshing process info 382
 - released 193
 - releasing 193, 196, 383
 - restarting 172
 - single-stepping 516
 - slave, breakpoints in 469
 - spawned 428
 - starting 392
 - state 374
 - status of 374
 - stepping 400, 517
 - stop all related 190
 - stopped 193
 - stopped at barrier point 196
 - stopping 197, 378
 - stopping all related 123
 - stopping intrinsic 346
 - stopping spawned 469
 - synchronizing 431, 518
 - tab 379
 - terminating 421
 - types of process groups 389
 - when stopped 517
- Processes button 190
- process-level stepping 400
- processors and threads 356
- procgroupp file 471
 - using same absolute path names 471
- procmod permission, Mac OS X 89
- Program arguments
 - in Debug New Program dialog 100
- Program Browser 230
 - explaining symbols 230
 - improving performance 231
- program control groups

- defined 526
- naming 389
- program counter (PC) 149
 - arrow icon for PC 149
 - indicator 149
 - setting 173
 - setting program counter 173
 - setting to a stopped thread 173
- program execution
 - advancing 430
 - controlling 430
- Program Session dialog 99
- program state, changing 417
- program visualization 304
- programming languages, determining which used 86
- programming TotalView 8
- programs
 - compiling 32, 85, 372
 - compiling using `-g` 85
 - correcting 201
 - deleting 172
 - killing 172
 - not compiled with `-g` 85
 - patching 200
 - restarting 172
- prompt and width specifier 530
- PROMPT variable 426
- Properties command 175, 184, 189, 191, 194, 198, 413
- Properties window 186
- properties, of action points 177
- prototypes for temp files 454
- prun command 483
- pthread ID 429
- \$ptree assembler pseudo op 342
- pushing focus 521

Q

- QSW RMS applications 483
 - attaching to 483
 - debugging 483
 - starting 483
- quad assembler pseudo op 343
- Quadrics RMS 483
- quartiles array statistic 298

R

- R state 376
- raising process window 123
- rank display 405
- rank for Visualizer 324
- ranks 406
- ranks tab 379, 405
- Raw Format command 235
- raw memory contents 235
- raw memory data 236
- RDMA optimizations
 - disabled with Infiniband 490
- read_symbols command 569
- reading loader and debugger symbols 567
- \$real data type 262
- \$real_16 data type 262
- \$real_4 data type 262
- \$real_8 data type 262
- rebinding the Variable Window 238
- recursive functions 170
 - single-stepping 169
- redive 241
- redive all 241
- redive buttons 240
- redive icon 154, 240
- registers
 - editing 233
 - interpreting 233
- Release command 383
- release state 383
- Release Threads command 384
- reloading breakpoints 478
- remembering window positions 151
- remote command-line option 90, 453
- Remote Debug Server Launch preferences 452
- remote debugging
 - in Debug New Program dialog 100
 - performance 442
- remote executables, loading 91
- remote hosts 90
 - adding 111
 - viewing remote server launch command 112
- remote login 477
- remote option 90
- Remote Server Launch Command field
 - Advanced button in Add Host dialog 112
- remote server launch string
 - saving as a preference 113
- remote shell command, changing 446
- removing breakpoints 139, 177
- remsh command 446
 - used in server launches 456
- replacing default arguments 424
- ReplayEngine
 - and Infiniband MPis 490
 - CUDA limitations 598
- researching directories 127
- Reset command 158, 160
- Reset command (Visualizer) 320
- resetting command-line arguments 116
- resetting the program counter 173
- resolving ambiguous names 158
- resolving multiple classes 158
- resolving multiple static functions 158
- Restart Checkpoint command 562
- Restart command 172
- restarting
 - parallel programs 401
 - program execution 172, 420
- restoring focus 521
- restricting output data 155
- results, assigning output to variables 422
- resuming
 - executing thread 173
 - executing 383, 392
 - processes with a signal 171
- returning to original source location 158

- reusing windows 153
- Reverse Debugging option in
 - Program Session dialog 114
- .rhosts file 446
- right angle bracket (>) 153
- right mouse button 139
- RMS applications 483
 - attaching to 483
 - starting 483
- Root Window 140
 - Attached Page 479
 - selecting a process 152
 - starting CLI from 418
 - state indicator 374
- rounding modes 233
- routine visualization 304
- routines, diving on 153
- routines, selecting 149
- RS_DBG_CLIENTS_PER_SERVER
 - environment variable 499, 500
- rsh command 446, 477
- rules for scoping 281
- Run To command 166, 399
- "run to" commands 169, 518
- running CLI commands 93
- running groups 403
- running operator 540

S

- s command-line option 93, 418
- S share group specifier 528
- S state 376
- S width specifier 529
- sample programs
 - make_actions.tcl 419
- sane command argument 418
- Satisfaction group items
 - pulldown 195
- satisfaction set 195
- satisfied barrier 195
- Save All (action points)
 - command 213
- Save All command 213
- Save Pane command 155
- saved action points 94
- saving
 - action points 213
 - TotalView messages 422
 - window contents 155
- saving data, restricting
 - output 155
- sb option 213
- scope
 - determining 227
- scopes
 - compiled in 280
- scoping 226, 280
 - as a tree 281
 - floating 247
 - issues 227
 - rules 281
 - Variable Window 222
 - variables 226
- scrolling 139
 - output 423
 - undoing 160
- search
 - for processes in Attach to a
 - Program dialog 103
- Search Path command 100, 125, 126, 479
 - search order 125, 126
- search paths
 - default lookup order 125
 - for initialization 93
 - not passed to other
 - processes 127
 - order 125
 - setting 125
- search_port command-line
 - option 450
- searching 156
 - case-sensitive 156
 - for source code 159
 - functions 157
 - locating closest match 157
 - source code 157
- searching, variable not
 - found 157
- seeing structures 225
- seeing value changes 223
 - limitations 225
- select button 139
- selected line, running to 519
- selecting
 - different stack frame 149
 - routines 149
 - source code, by line 173
 - source line 395
- selecting a target 377
- selecting process for a
 - group 542
- selection and Expression List
 - window 247
- sending signals to program 124
- serial command-line
 - option 460
- serial line
 - baud rate 460
 - debugging over a 460
- server launch 452
 - command 453
 - enabling 452
 - replacement character
 - %C 455, 456
- server launch command
 - viewing in Add Host
 - dialog 112
- server on each processor 351
- server option 450
- server_launch_enabled
 - variable 450, 452
- server_launch_string
 - variable 453
- server_launch_timeout
 - variable 453
- service threads 358, 362
- sessions
 - launching your last
 - session 109
 - loading into TotalView using
 - load_session flag 89
- Set Barrier command 194
- set expressions 540
- set indicator, uses dot 522, 541
- Set PC command 173
- set_pw command-line
 - option 446
- set_pw single process server
 - launch command 456

- set_pws bulk server launch command 457
- setting
 - barrier breakpoint 194
 - breakpoints 139, 179, 189, 438, 477, 515
 - breakpoints while running 179
 - evaluation points 139, 198
 - options 134
 - preferences 134
 - search paths 125
 - thread specific
 - breakpoints 344
 - timeouts 477
- setting focus 520
- setting up, debug session 96
- setting up, parallel debug session 492
- setting up, remote debug session 443
- setting up, MPI debug session 461
- setting X resources 134
- settings
 - for use of Infiniband MPIs and ReplayEngine 490
- SGROUP variable 533
- shape arrays, deferred types 276
- Share > Halt command 378
- share groups 361, 389, 526
 - defined 360
 - determining 391
 - determining members of 391
 - discussion 389
 - naming 389
 - overview 526
 - S specifier 528
- SHARE_ACTION_POINT variable 184, 190, 191
- shared libraries 564
 - controlling which symbols are read 567
 - loading all symbols 568
 - loading loader symbols 568
 - loading no symbols 568
 - preloading 565
 - reading excluded information 569
- shared library, exclusion list order 568
- shared library, specifying name in scope 281
- shared variables 493
 - in OpenMP 495
 - OpenMP 494, 497
 - procedure for displaying 495
- sharing action points 191
- shell, example of invoking CLI program 419
- SHLIB_PATH environment variable 94
- SHMEM library code debugging 506
- \$short data type 262
- Show full path names check box 159, 186
- showing areas of memory 236
- side 329
- side-effects of functions in expression system 329
- SIGNALRM 413
- SIGFPE errors (on SGI) 122
- SIGINT signal 489
- signal handling mode 123
- signal_handling_mode variable 123
- signal/resignal loop 124
- signals
 - affected by hardware registers 122
 - clearing 171
 - continuing execution with 171
 - discarding 124
 - error option 124
 - handler routine 122
 - handling 122
 - handling in TotalView 122
 - handling mode 123
 - ignore option 124
 - resend option 124
 - sending continuation signal 171
 - SIGNALRM 413
 - stop option 124
 - stops all related processes 123
 - that caused core dump 107
- Signals command 123
- SIGSTOP
 - used by TotalView 122
 - when detaching 105
- SIGTRAP, used by TotalView 122
- single process server launch
 - 442, 452, 455
- single process server launch command
 - %D 456
 - %L 456
 - %P 456
 - %R 456
 - %verbosity 456, 458
 - callback_option 456
 - n 456
 - set_pw 456
 - working_directory 456
- single-stepping 166, 516
 - commands 166
 - in a nested stack frame 519
 - into function calls 167
 - not allowed for a parallel region 494
 - on primary thread only 516
 - operating system dependencies 169, 171
 - over function calls 168
 - recursive functions 169
- skipping elements 286
- slash in group specifier 528
- sleeping state 376
- slices
 - defining 284
 - descriptions 287
 - examples 285
 - lower bound 285
 - of arrays 284
 - operations using 276
 - stride elements 285
 - UPC 507
 - upper bound 285
 - with the variable command 287
- SLURM 498
- smart stepping, defined 516
- SMP machines 468

- sockets 460
- Sorted Variable Window
 - figure 296
- sorting
 - array data 296
- Source As > Assembler 161
- Source As > Both 161, 173
- Source As > Both command 173
- Source As > Source 161
- source code
 - finding 157, 159
 - navigating 160
- Source command 161
- source file, specifying name in
 - scope 281
- source lines
 - ambiguous 395
 - editing 164
 - searching 395
 - selecting 395
- Source Pane 148, 149
- source-level breakpoints 179
- space allocation
 - dynamic 203, 204
 - static 203, 204
- spawned processes 428
 - stopping 469
- specifier combinations 528
- specifiers
 - and dfocus 530
 - and prompt changes 530
 - example 533
 - examples 529, 530, 531
- specifying groups 527
- specifying search
 - directories 127
- splitting up work 352
- stack
 - master thread 495
 - trace, examining 232
 - unwinding 173
- stack context of the OpenMP
 - master thread 495
- stack frame 222
 - current 160
 - examining 232
 - matching 300
 - pane 149
 - selecting different 149
- Stack Frame Pane 149, 237
- stack parent token 497
 - diving 497
- Stack Trace Pane 149, 569
 - displaying source 153
- standard deviation array
 - statistic 298
- Standard I/O
 - in Program Sessions
 - dialog 116
- standard I/O, altering 116
- standard input, and launching
 - tvdsrv 447
- Standard Template Library 215
- Start a Debugging Session
 - dialog 99
- starting 504
 - CLI 87, 89, 418
 - groups 392
 - parallel tasks 478
 - TotalView 87, 88, 477
 - tvdsrv 90, 449
- starting MPI programs 463
- starting Open MPI
 - programs 482
- starting Totalview 84
- Startup command 90
- startup file 93
- startup options
 - no_startup_scripts 93
- Startup Parameters
 - command 127
- state characters 375
- states
 - and status 374
 - initializing 93
 - of processes and
 - threads 374
 - unattached process 375
- static constructor code 393
- static functions, resolving
 - multiple 158
- static internal counter 199
- static patch space
 - allocation 203, 204
- statistics for arrays 297
- status
 - and state 374
 - of processes 374
 - of threads 374
- status registers
 - interpreting 233
- Step command 166, 394, 400
- "step" commands 167
- Step Instruction command 394
- stepping
 - see also* single-stepping
 - apparently hung 400
 - at process width 517
 - at thread width 518
 - goals 517
 - into 167
 - multiple statements on a
 - line 167
 - over 168
 - primary thread can fail 518
 - process group 517
 - processes 400
 - Run (to selection) Group
 - command 399
 - smart 516
 - target program 430
 - thread group 517
 - threads 538
 - using a numeric argument
 - in CLI 167
 - workers 538
- stepping a group 517
- stepping a process 517
- stepping commands 394
- STL 215
 - list transformation 217
 - map transformation 215
- STL preference 218
- STLView 215
- \$stop assembler pseudo op 342
- \$stop built-in function 346
- Stop control group on error
 - check box 124
- Stop control group on error sig-
 - nal option 123
- STOP icon 9, 139, 176, 177, 179,
 - 188, 515

- for breakpoints 139, 179
 - Stop on Memory Errors
 - checkbox 114
 - STOP_ALL variable 184, 190
 - stop, defined in a multiprocess environment 430
 - \$stopall built-in function 346
 - Stopped Execution of Compiled Expressions figure 203
 - stopped operator 540
 - stopped process 196
 - stopped state
 - unattached process 376
 - stopping
 - all related processes 123
 - groups 403
 - processes 378
 - spawned processes 469
 - threads 378
 - \$stopprocess assembler pseudo op 342
 - \$stopprocess built-in function 346
 - \$stopthread built-in function 347
 - storage qualifier for CUDA. See CUDA, storage qualifier
 - stride 285
 - default value of 285
 - elements 285
 - in array slices 285
 - omitting 285
 - Stride Displaying the Four Corners of an Array figure 286
 - \$string data type 262
 - string assembler pseudo op 343
 - \$string data type 263
 - structs
 - defined using typedefs 260
 - how displayed 259
 - structure information 225
 - Structured command 235
 - structures 240, 259
 - collapsing 225
 - editing types 256
 - expanding 225
 - expression evaluation 328
 - viewing across 301
 - stty sane command 418
 - subroutines, displaying 153
 - subset attach command 402
 - substructure viewing, limitations 225
 - suffixes of processes in process groups 389
 - suffixes variables 86
 - sum array statistic 299
 - Sun MPI 487
 - Suppress All command 185, 186
 - suppressing action points 185
 - surface
 - in dataset window 313
 - Surface command (Visualizer) 313
 - surface view 317, 318
 - Visualizer 310
 - surface visualization window 313
 - surface window, creating 313
 - suspended windows 338
 - switch-based communication 476
 - for PE 476
 - symbol lookup 281
 - and context 281
 - symbol name representation 280
 - symbol reading, deferring 567
 - symbol scoping, defined 281
 - symbol table debugging information 85
 - symbolic addresses, displaying assembler as 161
 - Symbolically command 161
 - symbols
 - loading all 568
 - loading loader 568
 - not loading 568
 - synchronizing execution 383
 - synchronizing processes 431, 518
 - syntax 527
 - system PID 429
 - system TID 429
 - systid 149, 429
 - \$systid built-in variable 344
- ## T
- T state 376
 - t width specifier 529
 - T+/T- buttons 381
 - tag field 188
 - area 149
 - Talking to Rank control 402
 - target process/thread set 430, 520
 - target program stepping 430
 - target, changing 521
 - tasks
 - starting 478
 - Tcl
 - and the CLI 8
 - CLI and thread lists 416
 - version based upon 416
 - TCP/IP address, used when starting 90
 - TCP/IP sockets 460
 - temp file prototypes 454
 - templates
 - expression system 333
 - maps 215
 - STL 215
 - terminating processes 421
 - Tesla GPU, compiling for. See CUDA, Tesla GPU.
 - testing for IEEE values 294
 - testing when a value changes 206
 - text
 - locating closest match 157
 - saving window contents 155
 - text assembler pseudo op 343
 - text editor, default 164
 - third party debugger and TotalView Visualizer 325
 - third party visualizer 310
 - and TotalView data set format 325
 - thread
 - width specifier, omitting 537
 - Thread > Continuation Signal command 105, 171

- Thread > Go command 392
- Thread > Hold command 383, 384
- Thread > Set PC command 173
- thread as dimension in Visualizer 312
- thread focus 520
- thread group 519
 - stepping 517
- thread groups 360, 518, 526
 - behavior 532
 - behavior at goal 518
- thread ID
 - about 149, 429
 - assigned to CUDA threads. See CUDA, assigned thread IDs.
 - system 344
 - TotalView 344
- thread local storage 496
 - variables stored in different locations 496
- thread numbers are unique 428
- Thread Objects command 278
- thread objects, displaying 278
- Thread of Interest 392
- thread of interest 522, 524
 - defined 378, 522
- thread stepping 538
 - platforms where allowed 518
- Thread Tab 149
- THREADPRIVATE common block, procedure for viewing variables in 496
- THREADPRIVATE variables 497
- threads
 - call graph 304
 - changing 381
 - changing in Expression List window 251
 - changing in Variable window 238
 - creating 353
 - displaying source 152
 - diving on 149, 152
 - finding window for 149
 - holding 194, 383, 519
 - ID format 149
 - listing 149
 - manager 358
 - opening window for 149
 - releasing 193, 194, 383
 - resuming executing 173
 - service 358
 - setting breakpoints in 344
 - single-stepping 516
 - stack trace 149
 - state 374
 - status of 374
 - stopping 378
 - systid 149
 - tid 149
 - user 357
 - width 517
 - width specifier 523
 - workers 357, 359
- threads model 353
- threads tab 380
- thread-specific breakpoints 344
- tid 149, 429
- \$tid built-in variable 344
- TID missing in arena 523
- timeouts
 - avoid unwanted 413
 - during initialization 478
 - for connection 453
 - TotalView setting 477
- timeouts, setting 477
- TOI defined 378
 - again 514
- toolbar, using 377
- Tools > Attach Subset command 402
- Tools > Call Graph command 304
- Tools > Command Line command 87, 418
- Tools > Create Checkpoint command 562
- Tools > Evaluate command 245, 322, 323, 337, 344, 565
- Tools > Evaluate Dialog Box figure 339
- Tools > Evaluate Window expression system 330
- Tools > Expression List Window 247
- Tools > Fortran Modules command 273
- Tools > Global Arrays command 504, 505
- Tools > Manage Shared Libraries command 565
- Tools > Message Queue command 407, 408, 409
- Tools > Message Queue Graph command 406
- Tools > Program Browser command 221
- Tools > Restart Checkpoint command 562
- Tools > Statistics command 297
- Tools > Thread Objects command 278
- Tools > Variable Browser command 230
- Tools > View Across command 510
- Tools > Visualize command 17, 302, 312
- Tools > Visualize Distribution command 509
- Tools > Watchpoint command 208, 211
- Tools > Watchpoint Dialog Box figure 209
- tooltips 220
 - evaluation within 220
- TotalView
 - and MPICH 468
 - core files 87
 - initializing 93
 - invoking on CAF 511
 - invoking on UPC 507
 - programming 8
 - relationship to CLI 416
 - starting 87, 88, 477
 - starting on remote hosts 90
 - starting the CLI within 418
 - Visualizer configuration 323
- TotalView assembler operators
 - hi16 341
 - hi32 341

- lo16 341
- lo32 341
- TotalView assembler pseudo ops
 - \$debug 341
 - \$hold 341
 - \$holdprocess 341
 - \$holdprocessstopall 341
 - \$holdstopall 341
 - \$holdthread 341
 - \$holdthreadstop 341
 - \$holdthreadstopall 341
 - \$holdthreadstopprocess 341
- 1
- \$long_branch 341
- \$ptree 342
- \$stop 342
- \$stopall 342
- \$stopprocess 342
- \$stopthread 342
- align 342
- ascii 342
- asciz 342
- bss 342
- byte 342
- comm 342
- data 342
- def 342
- double 342
- equiv 342
- fill 342
- float 342
- global 342
- half 342
- lcomm 342
- lysm 342
- org 343
- quad 343
- string 343
- text 343
- word 343
- zero 343
- totalview command 87, 93, 480, 485
- TotalView data types
 - \$address 261
 - \$char 261
 - \$character 261
 - \$code 261, 265
 - \$complex 261
 - \$complex_16 261
 - \$complex_8 261
 - \$double 261
 - \$double_precision 261
 - \$extended 261
 - \$float 261
 - \$int 261
 - \$integer 261
 - \$integer_1 261
 - \$integer_2 262
 - \$integer_4 262
 - \$integer_8 262
 - \$logical 262
 - \$logical_1 262
 - \$logical_2 262
 - \$logical_4 262
 - \$logical_8 262
 - \$long 262
 - \$long_long 262
 - \$real 262
 - \$real_16 262
 - \$real_4 262
 - \$real_8 262
 - \$short 262
 - \$string 262, 263
 - \$void 262, 265
 - \$wchar 262
 - \$wchar_s16 262
 - \$wchar_s32 262
 - \$wchar_u16 262
 - \$wchar_u32 262
 - \$wstring 262
 - \$wstring_s16 262
 - \$wstring_s32 263
 - \$wstring_u16 262
 - \$wstring_u32 263
- TOTALVIEW environment variable 91, 411, 469
- totalview subdirectory 94
- TotalView windows
 - action point List tab 149
- totalviewcli command 87, 89, 90, 93, 418, 420, 480, 485
 - remote 90
- trackball mode, Visualizer 310
- tracking changed values 223
 - limitations 225
- transformations, creating 217
- transposing axis 316
- TRAP_FPE environment variable on SGI 122
- troubleshooting 630
 - MPI 489
- ttf variable 218
- ttf_max_length variable 218
- TV
 - recurse_subroutines setting 231
- tv command-line option 468
- TV:: namespace 425
- TV::GUI:: namespace 425
- TVDB_patch_base_address object 204
- tvdb_patch_space.s 205
- tvdsvr 90, 91, 202, 445, 447, 452, 453, 460
 - callback command-line option 446
 - Cray XT3 499
 - editing command line for poe 478
 - fails in MPI environment 489
 - launch problems 453, 455
 - launching 455
 - launching, arguments 447
 - port command-line option 450
 - search_port command-line option 450
 - server command-line option 450
 - set_pw command-line option 446
 - starting 449
 - starting for serial line 460
 - starting manually 449
- tvdsvr command 450
 - timeout while launching 453, 455
- tvdsvr_rs 499
- TVDSVRLAUNCHCMD environment variable 456
- two-dimensional graphs 315
- type casting 256
 - examples 266
- type strings
 - built-in 261
 - editing 256
 - for opaque types 266
 - supported for Fortran 256
- type transformation variable 218

- type transformations,
 - creating 217
- typedefs
 - defining structs 260
 - how displayed 259
- types supported for C
 - language 256
- types, user defined type 275

U

- UDT 275
- UID, UNIX 450
- unattached process states 375
- undive 241
- undive all 241
- undive buttons 240
- undive icon 154, 158, 240
- Undive/Redive Buttons
 - figure 240
- undiving, from windows 241
- unexpected messages 408, 411
- unheld operator 540
- union operator 540
- unions 259
 - how displayed 260
- unique process numbers 428
- unique thread numbers 428
- unsuppressing action
 - points 186
- unwinding the stack 173
- UPC
 - assistant library 507
 - phase 509
 - pointer-to-shared data 509
 - shared scalar variables 507
 - slicing 507
 - starting 507
 - viewing shared objects 507
- UPC debugging 507
- Update command 382
- upper adjacent array
 - statistic 299
- upper bounds 258
 - of array slices 285
- USEd information 274
- user defined data type 275

- user mode 357
- user threads 357
- users
 - adding to an Attach to a Program debug session 103
- Using Assembler figure 340

V

- Valid in Scope list 280
- value changes, seeing 223
 - limitations 225
- value field 338
- values
 - editing 10
- Variable Browser command 230
- variable scope 226
- variable scoping 280
- Variable Window 244
 - and expression system 329
 - changing threads 238
 - closing 239
 - displaying 220
 - duplicating 241
 - expression field 223
 - in recursion, manually refocus 222
 - rebinding 238
 - scope 226
 - scoping display 222
 - stale in pane header 222
 - tracking addresses 222
 - type field 223
 - updates to 222
 - view across 301
- variables
 - assigning p/t set to 524
 - at different addresses 301
 - bluegene_io_interface 481
 - bluegene_server_launch 481
 - CGROUP 526, 532
 - changing the value 254
 - changing values of 254
 - comparing values 228
 - display width 218
 - displaying all globals 230
 - displaying contents 152
 - displaying long names 222

- displaying STL 215
- diving 152, 153
- freezing 228
- GROUP 533
- in modules 273
- locating 157
- not updating display 228
- precision 218
- previewing size and precision 219
- setting command output to 422
- SGROUP 533
- stored in different locations 496
- ttf 218
- View Across display 300
- watching for value changes 16
- WGROUP 532
- variables and expressions 244
- variables, viewing as list 246
- VERBOSE variable 417
- verbosity bulk server launch command 457
- verbosity level 485
- verbosity single process server launch command 456, 458
- vh_axis_order header field 325
- vh_dims dataset field 325
- vh_dims header field 325
- vh_effective_rank dataset field 326
- vh_effective_rank header field 326
- vh_id dataset field 326
- vh_id header field 326
- vh_item_count dataset field 326
- vh_item_count header field 326
- vh_item_length dataset field 326
- vh_item_length header field 326
- vh_magic dataset field 326
- vh_magic header field 326

- vh_title dataset field 326
- vh_title header field 326
- vh_type dataset field 326
- vh_type header field 326
- vh_version dataset field 326
- vh_version header field 326
- View > Add to Expression List command 247
- View > Assembler > By Address command 161
- View > Assembler > Symbolically command 161
- View > Block Status command 236
- View > Collapse All command 225
- View > Compilation Scope > Fixed command 226
- View > Compilation Scope > Floating command 222, 226
- View > Compilation Scope commands 226
- View > Dive command 253
- View > Dive In All command 242
- View > Dive in New Window command 12
- View > Dive Thread command 279
- View > Dive Thread New command 279
- View > Examine Format > Structured command 235
- View > Examine Format > Raw command 235
- View > Expand All command 225
- View > Freeze command 227
- View > Graph command 313
- View > Graph command (Visualizer) 313
- View > Lookup Function command 157, 159, 160
- View > Lookup Variable command 157, 221, 232, 236, 275, 495, 496
- View > Lookup Variable specifying slices 287
- View > Reset command 158, 160
- View > Reset command (Visualizer) 320
- View > Show Across > Process 300
- View > Show Across > Thread 300
- View > Source As > Assembler command 161
- View > Source As > Both command 161, 173
- View > Source As > Source command 161
- View > Surface command (Visualizer) 313
- View > View Across > None command 300
- View > View Across > Process command 300
- View > View Across > Thread command 300
- View > View Across > Threads command 496
- View Across arrays and structures 301
- view across editing data 301
- View Across command. 496
- View Across None command 300
- View simplified STL containers preference 218
- viewing across variables 300
- Viewing Across an Array of Structures figure 301
- viewing across processes and threads 13
- Viewing Across Threads figure 300
- Viewing Across Variable Window 301
- viewing across variables and processes 300
- viewing acrosscross diving in pane 301
- viewing assembler 161
- viewing opaque data 265
- viewing shared UPC objects 507
- viewing templates 215
- viewing variables in lists 246
- viewing wide characters 264
- virtual functions 331
- vis_ao_column_major constant 325
- vis_ao_row_major constant 325
- vis_float constant 326
- VIS_MAGIC constant 326
- VIS_MAXDIMS constant 325
- VIS_MAXSTRING constant 326
- vis_signed_int constant 326
- vis_unsigned_int constant 326
- VIS_VERSION constant 326
- visualization deleting a dataset 313
- \$visualize 347
- visualize 322
- \$visualize built-in function 322
- Visualize command 17, 302, 312, 325
- visualize command 323
- visualize.h file 325
- Visualizer 302, 312
 - actor mode 310, 321
 - auto reduce option 319
 - autolaunch options, changing 324
 - camera mode 309, 321
 - choosing method for displaying data 311
 - configuring 323
 - configuring launch 323
 - creating graph window 313
 - creating surface window 313
 - data sets to visualize 311
 - data types 311
 - dataset defined 311
 - dataset window 312, 313, 314
 - deleting datasets 313
 - dimensions 312
 - exiting from 313
 - file command-line option 323, 325
 - graphs, display 315, 316
 - joy stick mode 310

- joystick mode 321
- launch command, changing
 - shell 325
- launch from command line 323
- launch options 324
- method 311
- number of arrays 311
- obtaining a dataset value 317
- pan 321
- persist command-line option 323, 325
- pick 309
- picking 321
- rank 324
- relationship to
 - TotalView 310
- restricting data 312
- rotate 321
 - rotate, Visualizer 309
- scale 321
- shell launch command 325
- slices 311
- surface view 310, 317, 318, 321
- third party 310
 - adapting to 325
 - considerations 325
- trackball mode 310, 321
- using casts 322
- view across data 312
- view window 312
- windows, types of 312
- wireframe mode 310
- wireframe view 321
- zoom 321

visualizer

- closing connection to 324
- customized command for 324

visualizing

- data 309, 313
- data sets from a file 323
- from variable window 312
- in expressions using \$visualize 322

visualizing a dataset 322

\$void data type 262, 265

W

W width specifier 529

W workers group specifiers 528

Waiting for Command to Complete window 400

Waiting to Complete Message Box figure 338

warn_step_throw variable 123

watching memory 210

Watchpoint command 208, 211

watchpoint operator 540

watchpoints 16, 206

- \$newval watchpoint variable 211
- \$oldval 211
- alignment 212
- conditional 206, 211
- copying data 211
- creating 208
- defined 175, 431
- disabling 210
- enabling 210
- evaluated, not compiled 212
- evaluating an expression 206
- example of triggering when value goes negative 212
- length compared to \$oldval or \$newval 212
- lists of 149
- lowest address triggered 211
- modifying a memory location 206
- monitoring adjacent locations 211
- multiple 211
- not saved 213
- on stack variables 209
- PC position 210
- platform differences 207
- problem with stack variables 210
- supported platforms 206
- testing a threshold 206
- testing when a value changes 206
- triggering 206, 210

watching memory 210

\$whchar data type 264

wchar_t wide characters 264

WGROUPO variable 532

When a job goes parallel or calls exec() radio buttons 404

When a job goes parallel radio buttons 404

When Done, Stop radio buttons 195

When Hit, Stop radio buttons 195

wide characters 264

width relationships 524

width specifier 522

- omitting 536, 537

wildcards, when naming shared libraries 568

Window > Duplicate Base Window (Visualizer) 314

Window > Duplicate command 153, 154, 228, 241

Window > Memorize All command 151

Window > Memorize command 151

Window > Update command 382

window contents, saving 155

windows 239

- closing 154, 239
- dataset 314
- dataset window 313
- dataset window (Visualizer) 315
- graph data 315
- popping 153
- resizing 151
- surface view 317
- suspended 338

wireframe view, Visualizer 310

word assembler pseudo op 343

worker threads 357, 494

workers group 362, 519

- defined 360
- overview 527

workers group specifier 528

working directory 126
working independently 351
-working_directory bulk server
 launch command 457
-working_directory single pro-
 cess server launch
 command 456
writing array data to files 437
\$wstring data type 264

X

X resources setting 134
xterm, launching tvdsvr
 from 447

Y

yellow highlighted variables 223,
 225

Z

Z state 376
zero assembler pseudo op 343
zero count array statistic 299
zombie state 376

