Debugging a Program

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Part No: 801-5106-10
Revision A December 1993

Contents

Preface

This manual explains how to use the Debugger, a multi-language source and machine level debugging tool. The Debugger is an integrated component of the SPARCworks™ toolset, which also includes:

- Analyzer
- dbx
- FileMerge
- Maketool
- Manager
- SourceBrowser

Before You Begin

This manual is written for programmers who want to use the Debugger on Sun™ workstations running ANSI C, C++, FORTRAN, and Pascal. This manual assumes you are familiar with

- Sun® operating system commands and concepts
- The OPEN LOOK® interface and the OpenWindows™ environment, particularly the use of the mouse to activate a window, select text, and click on buttons

  If you are not familiar with the OPEN LOOK interface, see Chapter 4, "The OPEN LOOK GUI," in *Managing SPARCworks Tools*. For more information on the OPEN LOOK GUI, see the *OPEN LOOK Application Style Guidelines*.

For more information on the OpenWindows environment, see the *OpenWindows Developer's Guide 3.0.1 User's Guide*.

Operating Environment

The Debugger runs under the Solaris® 2.x operating environment.

Solaris 2.x implies:

- Solaris 2.2 or later
- SunOS™ 5.2 (or later) operating system
- A SPARC® computer (either a server or a workstation)
- The OpenWindows 3.x application development platform

The SunOS 5.x operating environment is based on the System V Release 4 (SVR4) UNIX[1] operating system, and the ONC™ family of published networking protocols and distributed services.

How this Book is Organized

This manual is organized as follows:

Part 1— Overview of the Debugger

- **Chapter 1, "Introduction to the Debugger,"** is an overview of the user-interface and the capabilities of the Debugger.

Part 2—Basic Debugging

- **Chapter 2, "Preparing Programs for the Debugger,"** explains how to compile programs for use with the Debugger.
- **Chapter 3, "Starting the Debugger,"** describes how start and quit the Debugger, including options to the start-up command.
- **Chapter 4, "Viewing and Visiting Code,"** describes the information fields by which users navigate while debugging. It also explains how to visit code away from the current stop location and how to qualify the scope of the

1. UNIX is a registered trademark of UNIX System Laboratories, Inc.

debugging command when working from the command pane; also, how to query for the location of symbols, and to display declarations and definitions of identifiers, types, and C++ classes.

- **Chapter 5, "Setting Breakpoints and Traces,"** describes how to use event management commands to stop the program execution at a specified location or when a specified condition arrises, and how trace program execution.
- **Chapter 6, "Event Management,"** describes the general capability of the Debugger to perform certain actions when certain events take place in the program being debugged.
- **Chapter 7, "Running, Stepping, Continuing,"** describes how to run a program with or without arguments, continue after stopping, and single-step through lines of code.
- **Chapter 8, "Saving and Restoring a Debugging Run,"** describes how to save a debugging run, and how to replay it later.
- **Chapter 9, "Examining the Call Stack,"** describes how to display functions currently on the stack.
- **Chapter 10, "Evaluating and Displaying Data,"** describes how to spot-check the values of expressions and variables and how to use the Data Display window to monitor expressions and variables as the program accesses them.
- **Chapter 11, "Visual Data Inspector,"** describes how to examine program variables including complex structures, and how to monitor values during program execution.
- **Chapter 12, "Process/Thread Inspector,"** describes how to find information about threads by using the Process/Thread Inspector.
- **Chapter 13, "Customizing the Debugger,"** describes how to set controls for customizing attributes of the debugging environment: including how to use the initialization file, `.dbxrc`.
- **Chapter 14, "Editing a Program,"** describes how to edit source files without leaving the Debugger. You can start up an edit session in a new shell or convert the source display to an editable text pane.

Part 3—Advanced Debugging

- **Chapter 15, "Debugging at the Machine-instruction Level,"** explains the use of the machine-instruction variants of several event management commands and how to display the contents of memory.
- **Chapter 16, "Debugging Child Processes,"** shows how to debug processes that create children via fork(2) and exec(2).
- **Chapter 17, "Working With System Signals,"** describes how to control the list of signals the Debugger will catch.
- **Chapter 18, "Collecting Performance Tuning Data,"** shows you how to take a manual sample of program data for performance analysis.
- **Chapter 19, "Runtime Checking,"** describes how to automatically detect run time errors in an application during the development phase.
- **Chapter 20, "Fix and Continue,"** describes how to fix (change) a file, recompile it with the same options, install the new code in the program, and continue.
- **Chapter 21, "Handling Exceptions in the Debugger,"** describes how to set up try blocks to catch exceptions that have been raised by throw expressions defined earlier in the code.
- **Chapter 22, "Debugging with Templates,"** describes how to load programs containing class and function templates into the Debugger and invoke any of the debugging commands on a template that you would use on a class or function.
- **Chapter 23, "Korn Shell,"** describes the Debugger command language, which is based on the Korn shell and includes I/O redirection, loops, built-in arithmetic, history, and command-line editing.

Part 4—Appendixes

- **Appendix , "Debugger Commands,"** is a reference list of Debugger text commands that you may use in the command pane.
- **Appendix B, "Operators Recognized By the Debugger,"** contains two tables that describe operators, their precedence and associativity.

What Typographic Changes and Symbols Mean

The following table describes the notational conventions and symbols used in this book.

Table P-1 Typographic Conventions

Typeface or Symbol	Meaning	Example
`AaBbCc123`	The names of commands, files, and directories; on-screen computer output	Edit your `.login` file. Use `ls -a` to list all files. `system% You have mail.`
`AaBbCc123`	What you type, contrasted with on-screen computer output	`system% su` `Password:`
AaBbCc123	Command-line placeholder: replace with a real name or value	To delete a file, type `rm` *filename*.
AaBbCc123	Book titles, new words or terms, or words to be emphasized	Read Chapter 6 in *User's Guide*. These are called *class* options. You *must* be root to do this.
♦	A single-step procedure	♦ **Click on the Apply button.**

Code samples are included in boxes and may display the following:

%	UNIX C shell prompt	`system%`
$	UNIX Bourne and Korn shell prompt	`system$`
#	Superuser prompt, all shells	`system#`

How to Get Help

SPARCworks tools include the following on-line help facilities:

- **AnswerBook® system** displays all SPARCworks tools manuals. You can read this manual on line and take advantage of dynamically linked headings and cross-references.

  To start the AnswerBook system, type: `answerbook`

- **Magnify Help**™ messages are a standard feature of the OpenWindows software environment. If you have a question, place the pointer on the window, menu, or menu button and press the Help key.
- **Notices** are a standard feature of OPEN LOOK. Some notices inquire about whether or not you want to continue with an action. Others provide information about the end result of an action and appear only when the end result of the action is irreversible.
- **SunOS Manual Pages** (man pages) provide information about the command-line utilities of the SunOS operating system. Each tool has at least one man page.

  The Debugger manual pages include:

  ```
  debugger(1)
  dbx(1)
  dbxinit(4)
  bcheck(1)
  ```

♦ **To access the man pages, type**: `man` ***utility_name***

- **Command Pane Help** lists all of the commands you can use in the command pane (or in a shell or tty terminal) when you type `help` at the prompt in the Debugger command pane. Type `help` *command_name* to display a brief help message for each Debugger command.

Related Documentation

This manual is part of the SPARCworks document set. Other manuals in this set include:

- *Installing SunPro Software on Solaris*
- *SPARCworks Tutorial*
- *Browsing Source Code*
- *Building Programs with MakeTool*
- *Managing SPARCworks Tools*
- *Merging Source Files*
- *Performance Tuning an Application*

You can find these and other related documents in the on-line AnswerBook system. AnswerBook products available for the SPARCworks 3.0 release are:

- **SPARCworks documents —** *SPARCworks 3.0 AnswerBook*

- **Common tools document**s **—** *SPARCworks/SPARCompiler 3.0 Common Tools & Related Material AnswerBook*
- **Installation guide —** *SPARCworks/SPARCompiler 3.0 Installation AnswerBook*

To access the AnswerBook system, refer to *Installing SunPro Software on Solaris*.

Part 1 — Overview of the Debugger

Introduction to the Debugger 1

The Debugger is an interactive, window-based, source code and machine-instruction level debugging tool. It provides facilities to run a program in a controlled fashion and to inspect the state of a stopped program. The Debugger gives you complete control of the dynamic execution of a program, including the collection of performance data.

This overview chapter is organized into the following sections:

1.1 Solaris 2.2

The Debugger runs under Solaris 2.2—which uses the SunOS 5.2 operating system.

Note – If the Debugger is started on a machine running Solaris 2.2, and the DISPLAY environment variable is set for a machine running Solaris 1.1, you must install patch 100626-05 on 4.x to allow the Debugger to work properly. To

kill the *ttsession* on the Solaris 1.1 (SunOs 4.x) machine before starting the Debugger is an alternative that may not be feasible if an application requires *ttsession*. The application may hang or die.

Also set the `$OPENWINHOME` environment variable to `/usr/openwin/bin` and place the path at the beginning of your `PATH` variable.

1.2 Debugger and dbx

The Debugger is a sophisticated window-based tool that interfaces with dbx. dbx is an interactive, line-oriented, source-level, symbolic debugger. It lets you determine where a program crashed, view the values of variables and expressions, set breakpoints in the code, and run and trace a program. In addition, machine-level and other commands are available to help you debug code.

During program execution, dbx obtains detailed information about program behavior and supplies the Debugger with this information via a communications protocol.

The Debugger is a window-based interface to dbx. Debugging is easier because you can use the mouse to enter most commands from redefinable buttons on the graphical user interface. You can use any of the standard dbx commands in the command window.

The Debugger also offers a program editing facility to minimize the need to change tools.

1.3 How the Debugger Works

The Debugger relies on debugging information a compiler generates using the compiler option `-g` (or `-g0` for C++) to inspect the state of the process. By default, debugging information for each program module is stored in the module's `.o` file. The Debugger reads in the information for each module as it is needed. This facility is called the Auto-Read facility.

(For Auto-Read to work, you must preserve a module's `.o` files. You can disable Auto-Read by compiling with the `-xs` option. See Section 2.2, "Using the Auto-Read Facility," on page 2-22 for details.)

Quick Start

While reading this and the remaining parts of the overview chapter, you may want to start the Debugger and explore the tool as you read.

To start the Debugger:

- **Type** `debugger` **at a command shell prompt or doubleclick the Debugger icon in the SPARCworks Manager.**
  (See Chapter 3, “Starting the Debugger“, for more information.

The user interface combines the advantages and conveniences of both a window-based, select-operate interface and a text command-based interface. dbx, the familiar Sun Debugger, provides the underlying debugging engine; dbx commands remain available as *Debugger commands* entered in the integrated *command pane*. The Debugger command language is based on the Korn Shell[1] (ksh-88). The GUI aspect of the interface is a redesigned and extended OPEN LOOK version of dbxtool.

Note – In OpenWindows, you can specify the mouse pointer focus as “follow pointer” or “click to focus”. You make the selection in the OpenWindows properties sheet, Miscellaneous Category, and Set Active Window field. Selections are “Move Pointer” and “Click Mouse”. Choose Click Mouse to avoid the possibility of typing into a new pop-up window by mistake. If you choose Move Pointer, wait for all pop-up windows to display before typing.

1.3.1 Loading a Program or Attaching to a Process

The Debugger allows you to place a program under its control by:

- Loading a program into the Debugger.
- Attaching the Debugger to a running program. After debugging the process, you detach the Debugger from it without quitting or killing it.
- Debugging the core file of a crashed program (“Postmortem debugging”).

1. The Korn Shell Command and Programming Language, Morris I. Bolsky and David G. Korn, Prentice Hall, 1989

1.3.2 Main Features of the Debugger

The Debugger provides an extensive range of event management, process control, and data inspection features. You can:

- *Set breakpoints* at lines or in functions; *trace* program execution line by line across a whole program or within a function; *set watchpoints* to stop or trace a program if a specified value or expression changes or meets some other condition.
- *Set multiple breakpoints or tracepoints in C++* code: in all member functions of the same name across a class; in all members of a specified class; in all regular (that is, nonmember) functions of the same name (overloaded functions).
- *Single-step* through program code one line at time at either the source or machine-language level; step "over" or "into" function calls; step "up" and "out" of a function call arriving at the line of the calling function line (but after the call).
- *Run, stop, and continue* execution (at the next line or at some other line); *save and then replay* all or part of a debugging run.
- Use the *performance-tuning data collection facility* for collecting data for use with the Analyzer tool.
- Use *Run Time Checking* (RTC) to automatically detect run time errors in an application. RTC detects memory access errors and memory leaks.
- *Look up declarations* of identifiers and definitions of types, classes and templates.
- *Spot check the value of variables or expressions* whenever the program is stopped; *monitor variables or expressions for chang*es over time; examine the call stack; move up and down the call stack, and call functions in the program.
- Use *Data Inspector* to graphically examine program variables including complex structures and arrays, and monitor values during program execution.
- Use *Process/Thread Inspecto*r to display lists of threads.
- Use *Fix and Continue* to fix (change) a file, recompile it with the same options, install the new code in the program, and continue.
- Support Virtual Functions for C++.

- Use Function Overloading (C++) for argument resolution.
- Use Default arguments (C++).
- Use an embedded Korn shell for *Programmability*.
- Use the *Program Input/Output Window* to provide an I/O command interface for applications which does not interfere with the dbx interaction in the command window.
- *Follow programs* as they fork(2) and exec(2).

1.3.3 Interaction of dbx with the Dynamic Linker

The SunOS 5.2 Debugger provides full debugging support for programs that use dynamically-linked, shared libraries, provided that these libraries were compiled using the `-g` option.

Definitions

The dynamic linker, also known as “rtld”, “RunTime ld”, or “ld.so”, arranges to bring shared objects (load objects) into an executing application. There are two primary areas where rtld is active:

1. **Program startup**
   At program startup, rtld runs first and dynamically loads all shared objects specified at link time. (You can use `ldd(1)` to find out what shared objects a program will load.) These are “preloaded” shared objects and commonly include `libc.so`, `libC.so`, `libX.so`, and so on.

2. **Application Requests**
   The application uses function calls `dlopen(3)` and `dlclose(3)` to dynamically load and unload shared objects, or plain executables. dbx uses the term “load objects” to refer to a shared object (`.so`) or plain executable (`a.out`).

The dynamic linker maintains a list of all loaded objects in a list called a “link map”. The link map is maintained in user memory, and is indirectly accessed via the symbol name `_DYNAMIC`.

dbx traverses the link map to see:

- Which objects were loaded
- What their corresponding binaries are

- At what base address they were loaded

Corruption of these data structures can at times confuse dbx.

Debugging Support for Shared Objects

dbx can debug shared objects, both preloaded and those opened with `dlopen()`. Some restrictions and limitations are described in the following sections.

Startup Sequence

To put breakpoints in preloaded shared objects, the address of the routines has to be known to the Debugger. For the Debugger to know the address of the routines, it must know the shared object base address. Doing something as simple as

```
stop in printf
run
```

requires special consideration by the Debugger. Whenever you load a new program (either by starting dbx from the shell, the Debugger from a menu, or by using the `debug` command), dbx automatically executes the program up to the point where rtld has completed construction of the link map. dbx then reads the link map and stores the base addresses. After that, the process is killed and you see the prompt. These dbx tasks are completed silently.

At this point, the symbol table for `libc.so` is available as well as its base load address. Therefore, the address of `printf` is also known.

The activity of dbx *waiting* for rtld to construct the link map and accessing the head of the link map is known as the “rtld handshake”. The event (see Chapter 6, “Event Management“) `syncrtld` occurs when rtld is done with the link map and the Debugger has read all of the symbol tables.

With this scheme, the Debugger depends on the fact that when the program is Run, the shared libraries are loaded at the same base address. The assumption that shared libraries are loaded at the same base address is seldom violated; usually only if you change `LD_LIBRARY_PATH` between loading of the program and running it. In such cases, dbx takes note of the new address and prints a message. However, breakpoints in the moved shared object may be incorrect.

Startup Sequence and `.init` *Sections*

A `.init` section is a piece of code belonging to a shared object that is executed when the shared object is loaded. For example, the `.init` section is used by the C++ runtime system to call all static initializers.

The dynamic linker first maps in all the shared objects, putting them on the link map. Then, the dynamic linker traverses the link map and executes the `.init` section for each shared object.

Under Solaris 2.2 (and prior versions), the `syncrtld` event occurs after the `.init` sections have been run. You should note the following precautions:

- When you start debugging a new program, even though you have not invoked Run, the hidden handshake causes the `.init` sections to get executed.
- Because a shared objects symbol table is not available until after `syncrtld`, you cannot put breakpoints in the `.init` section.

  But, if a fatal error occurs in the `.init` section before the rtld handshake is complete, the process is not killed and you can still get a stack trace. If the program crashed in an `.init` section while running outside of the Debugger and generates a coredump, you can successfully do a postmortem analysis.

(After Solaris 2.2, the `syncrtld` point is between the link map construction and the execution of the `.init` sections; the precautions are not necessary.)

`dlopen()` *and* `dlclose()`

dbx automatically detects that a `dlopen` or a `dlclose` has occurred and loads the symbol table of the loaded object. You can put breakpoints in and debug the loaded object like any part of your program.

When a shared object is unloaded, the symbol table is discarded and the breakpoints are marked as "`(defunct)`" when you request `status`. Unfortunately, there is no way to automatically re-enable the breakpoints if the object is opened again on a consecutive run.

Two events, `dlopen` and `dlclose` (see Chapter 6, "Event Management", Section 6.4, "Event Specifications," on page 6-78), can be used with the `when` command, and some shell programming, to help ease the burden of managing breakpoints in `dlopen` type shared objects.

Procedure Linkage Tables (PLT)

PLTs are structures used by the rtld to facilitate calls across shared object boundaries. For instance, the call to `printf` goes via this indirect table. The details of how this is done can be found in the generic and processor specific SVR4 ABI reference manuals.

For the Debugger to handle `step` and `next` commands across PLTs, it has to keep track of the PLT table of each load object. The table information is acquired at the same time as the rtld handshake.

1.3.4 Debugging Optimized Code

You can debug optimized code in the Debugger; that is, code compiled with both the `-O` option and the `-g` option. However, a number of restrictions apply. See Section 2.3, “Debugging Optimized Code,” on page 2-24.

1.3.5 History Facility

The Debugger records each command you enter. You can display the history of a session by typing `history` in the command pane. You can also issue a command from the list by number, using substitution commands that follow the csh (for backward compatibility) `history` conventions (`!!`, `!n`, `!chars`). The history is also used by the `replay` functionality.

1.4 Graphical Overview

The Debugger base window consists of a source display, a set of menu buttons, three rows of information fields, two rows of default button commands, a command pane, and a message/status area.

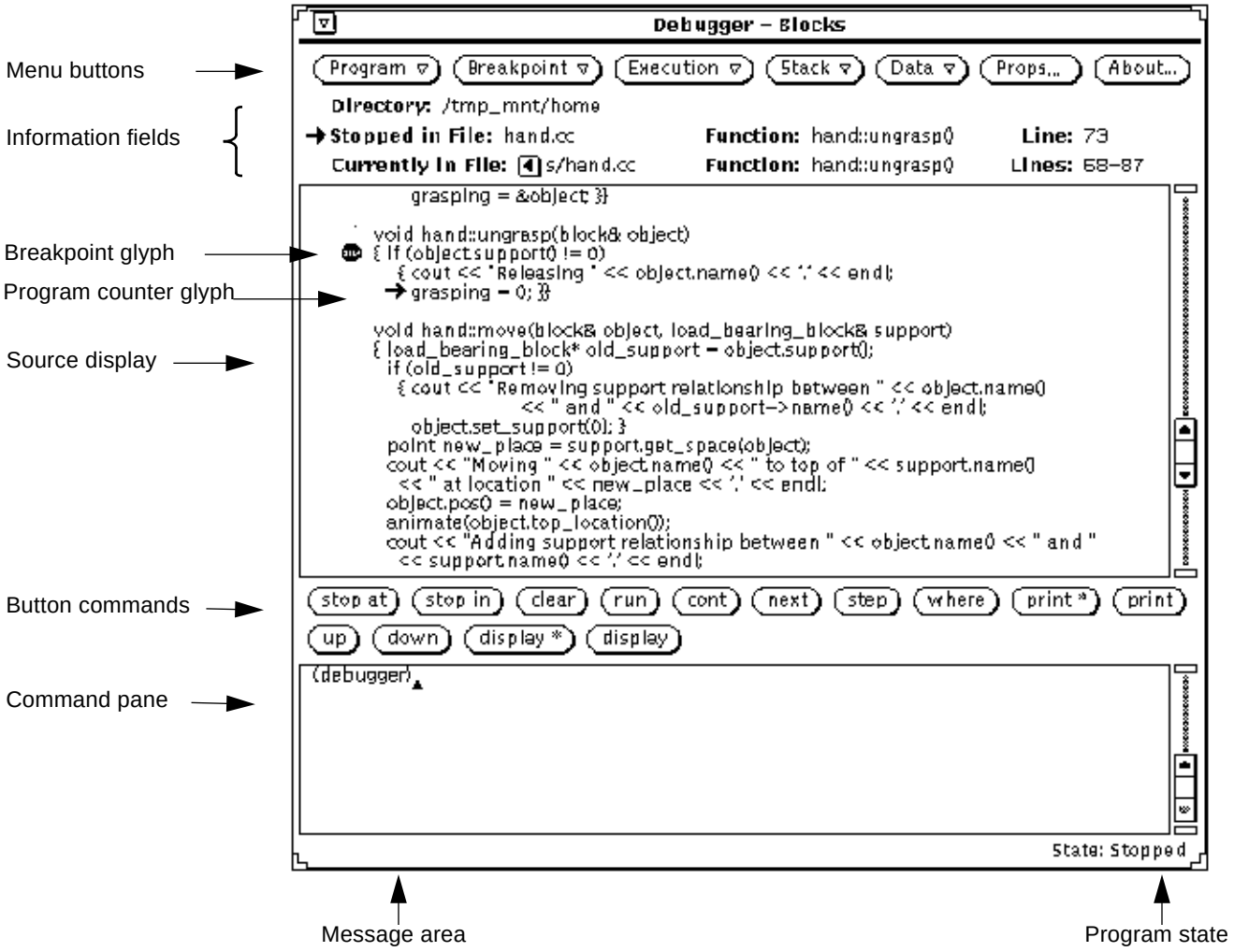
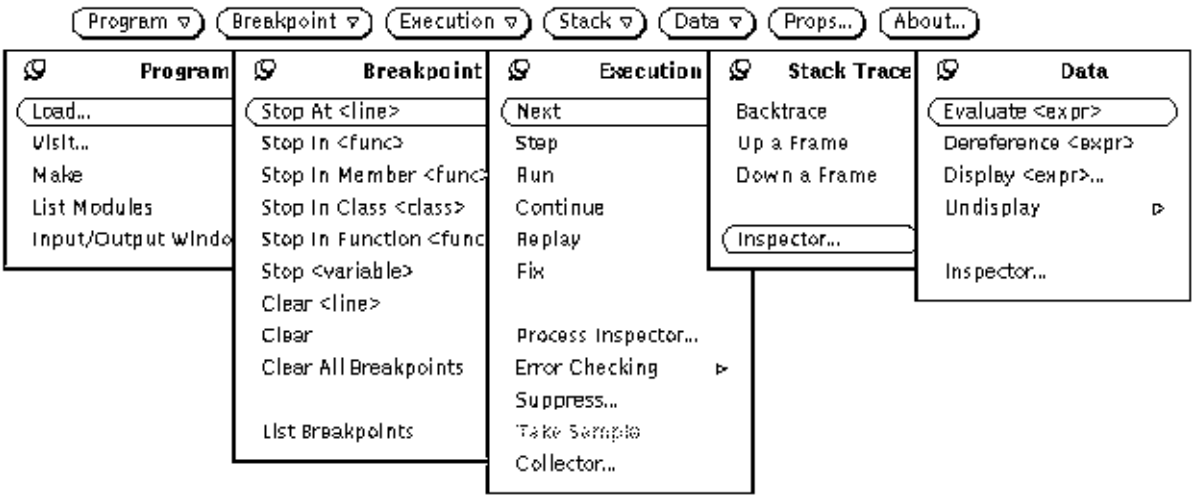


Figure 1-1 Debugger Base Window

1.4.1 Menu Items

The menu buttons beneath the Debugger title bar contain the most important and commonly-used debugging commands, as well as an assortment of debugging utility commands and Property window controls. The Props button is described in Section 1.4.7, “Debugger Properties Window Panes,” on page 1-17. The About button displays a window that briefly describes the Debugger tool. The circled item in each menu is the default item; you do not have to open the menu to choose the default item, just click on the menu button:



1.4.2 Information Fields

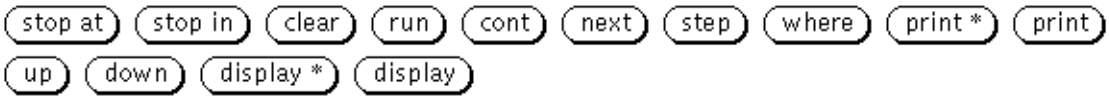
The information fields tell you where the program is stopped, what code is displayed in the source display, and the name of the current function. (See Chapter 4, “Viewing and Visiting Code,” for a detailed description of how to read the information presented in the base window.)

1.4.3 Source Display

The source display displays either the code where the program is stopped or code you are visiting away from the stop location. By default, the source display is a read-only pane. You can convert the source display to a text editor pane by choosing Enable Edit from the source display floating menu.

1.4.4 Button Commands

Button commands appear between the source display and the command pane. The Debugger opens with these preset button commands.



The preset button commands have the same function as their menu item or text command counterparts of the same name.

Using the Debugger `button` command and its modifiers, you can change any of these button commands, deleting, adding or rearranging them as you like. If your set of buttons cannot fit on these two rows, the Debugger creates a new row beneath the second one.

1.4.5 Command Pane

The command pane is at the bottom of the Debugger main window. The command pane serves as a subwindow for entering Debugger text commands and as an output device for displaying the results of various debugging commands. For example, if you choose Evaluate from the Data menu, the Debugger prints the value of the selected variable in the command pane.

Note that the Debugger supports a number of more sophisticated debugging commands or variants of simpler commands as *text commands only—commands which you enter in the command pane.* The Debugger command pane does not support the full ksh command line editing functionality. See Appendix A, “Debugger Commands,” for a reference to the command pane commands.

In most cases, working with Debugger text commands in the command pane is the same as using dbx in a Command shell. However, there are a few differences. These differences reflect how the Debugger takes advantage of the source display for displaying code, rather than printing lines of code in the command pane. For example, when you issue a Debugger line-command like `list` *function_name*, the Debugger displays the code in the source display, not in the command pane.

The *Currently in Function* information field keeps track of the *current function*, that is the function that holds the Debugger focus for the targeting variables and visiting functions using Debugger line commands. See Section 4.4, "Visiting Functions from the Command Pane," on page 4-47 for details.

Shell Commands for the Command Pane

The Debugger supports a number of primitive commands for debugging. If `set -o path` is used, path searching is enabled and common UNIX commands are available. With or without `set -o path`, certain common commands not used for debugging are also built-in. These commands might have slightly different semantics.

`cd`	Change working directory.
`pwd`	Print working directory.
`use`	Set path for the Debugger to search for source files (debugging specific).
`search`	Search for a pattern matching *strings* in the current file (debugging specific).
`bsearch`	Search backwards for a pattern matching *strings* in the current file (debugging specific).
`dalias`	Make an alias for a debugging command.
`history`	Print a list of the most recent debugging commands (default 15), type `history` *n* to change default to *n*.
`kill`	Kill the process loaded in the Debugger, but not the Debugger.
`quit`	Terminate the session; detach the process if it was attached.
`sh` *shell_cmd*	Issue a shell command (unnecessary if `set -o path` is used).
`!!`	Execute previous command.
`!`*num*	Execute command number *num*.

`!-`*num*	Execute the command *num* commands before the current command.
`!`*str*	Execute most recent command starting with *str.*
`:s/l/r/`	Substitute modifier: substitute `r` for `l`.
`:p`	Print modifier: print (but not execute) the command.
`^l^r^`	Quick substitution: substitute `r` for `l`.

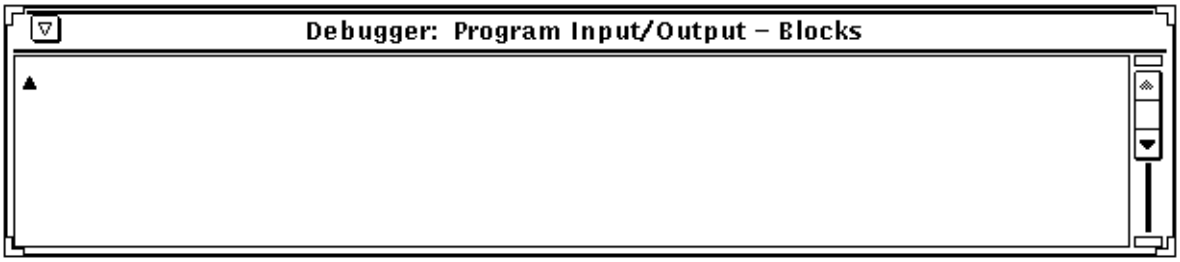
Note – If a program is running in the Debugger, Cntl-C (`^c`) interrupts the program, returning control to the Debugger.

The Debugger ignores a Cntl-D (`^d`) in the command pane. Use `quit` to end the Debugging session.

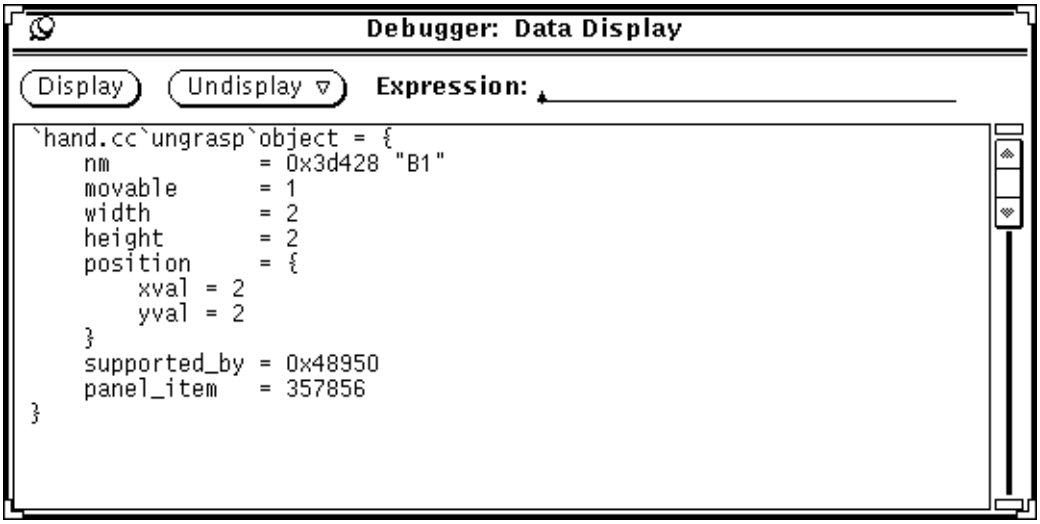
1.4.6 Program Input/Output Window (PIO)

The PIO window is a separate window that pops up initially at the bottom of the Debugger main window. The PIO serves as a display window for all input/output activities of the program being debugged. This window allows for separation of the usual debugging I/O from the program I/O.

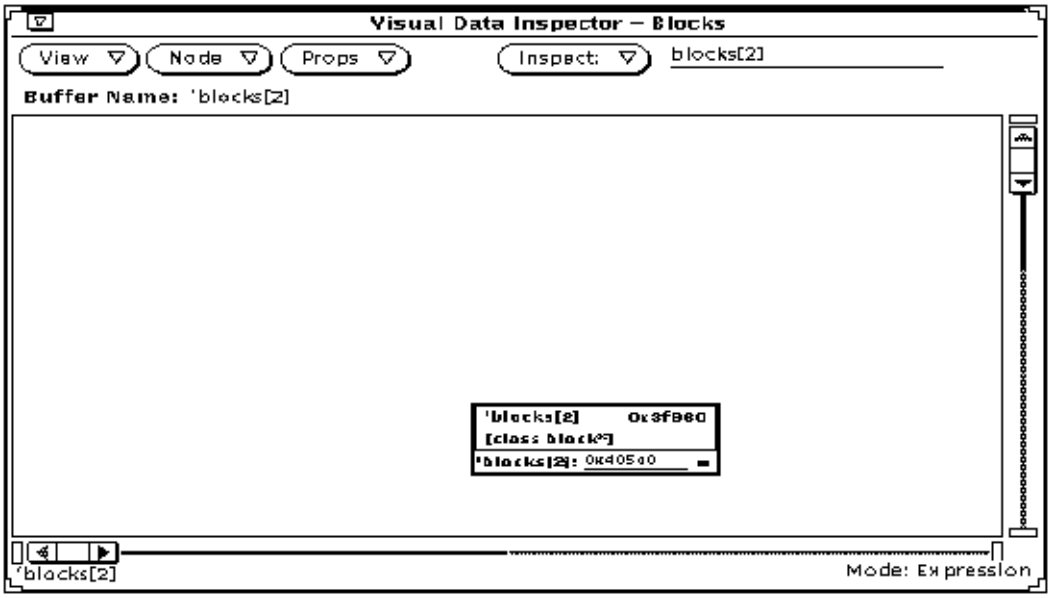
To move the PIO window to the top of the workspace, click on the Input/Output Window item on the Program menu.



In addition to the base window, the Debugger uses windows to monitor expressions and variables: the Data Display window and the Visual Data Inspector window. Here is the Data Display window:

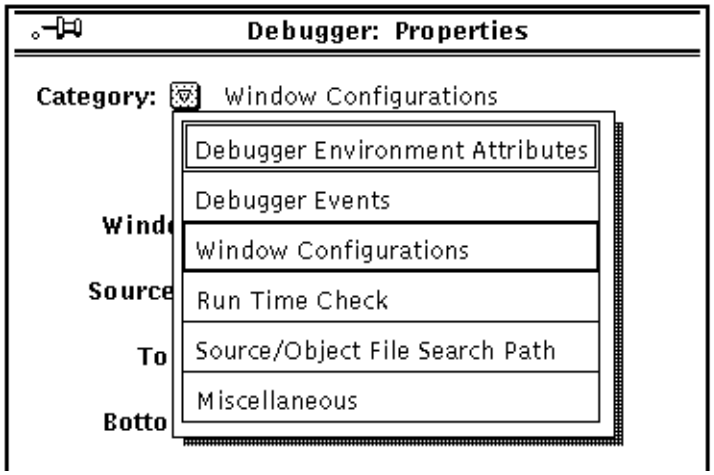


Here is the Visual Data Inspector window.



1.4.7 Debugger Properties Window Panes

The Debugger Props button displays the Properties window. See Chapter 13, “Customizing the Debugger“, for details. Use the Category menu to move from one property sheet to another:

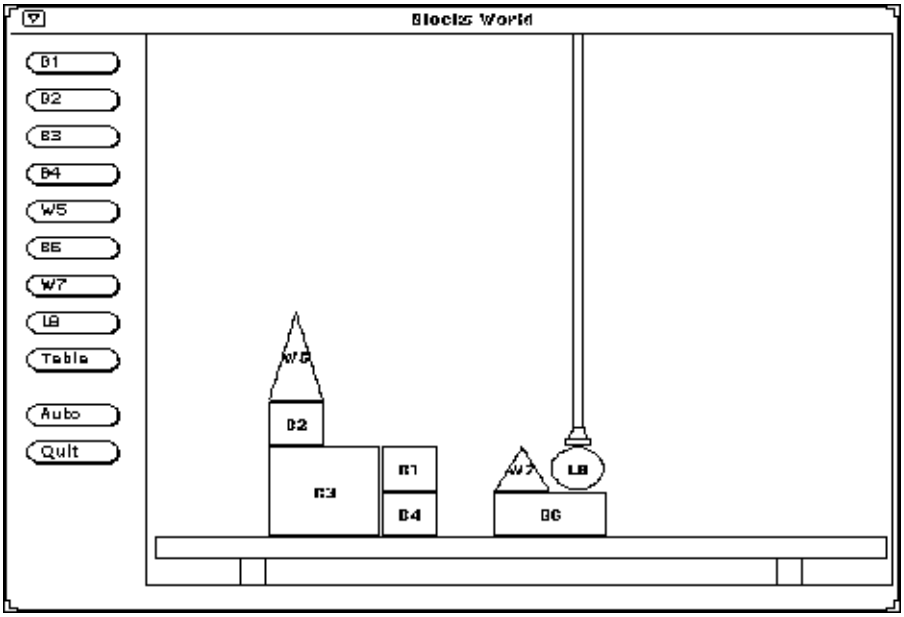


1.4.8 The Debugger Initialization File

The Debugger supports an initialization file, `.dbxrc` with new syntax (Korn shell) or `.dbxinit` with the old syntax (for backwards compatibility). In `.dbxrc` you can store debugging environment commands, commands to create customized button commands, source and object file search path settings, user-defined aliases for debugging commands, and user-defined Korn Shell functions for debugging. Also, `.debugger-init` controls the GUI resources. See Chapter 13, “Customizing the Debugger“, for details on how to use this file.

1.5 Example Application Program

This manual uses the Blocks[1] application in examples for data collection. Blocks is a C++ implementation of a Lisp application called Blocks World. The Blocks application defines several types of blocks (bricks, wedges, a ball, and a table) as subclasses of the basic class block. The Blocks application is used to move blocks on top of other blocks. The Blocks application installs automatically when you install the Debugger.



To use the Blocks application in the examples of this manual, you need to compile the application as specified in Section 2.1, “Compiling with the -g Option,” on page 2-21.

1. The Blocks application used in this manual is derived from “Blocks World CLOS demo” from Chapter 21 of “Lisp”, third edition, by Patrick Henry Winston and Berthold K. P. Horn, Copyright (c) 1989, 1984, 1981 by Addison-Wesley Publishing Company, Inc. and San Marco Associates.

Part 2 — Basic Debugging

Preparing Programs for the Debugger 2

To use the Debugger effectively, a program must have been compiled with the `-g` or `-g0` option. The `-g` option instructs the compiler to generate Debugger information during compilation. The `-g0` (zero) option is for C++ support.

This chapter is organized into the following sections.

2.1 Compiling with the `-g` *Option*

To compile a program for full Debugger support of the resulting code

♦ **Compile the source code with the** `-g` **option.**

2.1.1 Limited Support for Code Compiled Without `-g` *Option*

While most debugging support requires that a program be compiled with `-g`, the Debugger still provides the following level of support for code compiled without `-g`:

- Backtrace (Stack menu or the Debugger `where` command)
- Calling a function (but without parameter checking)

- Checking global variables

Note, however, that the Debugger cannot display source code in the source display unless the code was compiled with the `-g` option.

2.1.2 Shared Libraries Need `-g` for Full Debugger Support

For full debugger support, a shared library must also be compiled with the `-g` option. If you build a program with some shared library modules that were not compiled with `-g`, you can still debug the program. However, full debugging support is not possible because the information was not generated for those library modules.

2.1.3 C++ Support and the `-g` Option

In C++, `-g` turns on debugging and turns off inlining of functions. The `-g0` (zero) option turns on debugging and does not affect inlining of functions. You cannot debug inline functions with this option. The `-g0` option can significantly decrease link time and Debugger start-up time (depending on the use of inlined functions by the program).

2.2 Using the Auto-Read Facility

In general, you should compile the entire program you want to debug using the `-g` option. Depending on how the program was compiled, the debugging information generated for each program and shared library module is stored in either the:

- Object code file (`.o` file) for each program and shared library module
- Program executable file

2.2.1 Auto-Read is the Default for the Debugger

When you compile with the `-g` compiler option, debugging information for each module remains stored in its `.o` file. The Debugger then reads in debugging information for each module automatically, as it is needed, during a session. This read-on-demand facility is called *Auto-Read*. For a large program,

Auto-Read saves considerable time when loading the program into the Debugger. Auto-Read depends on the continued presence of the program `.o` files in a location known to the Debugger.

Note – If you archive `.o` files into `.a` files, and then link using the archive libraries, you can then remove the associated `.o` files, but you must keep the `.a` files.

By default, the Debugger looks for files in the directory where they were when the program was compiled and the `.o` files in the location from which they were linked. If the files are not there, the Debugger uses the *Source/Object File Search Path* (the Debugger `use` command) to look for it. If you move source files or `.o` files, or use different mount points for the same files, be sure to set the Search Path accordingly. See Section 3.2, “Setting the Source / Object File Search Path,” on page 3-30, for more information. See also: the `use` command and the `pathmap` command.

If No Object File Produced, Debugging Info Stored in Executable

For a compilation that does not produce `.o` files, the Debugger stores all the debugging information in the executable and does not use the Auto-read facility.

2.2.2 Disabling Auto-Read with the `-xs` Compiler Option

As explained above, programs compiled with `-g` store debugging information for each module in the module’s `.o` file. Auto-Read requires the continued presence of the program and shared library `.o` files.

In circumstances where it is not feasible to keep program `.o` files or shared library `.o` files for modules that you want to debug, compile the program using the compiler `-xs` option (use in addition to `-g`). (You can have some modules compiled with `-xs` and some without.) The `-xs` option instructs the compiler to have the linker place all of the debugging information in the program executable. Then when you load the program executable into the Debugger, all of the information loads at once. For a large program compiled with `-xs`, reading in the debugging information requires additional time; however, debugging is no longer dependent on the availability of the `.o` files.

2.2.3 Listing Modules that Have Been Read In

The `modules` command lists the modules for which debugging information is already read-in to the Debugger (optionally, it lists the `modules` not yet read-in.) For programs using the Auto-Read facility, use the `module` *module_name* command to specify modules to read in immediately. You can also have the Debugger read in the information for all of the modules, by using the `module -a` command. See Section 3.3, "Listing and Reading-in Program Modules," on page 3-33 for more information.

2.3 Debugging Optimized Code

The Debugger provides partial debugging support for optimized code. When analyzing optimized code, you can

- Stop execution at the start of any function (`stop in` *function* command)
- Display global variables and arguments
- Evaluate, display, or modify global or static variables

However, with optimized code, the Debugger cannot

- Single-step from one line to another (`next` or `step` command)
- Evaluate or display (monitor) local variables
- Assign values to local variables

To compile optimized code for use with the Debugger:

♦ **Compile the source code with both the `-O` (upper-case letter O) and the `-g` options.**
For example, to compile using C++:

% **CC -O -g example_source.cc**

Starting the Debugger 3

This chapter describes how to start a debugging session. You can start the Debugger from the *SPARCworks Manager* or a *Command* or *Shell* tool window. This chapter describes start-up options and how to quit or kill a session.

This chapter is organized into the following sections:

Note – These start-up instructions assume that the two component SPARCworks Debugger programs, `dbx` and `debugger`, are correctly installed on your system. See *Installing SunPro Software on Solaris* for details.

3.1 Starting a Debugging Session

Start the SPARCworks Debugger from

- SPARCworks Manager (double-click on the Debugger tool icon)
- Command or Shell Tool window (type `debugger`)

3.1.1 Starting the Debugger from the Manager

To start the Manager,

- **Type** `sparcworks` **at the prompt in a Command or Shell tool.**

To start the Debugger from the Manager:

- **Double-click on the Debugger icon or drag and drop it onto the workspace.**

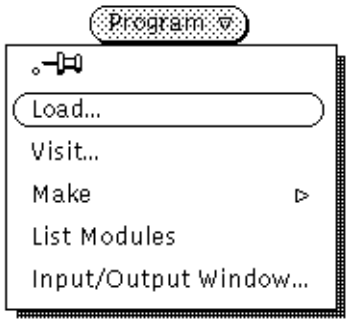
Program Loader

When starting the Debugger from the Manager, the Debugger displays the base window, which is empty because no program is yet loaded.

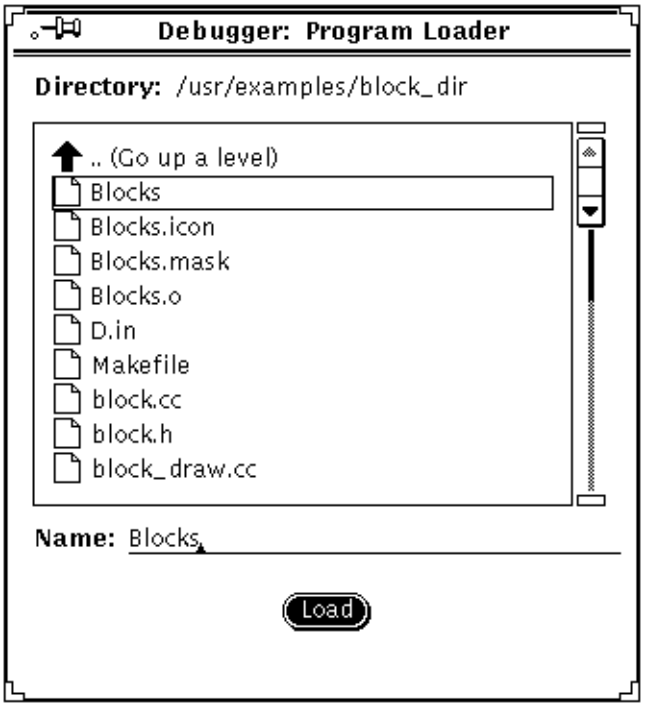
Use the Program Loader as a file chooser to select a program executable to load into the Debugger. Also, use the Program Loader to load a new program into the Debugger (replacing one already loaded).

To load a program for debugging:

1. **Choose Load from the Program menu to display the Program Loader, if it is not already displayed.**



2. **Click on a filename to select a program, then click Load (or double-click on the filename).**
   You can also type the name of the program in the Name field and then press Load.



Or, you can use the `debug` command in the command pane:

`(debugger)` **`debug`** [*program_name* [*corefile* | *process_id*]]

3.1.2 Starting the Debugger from a Command Tool

To start the Debugger from a Command tool (or Shell tool) window,

- **At the prompt, type**

  `%` **`debugger`** [`-`*options*] [*program_name* [*corefile* | *process_id*]]

You can use the program Loader to choose a program executable file to debug.

For a list and description of the options to the start-up command, see Section 3.4, “Options to the Debugger Start-up Command,” on page 3-34.

3.1.3 If a Core File Exists

If a file named `core` exists in the directory where you start the Debugger, it is not read in by default, you must explicitly request the core file with the `debug` command or on the Debugger command line. Use the Stack (or the Debugger `where`) command to see where the program was executing when it dumped core.

Note – To prevent you from overwriting a `core` file from a previous dump stored in the default location (the directory where you started the Debugger), the Debugger saves any core file generated by the Debugger in `/tmp`. If dbx or Debugger suffers an internal failure and dies, any existing core in `/tmp` is renamed.

3.1.4 Quitting a Debugging Session

A Debugger session runs from the time you start the Debugger until you quit or kill the Debugger; you can debug any number of programs in succession during a Debugger session.

To quit a debugging session:

- **Choose `Quit` from the base window title bar menu or type `quit` in the command pane.**

If, when you start the Debugger, you attach it to a running process by using the *process_id* option, when you quit the Debugging session, the process survives and continues. That is, the Debugger performs an implicit `detach` before quitting the session. See Section 3.1.7, “Detaching a Process from the Debugger,” on page 3-29, for more on `detach`.

3.1.5 Killing a Program Without Terminating the Session

The Debugger `kill` command terminates debugging of the current process as well as killing the process. However, `kill` preserves the Debugger session itself and the Debugger is ready to debug another program.

Killing a program is a good way of eliminating the remains of a program you were debugging without exiting the Debugger.

To kill a program that is executing in the Debugger:

♦ **Type, in the command pane,**

(debugger) **kill**

3.1.6 Attaching the Debugger to a Process

You can attach a running process to the Debugger by using the process *process_id* (*pid*) as an argument to the `debugger` command (or, if the Debugger is already in session, the `debug` command.)

Chapter 16, “Debugging Child Processes“, describes how to attach the Debugger to a child process.

You can also attach to a process using its process ID number without knowing its name:

```
% debugger - pid                    / / dash space process_id
```

Because the name remains unknown to the Debugger, you cannot pass arguments to the process in a `run` type command.

3.1.7 Detaching a Process from the Debugger

If you have attached a process to the Debugger, you can detach the process from the Debugger without killing it or the Debugging session.

To detach a process from the Debugger without killing the process:

♦ **Type in the command pane,**

`(debugger) detach`

3.1.8 Debugger at Start-up

As the Debugger loads information, it prints a message in the command pane: `Reading symbolic information...` If the Debugger encounters problems loading the program, it prints messages reporting the problems.

Once the program is finished loading, the Debugger is in a ready state, visiting the "begin" block of the program (For C or C++: `main()`; for FORTRAN `MAIN()`). Typically, you want to set a breakpoint and then issue a `run` command.

3.1.9 Running dbx Alone from Terminal or Shell

You can also start `dbx`—the command-line version of the Debugger—in a shell, and use it without the window interface component. Note that to run dbx outside of Openwindows, dbx still requires access to two shared libraries that are located in the Openwindows directory hierarchy:

installation_specific_location.../`usr/openwin/lib/libtt.so`
installation_specific_location.../`usr/openwin/lib/libX11.so`

If Openwindows is already installed in the default location on your system, then dbx should already have access to these two libraries. If not, put the directory containing the two libraries shown above in your `LD_LIBRARY_PATH`.

To start dbx:

- **In a Command or Shell Tool, or at a tty terminal, type**

  % **dbx** [-*options*] [*program_name* [*corefile* | *process_id*]]

You can also start the Debugger with a process ID number:

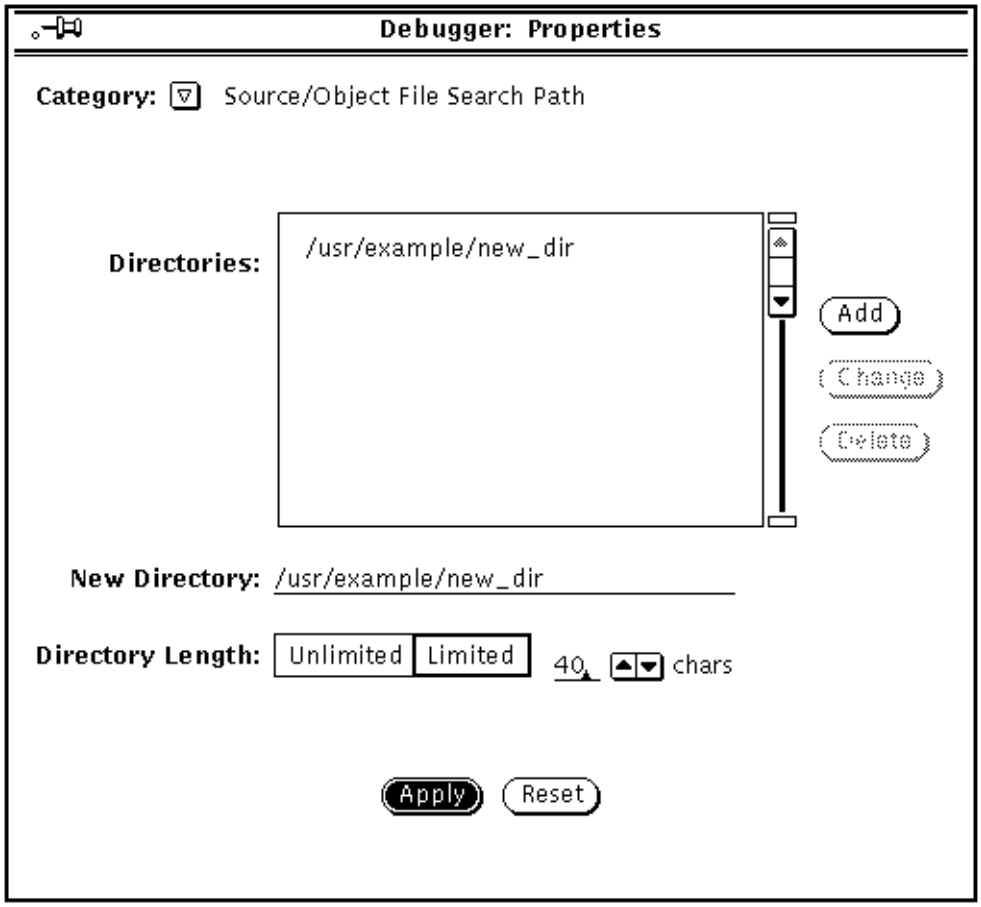
  % **dbx - pid** / / dash space *process_id*

3.2 Setting the Source/Object File Search Path

By default, the Debugger looks for the source files associated with the program being debugged in the directory in which they were when the program was compiled. If you move source/object files you must inform the Debugger of their new location. You can check the path, add to the list, edit a pathname, or delete a pathname:

To check the current File Search Path:

- **Display the Properties Window and choose Source/Object File Search Path from the Category menu.**



You must click the Apply button to execute the changes you make to the search path. Until you click Apply, the search path does not change. You can click Reset *before* clicking Apply to discard your most recent edits.

To Add a directory to the Source/Object File Search Path:

1. **Type in the name of the directory you want to add in the New Directory text field; click Add.**
   The directory name is displayed in the Directories display box.
2. **Click Apply to execute the change.**

To Change a path name already on the list:

1. **Select the path you want to edit by clicking on it in the Directories display box.**
   The selected entry is boxed.
2. **Click the Change button.**
   The command writes the pathname on the New Directory text field.
3. **Edit the pathname on the New Directory text field; then click Apply.**

To delete a path from the search path list:

- **Select a pathname in the Directories box; click Delete; then click Apply.**

Adjusting the Display of Pathnames in the Directories Box

By default, the Directories box truncates pathnames on the left if they are larger than 40 characters. You can adjust this setting up or down to see more or less of the pathnames.

Also, if you set Directories Length to Unlimited, the box expands to accommodate the longest pathname, up to the maximum number of characters before truncating the name.

3.2.1 Setting the Search Path in the Initialization File

If you want the Debugger to use a special source and object file search path each time you start a new session, add a line to your `.dbxrc` initialization file using the `use` command and pathname.

3.2.2 Setting the Search Path with `pathmap`

The `pathmap` command creates a mapping from one pathname to another. The mapping is applied to source paths, object file paths, and the current working directory (if "`-c`" is used).

The pathmap command is useful for dealing with automounted and explicit NFS mounted file systems with different paths on differing hosts. Use "`-c`" when you try to correct problems due to the automounter because current working directories are inaccurate on automounted file systems.

`pathmap /tmp_mnt/` exists by default.

To establish a new mapping from <`from`> to <`to`>, where <`from`> and <`to`> are file path prefixes, type:

```
(debugger) pathmap [ -c ] <from> <to>
```

If "`-c`" is used, the mapping is applied to the current working directory as well.

To list all existing path mappings:

```
(debugger) pathmap
```

To delete the given mapping:

```
(debugger) pathmap -d <from>
```

3.3 Listing and Reading-in Program Modules

By default, the compilers leave debugging information for each module compiled using the `-g` option, dispersed in each module `.o` file. The Debugger reads in the debugging information as it is needed. (For more on this topic, see "Using the Auto-Read Facility" on page 2-22.)

Listing Modules

The Debugger `modules` command and its options help you to keep track of program modules during the course of a debugging session. The List Modules item on the Program menu is equivalent to the first of the Debugger `modules` commands listed here: `modules -read`.

To list names of all program modules (with or without debugging info):

```
(debugger) modules [-a]
```

To list the names of modules containing debugging information that have already been read into the Debugger:

```
(debugger) modules -read
```

To list all program modules with debugging info:

```
(debugger) modules -debug
```

Reading in Debugging Information

Use the `module` command to read in debugging information for one or all modules.

To print the name of the current module:

```
(debugger) module
```

To read in debugging information for a module *name*:

```
(debugger) module [-f] [-q] <name>
```

To read in debugging information for all modules:

```
(debugger) module  [-f] [-q] -a
```

where,

`-f` forces reading of debugging information, even if the file is newer than the executable (use with caution).

`-q` is quiet mode.

3.4 Options to the Debugger Start-up Command

This section describes the options to `debugger`, the Debugger start-up command. Enter options after the command and before the name of a program, corefile, or process_ID you may want to load at start-up.

```
% debugger [-options] [program_name [corefile | process_ID]]
```

The options are organized in the table into the following categories:

- Help option
- Remote display option
- Source display buffer option
- Window applications option
- dbx options

Note – These start-up options are different from the Debugger environment attributes and Debugger window configuration options. You set environment and window controls from a Property window or by using `dbxenv` or `dbx setenv` commands. See Chapter 13, “Customizing the Debugger“ for more information.

Table 3-1 Options to `debugger`, the Start-up Command

Help Option	Description
`-help`	Display a brief summary of these debugging options.

Remote Display Option	Description
`-display` *hostname*`:0.0`	Display the Debugger on a remote display; *hostname* is the name of the remote machine.

Source Display Buffer Option	Description
`-M` *bytes*	Set a limit on the size of the file buffer associated with code displayed in the source display. The default is no limit, which means that the Debugger uses as much disk space as it needs to display in the source display on a cumulative basis (like a Command tool). For a system with a small amount of disk space, this no limit default could use all available disk space. For long debugging sessions on systems with a small amount of disk space, set *bytes* to 20000.

Window Applications Option	Description
`-Wfsdb`	Allows debugging of an OpenWindows program on the same server as the one on which it displays. Active grabs are disabled when you press a key, move the pointer, or perform a server action. Passive grabs are disabled when you press a mouse button. Note: you must set `-Wfsdb` as an argument to the Run item (or debugging `run` command) for OpenWindows applications. Without this option, the program may hang.

dbx Options	Description
`-c` *"dbx_cmd; ...;"*	Execute *dbx_commands* after initialization. Use quotation marks around debugging commands; for example, **`% debugger -c "stop in main" demo`**
`-e`	Echo all input commands on standard out.
`–I` *dir*	Add *dir* to the list of directories searched when looking for a source file. Normally, the Debugger looks for source files in the directory where the source file was compiled. If it cannot find the source files in that directory, it complains. If the source files are not in the compile directory, you must tell `dbx` where to find them, using either this option or setting the directory search path with the `use` command.
`-kbd`	Debug a program that sets the keyboard into up-down translation mode. This flag is necessary if a program uses up-down decoding.
`-r`	Load and then run the executable file immediately (instead of loading and waiting for a `run` command). Arguments to the program being debugged follow the object filename (redirection is handled properly). If the program terminates successfully, the Debugger exits. Otherwise, the Debugger reports the reason for termination and waits for your response. When `–r` is specified and standard input is not a terminal, the Debugger reads from `/dev/tty`.
`-q`	Silence the echoing of the "`Reading symbol table for` ..." message and the "`Attached to`..." message.

`-s` *start-up*	Read initialization commands from the file named *start-up*, not from the `.dbxrc` file.
`-sr` *start-up*	Read and delete "`start-up`".
`-wskip` *n*	Cause the `where` command to skip the first *n* stack frames.
`-C`	Enable Run Time Checking.
`-notempl`	Suppress Template processing.

Viewing and Visiting Code 4

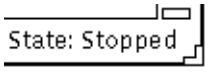
This chapter describes how the Debugger reports what is happening during a debugging session. It also covers how to use commands to visit code or look up declarations for identifiers, types, and classes.

In general, each time the program stops, the code displayed in the source display is the code associated with the *stop location*. Also, each time the program stops, the Debugger resets the value of the *current function* to the function in which the program is stopped. When the program is stopped, you can "visit" functions and files elsewhere in the program.

This chapter is organized into the following sections:

4

4.1 Knowing the State of the Program



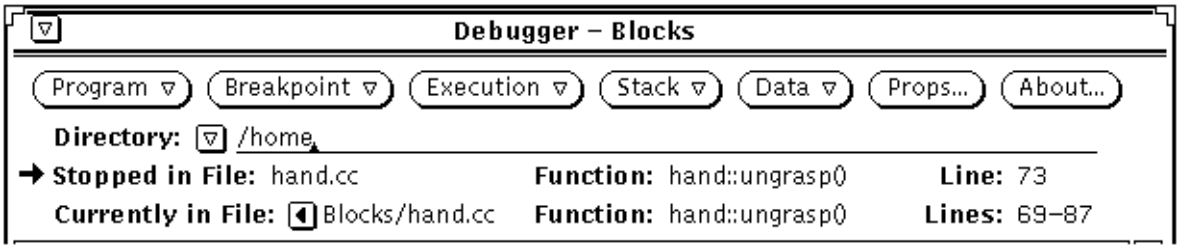
The Debugger reports the state of the program in the lower right message area of the base window.

The program may be in one of the following states:

- exiting
- killed
- initial
- ready
- resumed
- running
- stopped

4.2 Reading the Information Fields

The Debugger displays three information fields beneath the menu buttons: Directory, Stopped in (File, Function, Line), and Currently in (File, Function, Lines).



4.2.1 Directory

The Directory information field lists the current directory of the Debugger. Initially, Directory is the Debugger start-up directory name.

The Directory field is initially read-only, but if you click on any character in the directory name, the field converts to an editable text field:

When you edit the directory name and then press Return, The Debugger changes to the new Directory.

Returning to a Directory

When you change the directory, the Directory menu records the history of the directories to which you have changed during the current session.

To change the location of the Debugger to a previous working directory,

- **Choose the directory item from the Directory menu.**

Note – The Debugger must know where the source and object code files associated with a program are located. The default directory for the object files is the one they were in when the program was last linked. The default directory for the source files is the one they were in when last compiled. If you move the source or object files, or copy them to a new location, you must either relink the program or enter the new location in the Source / Object File Search Path before debugging. (See Section 3.2, “Setting the Source / Object File Search Path,” on page 3-30, and “Scope Resolution Search Path” on page 4-50.)

4.2.2 Stopped in File…Function…Line

The Stopped in information fields tells you where the program is stopped by filename, function name, and the line number. Also, when a program is stopped, a *solid black arrow* is displayed to the left of the Stopped in information fields; the same type of arrow is displayed in the source display to the left of the line where the program stopped.

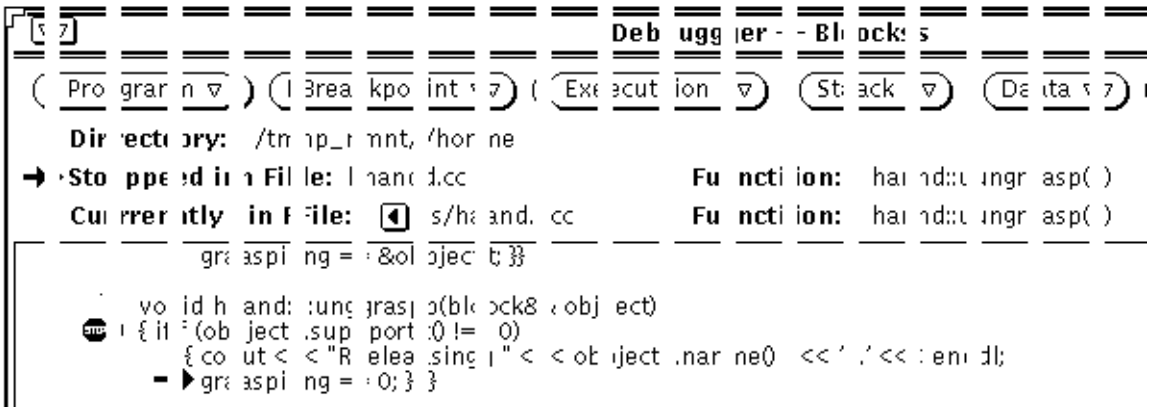


Figure 4-1 Stopped in File-Function-Line Information Field

4.2.3 Currently in File…Function…Lines

The Currently in fields report which code is shown in the source display. Currently in Function also reports the name of the *current function* (as shown in the next illustration).

Notice that in Figure 4-1, the values of Stopped in Function and Currently in Function are the same: every time the program stops, the Debugger changes the current function (the value of Currently in Function, and the value of the Debugger `func` command) to match Stopped in Function. However, when you *visit* a function, the two values diverge:

➜ **Stopped in File:**	hand.cc	**Function:**	hand::animate	**Line:**	26
Currently in File:	hand.cc	**Function:**	hand::draw	**Lines:**	3–22

The *current function* is the function that holds the Debugger's "focus" or "attention" for the purposes of targeting debugging line commands.

Specifically, the current function determines the *scope resolution search order* that applies when you give a variable name to a Debugger command in the command pane. Knowing the current function is mainly important for issuing `Print`, `Print*`, `Stop in`, and `Display` line commands in the command pane. See “Visiting Functions from the Command Pane” on page 4-47, for details.

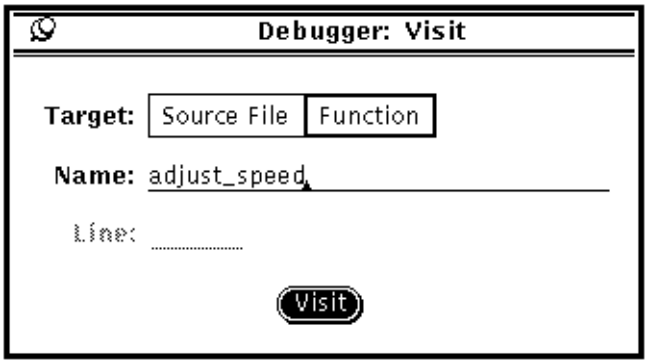
4.3 Visiting Code

When a program is stopped, you can visit code elsewhere in the program. The Currently in fields show what code you are visiting. You can visit any function or file that is part of the program.

4.3.1 Visiting a Function

To visit a function:

- **Choose Visit from the Program menu to display the Visit pop-up window; set Target to Function.**
  When visiting among a number of functions (or files), consider pinning open the Visit pop-up window.



- **Type in the name of the function and press Visit.**

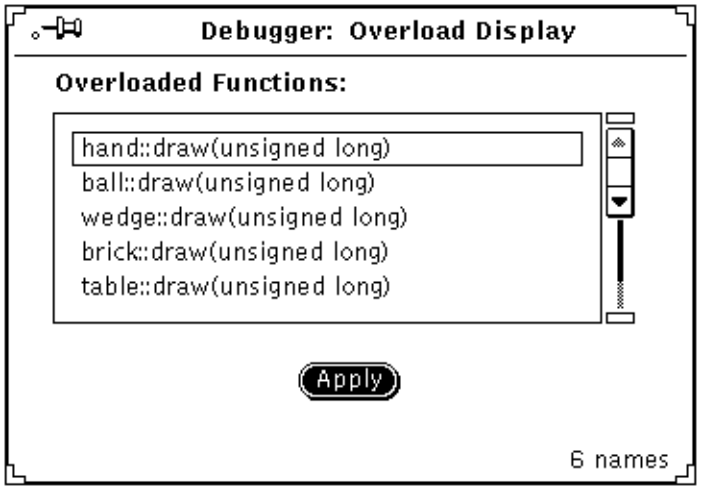
  You can also use a dbx command to visit a function:

  Type the command `func` followed by the function name. For example:

  ```
  (debugger) func adjust_speed
  ```

4.3.2 Selecting from a List of C++ Ambiguous Function Names

If you try to visit a C++ member function with an ambiguous name or an overloaded function name, the Overload Display pop-up window is displayed, showing a list of all functions with the overloaded name.



To specify a function from the list of ambiguous or overloaded function names:

♦ **Click the name of the function you want to visit and then click Apply.**

After visiting a function, Currently in Function reports the new current function. If the function is in a different file, Currently in File changes too. Lines reports which line numbers are visible in the source display. Note that no arrow is displayed in the source display next to a function you are visiting (unless it is part of the active call stack).

You can also type in the command pane instead of using the menu:

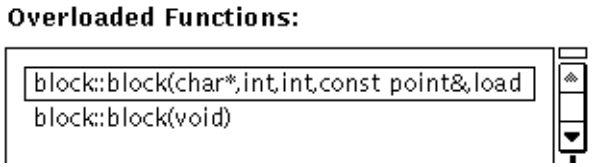
```
(debugger) func block::block()
```

If the Search for a Symbol Name Finds Multiple Occurrences

If, at any place along the search path the search finds multiple occurrences of *symbol* at the same scope level, The Debugger prints a message in the command pane reporting the ambiguity:

```
(debugger) func main
(debugger) which block::block
Class block has more than one function member named
block.
```

At the same time, the Debugger pops up the Overload Display window listing the ambiguous symbols names:



In the context of the `which` command, choosing from the list of occurrences does not affect the state of the Debugger or the program. Whichever occurrence you choose, the Debugger merely echoes the name in the command pane.

Remember that the `which` command gives you a preview of what happens if you make *symbol* (in this example, `block`) the target of a command that must operate on *symbol* (for example, `a print` command). In the case of ambiguous names, the Overload Display window indicates that the Debugger does not yet know which occurrence of two or more names it would use. The Debugger lists the possibilities and waits for you to choose one.

4.3.3 Redisplaying the Line Where the Program is Stopped

When a program is stopped, the solid black arrow is displayed to the left of the Stopped in fields. The arrow remains there when you visit a function or file.

To redisplay the stop location:

♦ **Click on the solid black arrow to the left of the Stopped in fields.**

Note – Redisplaying the stop location by clicking on the arrow does *not* change the current function. The Debugger changes the current function to match the stop location only after the program executes lines of code and stops again.

4.3.4 *Using* `list` *to Display a Function*

As noted already, visiting a function changes the current function. To display a function *without* changing the current function, use the Debugger line command, `list`:

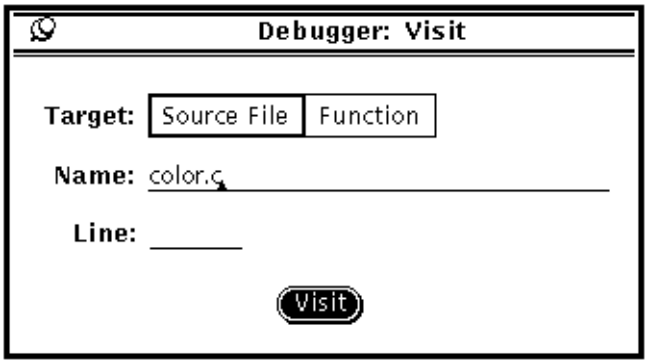
```
(debugger) list function_name
list function_name (args)
```

4.3.5 *Visiting a File*

You can visit any file the Debugger recognizes as part of the program (even if a module or file was not compiled with the `-g` option.) Visiting a File does *not* change the current function. So, if you visit a file, the Currently in File field reports the name of the file currently displayed in the source display, but the Currently in Function field still reports the function that holds the Debugger focus.

To visit a file:

- **Choose Visit from the Program menu to display the Visit pop-up window; set Target to File; type in the name of the file and click Visit.**



You can specify a line number in the source file for the Debugger to display. Otherwise, the Debugger displays the file from its first line.

4.3.6 Walking the Call Stack to Visit Code

Another way to visit code is to "walk the call stack," that is, to use the Stack commands or the Up and Down command buttons to view some function currently on the stack. (See Section 9.2, "The Stack Inspector," on page 9-114, for details on how to use the Stack Inspector to visit code.)

Walking the stack causes the current function to change each time you display a stack function. (The stop location is considered to be at the "bottom" of the stack; so to move away from it, you must use the Up command, that is, move toward the `main` or `begin` function.)

When you move away from the stop-location using Stack commands, a hollow arrow is displayed to the left of the *Currently in* fields. This hollow arrow reminds you that the function displayed is *on* the stack but *not at the top* of the stack:

See Chapter 9, "Examining the Call Stack", for more information.

Note – If you have the SrcDisp Synchronization control (Props menu) set to Always, and the companion control(s) set correctly in SourceBrowser, CallGrapher, ClassBrower, or ClassGrapher, you can display code selected from these tools in the Debugger source display.

4.4 Visiting Functions from the Command Pane

Using the `func` command in the command pane is equivalent to visiting a function using Program:Visit-Function. Also, the Debugger `file` command is equivalent to using Program:Visit-Source File. However, when using `func` or `file`, you may need to use *scope resolution operators* to qualify the names of the functions or files that you give as targets for these line commands.

For instance, in a C++ program, you may want to qualify an overloaded function name. If you do not qualify it, the Debugger pops up the Overload Display window for you to choose which function you mean to visit. (See "Selecting from a List of C++ Ambiguous Function Names" on page 4-44.) If

you know the function class name, you can use it with the double colon scope resolution operator to qualify the name and avoid popping up the Overload Display window.

```
(debugger) func class::function_name (args)
```

Also, a program may use the same function name in two different files (or compilation modules). In this case, you must also qualify the function name to the Debugger so that it knows which function you mean to visit. To qualify a function name with respect to its filename, use the general purpose backquote (‘) scope resolution operator:

```
(debugger) func ‘file_name‘function_name
```

4.4.1 Qualifying Symbols with Scope Resolution Operators

The Debugger provides three scope resolution operators with which to qualify symbols: the backquote operator (‘), the C++ double colon operator (::), and the block local operator (:<*lineno*>). You use them separately, or in some cases, together.

Note – In addition to qualifying file and function names when visiting code, symbol name qualifying is also necessary for printing and displaying out-of-scope variables and expressions, and for displaying type and class declarations (`whatis` command). The symbol qualifying rules are the same in all cases; this section covers the rules for all types of symbol name qualifying.

Backquote Scope Resolution Operator

The syntax for the backquote character(‘) are:

‘*global* // search for variable of global scope

[‘*source_file_name*‘]*function_name*‘*variable_name*

[`*source_lib_name*`] *function_name:line_number*`*name* // search for a block\ local variable

[‘*source_file_name*‘]*name* // search for file static variable or function name
// search for file statics in all files

Here, *source_file_name* is a name of a compilation unit. The Debugger accepts two forms of filenames:

source_file_name.*language_specific_suffix*	`animate.c`
source_file_name.`o`	`animate.o`

Examples; where `animate.c` is a source file, `change_glyph()` a function, `item` a nonunique variable name, and `color` a file static variable name:

```
(debugger) print change_glyph`item
(debugger) print `animate.o`change_glyph`item
(debugger) print `animate.0`change_glyph:230`item
(debugger) display `animate.c`color
```

Nested Functions in Pascal

To qualify a symbol within a nested function in Pascal, extend the qualifier to include the name of the nested function. Here is the generic syntax:

function_name[`*function_name* `...`]`*symbol*

For commands that target a Pascal nested function, the last name is a name of the function:

```
(debugger) stop in function_name['function_name...]
'function_name
```

C++ Double Colon Scope Resolution Operator

Use the double colon operator (`::`) to qualify a C++ member function or top level function with

- an overloaded name (same name used with different argument types)
- an ambiguous name (same name used in different classes)

The syntax is:

class_name`::`*function_name*

```
(debugger) func hand::draw
```

4.4.2 Linker Names

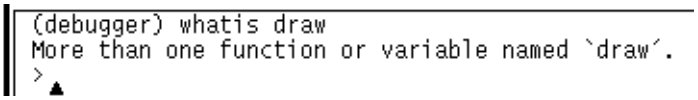
The Debugger provides a special syntax for looking up symbols by their linker names (mangled names in the case of C++). You prefix the symbol name with a '#' character (and use the ksh escape character '\' before any '$' characters).

Examples:

```
(debugger) stop in #.mul
(debugger) whatis #\$FEcopyPc
(debugger) print `foo.c `#staticvar
```

4.4.3 Ambiguous or Overloaded Function Names in Command Pane

If you issue a command for an overloaded or ambiguous target (as shown in the figure), the command pane reports the situation and the Debugger pops up the Overload Display window. (See Section 4.3.2, "Selecting from a List of C++ Ambiguous Function Names," on page 4-44.)



- **Select from the list of member functions in the pop-up window and click Apply.**
  The command pane echoes a number, which corresponds to the number of the function you selected on the list, counting from the top of the list.

4.4.4 Scope Resolution Search Path

When you issue a debugging command with a *symbol* target name that requires the Debugger to search for *symbol*, the search order is as follows:

1. The Debugger first *searches within the scope of the current function*. If the program is stopped in a nested block, the Debugger searches within that block, then within the scope of all enclosing blocks declared by that function. If it does not find the symbol, the search continues along this path.
2. For Pascal only: the next immediately enclosing function.
3. For C++ only: class members of the current function's class.

4. The immediately enclosing “compilation unit”: generally, the file containing the current function.
5. The global scope.
6. If none of the above searches are successful, the Debugger assumes that you are referencing a private variable, that is, a “file static” variable or function. The Debugger optionally searches for a file static symbol in every compilation unit depending on the value of the dbxenv “lookaside” setting.

The Debugger uses whichever occurrence of the symbol it first finds along this search path. If the Debugger cannot find a variable, it reports an error.

4.5 *Locating Symbols: the* `whereis` *and* `which` *Commands*

In a program, the same name may refer to different types of program entities and occur in many locations. The Debugger `whereis` command lists the fully qualified name—hence, the location—of all symbols of that name. The Debugger `which` command tells you which occurrence of a symbol the Debugger will use if you give that name as the target of a debugging command.

4.5.1 `whereis`*: Printing a List of Occurrences of a Symbol*

To print a list of all the occurrences of a specified symbol:

- **In the command pane, type** `whereis` *symbol*.
  symbol may be any user-defined identifier. For example:

```
(debugger) whereis table
in loadable object "Blocks"
class:  table
class:  table
class:  table
class:  table
class:  table
class:  table
function:        `table::table
in loadable object "/usr/lib/libc.so.1.6"
variable:        `hsearch.o`table
(debugger)
```

Notice in the previous example that the output includes the name of the loadable object(s) where the program defines *symbol*, as well as the kind of entity each object is: in the example, class, function, or variable.

Note – Because the Auto-load facility reads in information from the Debugger symbol table as it is needed, the `whereis` command knows only about occurrences of a symbol that are already loaded. As a debugging session gets longer, the list of occurrences may grow.

4.5.2 Seeing a Preview of Which Symbol the Debugger Will Use

The `which` command tells you which symbol with a given name it will use if you specify that name (without fully qualifying it) as the target of a debugging command.

To see which symbol the Debugger will use:

- **Type, in the command pane,** `which` *name.*
  For example:

```
(debugger) func
wedge::wedge
(debugger) which draw
`block_draw`wedge::draw
```

If a Symbol Name is Not in Scope

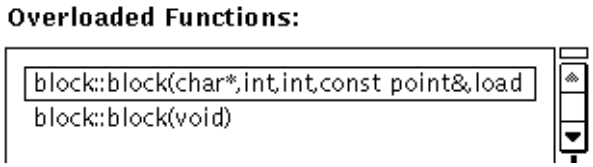
If a specified symbol name is not in a local scope, the `which` command searches for the first occurrence of the symbol along the *scope resolution search path*. (See “Scope Resolution Search Path” on page 4-50.) If `which` finds the name, it reports the fully qualified name in the command pane.

If the Search for a Symbol Name Finds Multiple Occurrences

If, at any place along the search path the search finds multiple occurrences of *symbol* at the same scope level, The Debugger prints a message in the command pane reporting the ambiguity:

```
(debugger) func main
(debugger) which block::block
Class block has more than one function member named
block.
```

At the same time, the Debugger pops up the Overload Display window listing the ambiguous symbols names:



In the context of the `which` command, choosing from the list of occurrences does not affect the state of the Debugger or the program. Whichever occurrence you choose, the Debugger merely echoes the name in the command pane.

Remember that the `which` command gives you a preview of what happens if you make *symbol* (in this example, `block`) the target of a command that must operate on *symbol* (for example, a `print` command). In the case of ambiguous names, the Overload Display window indicates that the Debugger does not yet know which occurrence of two or more names it will use. The Debugger lists the possibilities and waits for you to choose one.

4.6 Looking Up Variables, Members, Types, and Classes

The Debugger `whatis` command prints the declarations or definitions of identifiers, structs, types and C++ classes, or the type of an expression. Among the identifiers you can look up are: variables, functions, fields, arrays, and enumeration constants. For example:

`whatis` [-*n*] [-*r*] non-type identifier
`whatis -t` [-*r*] type identifier
`whatis -e` [-*r*] expression

4.6.1 Displaying Declarations of Variables and Members

To print out the declaration of an identifier:

- **Type in the command pane**

```
(debugger) whatis identifier
```

Qualify the identifier name with file and function information as needed. Here are some examples.

whatis *a Member Function*

```
(debugger) whatis block::draw
void block::draw(unsigned long pw);

(debugger) whatis table::draw
void table::draw(unsigned long pw);

(debugger) whatis block::pos
class point *block::pos();
```

Notice that `table::pos` is inherited from block:

```
(debugger) whatis table::pos
class point *block::pos();
```

whatis *a Data Member*

```
(debugger) whatis block::movable
int movable;
```

whatis *a Variable or a Field*

On a variable, `whatis` tells you the variable's type:

```
(debugger) whatis the_table
class table *the_table;
```

On a field, `whatis` tells you the field's type:

```
(debugger) whatis the_table->draw
void table::draw(unsigned long pw);
```

whatis *on the* this *Pointer*

When you are stopped in a member function, you can lookup the `this` pointer. Notice that in this example, the output from the `whatis` shows that the compiler automatically allocated this variable to a register.

```
(debugger) stop in brick::draw
(debugger) cont
```

/ / expose the blocks window (if exposed, hide then expose) to force program to hit the breakpoint.

```
(debugger) where 1
brick::draw(this = 0x48870, pw = 374752), line 124 in
      "block_draw.cc"
(debugger) whatis this
register class brick *this;
```

Looking Up or Evaluating a Member of the `this` *Object*

Continuing with the previous example: to see the type of a member of the `this` pointer (or to evaluate it):

```
(debugger) whatis this
register class brick *this;
(debugger)  whatis this->movable
int movable;
(debugger) print this->movable
this->movable = 1
```

Or simply:

```
(debugger) whatis movable
int movable;
(debugger) print movable
movable = 1
```

4.6.2 Looking Up Definitions of Types and Classes

To print the declaration of a type or C++ class:

- **Type in the command pane**

```
(debugger) whatis -t type_or_class_name
```

Using whatis *On a Class Name*

```
(debugger) whatis -t class block
class block {
     block::block();
     block::block(char *name, int w, int h, class point&pos,
          class load_bearing_block *blk);
     char *block::type();
     char *block::name();
     int block::is_movable();
     int block::w();
     int block::h();
     class point *block::pos();
// 15 members removed from this example
     char *nm;
     int movable;
     int width;
     int height;
     class point position;
     class load_bearing_block *supported_by;
 Panel_item panel_item;
};
```

4.6.3 *Using* whatis *to See Inherited Members*

The whatis command takes an option, -r (for recursive), that displays the declaration of a specified class together with the members it inherits from parent classes.

```
(debugger) whatis -t -r class_name
```

The output from a whatis -r query may be long, depending on the class hierarchy and the size of the classes. The output begins with the list of members inherited from the most ancestral class. Note the inserted comment lines separating the list of members into their respective parent classes.

Here are two examples, using the class table, a child class of the parent class load_bearing_block, which is, in turn, a child class of block. The first whatis command does not use the -r option, the second one does.

Using whatis *on a Class Name without the* -r *option*

Without -r, whatis reports the members declared in class table:

```
(debugger) whatis -t class table
class table : public load_bearing_block {
     table::table(char *name, int w, int h, class point
          &pos);
     char *table::type();
     void table::draw(unsigned long pw);
};
```

Using whatis -r *on a Child Class to see Members it Inherits*

```
(debugger) whatis -t -r class table
class table : public load_bearing_block {
     /* from base class table::load_bearing_block::block */
     block::block();
     block::block(char *name, int w, int h, class point &pos, class
           load_bearing_block *blk);
     char *block::type();
     char *block::name();
     int block::is_movable();
// 20 members removed from this example
     class point  position;
     class load_bearing_block *supported_by;
     Panel_item panel_item;
     /* from base class table::load_bearing_block */
     load_bearing_block::load_bearing_block();
     load_bearing_block::load_bearing_block(char *name, int w, int h,
           class point &pos, class load_bearing_block *blk);
// 10 members removed from this example
     class list *support_for;
     /* from class table */
     table::table(char *name, int w, int h, class point &pos);
     char *table::type();
     void table::draw(unsigned long pw);

};
```

Setting Breakpoints and Traces 5

This chapter describes how to set breakpoints and traces. The various forms of these commands are called, collectively, *event management* commands. Event management refers to the general capability of the Debugger to perform certain actions when certain events take place in the program being debugged.

The most common example of this association of a program event with a Debugger action is the simple breakpoint set at a line.

This chapter is organized into the following sections:

5.1 Setting Breakpoints

There are three types of breakpoint action commands:

- `stop` **type breakpoints —** If the program arrives at a breakpoint created with a `stop` command, the program halts. The program cannot resume until you issue another debugging command.

- when **type breakpoints —** the program halts and the Debugger executes one or more debugging commands, then the program continues (unless one of the commands is stop).
- trace **type breakpoints —** the program halts and an event-specific trace information line is emitted, then the program continues.

Note – If the line selected in the source display or specified in a stop or when Debugger command is not an executable line of source code, the Debugger sets the breakpoint at the next line after the specified line that is executable.

The Breakpoint Menu

The Breakpoint menu contains items for setting location type breakpoints, including multiple breakpoints for C++ code, and for listing and clearing breakpoints.

To set conditional type breakpoints and when type breakpoints and traces, use the appropriate Debugger command in the command pane.

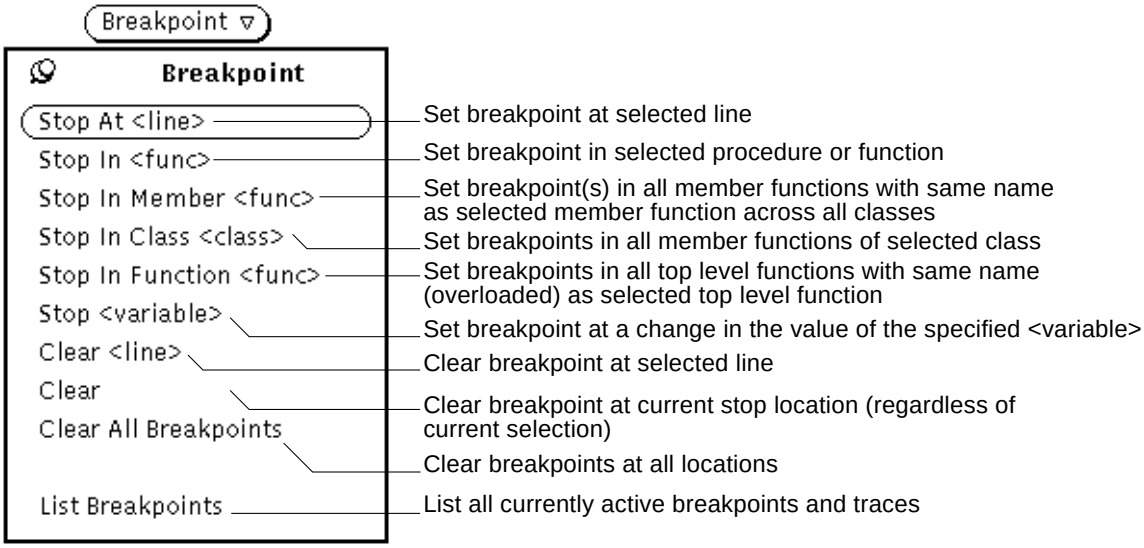


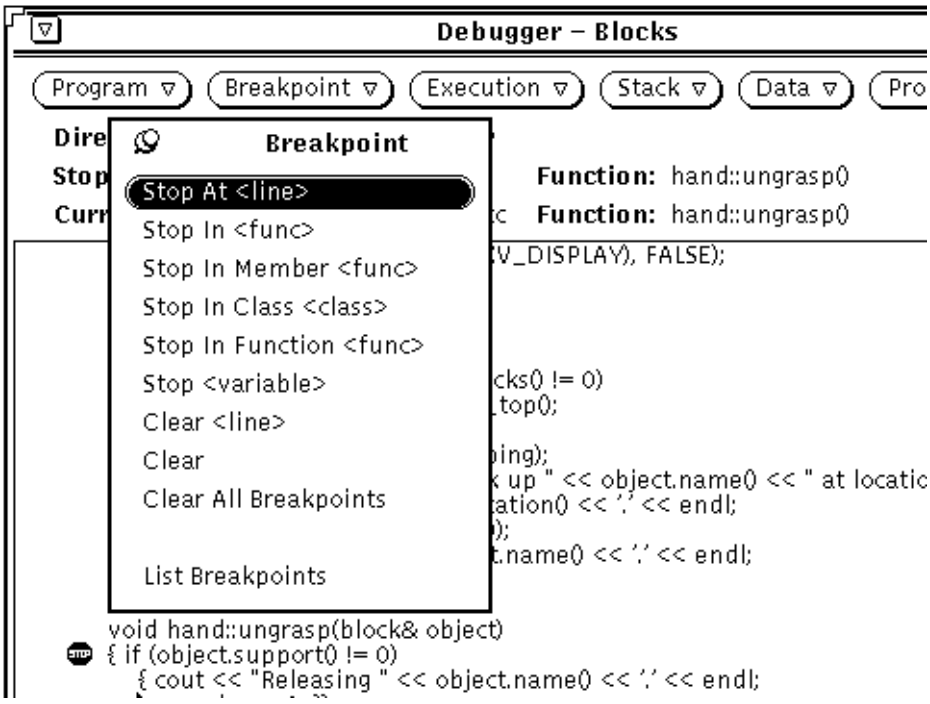
Figure 5-1 Breakpoint Menu

5.1.1 Setting a Breakpoint at a Line of Source Code

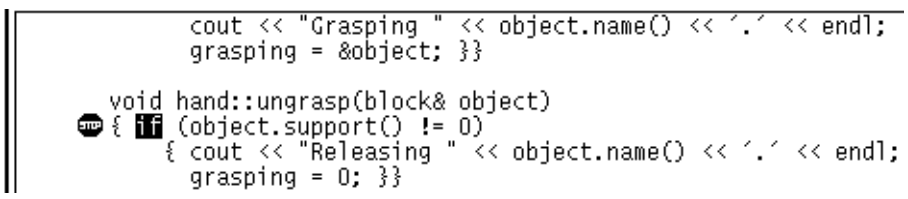
To set a breakpoint at the start of a line of source code:

- **Select any character in the line, then choose Stop At <line> from the Breakpoint menu.**

.



You can also use the stop at button in the Debugger base window display. The Debugger shows the “stop sign” breakpoint glyph to the left of the line at which you set the breakpoint.



You can set a breakpoint at a line from the command pane, using the Debugger `stop at` command:

`stop at [`*filename*`:]`*n*

where `n` is a source code line number and *filename*`:` is an optional program filename qualifier. For example,

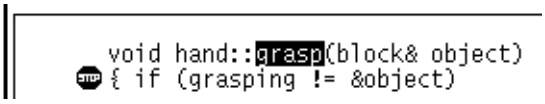
```
(debugger) stop at main.cc:3
```

To use the `stopi` command for setting a breakpoint at a machine instruction, see "Setting Breakpoints at Machine-instruction Level" on page 15-185.

5.1.2 Setting a Breakpoint in a Function

To set a simple breakpoint in a function call:

- **Select the name of the function, then choose Stop In <func> from the Breakpoint menu.**
  You can also use the stop in button in the Debugger base window. The Debugger shows the breakpoint glyph to the left of the line containing the function call.



When selecting a function name, do not select the parentheses or the parameters.

5.1.3 Setting a Breakpoint in a Dynamically Linked Library

The Debugger provides full debugging support for code that makes use of the programmatic interface to the run-time linker; that is, code that calls `dlopen()`, `dlclose()` and their associated functions. The run-time linker binds and unbinds shared libraries during program execution. Debugging support for `dlopen()/dlclose()` allows you to step into a function or set a breakpoint in functions in a dynamically shared library just as you can in a library linked when the program is started.

Two exceptions:

- You cannot set a breakpoint in a `dlopen`'ed library before that library is loaded by `dlopen()`.

- When a library is loaded by `dlopen()`, an initialization routine named `_init()` is called. This routine may call other routines in the library. The Debugger cannot place breakpoints in the loaded library until after this initialization is completed. In specific terms, this means you cannot have the Debugger stop at `_init()` in a library loaded by `dlopen`.

5.2 Setting Multiple Breaks in C++ Programs

The nature of debugging object-oriented programming is such that you may want to check for problems related to calls to members of different classes, calls to any members of a given class, or calls to overloaded top-level functions. You can use one of three keywords—`inmember`, `inclass`, `infunction`—with a `stop` or `when` command to set multiple breaks in C++ code.

The Breakpoints menu contains the `stop` command versions of these keyword commands: `Stop in Member`, `Stop in Class`, `Stop in Function`. (See Figure 5-1). Enter the `when` variants from the command pane.

When you set multiple breakpoints, the command pane reports them as a single set of breakpoints.

```
(debugger) stop inclass hand
(2) stop inclass hand
(debugger)
```

5.2.1 Set Breakpoints in Member Functions of Different Classes

To set a breakpoint in each of the object-specific variants of a particular member function (same member function name, different classes),

- **Select the member function name in the source display and then choose Stop in Member from the Breakpoint menu.**
  To set a `when` type breakpoint, use the `when` command with the keyword `inmember`. For example, in the Blocks demo program, a member function `draw()`, is defined in each of five different classes (hand, brick, ball, wedge, table). To place a breakpoint in each `draw()` function:

  ```
  (debugger) when inmember draw {cmd;}
  ```

5.2.2 Setting Breakpoints in Member Functions of Same Class

To set a breakpoint in all member functions of a specific class:

- **Select the class name in the source display and then choose Stop in Class from the Breakpoint menu.**
  To set a `when` type breakpoint, use the `when` command with the keyword `inclass`. For example, in the Blocks demo program, to set a breakpoint in all member functions of the class hand:

  ```
  (debugger) when inclass hand {cmd;}
  ```

Note – Breakpoints are inserted in only the class member functions defined in this class. It does not include those that it may inherit from base classes.

5.2.3 Setting Multiple Breakpoints in Nonmember Functions

To set multiple breakpoints in nonmember functions with overloaded names (same name, different type or number of arguments):

- **Select the function name in the source display and then choose Stop in Function from the Breakpoint menu.**
  To set a `when` type break, use the `when` command with the keyword `infunction`. For example, if a C++ program has defined two versions of a function named `sort()`, one which passes an `int` type argument, the other a `float`, then, to place a breakpoint in both functions:

  ```
  (debugger) when infunction sort {cmd;}
  ```

5.2.4 Setting a `When` Type Breakpoint at a Line

A `when` type breakpoint command accepts other Debugger commands as side-effect commands. `when` accepts commands like `list`, allowing you to write your own version of trace.

```
(debugger) when at 123 { list $lineno; }
```

Note – `when` operates with an implied `continue`. In the example above, after listing the source code at the current line, the program continues executing.

5.3 Tracing Code

Tracing displays information in the command pane about the line of code about to be executed or a function about to be called. Trace monitors the execution of a specified line of code, all lines within a specified function, or even the whole program. The information printed as each line comes up for execution depends on the type of trace you set and the line of code to be executed.

The location in the program where a trace begins is called the *tracepoint*. The Debugger turns off tracing once the program leaves the scope of the trace.

5.3.1 Setting Trace Commands

Set trace commands from the command pane. The following table shows the command syntax for the types of traces that you can set. The information a trace provides depends on the type of *event* associated with it.

If you use a command:	**Then, `trace` prints:**
`trace`	echo every line in program as it is about to be executed.
`trace in` *function*	the line number of each line while the program is in the function
`trace [at]` *line_number*	line number and the line itself, as that line becomes the next line to be executed.
`trace` *expression* **`at`** *line_number*	value of *expression* when *line_number* is next line to be executed.
`trace` *function*	name of the function that called *function*; line number, parameters passed in, and return value.

trace inmember *member_function*	name of the function that called *member_function* of any class; its line number, parameters passed in, and its return value.
trace inclass *class*	name of the function that called any member_function in *class*; its line number, parameters passed in, and return value.
trace infunction *function*	name of the function that called any nonmember function in C++ program; its line number, parameters passed in and its return value.
trace *variable* [in *function*]	new value of *variable*, if it changes, and the line at which it changed.

5.3.2 Controlling the Speed of a Trace

The Debugger tries to follow a trace in the source display by placing an arrow glyph to the left of the line that is about to be executed. In many programs, code execution is so fast that you would not see much. An environment variable allows you to control the time interval between the execution of each line of code within the scope of the trace. The default interval is `0.5` seconds.

To set the interval between execution of each line of code during a trace:

1. **Choose Debugger Events from the Category menu of the Properties Window.**

2. **Type the time interval in the Trace Speed control text field and press Apply.**

5.4 Setting Event Filters

In the Debugger, most of the event management commands also support an *optional event filter* modifier statement. The simplest filter (see Chapter 6, "Event Management") instructs the Debugger to test for a condition:

- After the program arrives at a breakpoint or tracepoint, or
- After a watch condition occurs.

If this filter condition evaluates to true (non 0), the event command applies. If the condition evaluates to false (0), the Debugger continues program execution as if the event never happened. To set a breakpoint at a line or in a function that includes a conditional filter:

♦ **Add the optional** `if` *condition* **statement to the end of a stop or trace command**

The condition can be any valid expression, including function calls, returning Boolean or integer in the language current at the time the command is entered.

Note – The scope of the condition is the scope at the time of entry, not at the time of the event. So you might have to utilize syntax to specify the scope precisely.

New users sometimes confuse setting a conditional event command (a watch-type command) with using filters. "Watching" creates a *precondition* that must be checked before each line of code executes (within the scope of the watch). But even a breakpoint command with a conditional trigger can also have a filter attached to it. Consider this case: first the syntax, then a specific example,

```
stop modify <address> -if condition
```

```
(debugger) stop modify &speed -if speed==fast_enough
```

This command instructs the Debugger to monitor the variable, *speed*; if the variable *speed* is written to (the "watch" part), then the `-if` filter goes into effect. The Debugger checks to see if the new value of *speed* is equal to `fast_enough`. If it is not, the program continues on, "ignoring" the `stop`.

In the Debugger syntax, the post-break modifier is represented in the form of an `[-if` *condition*`]` statement at the end of the formula:

```
stop in function [-if condition]
```

5.5 Listing and Clearing Event Management Commands

Often, you set more than one breakpoint or tracepoint during a debugging session. The Debugger supports commands for listing and clearing them.

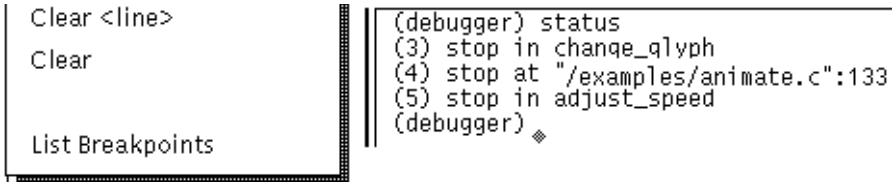
5.5.1 Listing Breakpoints and Traces

The List Breakpoints item on the Breakpoints menu lists all currently active breakpoint commands in the command pane.

To display a list of all active breakpoints in the command pane:

- **Choose List Breakpoints from the Breakpoint menu.**
  List Breakpoints is the same as the Debugger `status` command.

  The Debugger echoes the command and lists the breakpoints in the command pane.



  Notice the ID number in parentheses to the left of each listed breakpoint. You can use these IDs to clear the corresponding breakpoints.

  As noted in the section on C++ multiple breakpoints, the Debugger reports multiple breakpoints set with the `inmember`, `inclass`, and `infunction` keywords as a single set of breakpoints with one status ID number.

5.5.2 Clearing a Breakpoint at a Line

To clear a single breakpoint at a specific line:

1. **Select the line in the source display where the breakpoint is set.**
2. **Choose Clear <line> from the Breakpoint menu.You can also use the clear button from the Debugger base window.**

5.5.3 Clearing a Breakpoint from the Current Focus Line

To clear a breakpoint set at the current focus line:

- **Choose Clear from the Breakpoint menu.**

5.5.4 Deleting Specific Breakpoints Using Status ID Numbers

When you list event management commands in the command pane (using either List Breakpoints or the Debugger `status` command), the Debugger assigns an ID number to each event handler. Using the `delete` command in the command pane, you can remove event handlers by ID number, or use the keyword `all` to remove all event handlers currently set anywhere in the program.

To delete event handlers by ID number,

- **Use the** `delete` *ID_number* **command in the command pane.**

  `(debugger)` **delete 3 5**

To delete all event management commands set in the program currently loaded in the Debugger,

- **Give the** `delete` **command an argument of** `all`:

  `(debugger)` **delete all**

5.5.5 Watchpoints

Watchpointing is the general capability of the Debugger to note when the value of a variable or expression has changed and fired an event.

Stopping Execution When the Contents of an Address gets Written to

To stop program execution when the contents of an address gets written to:

`(debugger)` **`stop modify &<variable>`**

Points to keep in mind when using `stop` *modify*

- The event occurs when a variable gets written to even if it is the same value.
- The event occurs at the instruction that wrote to the variable, although its new contents are set. The program location arrow typically points to the line that does the modification.
- You cannot use addresses of stack variables, for example, automatic function local variables.

Stopping Execution When a Specified Variable Changes

To stop program execution if the value of a specified variable changes:

♦ **Use the** `stop` *variable* **or the** `when` *variable* **command formula in the command pane:**

`(debugger)` **stop variable**

`(debugger)` **when variable {cmd;...}**

The `when` *variable* command accepts follow-on commands, as explained in "Setting a When Type Breakpoint at a Line" on page 5-64.

Points to Keep in Mind When Using `stop` *variable*

Consider the following points when using `stop` *variable*. Note that, except for the first point, these points apply to using `trace` *variable* as well:

- The Debugger stops the program *at the line after* the line that caused a change in the value of the specified variable. So, when the program stops, the program location arrow does not point to the actual line that triggered the change in value. (Does not apply to `trace` *variable*.)
- If *variable* is local to a function, the variable is considered to have changed when the function is first entered and storage for *variable* is allocated. The same is true with respect to parameters. (Applies also to `trace` *variable*.)

  The Debugger implements `stop` *variable* by causing automatic single stepping together with a check on the value at each step. Stepping skips over library calls. So, if control flows in the following manner:

```
user_routine calls
   library_routine, which calls
      user_routine2 // changes variable
```

the Debugger does not trace the nested *user_ routine2*. It does not trace the nested call because tracing skips the library call and the nested call to `user_routine2`, so the change in the value of *variable* appears to have occurred after the return from the library call, not in the middle of user_routine2. (Applies also to `trace` *variable*.)

- The Debugger cannot set a breakpoint for a change in a block local variable, that is, a variable nested in {}. If you try to set a breakpoint (or trace) a block local "nested" variable, the Debugger issues an error informing you that it cannot perform this operation. (Applies also to `trace` *variable*.)

Stopping Execution if a Specified Condition Occurs

To stop program execution if a conditional statement evaluates to true:

♦ **Use** `stop if` *condition*:

`(debugger)` **stop if condition**

5.6 Event Efficiency

Various events have varying degrees of overhead in respect to the execution time of the program being debugged. Some events, like the simplest breakpoints have practically no overhead. Events based on a single breakpoint, like

`trace` <*lineno*>

`trace` <*expression*> `at` <*lineno*>

also have minimal overhead. Multiple breakpoints (such as `inclass`) that might sometimes result in hundreds of real breakpoints, have an overhead only during installation time. This is because dbx uses permanent breakpoints, that is, the breakpoints are retained in the process at all times and are not taken out on every stoppage and put in on every `cont`.

Note – In the case of `step` and `next`, by default all breakpoints are taken out before the process is resumed and reinserted once the step completes. If you are using many breakpoints or multiple breakpoints on prolific classes the speed of `step` and `next` slows down considerably.

Use the dbxenv `stepevents` variable to control whether breakpoints are taken out and reinserted after each `step` or `next`.

The slowest events are those that utilize automatic single stepping. This might be explicit and obvious as in the plain `trace` command, which single steps through every source line. Other events, like `stop` <*expr*> or `trace` <*variable*> (a class of events called *watchpoints*) not only single step automatically but also have to evaluate an expression or a variable at each step.

These are very slow, but you can often overcome the slowness by bounding the event with a function using the `-in` modifier. For example:

- `trace -in mumble`

  Do not use `trace -in main` because the `trace` is effective in the functions called by `main` as well.

- `stop clobbered_variable -in lookup`

  Do not use in the cases where you suspect that the `lookup()` function is clobbering your variable.

A faster way of doing watchpoints is to use the `modify` event. For information on the `modify` event, see Section 6.4, “Event Specifications,” on page 6-78.

Instead of automatically single-stepping the program, it uses a page protection scheme which is much faster. The speed depends on how many times the page on which the variable you are watching is modified, as well as the overall system call rate.

Event Management 6

This chapter describes *event management*. Event management refers to the general capability of the Debugger to handle events by performing certain actions when certain events take place in the program being debugged.

This chapter is organized into the following sections:

The most common example of the association of a program event with a Debugger action is setting a breakpoint on a particular line. A change in the value of a specified variable is another type of event that triggers a stop.

Event management is based on the concept of a "*Handler*". The name comes from an analogy with hardware interrupt handlers. Each event management command typically creates a handler. To do that an *event specification* and a series of side-effect actions need to be specified. The most generic form of creating a handler is through the `when` command:

when *event-specification* { *action*; ... }

Although all event management can be performed through when, dbx has historically had many other commands. Those commands are still retained, either for backward compatibility, or because they are simpler and easier to use.

In many places examples are given on how a command (like stop, step, or ignore) can be written in terms of when. These examples are meant to illustrate the flexibility of the when and the underlying *handler* mechanism, but they are not always exact replacements.

6.1 Event Management Commands

The following commands (when, stop, and trace) create event handlers. An *event-spec* is a specification of an event as documented in this chapter.

An attempt has been made to make the stop and when commands regular and to make them conform to the handler model. However, backward compatibility forces some deviations. For instance:

```
when cond body
when cond in func body
```

are really equivalent to

```
when step -if cond body
when next -if cond -in func body
```

The point being illustrated here is that *cond* is not a pure event; there is no internal handler for "conditions".

Every command returns a number known as a handler id (*hid*). This number can be accessed via the predefined variable $newhandlerid.

when when *event-spec* [*modifier* ...] { *dbx-cmd* ; [...] }
wheni *event-spec* [*modifier* ...] { *dbx-cmd* ; [...] }

When the specified event occurs, execute the series of dbx commands. Once the commands have all executed, the process is automatically continued.

stop `stop` *event-spec* [*modifier* ...]
`stopi` *event-spec* [*modifier* ...]

When the specified event occurs, stop the process and notify the user. `stop` is shorthand for a common `when` idiom:

`when` *event-spec* { `stop -update; whereami;` }

trace `trace` *trace-event-spec*

The `trace` command is divided into three categories, and all categories can be filtered. The categories are described in this section.

- Line tracing
- Function tracing
- Variable and expression tracing

Line Tracing

`trace`
Automatically steps and prints every line that is executed. Function calls and returns are traced as well.

`trace in` *func*

A “bounded” version of `trace`. Automatically performs a `next` and prints every line within the given function.

`trace` [`at`] *line*

Prints the line every time you go through it. Implemented using breakpoints.

Function Tracing

`trace` *func*

Prints information about every entry and return from the given function.

`trace inmember/infunction` *func*

Prints information about every entry and return from the given member or overloaded function.

`trace inclass` *class*

Prints information about every entry and return from members of the given class.

Variable and Expression Tracing

`trace` *expr* `at` *line*

Is equivalent to:

```
when at line { print expr; }
```

`trace` *expr* [`in` *func*]

Automatically single-steps the program and if the given expression changes value, prints the new value. If `in` *func* is used, the stepping and checking is "bounded" by the given function.

If you do not provide an `in` but *expr* is comprised of local variables, dbx automatically determines the function and adds in an implicit `in` *func*. If the expression is too complicated and involves variables from multiple function scopes, the heuristics that dbx uses to determine the bounding function may fail.

Filtering

`trace` ... `if` *cond*

All of the `trace` forms can be filtered by using the `if` notation.

Most of the `trace` commands described can be hand-crafted by using the `when` command, ksh functionality, and event variables. This is especially useful if you want stylized tracing output.

`Trace` functions that depend on automatic single-stepping are inherently slow, particularly for tracing variable changes. Use the "`when modify`" command for a faster version. For a general discussion of speed and efficiency, see Section 5.6, "Event Efficiency," on page 5-71.

The `when`, `stop`, and `trace` commands are fully backward compatible. In addition, the `stop` and `when` commands have many new extensions as documented later in this chapter.

6.2 Commands to Manipulate the Event Handlers

The following list contains commands to manipulate event Handlers:

status

`status` [-s]
`status` [*-s*] *hid*

`status` with no argument lists all handlers, that is, `trace`, `when`, and `stop`; `status` *hid* lists the given handler. If the handler is disabled, its *hid* is printed surrounded by [ ] square brackets instead of the normal ( ) parentheses.

The output of `status` can be redirected to a file. Nominally, the format is unchanged during redirection. You can use the `-s` flag to produce output that allows a handler to be reinstated by using the `source` command.

The original technique of redirecting handlers by using `status` and `source`'ing the file was a way to compensate for the lack of handler enabling and disabling functionality (see `handler -enable`).

delete

`delete` *hid* [*hid* ...]
`delete all`
`delete` 0

`delete` *hid* deletes the specified handler; `delete all` or `delete` *0* (zero) deletes all handlers.

clear

`clear`
`clear` *line*

`clear` with no arguments deletes all handlers based on breakpoints on the current line; `clear` *line* deletes all handlers based on breakpoints on the designated line.

handler disable

`handler -disable` *hid* [...]
`handler -disable all` [...]

`handler -disable` *hid* disables the specified event; `handler -disable all` disables all handlers.

handler enable

`handler -enable` *hid* [...]
`handler -enable all`

`handler -enable` *hid* enables the specified handler; `handler -enable all` enables all handlers.

6.3 Event Counters

Event handlers have trip counters. There is a count limit and the actual counter. Whenever the event occurs, the counter is incremented. The event fires only if the count reaches the limit, at which point the counter is automatically reset to 0. The default limit is 1. Whenever a process is rerun, all event counters are reset.

The count limit can be set using the `-count` modifier as explained in Section 6.4, "Event Specifications," on page 6-78. Otherwise, the following commands can be used to manipulate event handlers individually.

handler

`handler -count` *hid*
`handler -count` *hid new-count*
`handler -reset` *hid*

`handler -count` *hid* returns the count of the event in the form *curcount*/*limit* (same as printed by `status`). *limit* might be the keyword `infinity`. Use the ksh modifiers `${#}` and `${##}` to split the printed value.

`handler -count` *hid new-count* assigns a new count limit to the given handler.

`handler -reset` *hid* resets the count of the handler to 0 (zero).

6.4 Event Specifications

Event specifiers are used by the `stop` and `when` commands to denote event types and parameters. The format is that of a keyword to represent the event type and optional parameters. Exceptions are *expression* (included to maintain backwards compatibility) and the `trace` command, where the event specifier syntax is not as regular.

When no keyword is recognized, an expression is assumed. Also, depending on whether `stop` or `when` is used, *expression* is either a variable (value) to be watched, or has to be a boolean valued expression to be used as a condition.

A list of all types, their eventspec syntax, and semantics follows:

in *func* The function has been entered and the first line is about to be executed. If the `-instr` modifier is used, it is the first instruction of the function about to be executed. (Do not confuse `in func` with the `-in` *func* eventspec. For information on the `-in` *func* modifier, see "Event Specification Modifiers" on page 6-85.)

The *func* specification can take a formal parameter signature to help with overloaded function names, or template instance specification. For example, you can say:

```
stop in mumble(int, float, struct Node *)
```

at *lineno*

at *filename*:*lineno* The designated line is about to be executed. If *filename* is provided, then the designated line in the specified file is about to be executed.

infunction *func* Equivalent to `in` *func* for all overloaded functions named *func*, or all template instantiations thereof.

inmember *func*

inmethod *func* Equivalent to `in` *func* for the member function named *func* for every class.

inclass *classname* Equivalent to `in` *func* for all member functions that are members of *classname*.

expression With `stop`: the value of *expression* has changed. *expression* must be an lvalue.

With `when`: the *expression* evaluates to true. *expression* must be a boolean value.

To implement this event, dbx automatically single-steps the application and checks for the condition on each single step.

Note that event specifications are keyword driven. The last one, *expression*, is an exception for backward compatibility. Whenever no keyword is recognized, an expression is assumed.

See Section 5.5.5, "Watchpoints," on page 5-69 for important points to remember when using stop.

returns This event is just a breakpoint at the return point of the current *visited* function. The visited function is used so that you can use the `returns` event spec after doing a number of 'up's. The plain return event is always `-temp` and can only be created in the presence of a live process. As an example, consider that

```
step up
```

is equivalent to:

```
when returns {
    stop; echo returned to $func
}
cont
```

returns *func* It is another way of saying:

```
when in func { stop returns; }
```

This event fires each time the given function returns to its call site. This is not a temporary event. The return value is not provided, but you can find it through `$O0` on SPARC and `$eax` on x86.

step The `step` event fires when PC reaches the first instruction of a source line. For example, the `trace` command is equivalent to:

```
when step { echo $lineno: $line; }
```

When enabling a step event you basically instruct dbx to single-step automatically next time `cont` is used.

The `step` *command* can be implemented as follows:

```
alias step="when step -temp { whereami; stop; }; cont"
```

next Similar to `step` except that functions are not stepped into.

throw `throw` **[***type***]**

This event fires when a C++ `throw` statement is executed with an expression of type *type*. The rules for matching an expression of a specific type are as follows:

A handler type T matches a `throw` type E if any of the following is true,

- T is same as E;
- T is const or volatile of E;
- E is const or volatile of T;

- T is ref of E or E is ref of T;
- T is a public or protected base of E;
- T and E are both pointer types and E can be converted to T by standard pointer conversion.

If no T type is provided, any C++ throw statement causes this event.

Note – While handlers of type (`X`) and (`X&`) both match an exception of type `X`, the semantics are different. The use of a handler with type (`X`) results in the invocation of its copy constructor and possible truncation of the object (happens when the exception is derived from `X`).

---

sig *sig* When the specified signal is first delivered to the child this event fires. This is completely independent of the `catch`/`ignore` commands although the `catch` command can be implemented as follows:

```
function simple_catch
{
    when sig $1 {
        stop;
        echo Stopped due to $sigstr $sig
        whereami
        }
}
```

The `ignore` command disables anything established by `catch`, it doesn't mask out signals.

Note – When the sig event is received, the process is still alive. Only if you `cont` the process with the given signal is the signal forwarded to it.

---

sig can either be a decimal number or the signal name in either upper or lower case, with the "SIG" prefix being optional.

sig *sig sub-code* When the specified signal with the specified sub-code is first delivered to the child this event fires.

Just as with signals, the sub-code can be entered as a decimal number, in capital or lower case; the prefix is optional.

A list of the names of all signals and sub-codes and their numerical equivalents can be accessed using “help signals”.

fault *fault* This event fires when the specified fault occurs. The faults are architecture dependent, but a standard set of them is known to dbx:

FLTILL	Illegal instruction
FLTPRIV	Privileged instruction
FLTBPT	Breakpoint instruction
FLTTRACE	Trace trap (single step)
FLTACCESS	Memory access (such as alignment)
FLTBOUNDS	Memory bounds (invalid address)
FLTIOVF	Integer overflow
FLTIZDIV	Integer zero divide
FLTPE	Floating-point exception
FLTSTACK	Irrecoverable stack fault
FLTPAGE	Recoverable page fault

These faults are taken from `sys/fault.h`. *fault* can be any of those listed above, in upper or lower case, with or without the FLT- prefix, or the actual numerical code. Be aware that BPT, TRACE, and BOUNDS are used by dbx to implement breakpoints, single-stepping, and watchpoints. Handling them may interfere with the inner workings of dbx.

stop The process has stopped. Whenever the process stops such that the user gets a prompt, particularly in response to a `stop` handler, this event is fired.

sync The process being debugged has just been `exec`'ed. All memory specified in `a.out` is valid and present but pre-loaded shared libraries have not been loaded yet. For example, `printf`, although known to the Debugger, has not been mapped into memory yet.

A `stop` on this event is ineffective; however, you can use this event with the `when` command.

syncrtld This event is fired after a `sync` (or `attach` if the process being debugged has not yet processed shared libraries). It fires after the startup code has executed and the symbol tables of all preloaded shared libraries have been loaded.

A `stop` on this event is ineffective; however, you can use this event with the `when` command.

attach The process being debugged has just attached to the process to be debugged.

lastrites The process being debugged is about to expire. There are only three reasons that this can happen:

- The `_exit`(2) system call has been called. (This happens either through an explicit call, or when `main`() returns.)
- A terminating signal is about to be delivered.
- The process is being killed by the dbx `kill` command.

dlopen [*lib-path*]

dlclose [*lib-path*]

These events are fired after a `dlopen`() or a `dlclose`() call succeeds. A `dlopen`() or `dlclose`() call can cause more than one library to be loaded. The list of these libraries is always available in the predefined variable `$dllist`. The first word in `$dllist` is actually a "+" or a "-", indicating whether the list of libraries is being added or deleted.

lib-path is the full pathname of a shared library you are interested in. If it is specified, the event only fires if the given library was loaded or unloaded. In that case `$dlobj` contains the name of the library. `$dllist` is still available.

If *lib-path* is not specified, then the events always fire whenever there is any `dl`-activity. `$dlobj` is empty but `$dllist` is valid.

modify *addr-exp* [, *byte-size*]

The specified address range has been modified. This is the general "watchpoint" facility.

The syntax of the event-specification for watchpoints is:

`modify` <*addr-exp*> [, <*byte-size-exp*>]

<*addr-exp*> is any expression that can be evaluated to produce an address. If a symbolic expression is used, the size of the region to be watched is automatically deduced, or you can override that with the `,' syntax. You can also use nonsymbolic, typeless address expressions; in which case, the size is mandatory. For example:

```
stop modify 0x5678, sizeof(Complex)
```

There are two styles of watchpoints in dbx. The older, slower style uses automatic single-stepping and is invoked by using:

`trace` <*expr*>
`stop` <*cond*>
`when` <*variable*> {`...`}

Limitations

Addresses on the stack cannot be watched.

The event is not fired if the address being watched is modified by a system call.

Shared memory (MAP_SHARED) cannot be watched, because the Debugger cannot catch the other processes stores into shared memory. Also, the Debugger cannot properly deal with SPARC `swap` and `ldstub` instructions.

sysin ***code*|*name*** The specified system call has just been initiated and the process has entered kernel mode.

The concept of "system call" supported by dbx is that provided by `procfs(4)`. These are traps into the kernel as enumerated in "`/usr/include/sys/syscall.h`".

This is not the same as the ABI notion of system calls. Some ABI system calls are partially implemented in user mode and use non-ABI kernel traps. However, most of the generic system calls (the exception being signal handling) are the same between "`syscall.h`" and the ABI.

sysout ***code*|*name*** The specified system call is finished and the process is about to return to user mode.

sysin

sysout Without arguments, all system calls are traced. Note that certain dbx features, for example `modify` event and RTC, cause the child to execute system calls for their own purposes and that these show up if traced.

6.5 *Event Specification Modifiers*

An Event Specification Modifier sets additional attributes of a handler, the most common kind being event filters. Modifiers have to appear after the keyword portion of an eventspec. They all begin with a '`-`', preceded by blanks. The non '`-`' version provides backward compatibility.

Modifiers consist of the following:

-if `-if` *cond*
`if` *cond*

The condition is evaluated when the event specified by the *event-spec* occurs. The event is fired only if the condition evaluates to nonzero. The non '`-`' version provides backward compatibility.

The condition is sometimes called a filter. A handler created with a filter is known as a filtered handler.

-in `-in` *func*
`in` *func*

The handler is enabled only while within the given function, or any function called from *func*. See Example Section 6.9.3, “Enable Handler While Within the Given Function (in func),” on page 6-91.

The number of times the function is entered is reference counted so as to properly deal with recursion.

The handler that has been modified by the `-in` modifier is said to be "bounded by *func*".

-disable `-disable`

Create the handler in the disabled state (see "`handler -disable`").

-count `-count` *n*
`-count infinity`

Have the handler count from 0. Each time the event occurs, `count` is incremented until it reaches *n*. Once that happens, the handler fires. The `status` command prints out the count in the form

curcount / *limit*

Counts of all enabled handlers are reset when a program is run or rerun. More specifically, they are reset when the `sync` event occurs (see "`handler -count`").

-temp `-temp`

Create a temporary handler. Once the event is fired it is automatically deleted. By default, handlers are not temporary. If the handler is a counting handler, it is automatically deleted only when the count reaches 0 (zero).

Upon `lastrites`, all temporary handlers are deleted.

-instr `-instr`

Makes the handler act at an instruction level. This replaces the traditional '`i`' suffix of most commands. It usually modifies two aspects of the event handler:

- Any message prints assembly level rather than source level information.
- The granularity of the event becomes instruction level. For instance, `step -instr` implies instruction level stepping.

-thread `-thread` *tid*

The event is fired only if the thread that caused it matches *tid*.

-lwp `-lwp` *lid*

The event is fired only if the thread that caused it matches *lid*.

6.6 A Note on Parsing and Ambiguity

Syntax for event-specs and modifiers is

- keyword driven.
- based on ksh conventions, mainly that everything is split into "words" delimited by spaces.

For the sake of backward compatibility, expressions can have spaces embedded in them. This can cause ambiguous situations. For example, consider the following two commands:

```
when a -temp          # first example
```

and

```
when a-temp           # second example
```

In the first example, even though the application might have a variable named *temp*, the dbx parser resolves the *event-spec* in favor of `-temp` being a modifier. In the second example, `a-temp` is collectively passed to a language specific expression parser and there must be variables named *a* and *temp* or an error occurs.

Use parentheses to force parsing. For instance, "`when` (`a -temp`)" is equivalent to the second example.

6.7 Additional Process Control Commands & Enhancements

stop

```
stop
stop -update|-noupdate
```

This form of the `stop` command is valid only inside the body of a `when`. Whereas normally the process is continued after the body has executed, the `stop` command prevents that. Normally the `stop` command causes an update message to be sent to various interested parties, like the "display" mechanism, and under the GUI, the Data Inspector and Stack Inspector. `-noupdate` disables the message.

In general, the following are equivalent:

```
stop event-spec
```

is equivalent to

```
when event-spec { whereami; stop; }
```

and

```
stopi event-spec
```

is equivalent to

```
when event-spec -instr { whereami -instr;stop; }
```

step `step [ -sig sig ]`

The `step` command is equivalent to:

```
when step -temp { stop; }; cont
```

The `step` command can take a `sig` argument. A `step` by itself cancels the current signal just like `cont` does. To forward the signal, you must explicitly give the signal. You can use the variable `$sig`, as in:

```
step -sig $sig
```

to step the program sending it the current signal.

cancel `cancel`

Only valid within the body of `when`. The `cancel` command cancels any signal that might have been delivered, and lets the process continue. For example:

```
when sig SIGINT { echo signal info;  cancel; }
```

6.8 Predefined Variables

Certain read-only ksh predefined variables are provided. The following are always valid:

`$pc`	current program counter address (hexadecimal)
`$ins`	disassembly of the current instruction
`$lineno`	current line number in decimal

`$line`	contents of the current line
`$func`	name of the current function
`$vfunc`	name of the current “visiting” function
`$class`	name of the class to which `$func` belongs
`$vclass`	name of the class to which `$vfunc` belongs
`$file`	name of the current file
`$vfile`	name of the current file being visited
`$loadobj`	name of the current loadable object
`$vloadobj`	name of the current loadable object being visited
`$funcaddr`	address of `$func` in hex
`$caller`	name of the function calling `$func`
`$dllist`	after `dlopen` or `dlclose` event, contains the list of load objects just dlopened or dlclosed. The first word of `dllist` is actually a “+” or a “-” depending on whether a `dlopen` or a `dlclose` has occurred.
`$newhandlerid`	id of the most recently created handler
`$proc`	process id of the current process being debugged
`$lwp`	lwp id of the current LWP
`$thread`	thread id of the current Thread
`$prog`	full pathname of the program being debugged

As an example, consider that `whereami` can be roughly implemented as:

```
function whereami {
      echo Stopped in $func at line $lineno in file $(basename $file)
        echo "$lineno\t$line"
```

6.8.1 Event-specific Variables

The following are only valid within the body of a `when`.

`$handlerid`

During the execution of the body, `$handlerid` is the id of the `when` command to which the body belongs. As a simple example consider that

```
when X -temp { do_stuff; }
```

is equivalent to

```
when X  { do_stuff; delete $handlerid; }
```

The following are only valid within the body of a `when` and in addition are event specific.

For Event `sig`

`$sig`	signal number that caused the event
`$sigstr`	name of `$sig`
`$sigcode`	subcode of `$sig` if applicable
`$sigcodestr`	name of `$sigcode`

For Event `exit`

`$exitcode`	value of the argument passed to `_exit`(2) or `exit`(3) or the return value of `main`.

For Events `dlopen` *and* `dlclose` *(only if a param was provided)*

`$dlobj`	pathname of the load object dlopened or dlclosed

For events `sysin` *and* `sysout`

`$syscode`	system call number
`$sysname`	system call name

6.9 Examples

6.9.1 Set Watchpoint for store to Array Member

To set a watchpoint on `array`[99]:

```
(dbx) stop modify &array[99]
(2) stop modify &array[99], 4
(dbx) run
Running: watch.x2
watchpoint array[99] (0x2ca88[4]) at line 22 in file
"watch.c"
     22    array[i] = i;
```

6.9.2 Simple Trace

To implement a simple trace:

```
(dbx) when step { echo at line $lineno; }
```

6.9.3 Enable Handler While Within the Given Function (`in` *func)*

For example:

```
trace -in foo
```

is equivalent to something like:

```
# create handler in disabled state
when step -disable { echo Stepped to $line; }
t=$newhandlerid    # remember handler id
when in foo {
    # when entered foo enable the trace
     handler -enable "$t"
     # arrange so that upon returning from foo,
     # the trace is disabled.
     when returns { handler -disable "$t"; };
}
```

6.9.4 Determine the Number of Lines Executed in a Program

To see how many lines were executed in a small program:

```
(dbx) stop step -count infinity # step and stop when count=inf
(2) stop step -count 0/infinity
(dbx) run
...
(dbx) status
(2) stop step -count 133/infinity
```

We obviously never stop—the program terminates. 133 is the number of lines executed. This process is very slow though. This technique is more useful with breakpoints on functions that are called many times.

6.9.5 Determine the Number of Instructions Executed by a Source Line

To count how many instructions a line of code executes (this was a requested RFE).

```
(dbx) ...                                   # get to the line in question
(dbx) stop step -instr -count infinity
(dbx) step ...
(dbx) status
(3) stop step -count 48/infinity # 48 instructions were executed
```

If the line you are stepping over makes a function call, you end up counting those as well. You can use the `next` event instead of `step` to count instructions, excluding called functions.

6.9.6 Enable Breakpoint after Event Occurs

Enable a breakpoint only after another event has fired. Suppose things go bad in function `hash`, but only after the 1300'th symbol lookup:

```
(dbx) when in lookup -count 1300 {
      stop in hash
      hash_bpt=$newhandlerid
      when lastrites -temp { delete $hash_bpt; }
}
```

Note that `$newhandlerid` is referring to the just executed `stop in` command.

6.9.7 *Set Automatic Breakpoints for* `dlopen` *Objects*

To have breakpoints in dlopened objects be managed automatically:

```
(dbx) when dlopen /home/myname/mylib.so {
      # delete old one
      if [ -n "$B1" ]
      then  delete "$B1"
      fi
      # create new one
      stop in func
      B1="$newhandlerid"
}
```

6.9.8 *Reset Application Files for* `replay`

If your application processes files that need to be reset during a `replay`, you can write a handler to do that for you each time you run the program:

```
(dbx) when sync { sh regen ./database; }
(dbx) run < ./database
...                     # during which database gets clobbered
(dbx) save
...
(dbx) restore           # implies a RUN, which implies the SYNC event,
                        # which causes regen to run
```

6.9.9 *Check Program Status*

To see quickly where the program is while it's running:

```
(dbx) ignore sigint
(dbx) when sig sigint { where; cancel; }
```

Then type ^C to see a stack trace of the program without stopping it.

This is basically what the collector hand sample mode does (and more of course). Use SIGQUIT (^\) to interrupt the program because ^C is now used up.

6.9.10 Catch Floating Point Exceptions

To catch only specific floating-point exceptions, for example, IEEE underflow:

```
(dbx)ignore FPE                    # turn off default handler
(dbx) help signals | grep FPE      # can't remember the subcode name
...
(dbx) stop sig fpe FPE_FLTUND
 ...
```

Running, Stepping, Continuing 7

This chapter describes how to run, attach to, continue, and rerun a program in the Debugger; and how to single-step through lines of program code. The commands —Run (`run`, `rerun`), Next (`next`), Step (`step`), and Continue (`cont`)— are called *process control* commands. Used together with the event management commands (`stop`, `when`, `trace`) described in Chapter 5, “Setting Breakpoints and Traces” on page 5-59, and Chapter 6, “Event Management” on page 6-73, you can control the run-time behavior of a program executing under the Debugger.

This chapter is organized into the following sections:

7.1 Running a Program in the Debugger

When you first load a program into the Debugger, the Debugger visits the program’s “main” block (`main()` for C and C++, `MAIN()` for FORTRAN). (See Section 1.3.3, “Interaction of dbx with the Dynamic Linker,” on page 1-7 for more information on what happens at program startup.) The Debugger waits for you to issue further commands; you can visit code or use event management commands.

You may choose to set breakpoints in the program before running it in the Debugger. When ready, use the `run` command to start program execution.

7.1.1 Running a Program Without Arguments

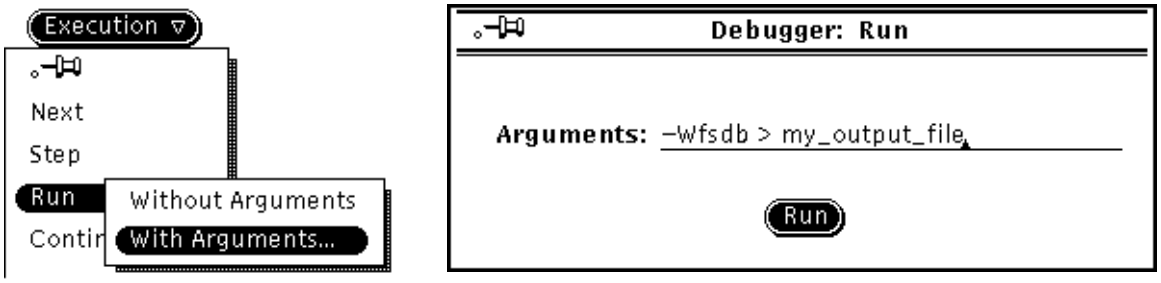
To run a program in the Debugger without arguments:

- **Choose Run from the Execution menu.**

7.1.2 Adding Arguments to the `Run` Command

To run a program with command line arguments:

- **Choose With Arguments from the Run pull-right menu to display the Run pop-up window; type in the arguments and click on Run. You can also use the run button in the Debugger base window.**



7.1.3 Redirecting Input and/or Output

You can redirect input and/or output to and from a specified file by specifying the input or output filenames in the Run With Arguments line pop-up window or in the command pane.

To redirect input and/or output to and from a file for the Run command,

- **Type the filename after any arguments, using the appropriate redirection operators:**

Redirect output only:

Arguments: -Wfsdb > my_output_file

Redirect input only:

Arguments: -Wfsdb < my_input_file

Here is the syntax for the corresponding Debugger command:

`run` [*arguments*][`<` *input_file* | `>` *output_file*]

Note that output from the Run command overwrites an existing file even if you have set `noclobber` for the shell in which you are running the Debugger.

7.1.4 Rerunning a Program

To run a program again, use the Run command to restart execution:

- **Choose Run:No Arguments or Run:With Arguments from the Execution menu.**
  If you use Run With Arguments, Run uses whatever arguments are on the Argument text field line in the Run pop-up window.

  If you choose Run:No Arguments, the program does not use arguments entered previously in the current debugging session. (The dbx `rerun` command is the equivalent of Run:No Arguments. dbx "`run`" reuses previous arguments.)

7.1.5 Attaching the Debugger to a Running Process

You may need to debug a program that is already running. For example, you may want to debug a running server and you do not want to quit or kill it; or a program may be looping indefinitely and you would like to examine it under the control of the Debugger without killing it. You can *attach* the Debugger to a running program by using the program's *pid* number as an argument to the `debug` command or to the Debugger start-up command.

Once you have debugged the program, you can then use the `detach` command to take the program out from under the control of the Debugger without terminating the process.

Note – If you quit the Debugger after having attached it to a running process, the Debugger implicitly detaches before terminating.

To attach the Debugger to a program that is running independently of the Debugger:

1. **Determine the** *process_ID* **of the program**
   One way is to use the `ps` utility,

2. **Then,**

   a. **If the Debugger is already running, type in the command pane:**
      `(debugger)` **debug** *program_name process_ID*

      You can substitute a dash "-" for the *program_name*. If you use a "-" instead of the program_name, the Debugger automatically finds the program associated with the pid and loads it. Note that you cannot use `run` because the full pathname is not known.

   b. **If the Debugger is not running, start the Debugger with the** *process_ID* **(`pid`) number as an argument:**

      `machine%` **debugger** *program_name process_ID*

      You can substitute a dash "-" for the *program_name*, as with the `debug` command.

After you have attached the Debugger to a program, the program stops executing. You can examine it as you normally would any program loaded into the Debugger. You can use any event management or process control commands to debug it.

7.1.6 Detaching a Process from the Debugger

When you have finished debugging the program, use the `detach` command to detach the Debugger from the program. The program then resumes running independently of the Debugger.

To detach a process from running under the control of the Debugger:

- **Use the Debugger** `detach` **command**

  `(debugger)` **detach**

7.2 *Single-step Execution:* Next, Step *and* Call

The Debugger supports two basic single step commands: `Next` and `Step`, plus a variant of Step, called `step up`. Both Next and Step cause the program to execute one source line.

If the line executed contains a function call, Next executes that call and returns from it ("steps over" the call). Step stops at the first line in a called function.

`step up` (available only as a dbx command) returns the program to the caller function after you have stepped into a function.

`pop` (available only as a dbx command) pops the top frame off the stack and adjusts the frame pointer and the stack pointer accordingly. The `pop` command also changes the program counter to the beginning of the source line. Type `help pop` in the command pane for more information.

7.2.1 *Issuing* Next *and* Step *Commands*

To single-step, stepping over functions:

- **Choose Next from the Execution Menu. You can also use the next button from the Debugger base window.**

The Program Location glyph advances and points to the new "next line."

To single step, stepping into functions:

- **Choose Step from the Execution menu. You can also use the step button from the Debugger base window.**

The source display shows the function and points at the first line.

Note that each time you single step to a line in a different function, the value of the Visiting Function information field changes automatically to match this new program location function.

To return to the caller after stepping into a function:

- **Type in the command pane**

  `(debugger)` **step up**

Specifying a Number of Single-steps

Note that the Debugger commands `step` and `next` accept a number arguments that let you specify an exact number of source lines to execute before stopping. The default is 1.

To single step a specified number of lines of code:

- **Use the appropriate debugger command,** `next` **or** `step` **followed by the number of lines** [*n*] **of code you want executed before stopping:**

  `(debugger)` **`step`** *n*

7.2.2 Calling a Function

When a program is stopped, you can call a function using the Debugger `call` command. The `call` command accepts values for the parameters that must be passed to the called function.

Note – By default, after every `call` command, the Debugger automatically calls `fflush(stdout)` to ensure that any information stored in the I/O buffer is printed. (A user may call a function *explicitly*, using the `call` command, or *implicitly*, either by evaluating an expression containing function calls, or using a conditional modifier (such as, "`stop in glyph if animate()`"). To turn off automatic flushing, set Auto Flush control to Off. Auto Flush is located on the Debugging Environment Attributes Property Window. You can also use `dbxenv autoflush` or `$DBX_autoflush`.

To call a procedure from the Debugger shell:

- **Type the name of the function and supply its parameters:**

```
(debugger) call change_glyph(1,3)
```

Here is the syntax for `call`:

```
call function_name ([parameters])
```

Notice that while the parameters are optional, you must type in the parentheses after the *function_name*, for example,

```
(debugger) call type_vehicle()
```

You can include backquotes as well as `classname::funcname()` for static member functions and `object.funcname` for member functions using "object" as the "this" parameter.

Unless the called function contains a breakpoint, when you use `call`, the Debugger behaves "next-like," returning from the called function. However, if the program hits a breakpoint in the called function, the Debugger stops the program at the breakpoint. If you now issue a `Stack Trace` command, the `stack trace` shows that the call originated from the *Debugger* command level.

If the source file in which the function is defined was compiled with the `-g` flag, or if the prototype declaration is visible at the current scope, the Debugger checks the number and type of arguments and issues an error message if there is a mismatch.

Note – For C++, the Debugger handles default arguments and function overloading as well.

If the above two conditions are not met, the Debugger does *not* check the number of parameters. The parameters are simply pushed on the stack as given in the parameter list.

Automatic resolution of the C++ overloaded functions is done if possible. If any ambiguity remains (for example, functions not compiled with `-g`), the Overloaded pop-up window is displayed.

7.3 Continuing a Program

To begin program execution again from the point where a program is stopped,

♦ **Choose Continue from the Execution menu. You can also use the** `cont` **button or type** `cont` **in the command pane.**

Here is the syntax for the Debugger `cont` command:

`cont [at` *line-number*`] [sig` *signal-number*`]`

The next subsection explains the `at` option. See Chapter 17, "Working With System Signals", for an explanation of how to use the `sig` option.

7.3.1 Skipping Lines of Code with `cont at <line>`

The Debugger `cont` command has a variant, `cont at` *line_number*, which allows you to specify a line at which to resume program execution other than the current program location line.

Among other uses, `cont at <line>` allows you to skip over one or a few lines of code that you know to be causing problems without having to recompile.

To continue a program at a specified line:

♦ Enter the `cont at` *n* command in the command pane. For example,

`(debugger)` **cont at 124**

Note that the source line number specified is evaluated relative to the file in which the program is stopped; the line number given must be within the scope of the function.

7.3.2 *Using* `cont at <line>` *with the* `assign` *Command*

One useful application of `cont at` is in conjunction with an `assign` command. Using `cont at` *line* with `assign`, you can avoid executing a line of code that contains a call to a function that may be incorrectly computing the value of some variable.

To resume program execution at a specific line:

1. **Use `assign` to give the variable a correct value.**
2. **Use `cont at` *line* to skip the line that contains the function call that would have computed the value incorrectly.**

Here is an example. Assume that a program is stopped at line 123. Line 123 calls a function, `how_fast()`, that computes incorrectly a variable, `speed`. You know what the value of speed should be, so you can assign a value to `speed`. Then continue program execution at line 124, skipping the call to `how_fast()`.

`(debugger)` **assign speed = 180; cont at 124;**

If you use this command with a `when` breakpoint command, the program skips the call to `how_fast()` each time the program attempts to execute line 123.

`(debugger)` **when at 123 { >/dev/null assign speed = 180; cont at 124;}**

7.4 *Using Cntl-C to Stop a Process*

You can stop a process running in the Debugger using `cntl-C` (`^c`). When you stop a process using `^c`, the Debugger ignores the `^c`, but the child process sees it as a `SIGINT` and stops. You can then inspect the process as if it had been stopped by a breakpoint.

7.4.1 *Generic Case*

To stop a running process (after having chosen Continue or Run):

- **Type `^c` in the command pane or the PIO window.**

7.4.2 If the Process was Attached While It was Running

To stop a process that was attached to the Debugger while it was running:

- **Type `^c` either in the window in which the process is running or in the Debugger command pane.**

7.4.3 Continuing Again, After Stopping Using `^c`

To resume execution after stopping a program with `^c`:

- **Choose Continue from the Execution menu (or use Debugger `cont`)**
  You do not need to use the `cont` optional modifier, `sig` *signal_name*, to resume execution. The `cont` button (or `cont` command) resumes the child process after cancelling the pending signal.

Saving and Restoring a Debugging Run 8

This chapter describes how to save all or part of a debugging run and replay it later. The Debugger provides three commands for handling this functionality:

- `save [-`*number*`] [`*file*`]`
- `restore [`*file*`]`
- `replay [-`*number*`]`

The Replay item on the Execution menu is the same as the default Debugger command, `replay -1`. By restoring a run except for the last debugging command entered, Replay works effectively as an “undo” command.

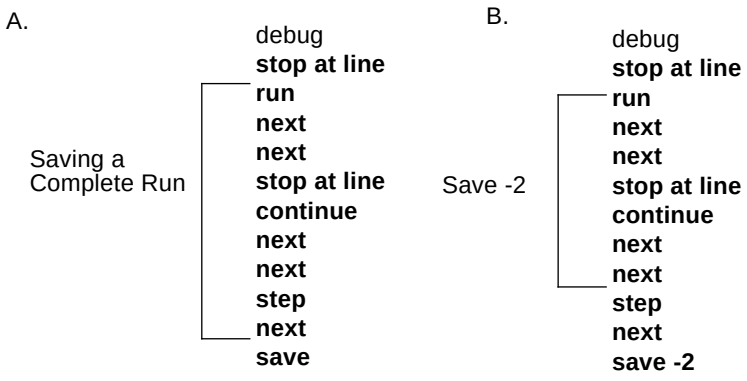
This chapter is organized into the following sections:

8.1 Saving a Debugging Run

The `save` command saves to a file all of the debugging commands issued from the last `run`, `rerun`, or `debug` command up to the `save` command. This segment of a debugging session is called a *debugging run*. (Note that when you load a program into the Debugger, the Debugger itself issues a `debug` command, thereby starting the first debugging run.)

The `save` command saves more than the list of debugging commands issued. It also saves debugging information associated with the state of the program at the start of the run — information about breakpoints, display lists, and the like. If you want to restore a saved run, the Debugger uses the information in the save-file.

You can save part of a debugging run; that is, the whole run minus a specified number of commands from the last one entered. Example A shows a complete saved run. Example B shows the same run saved, minus the last two steps:



If you are not sure where you want to end the run you are saving, use the `history` command to see a list of the debugging commands issued from the top of the session. The default for the history record is 15 commands. For use with the save and restore facility, you may want to set the number of commands recorded higher.

To save all of a debugging run up to the `save` command:

- **Type in the command pane,**

  `(debugger)` **save**

To save part of a debugging run

- **Type in the command pane,**

  `(debugger)` **save -***number*

  where *number* is the number of commands back from the save command that you do *not* want saved.

Saving a Series of Debugging Runs as Checkpoints

If you save a debugging run without specifying a *filename*, the Debugger writes the information to a special save-file. Each time you save, the Debugger overwrites this save-file. However, by giving the `save` command a *file_name* argument, you can save a debugging run to a file that you can restore later, even if you have saved other debugging runs since the one saved to *file_name*.

Using the *file_name* argument, you can save a series of debugging runs. Saving a series of runs gives you a set of *checkpoints*, each one starting farther back in the session. You can restore any one of these saved runs, continue, then reset the debugger back to the program location and state saved in an earlier run.

To save a debugging run to a file other than the default save-file:

- **Type in the command pane, use the *file_name* argument,**

  `(debugger)` **save** *file_name*

8.2 Restoring a Saved Run

After saving a run, you can then restore the run using the `restore` command. The Debugger uses the information in the save-file. When you restore a run, the Debugger first resets the internal state to how it was at the start of the run, *then* it reissues each of the debugging commands in the saved run.

Note – The `source` command also reissues a set of commands stored in a file, but it does not reset the state of the Debugger; it merely reissues the list of commands from the current program location.

Prerequisites for An Exact Restoration of a Saved Run

For exact restoration of a saved debugging run, *all* of the inputs to the run must be exactly the same: arguments to a `run`-type command, manual inputs, and file inputs.

Note – If you save a segment and then issue a `run`, `rerun`, or `debug` command *before* you do a `restore`, `restore` uses the arguments to the *second*, post-save `run`, `rerun`, or `debug` command. If those arguments are different, you may not get an exact restoration.

To restore a saved debugging run:

- **Type in the command pane,**

  ```
  (debugger) restore
  ```

To restore a debugging run saved to a file other than the default save-file:

- **Type in the command pane,**

  ```
  (debugger) restore file_name
  ```

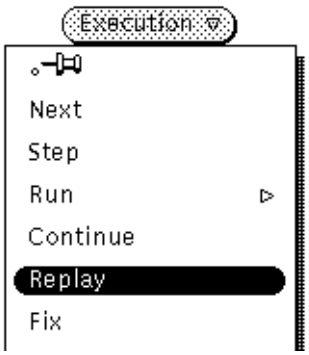
  where *file_name* is the name of the file to which you saved the debugging run.

8.3 *Saving and Restoring with the* `Replay` *Command*

The `replay` command is a combination command, equivalent to issuing a `save -1` followed immediately by a `restore`. The `replay` command takes a negative *number_of_ commands* argument, which it passes to the `save` portion of the command. By default, the value of *-number* is `-1`, so `replay` (and the Replay item on the Execution menu) works effectively as an "undo" command, restoring the last run up until (but not including the last command issued before the `replay` command).

To replay the current debugging run, minus the last debugging command issued:

♦ **Choose Replay from the Execution menu**



Replay — Replay is the same as the default Debugger line command, `replay`. `Replay` saves and restores the current run up to the last command issued prior to choosing Replay.

To replay the current debugging run and stop the run before the second to last command, use the Debugger `replay` command:

♦ **Type in the command pane,**

`(debugger)` **`replay -`***number*

where *number* is the number of commands back from the last debugging command.

Examining the Call Stack 9

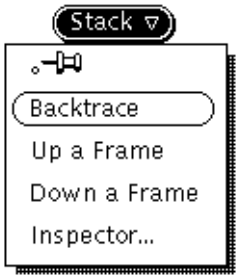
This chapter describes how to examine the *call stack*, how to use the Stack Inspector, and how to debug a core file with the `where` command or the stack menu. The call stack represents all currently active routines — that is, routines that have been called but have not yet returned to their respective caller. The Stack Inspector performs operations on the stack and dynamically updates the stack when you visit another process or thread.

This chapter is organized into the following sections:

9.1 Examining the Stack

Because the call stack grows from higher memory to lower memory, *up* means going up the memory to the caller's frame and *down* means going down the memory. The current program location (the routine that was currently executing when the program stopped at a breakpoint, after a single-step, or when the program faults, producing a core file) is in higher memory, while a caller routine, such as `main(),` is located lower in memory.

The Stack menu in the Debugger contains four items for examining the stack: Backtrace, Up a Frame, Down a Frame, and Inspector.



Backtrace — shows the call stack for your current process. Backtrace is equivalent to the where command.
Up a Frame — moves up one frame in the stack. Up a Frame is equivalent to the up command.
Down a Frame — moves down one frame in the stack. Down a Frame is equivalent to the down command.
Inspector — displays the Stack Inspector window.

To see all options to the `where` command,

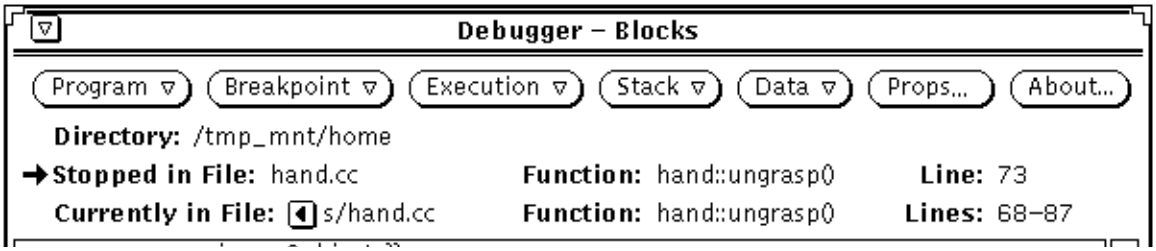
- **Type** `help where` **in the command pane.**

9.1.1 Walking the Stack and Returning Home

Moving up or down the stack is sometimes referred to as "walking the stack." When you visit a function by moving up or down the stack, the Debugger displays the function in the source display, marking it with a hollow arrow.

The location you start from, *home*, is the point where the program stopped executing and is indicated in the source display by a solid arrow. From home, you can move up or down the stack using the `up`, `down`, or `frame` commands.

To return "home," that is, to redisplay the function the program is stopped at,



- **Move the cursor over the arrow, which is to the left of the Stopped in File field in the Information fields area of the main Debugger window and click SELECT.**
  You may want to create a Current Focus command button to do this operation automatically through a command.

The Debugger commands `up [number]` and `down [number]` both accept a *number* argument that instructs the Debugger to change the current function some *number* of frames up or down the stack from the current frame. The `-h` option includes all hidden frames in the count.

`up [-h] [number]`

Move up the call stack (towards `main`) *n* levels. If *number* is not specified, the default is one. This command allows you to examine the local variables in functions other than the current one.

`down [-h] [number]`

Move down the call stack (towards the current stopping point) *n* levels. If *n* is not specified, the default is one.

The frame command is similar to the `up` and `down` commands. It allows you to go directly to the frame as given by numbers printed by the `where` command. This command is available from the command line only.

`frame`
`frame [-h] number`
`frame [-h] +[number]`
`frame [-h] -[number]`

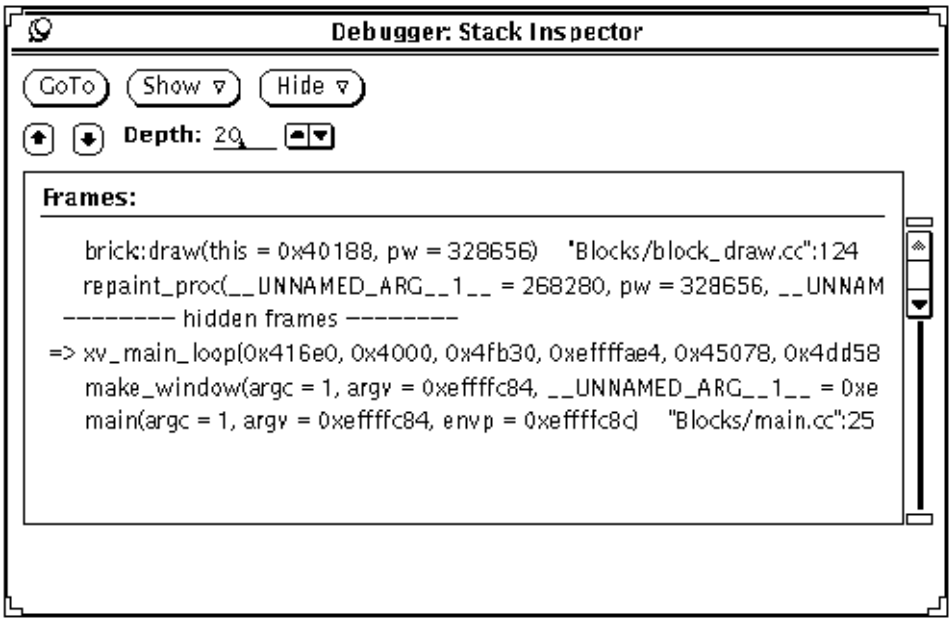
The frame command without an argument prints the current frame number. With *number*, the command allows you to go directly to the frame indicated by the number. By including a "+" or "-", the command allows you to move an increment of one level up (+) or down (-). If you include a positive or negative option with a number option, the command allows you to move up or down the specified number of levels. Including the `-h` option includes any hidden frames in the count.

9.2 The Stack Inspector

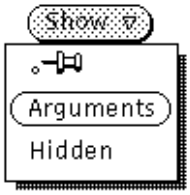
Use the items shown in the Stack Inspector window to view the stack. The Debugger displays the call stack in this window and dynamically updates it when you visit another process or thread.

The window contains a command button, two menu buttons, up and down arrows that move the cursor in the Frames pane and the Depth field, which specifies the number of stack frames currently displayed in the Frames pane.

The GoTo button moves the arrow in the Frames pane to the selected frame. You select a frame by moving the cursor over the desired frame and clicking SELECT.



9.2.1 The Stack Inspector Show Menu



Use the items listed in the Show menu to obtain information about the stack. The menu contains two items that toggle. Arguments is the default menu item.

Arguments — displays the following information:

- Function arguments
- Name of the source file and line number for the function, if compiled with the `-g` option

If no debugging information is available for a function on the call stack, the expanded information shows the:

- Function arguments (hexadecimal values of “in registers” `$i0` through `$i5`)
- Memory address of the function.

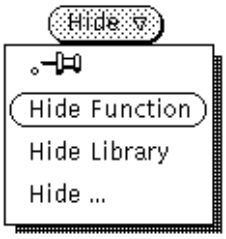
The command toggles to No Arguments.

No Arguments — displays a list of function names only.

Note – Obtaining full stack frame information requires more debugging information and slows down the Stack Inspector. Because No Arguments provides you with a list of function names only, the response time is much quicker than choosing Arguments.

Hidden — toggles between displaying all functions hidden by the Hide Function command in the Hide menu and re-hiding them.

9.2.2 The Stack Inspector Hide Menu



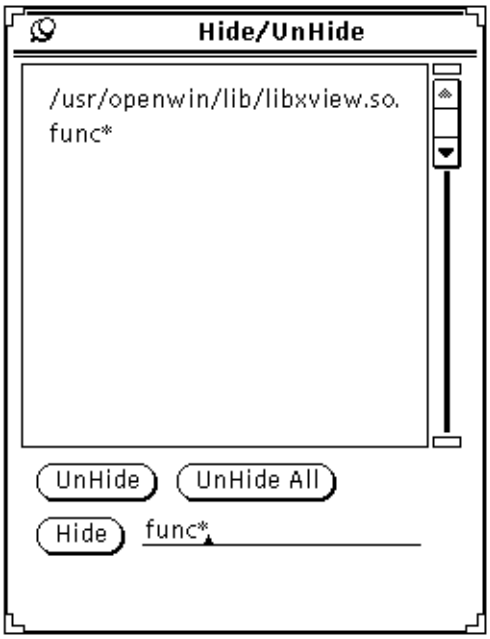
Hide Function — hides a selected function. This command hides functions by name. That is, all functions with the same name as the selected function are hidden.
Hide Library — hides all functions from the library that contains the selected function.
Hide — displays the Hide/Unhide window described in the next section.

Use the items listed in the Hide menu to hide stack inspector entries. Hide Function is the default menu item.

A placeholder in the Frames pane indicates that one or more functions are hidden.

Note – The top frame (frame number 1) and the first frame in a hidden library block are never hidden.

9.2.3 The Hide/Unhide Menu



Hide — adds the expression typed in the text field to the hidden list.
Unhide — deletes the selected expression(s) from the hidden list.
Unhide All — deletes all expressions from the hidden list.

Use the Hide / Unhide Menu to display a list of stack inspector *filters*. Filters are regular expressions that are matched to function names or library paths.

You can selectively hide or show functions by selecting the appropriate filter and choosing either the Hide Function or Hide Library command from the Hide menu.

9.3 Debugging a Core File

The `where` command or Stack menu is especially useful for learning about the state of a program that has crashed and produced a core file. When a program crashes and produces a core file, you can load the core file into the Debugger.

To load a core file into the Debugger:

- **Type in the command pane,**

  `(debugger)` **`debug program_name corefile`**

If the Debugger is not already running, you can load a core file into the Debugger when you start the session:

- **In a Command or Shell tool, type**

```
% debugger program_name corefile
```

Once the core file is loaded in the Debugger, choose Backtrace from the Stack menu to examine the call stack at the time the program faulted. The Debugger `where` command is the command pane equivalent of the Backtrace menu item command.

When you debug a core file, you can also evaluate variables and expressions to see what values they had at the time the program crashed, but you cannot evaluate expressions that make function calls.

Evaluating and Displaying Data 10

This chapter describes how to evaluate data, display the value of expressions, variables, and other data structures, and how to assign a value to an expression.

In the Debugger you can perform three types of data checking:

- Evaluate data (print)
  Spot-check the value of an expression by using the Evaluate/Print commands
- Display data (display)
  Monitor the value of an expression each time the program stops by using the Display command
- Inspect data (display plus relations)
  Examine program variables including complex structures by using Data Inspector. This feature is described in Chapter 11, “Visual Data Inspector.”

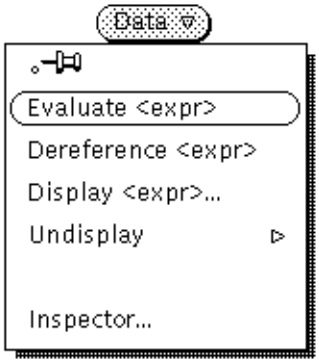
In addition to printing evaluations in the command pane, the Debugger features a separate Data Display window for monitoring data.

10

This chapter is organized into the following sections:

The Data Menu

You can perform most evaluation and display operations using the items on the Data menu.



Evaluate — displays the value of the selected expression Same as the print button.
Dereference — displays the value to which the selected pointer is a reference. Same as the print* button.
Display — displays the Data Display window, where the Debugger monitors the value of the selected expression. The Debugger updates the information automatically until you issue the Undisplay command. Same as the display button.
Undisplay — instructs the Debugger to stop monitoring the selected expression(s).
Inspector — displays the Data Inspector window. This feature is described in Chapter 11, “Visual Data Inspector.“

10.1 Evaluating and Dereferencing Variables and Expressions

This section shows how to evaluate variables and expressions or dereference pointers to them.

If you evaluate a variable name that is defined within the scope of the *current function* (value of Currently in Function and of `func`), then the Debugger uses that variable. Make sure the variable the Debugger evaluates is in the function you think it is.

Verifying Which Variable the Debugger will Use

If you are not sure which variable the Debugger will evaluate, use the `which` command to see the fully qualified name the Debugger will use. (For details, see Section 4.5.2, “Seeing a Preview of Which Symbol the Debugger Will Use,” on page 4-52.)

To see other functions and files in which a variable name is defined, use the `whereis` command. For details, see “Locating Symbols: the whereis and which Commands” on page 4-51.

Variables Outside the Scope of the Current Function

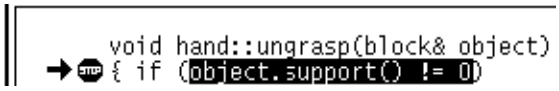
When you want to evaluate (or monitor) a variable that is outside the scope of the current function:

- Qualify the name of the function.
  See “Qualifying Symbols with Scope Resolution Operators” on page 4-48.
- Visit the Function; that is, change current function.
  See “Visiting Code” on page 4-43 for a description of how to change the current function.

10.1.1 Printing the Value of a Variable or an Expression

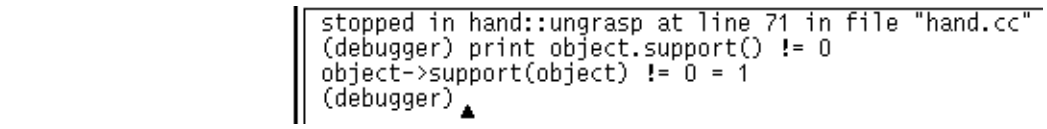
To evaluate a variable or expression:

1. **Select the target variable or expression in the source display.**



2. **Choose Evaluate from the Data menu.**
   Evaluate is the default item, so you can click on the Data menu button without displaying the menu. You can also click the Print command button.

The Debugger echoes the command and prints the evaluation in the command pane:



Evaluating Pascal Character Strings

To evaluate a Pascal character string in the Debugger, use the double quote ("") syntax to identify the string as a character string (as distinct from a character constant). This Debugger convention also applies to passing parameters when calling a Pascal function.

For example, to evaluate the Pascal character string, `abc`:

```
(debugger) print "abc"            //not print 'abc'
```

C++ Printing

You can use the commands `print` or `display` with a `-r` (recursive) option. The Debugger displays all the data members directly defined by a class and those inherited from a base class.

Evaluating Unnamed Arguments in C++ Programs

C++ allows you to define functions with unnamed arguments. For example:

```
void tester(int)
{
};

main(int, char **)
{
    tester(1);
};
```

Though you cannot use unnamed arguments elsewhere in a program, the Debugger encodes unnamed arguments in a form that allows you to evaluate them. The form is:

__UNNAMED_ARGUMENT_%n__
where the Debugger assigns an integer to %n.

To obtain an assigned argument name from the Debugger, issue the `whatis` command with the function name as its target:

```
(debugger) whatis tester
void tester(int _UNNAMED_ARGUMENT_0_);[222z
(debugger) whatis main
int main(int _UNNAMED_ARGUMENT_1_, char **_UNNAMED_
ARGUMENT_2_);
```

To evaluate (or display) an unnamed function argument,

- **Use the encoded name as the argument to the `print` (or `display`) command.**
  For example:

```
(debugger) print _UNNAMED_ARGUMENT_1_
_UNNAMED_ARGUMENT_1_ = 4
```

10.1.2 Dereferencing Pointers

When you dereference a pointer, you ask for the value stored in the container to which the pointer is a reference, not for the value of the pointer-variable.

To dereference a pointer:

1. **Select the indirection operator (*) together with the variable name**:

```
struct s{
int a;
} s, *t;
```

2. **Choose Dereference from the Data Menu.**
   You can also click the Print* button.

   The Debugger echoes the command and prints the evaluation in the command pane; in this case, the value pointed to by `t`:

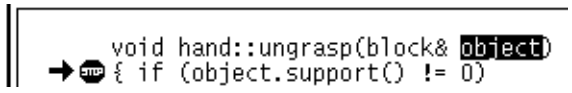
```
(debugger) print *t
*t = {
a = 4
}
(debugger)
```

10.2 Monitoring Expressions

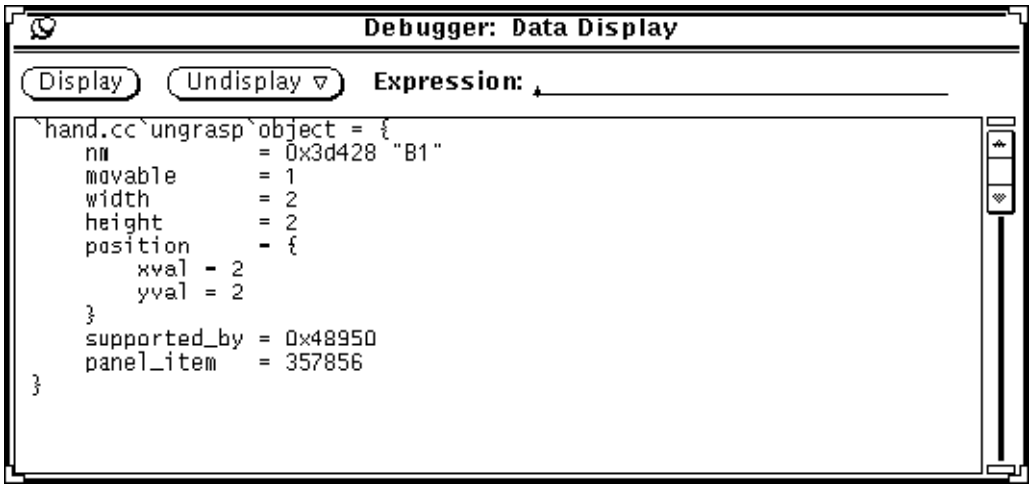
Monitoring the value of an expression each time the program stops is an effective technique for learning how and when a particular expression or variable changes. Display instructs the Debugger to monitor one or more specified expressions or variables. Monitoring continues until you turn it off with the Undisplay command. The Display command displays a separate Data Display pop-up window in which the Debugger displays the values of specified expressions.

To display the value of a variable or expression each time the program stops:

1. **Select the variable or expression in the source display**:
   For example,



2. **Choose Display from the Data menu to display the Data Display window, showing the values of the selected variable.**
   In this example, `object` is a reference to an instantiation of a block.



Now, each time the program stops, the Data Display window reports the value of the variable. The Data Display window has a text field labeled Expression; use this text field to enter the name of an additional expression you want to monitor. Pressing the Return key after the last character entered issues the new Display command.

You can monitor more than one variable at a time. The Data Display window displays each of the expressions you are currently viewing. (Note that the window has a scrollbar.)

10.2.1 Turning Off Display (Undisplay)

The Debugger continues to display the value of a variable you are monitoring until you turn off Display with the Undisplay command. You can turn off the display of a specified expression or turn off the display of all expressions currently being monitored.

To turn off the display of a particular variable or expression:

1. **Select the variable in either the Data Display window or the source display.**

2. **Click the Undisplay button in the Data Display window or choose Undisplay from the Data menu.**

To turn off the display of all currently monitored variables:

- **Type in the command pane,**

  (debugger) **undisplay 0**

10.3 Assigning a Value to an Expression

To assign a value to a variable:

- **Type in the command pane**

  (debugger) **assign** *variable* **=** *expression*

10.4 Evaluating Arrays

You evaluate arrays the same way you evaluate other types of variables. First, you select the array, then choose Evaluate from the Data menu. (See Chapter 11, “Visual Data Inspector“, for more information on inspecting arrays.)

Here is an example, using a FORTRAN array:

```
integer*4 arr(1:6, 4:7)
```

To evaluate the array:

- **Type in the command pane the print command followed by the array.** Here is an example using a FORTRAN array:

  (debugger) **print arr(2,4)**

Note – Memory limitations internal to the Debugger prevent the display of large arrays. While the Debugger now supports FORTRAN *array slicing* (see the following section), it does not yet offer this support for other languages.

10.4.1 Array Slicing for FORTRAN Arrays

For FORTRAN arrays, the Debugger `print` command allows you to evaluate part of a large array. FORTRAN array evaluation includes:

- Array Slicing

  Print any rectangular, *n*-dimensional box of a multi-dimensional array.

- Array Striding

  Print certain elements only, in a fixed pattern, within the specified slice (which may be an entire array).

You can slice an array, with or without striding (the default stride value is 1, which means print each element).

10.4.2 Syntax for FORTRAN Array Slicing and Striding

For *each* dimension of an array, the full syntax to the `print` command to slice the array is:

```
(debugger) print arr(exp1:exp2:exp3)
```

where:

exp1 = start_of_slice
exp2 = end_of_slice
exp3 = length_of_stride (the number of elements skipped is *exp3* - 1)

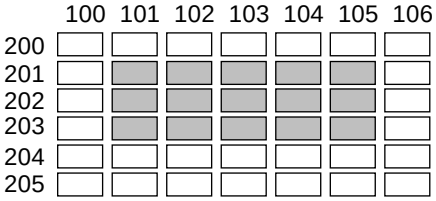
For an *n*-dimensional slice, separate the definition of each slice with a comma:

```
(debugger) print arr(exp1:exp2:exp3, exp1:exp2:exp3,...)
```

Slices

Here is an example of a two-dimensional, rectangular slice, with the default stride of 1 omitted:

```
print arr(201:203, 101:105)
```



This command prints a block of elements in a large array. Note that the commands omits exp3, using the default stride value of 1.

The first two expressions (`201:203`) specify a slice in the first dimension of this two-dimensional array (the three-row column). The slice starts at the row `201` and ends with `203`.The second set of expressions, separated by a comma from the first, defines the slice for the 2nd dimension. The slice begins at column `101` and ends after column `10`5.

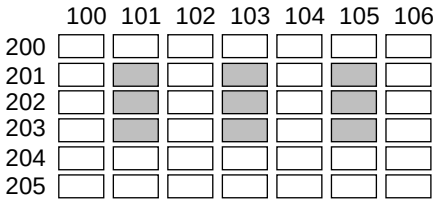
Strides

When you instruct `print` to *stride* across a slice of an array, the Debugger evaluates certain elements in the slice only, skipping over a fixed number of elements between each one it evaluates.

The third expression in the array slicing syntax, (*exp3*), specifies the length of the stride. The value of *exp3* specifies the elements to print; the number of elements skipped is equal to *exp3* `-1`. The default stride value is 1, meaning: evaluate all of the elements in the specified slices.

Here is the same array used in the previous example of a slice; this time the print command includes a stride of 2 for the slice in the second dimension.

```
print arr(201:203, 101:105:2)
```



A stride of 2 prints every 2nd element, skipping every other element.

Shorthand Syntax

For any expression you omit, `print` takes a default value equal to the declared size of the array. Here are examples showing how to use the shorthand syntax.

For a one-dimensional array:

`print arr`	Prints entire array, default boundaries.
`print arr(:)`	Prints entire array, default boundaries and default stride of 1.
`print arr(::`*exp3*`)`	Prints the whole array with a stride of *exp3*.

For a two-dimensional array:

`print arr`	Prints the entire array.
`print arr (:,::3)`	Prints every third element in the second dimension of a two-dimensional array.

Visual Data Inspector 11

This chapter describes the Visual Data Inspector (VDI), a new Debugger component that extends the data display and monitoring capability described in Chapter 10, “Evaluating and Displaying Data.” This VDI chapter shows pointer/reference relationships among data as well as the current data values.

For information on evaluating or displaying the value of expressions, variables, and other data structures, see Chapter 10, “Evaluating and Displaying Data.”

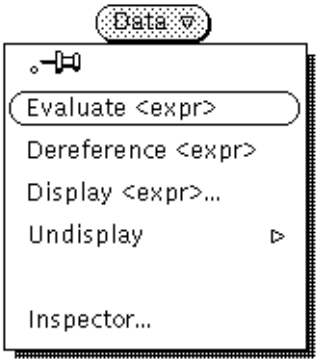
This chapter is organized into the following sections:

11.1 Starting the Visual Data Inspector (VDI)

♦ **Choose Inspector from the Data menu**

You start the Visual Data Inspector from the Data menu on the Debugger base window. Data menu options Evaluate, Dereference, Display, and Undisplay are described in Chapter 10, “Evaluating and Displaying Data”.

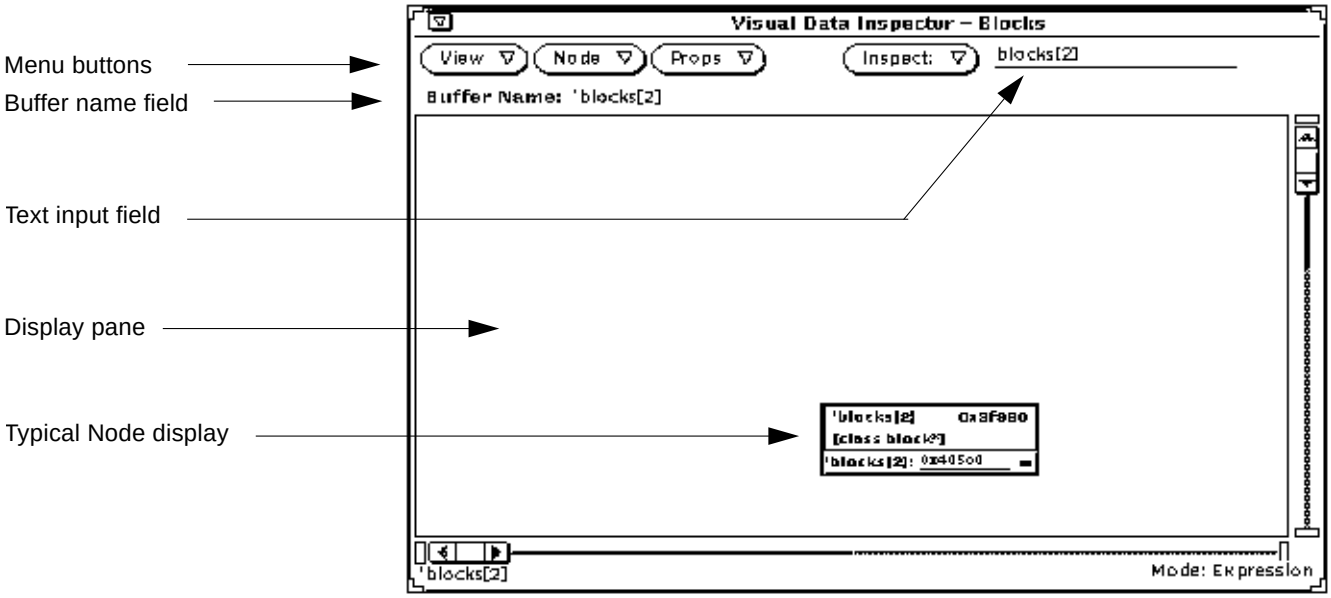
”



Evaluate — displays the value of the selected expression (Same as the print button.)
Dereference — displays the value to which the selected pointer is a reference in the command pane. (Same as the print* button.)
Display — displays the Data Display window, where the Debugger monitors the value of the selected expression.
Undisplay — instructs the Debugger to stop monitoring the selected expression.
Inspector — displays the Visual Data Inspector window, where the Debugger monitors and graphically displays program variables including data structures.

11.2 The Visual Data Inspector Window

The Visual Data Inspector window consists of a row of buttons, text-input field, buffer name field, graphical display pane, and a footer message area. The display pane displays nodes and pointer lines that connect nodes. A display node is a graphical display of a program variable that you entered in the text input field. You use the scrollbars to navigate in the display pane.



The window header shows the name of the executable program being inspected. The left footer shows the full pathname of the currently selected node. The node name may have been truncated in the display node header (as indicated by a "<" on the left of the name field). The right footer shows the VDI Inspect mode. (See Section 11.2.4, "The Inspect Menu," on page 11-137.)

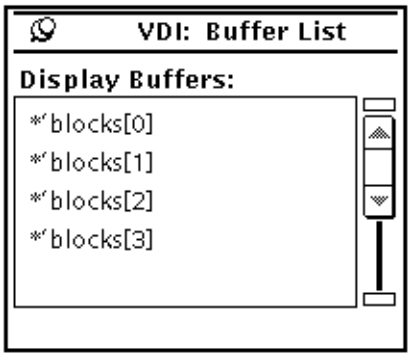
Nodes can be grouped in *buffers*. You create, select, delete, and arrange buffers in the display pane from the View Menu.

11.2.1 The View Menu

You control the display of buffer containers and nodes from the View menu.

Next Buffer — switches to the next available buffer.
Previous Buffer — switches to the available buffer opened before the current buffer.
List Buffers — displays the Buffer List window that shows all buffers by name.
New Buffer — creates an empty display pane.
Delete Buffer — deletes the viewed buffer.
Layout — arranges the display nodes in the buffer.

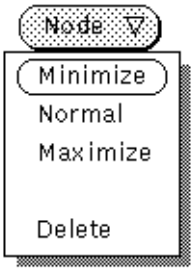
This illustration shows a typical VDI Buffer List window.



The VDI Buffer List window contains a list of open buffers. To select a buffer, click on the buffer name.

11.2.2 The Node Menu

You select how nodes are displayed from the node menu. You can select only one node at a time. The selected node is changed by the node option.



Minimize — place the selected node into an icon that remains in the same graphical position in the pane. This is useful when viewing multiple nodes.
Normal — place the selected node into the standard graphical form which displays up to five fields (Resource set by the user).
Maximize — expands a selected node to display all fields. Maximize has no effect on nodes with less than the normal display count Resource.
Delete — removes a selected node from the display pane.

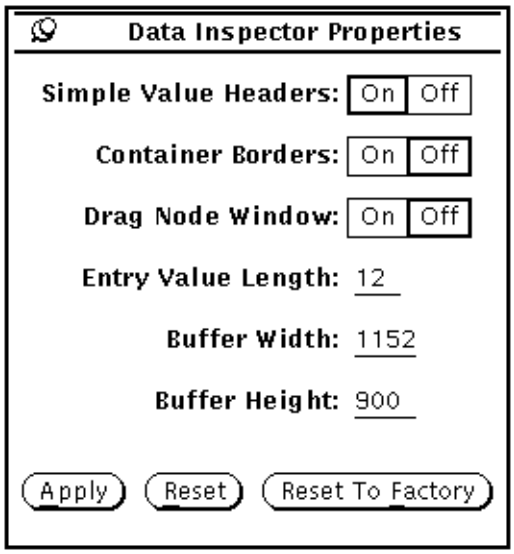
11.2.3 The Visual Data Inspector Props Menu

You use the Props menu to change the Visual Data Inspector environment and to display the current version of the Debugger.

Properties — displays the Visual Data Inspector Properties window.
Version — displays the current version of the Debugger in the left footer of the Visual Data Inspector window.

The Data Inspector Properties Window

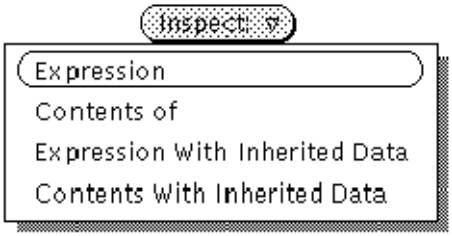
You use the Properties window to change the Visual Data Inspector environment.



Simple Value Headers — select On to display header information for each node. Select Off to display only a single value and name.
Container Borders — select On to display borders around s[222ztructures that are nested. Select Off to remove borders around the containers.
Drag Node Window — select On to drag nodes as solid objects. Select Off to drag node outlines.
Entry Value Length — specify the number of visible characters displayed in the node's data fields. This value only applies to newly created nodes. To change an existing length, the node must first be deleted, then inspected again.
Buffer Width and Buffer Height — allow the buffer dimensions to be increased beyond the default screen size. This attribute applies to the current buffer and buffers created after the new values are applied. The values cannot be set smaller than the screen dimensions.
Apply — set the selection in the appropriate nodes in the active buffer.
Reset — restore the options to their original states before a selection has been applied.
Reset To Factory — restore the settings to their original state as the

11.2.4 The Inspect Menu

Selection of these menu items sets the current mode for evaluating program variables. The current mode is displayed in the right footer area. This mode is persistent until a new option is chosen.



Expression — inspect the expression exactly as requested.
Contents of — inspect the contents of a pointer (dereference the pointer).
Expression With Inherited Data — for a C++ object, this is equivalent to the `print -r` option. This displays all data members of the object, including inherited data members.
Contents With Inherited Data — inspect the contents of a pointer to a C++ object (dereference the pointer), showing all data members of the object, including inherited data members.

11.3 Examining Variables and Complex Structures

This section describes how to select and display program variables and complex structures.

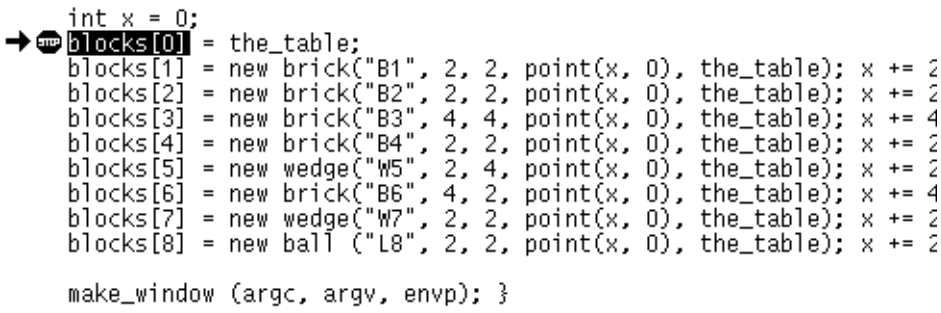
11.3.1 Starting an Inspection Session

You start a Data Inspector session by preparing the Debugger:

- Load the program containing the target variable into the Debugger.
- Select the target variable in the source display.
- Set a breakpoint in the source display.

You can set a breakpoint by clicking on the stop at button and then the run button in the Debugger base window. The program loaded in the Debugger runs and then stops at the set breakpoint.

This example from the source display shows a selected variable and set breakpoint used in this chapter.



♦ **Choose Inspector from the Data menu to start the Data Inspector.**

Enter the name of the variable to be inspected into the text input field. Note that multiple expressions in the text field are not allowed. You can enter the name in one of three ways:

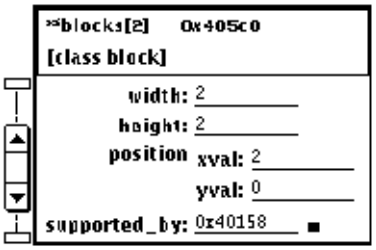
- Type the variable name in the Inspect text input field.
- Use the mouse to select the variable in the Debugger source display and drag the name to the text input field.
- Use the mouse to select the variable in the source display and use the keyboard keys Copy and Paste to enter the variable name in the text input field.

♦ **You then click on the Inspect button or use carriage return to start the inspection. A stopwatch is displayed when inspection is in progress.**

The selected variable is displayed in the Data Inspector display pane as a graphical node. More than one variable can be inspected in each buffer.

11.3.2 The Data Inspector Node

The Data Inspector displays nodes in the display pane. The `*'blocks[2]` node is shown in a scrolled position to display the pointer and Pointer glyph.



***'blocks[2] —** variable being inspected. The single quote (') indicates a global variable.
0x405c0 — address of the variable.
[block] — data type of the node.
Fields and values — up to five fields (default) are displayed in Normal view.
■ **Pointer-glyph —** single click here to view connecting nodes. This is used to follow pointers.
Scrollbar — shown in Normal view when the node selected has more than five fields (default setting).

11.3.3 The Data Inspector Display Pane

You can display nodes in three formats (see Figure 11-1):

- Minimize
  Displays node `*'blocks[1]` as an icon.
- Normal
  Displays node `*'blocks[2]` in the Normal format. For the default display count, up to five node fields can be displayed without scrolling. The floating scrollbar is displayed with a selected node that has more fields in the list than the current display count Resource.
- Maximize
  Displays node `*'blocks[0]` in the maximize option. All node fields are displayed in the maximize format. Use the scrollbar if the list of fields exceeds the display pane space.

This illustration shows multiple nodes and the three display formats.

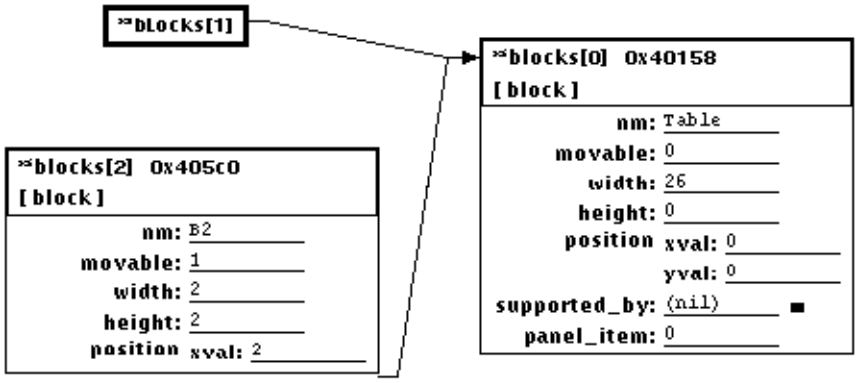


Figure 11-1 Display Pane Node Formats

11.3.4 Array Inspection

The Data Inspector is capable of displaying up to two-dimensional arrays of data in a form similar to a spreadsheet. If the size of the array is larger than the viewable area, horizontal and/or vertical scrollbars are provided. If the array dimensions are greater than two, the array is displayed as < `nD array`>, where *n* is the number of dimensions. Individual array data can be inspected in the normal manner.

Displayed Elements in an Array

The number of displayed elements in an array are set at creation time. If the number of elements exceeds the specified limit, a scrollbar is provided to scroll the array contents. The maximize option in the Node menu does not function on arrays; however, arrays can be minimized and reset to normal.

limitations

1. Display of arrays with dimensions greater than two is of the form <`nD array`>.
2. There is a dbx limit to the maximum number of array elements that can be inspected.

3. Arrays of pointers, arrays of pointers to pointers, and similar forms generated via `malloc` show only the first array address when inspected. This is a dbx limitation.
4. Arrays of pointers do not support pointer following. That is, no lines are drawn from internal array elements to external nodes in the display.
5. Display of arrays inside of a structure are presented as <`nD array`>, similar to limitation (1).
6. You cannot rename a buffer.

Assignment and array element updating are supported. Editing the value of a displayed array element also updates the value in the Debugger. Editing the value of an array element in the Debugger also updates the value in the displayed array element.

The display of array nodes behaves similar to the display of structure nodes. They can be moved, deleted and changed to an icon. A node can be in multiple buffers.

Process/Thread Inspector 12

This chapter describes how to find information about threads by using the Process/Thread Inspector.

This chapter is organized into the following sections:

12.1 Introduction to the Multithreaded Debugger

The Debugger recognizes a multithreaded program by checking whether it was compiled with `-lthread`.

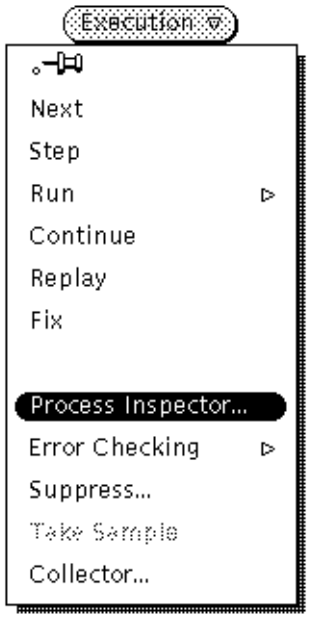
When the multithreaded features are enabled, the Debugger tries to `dlopen libthread_db.so` using the standard path. Use the `THREAD_DB_DIR` environment variable to specify a different path to `libthread_db.so`.

The Debugger is a synchronous debugger; that is, when any thread or LWP stops, all other threads and LWPs "sympathetically" stop. This behavior is sometimes referred to as the "stop the world" model.

12.2 Displaying the Process Inspector

To display the Process Inspector:

♦ **Choose Process Inspector from the Execution Menu.**



12.3 The Process/Thread Inspector Window

The Process Inspector is divided into two areas (see Figure 12-1 on page 146):

- Process
- Threads

The **Process** area shows the pid and full pathname of your program. See Chapter 16, “Debugging Child Processes” for more information.

The **Threads** area shows information about the threads active in the currently selected process.

The threads information is equivalent to the command pane `threads`

command. The Thread Inspector updates its information each time the program being debugged stops.

12.3.1 Thread Information

The following thread information is shown in Figure 12-1 on page 146:

- The **arrow** indicates the current thread.
- An ***** indicates that an event requiring user attention has occurred in this thread. The * is persistent; that is, it is reset only if the thread it is associated with resumes execution. Visiting a thread with an outstanding event produces a generic “stopped in” message, but gives no indication of the particular event that caused the thread to stop.

  An `o` indicates that an event has occurred that is of internal interest to the Debugger.
- **t@*num***, thread id, refers to a particular thread. The decimal number is the `thread_t` value passed back by `thr_create`.
- **b l@*num*** or **a l@*num*** (l is a lower-case L). Thread is bound to or active on the designated LWP. This means the thread is actually running. The state of a bound or active thread is really the state of its LWP; see Table 12-2.

  l@*num*,lwp id, refers to a particular LWP. The decimal number is equivalent to the value in `lwp_id_t`.

Note – At any given time the Debugger is focused on a single thread or LWP, known as the “current active entity.” When the current active entity is nonexistent, it is assumed to be dead and shows up as t@X or l@X. This happens when the Debugger steps over the return from a thread’s base function or the process terminates.

- Start function of the thread as passed to `thr_create`. A ?() means the start function is not known; for example, if the thread is private to `libthread` or it is the main thread.
- Thread state.
- The function the thread is currently executing.

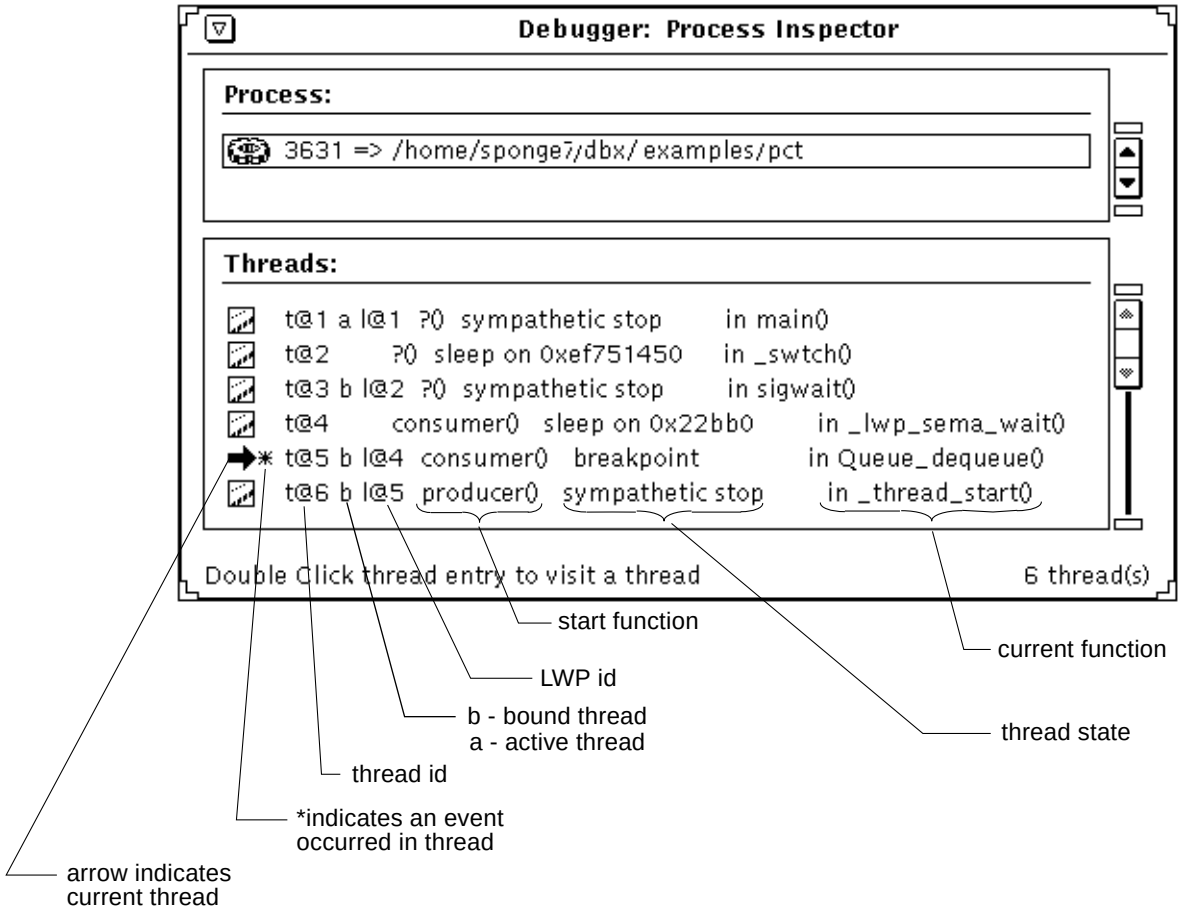


Figure 12-1 The Process/Thread Inspector Window

- Table 12-1 shows thread state information.

Table 12-1 Thread States

Thread State	Description
suspended	Thread has been explicitly suspended.
on run queue	Thread is runnable and is waiting for an LWP as a computational resource.
zombie	Thread has exited, but has not yet been “joined” or has not yet been reaped (if `THR_DETACHED` was used).
asleep on <`syncobj`>	Thread is blocked on the given synchronization object. Depending on what level of support `libthread` and `libthread_db` provide <`syncobj`> might be as simple as a hexadecimal address or something with more information content.
unknown	The Debugger cannot determine the state.

12.4 Viewing the Context of Another Thread

To switch the viewing context to another thread, double click the Thread window on the text line of the desired thread (see Figure 12-2 on page 148).

The Debugger dynamically updates the call stack to reflect the context of the currently selected thread.

The Debugger also dynamically updates the source display context to that of the currently selected thread. The source display is empty if source for the selected thread has not been compiled with `-g`.

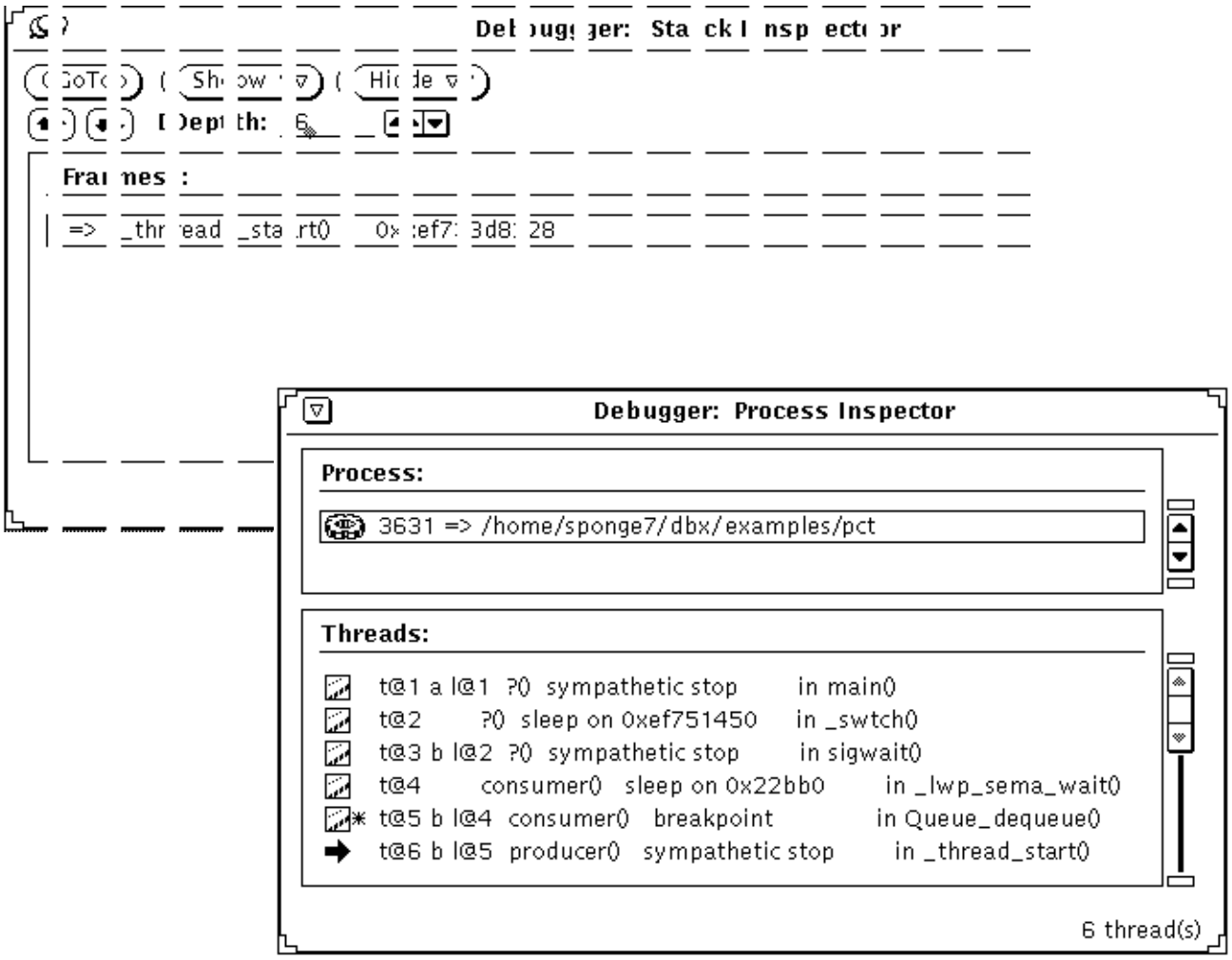
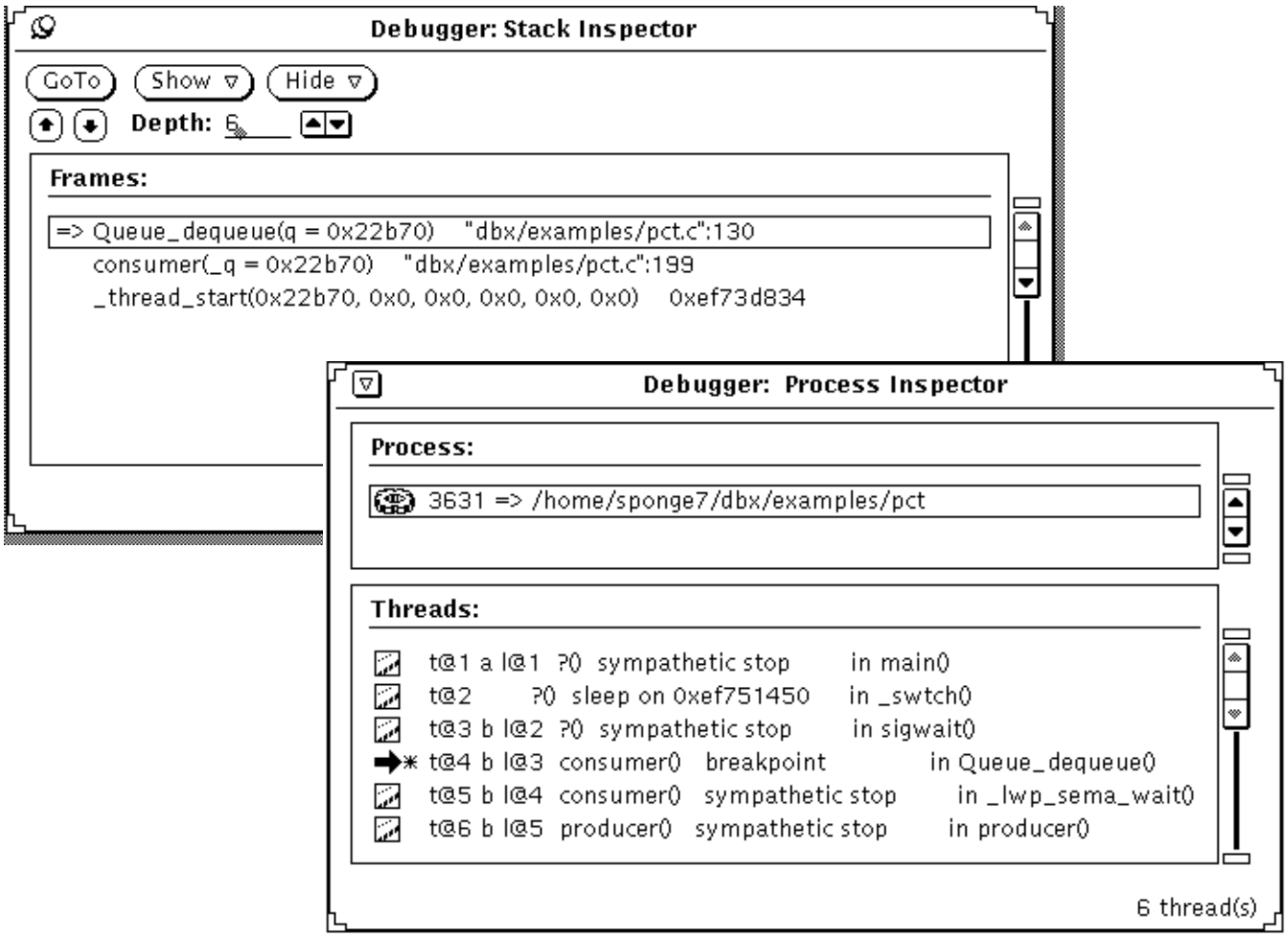


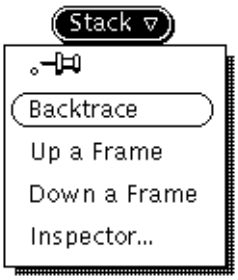
Figure 12-2 Viewing the Context of Another Thread


Debugger: Stack Inspector
GoTo
Show
Hide
Depth: 6
Frames:
=> Queue_dequeue(q = 0x22b70) "dbx/examples/pct.c":130
consumer(_q = 0x22b70) "dbx/examples/pct.c":199
_thread_start(0x22b70, 0x0, 0x0, 0x0, 0x0, 0x0) 0xef73d834
Debugger: Process Inspector
Process:
3631 => /home/sponge7/dbx/examples/pct
Threads:
t@1 a l@1 ?() sympathetic stop in main()
t@2 ?() sleep on 0xef751450 in _swtch()
t@3 b l@2 ?() sympathetic stop in sigwait()
t@4 b l@3 consumer() breakpoint in Queue_dequeue()
t@5 b l@4 consumer() sympathetic stop in _lwp_sema_wait()
t@6 b l@5 producer() sympathetic stop in producer()
6 thread(s)

The Stack Menu with Threads

The Stack Inspector is displayed to show how the stack information changes to the context of the "current" thread.

♦ **Choose Inspector from the Stack menu.**



Backtrace — shows the call stack for your current process. Backtrace is equivalent to the where command.
Up a Frame — moves up one frame in the stack. Up a Frame is equivalent to the up command.
Down a Frame — moves down one frame in the stack. Down a Frame is equivalent to the down command.
Inspector — displays the Stack Inspector window.

The Stack Inspector

The stack inspector updates itself when the current thread changes. Use the items listed in the Stack Inspector to perform operations on the stack. The Debugger displays the call stack in the Stack Inspector window and dynamically updates it when you visit another process or thread.

12.4.1 Resuming Execution

Use the `cont` command to resume program execution. Currently, threads use synchronous breakpoints so all threads resume execution.

12.5 LWP Information

Normally, you need not be aware of LWPs. There are times, however, when thread level queries cannot be completed. In this case, use the `lwps` command to show information about LWPs.

```
(debugger) lwps
 l@1 sympathetic stop in main()
 l@2 sympathetic stop in sigwait()
 l@3 sympathetic stop in _lwp_sema_wait()
```

```
*>l@4 breakpoint in Queue_dequeue()
 l@5 sympathetic stop in _thread_start()
(debugger)
```

The ***** indicates that an event requiring user attention has occurred in this LWP.

The **arrow** denotes the current LWP.

l@*num* refers to a particular LWP.

Table 12-2 describes the LWP states.

Table 12-2 LWP State

LWP State	Description
stopped by request	This LWP has stopped in sympathy with some other LWP.
system call to %d	This LWP is stopped on an entry into the given system call #.
system call return from %d	This LWP is stopped on an exit from the given system call #.
stopped due to job control	
suspended	Blocked in the kernel.
SINGLE STEP fault	The LWP has just completed a single step.
BPT fault	The LWP has just hit a breakpoint.
fault %d	The LWP has incurred the given fault #.
signal %s (%s)	The LWP has incurred the given signal.

in *func_name*() identifies the function that the LWP is currently executing.

Customizing the Debugger 13

This chapter describes how to use the controls on the Properties window and how to use the initialization file, `.dbxrc` (or `.dbxinit`), to customize the Debugger. You can make adjustments to certain attributes of the debugging environment and to the size of the source, command, and data display panes. You can also add command buttons and Custom menu items to the interface. The initialization file lets you preserve your changes and adjustments from session to session.

This chapter is organized into the following sections:

The Props Button

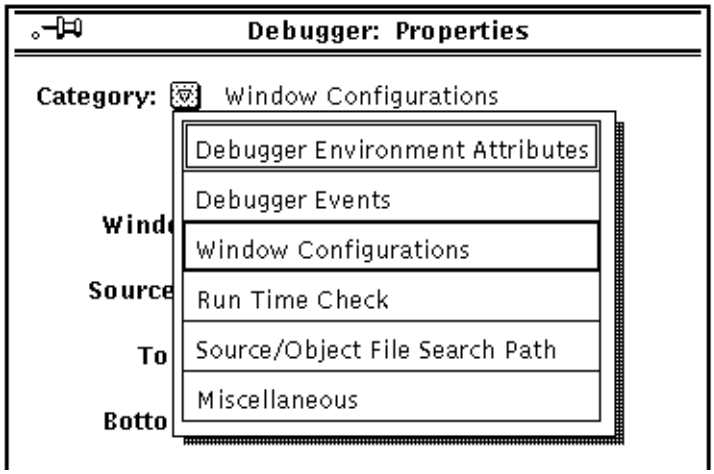
Clicking on the Props button displays the Properties window. The Properties window controls are arranged on six separate control panels:

- **Debugger Environment Attributes**
  Controls for each of the Debugger environment attributes: arguments to Matching, Auto Flush, Function Overload, Search Static Symbol, Short File Name, Stack Verbose, Stack Depth, and String Length.
- **Debugger Events**
  Controls for setting Auto Destruct, Follow Fork Inherit and Mode, and the Trace Speed.
- **Window Configurations**
  Controls to adjust the size of each of the display panes and the font file the Debugger uses to display code.
- **Run Time Check**
  Control for setting Auto continue and enter an Error Log Filename.
- **Source/Object File Search Path**
  Controls for setting the current Debugger source/object code search path (a window interface to the Debugger `use` command).
- **Miscellaneous**
  Controls to set Compress Stabs, Load Object Cache, and Collector Icon Animation on or off. You can also set Source Display Synchronization, Executable Cache Size, change the Log Filename, and set the Make Arguments.

The Properties window initially displays the Debugger Environment Attributes control panel.

To display a different control panel from the one currently displayed:

♦ **Use the Category menu to display a different panel.**



13.1 Changing the Debugger Environment Attributes

To display the Debugger Environment Attributes control panel:

1. **Choose Props to display the Properties window. Debugger Environment Attributes is the default category.**
   If the Properties window already displays one of the other panels, use the Category menu to select the Debugger Environment Attributes window.

2. **Set the new value for each attribute, then press the Apply button.**

Figure 13-1 shows the Debugger Environment Attributes.

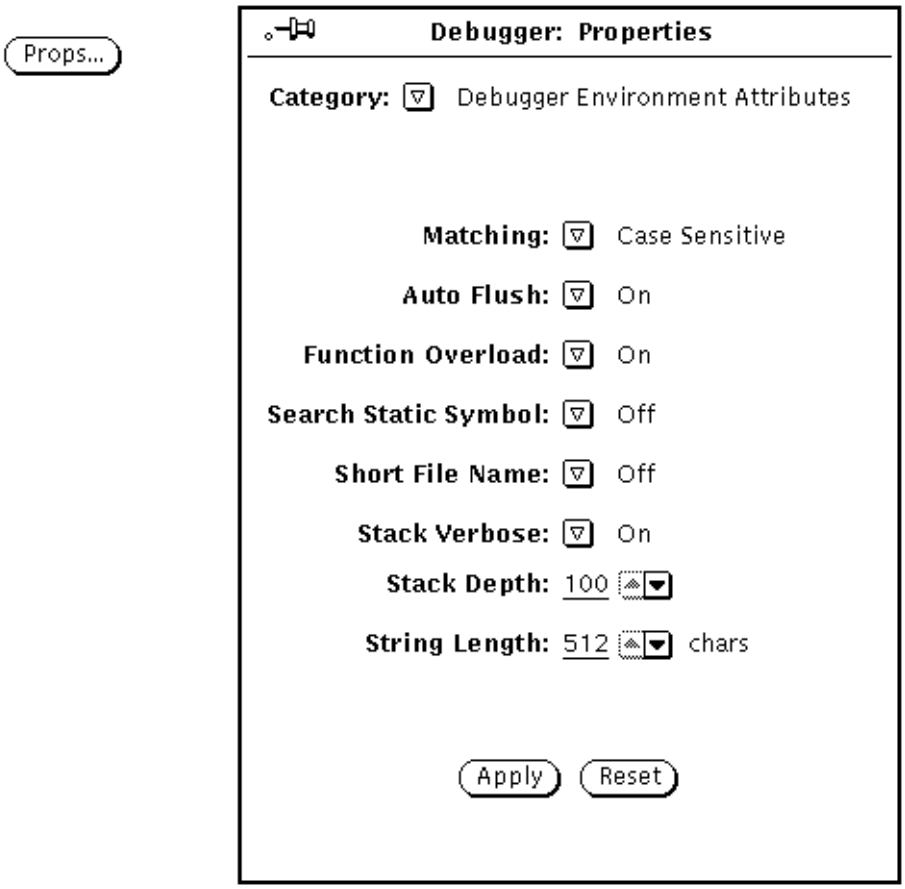


Figure 13-1 Debugger Environment Attributes Control Panel

Matching:

Set whether the Debugger distinguishes between upper- and lower-case characters when interpreting input.

`Case Sensitive`: treat upper and lower case distinctly.
`Case Insensitive`: process upper case characters as if lower case characters.

Default: Case Sensitive (C, C++, Pascal); Case Insensitive FORTRAN
Debugger command: `dbxenv case {sensitive | insensitive}`

Note – The Debugger detects when you load a FORTRAN module; it switches the setting automatically to `case insensitive` (with the exception that `MAIN()` must always be uppercase.) However, if during a session (or by setting `dbxenv case sensitive` in a `.dbxrc` file), you change the default manually, the Debugger does not override the manual setting when loading a FORTRAN module. Also, if the program was compiled using the `-u` option (case sensitive), the default becomes `dbxenv case sensitive`.

Auto Flush:

Set if you want the Debugger to call `fflush(stdout)` automatically after user calls to functions. `fflush(stdout)` flushes the I/O buffer, assuring that any information in it prints.

You can call a function *explicitly*, using the `call` command, or *implicitly*, by evaluating an expression containing a function or using a Debugger command with a conditional modifier containing a function (for example, in a command like `stop at glyph if animate()`).

To turn off automatic flushing, set the Auto Flush control to `Off`. Auto Flush is located on the Debugging Environment Attributes Properties Window.

On: Automatically call `fflush`() after user calls to functions.
Off: Do not call `fflush`() automatically user calls to functions.

Default: On
Debugger command: `dbxenv autoflush {on | off}`

Function Overload:

Set to allow the Debugger to do automatic overload resolution of C++ functions.

Default: On
Debugger command: `dbxenv func_overload {on | off}`

Search Static Symbol:

Set to find file static symbols, even when they are not in the scope.

Default: Off
Debugger command: `dbxenv lookaside {on | off}`

Short File Name:

Set if you want the Debugger to truncate full pathnames. Shortened names are especially helpful in reducing the output from the `where` command.

Off: Display full pathnames for files.
On: display short (relative) pathnames for files.

Default: Off
Debugger command: `dbxenv shortfname {on | off}`

Stack Verbose:

Set to allow printing of arguments and line information in `where`.

Default: On
Debugger command: `dbxenv stackverbose {on | off}`

Stack Depth:

Set the default size for the `where` command.

Default: 100
Debugger command: `dbxenv stackmaxsize <num>`

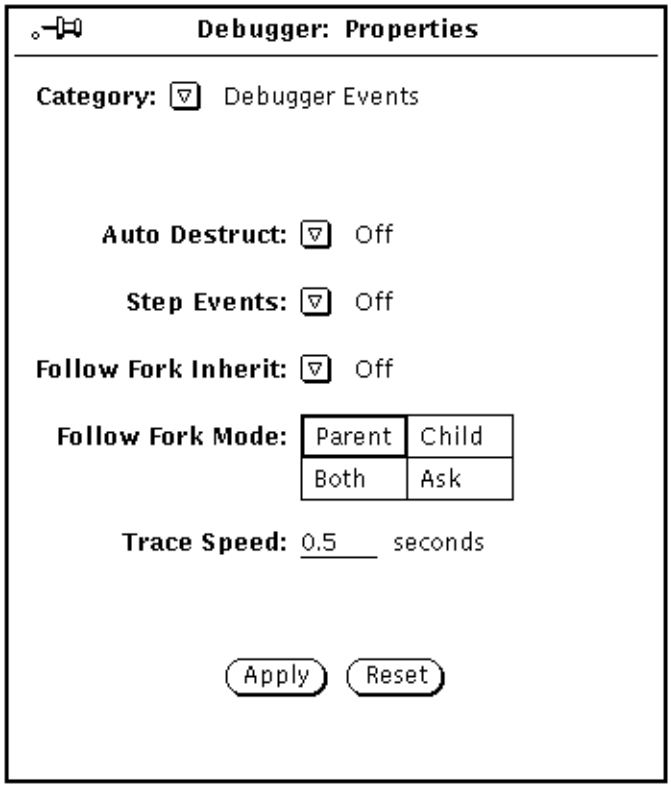
String Length:

Set maximum number of characters printed for character pointers, 'char *'.

Default: 512 characters.
Debugger command: `dbxenv stringlen` *num*ber

13.2 Debugger Events

You can set Auto Destruct, Step Events, and Follow Fork Inherit `on` or `off` from the Debugger Events Properties window. You can also set Follow Fork Mode to Parent, Child, Both, or Ask and you can set the Trace Speed.



Auto Destruct

Set to allow automatic call of appropriate destructors for locals when "popping" a frame.

Default: On
Debugger command: `dbxenv pop_autodestruct {on | off}`

Step Events

Set `on` to allow breakpoints while using the `step` and `next` commands.

Default: Off
Debugger command: `dbxenv stepevents {on | off}`

Follow Fork Inherit

When following a child process, set Follow Fork Inherit `on` to inherit events and `off` not to inherit events.

Default: Off
Debugger command: `dbxenv follow_fork_inherit {on | off}`

Follow Fork Mode

Set the Follow Fork Mode so when a process executes a fork, vfork, or a fork1, you can:

- Follow the parent
- Follow the child
- Follow both the parent and the child (Debugger window only)
- Follow the parent or the child after being asked by the Debugger

Default: Parent
Debugger command: `dbxenv follow_fork_mode {parent | child | ask}`

Trace Speed

Set the minimum time between each printout of information to the command pane during a trace command.

Default: 0.5 seconds
Debugger command: `dbxenv speed number_seconds`

13.3 Changing the Debugger Window Configurations

You can adjust the size of the source display, the command pane, and the Data Display window pane. You control the number of vertical lines in each pane. You control the width of the pane by setting a maximum number of characters before the line wraps. Finally, you control the number of lines that appear in the source display above and below the lines you bring into view.

You can also use the base window resize-corners to alter the size of the windows and panes.

You can change the default font that the Debugger uses for displaying code with the Font File control. Figure 13-2 shows the default settings.

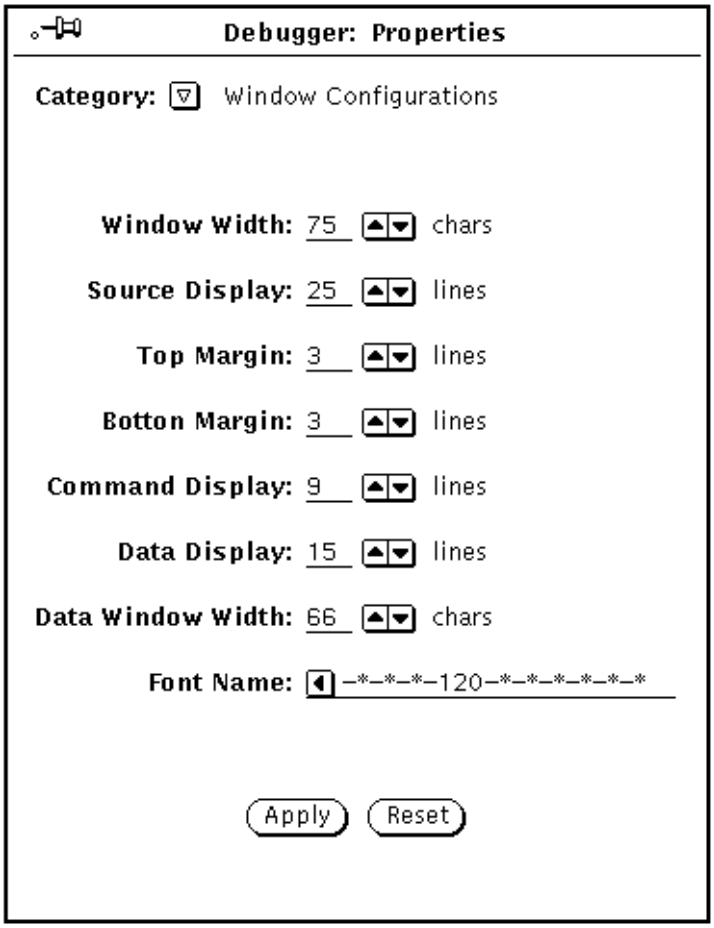


Figure 13-2 Window Configuration Control Panel

Window Width:

Set the width, in characters, of the source display or command pane.

Default: 80 characters
Command pane: `toolenv width` *num*

Source Display:

Set the number of lines of code displayed in the source display.

Default: 20 lines
Command pane: `toolenv srclines` *num*

Top Margin:

Set the minimum number of lines of code the Debugger displays above the line corresponding to the current program location each time the program stops.

Default: 3 lines
Command pane: `toolenv topmargin` *num*

Bottom Margin:

Set the minimum number of lines of code the Debugger displays below the line of code corresponding to the current program location each time the program stops.

Default: 3 lines
Command pane: `toolenv botmargin` *num*

Command Pane:

Set the number of lines displayed in the command pane.

Default: 8 lines
Command pane: `toolenv cmdlines` *num*

Data Display:

Set the number of lines displayed in the Data Display Window.

Default: 15 lines
Command pane: `toolenv displines` *num*

Data Window Width:

Set the width, in characters, of the Data Display Window.

Default: 60
Command pane: `toolenv dispwidth num`

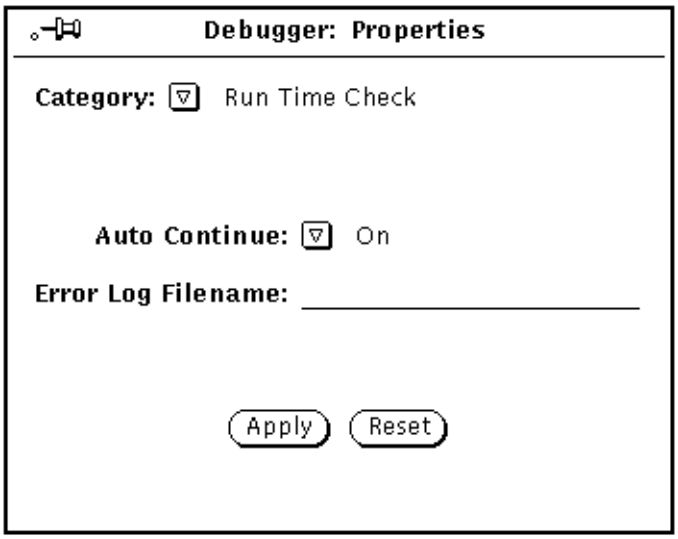
Font Name:

Set the name of the font file the Debugger uses to display code in the Debugger windows and panes.

Default: s*ystem_default_file*
Command pane: `toolenv font` *file*

13.4 Changing Settings for Run Time Check

You can set Auto Continue from the Run Time Check category window. With Auto Continue set to `on`, you can log Run Time Check errors to the `Error Log Filename` that you type in the Properties window.



Default: Off
Command pane: `dbxenv autocontinue {on | off}`
Command pane: `dbxenv errlogfile <filename>`

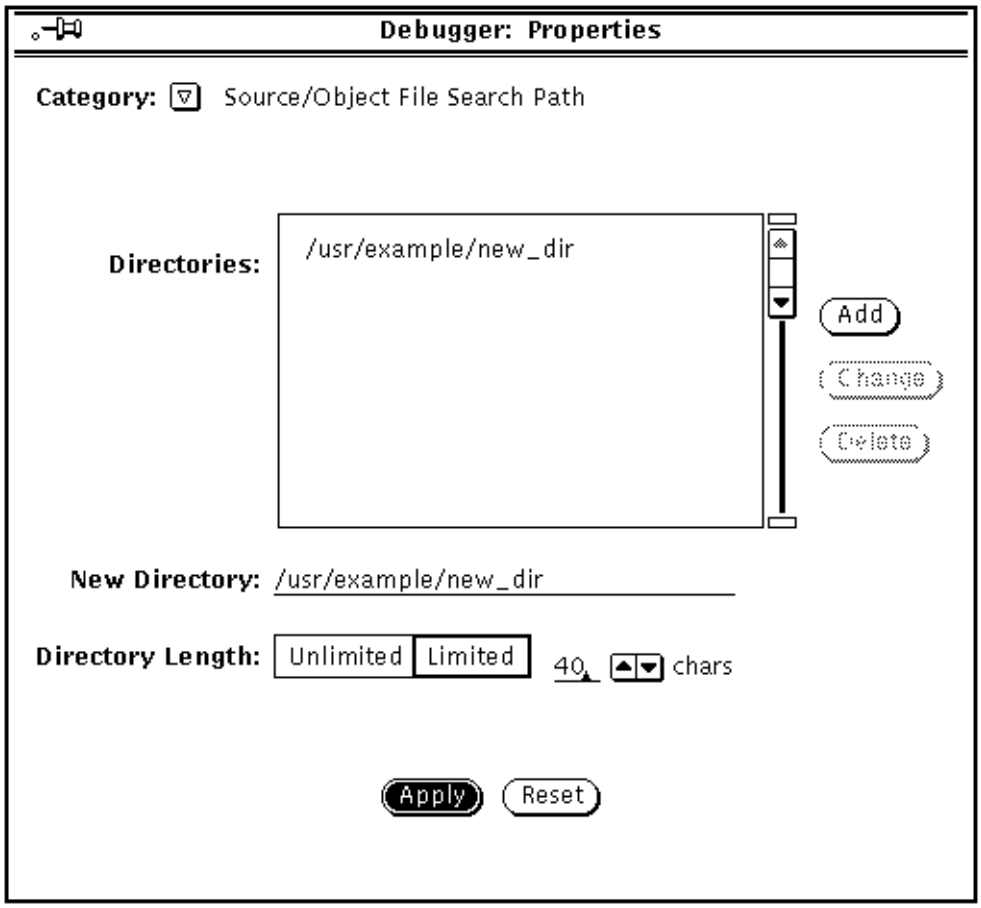
13.5 Setting the Source/Object File Search Path

You can check the path, add to the list, edit a pathname, or delete a pathname from the Source / Object File Search Path window.

To check the current File Search Path:

- **Display the Properties Window and choose Source/Object File Search Path from the Category menu.**

.



Note that you must click the Apply button to execute the changes you make to the search path. Until you click Apply, the search path does not change. You can click Reset *before* clicking Apply to discard your most recent edits.

To Add a directory to the Source/Object File Search Path:

1. **Type in the name of the directory you want to add in the New Directory text field; click Add.**
   The directory name appears in the Directories display box.
2. **Click Apply to apply the change.**

To Change a pathname already on the list:

1. **Select the path you want to edit by clicking on it in the Directories display box.**
   The control boxes the selected entry.
2. **Click the Change button.**
   The control writes the pathname on the New Directory text field.
3. **Edit the pathname on the New Directory text field; then click Apply.**

To delete a path from the search path list:

- **Select a pathname in the Directories box; click Delete; then click Apply.**

Adjusting the Display of Pathnames in the Directories Box

By default, the Directories box truncates pathnames on the left if they are larger than 40 characters. You can adjust this setting up or down to see more or less of the pathnames.

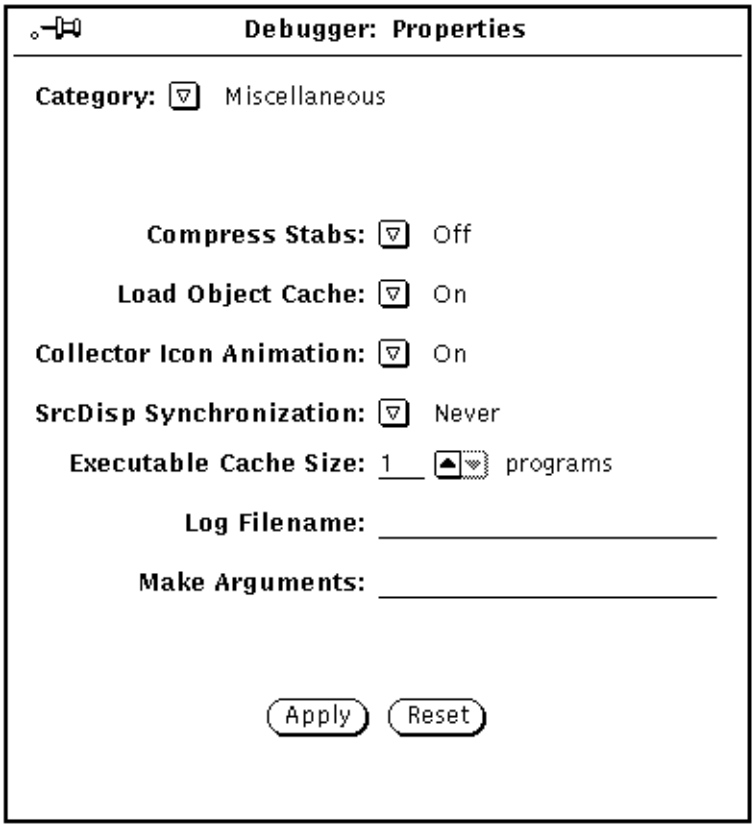
Also, if you set Directories Length to Unlimited, the box expands to accommodate the longest pathname, up to the maximum size of characters before truncating the name.

13.6 Setting Miscellaneous Properties

Choose Miscellaneous from the Debugger Properties menu to set Compress Stabs, Load Object Cache, and Collector Icon Animation On or Off. You can also set Source Display Synchronization, Executable Cache Size, change the Log Filename, and set the Make Arguments.

Compress Stabs

Set on to read debugging information for each include file only once.



Default: On
Debugger command: `dbxenv compress_stabs {on | off}`

Load Object Cache

Enable or disable the load object cache.

Default: On
Debugger command: `dbxenv lo_cache {on | off}`

Collector Icon Animation

Set the Animated Icon for the Collector Performance Tool to `On` or `Off`. This property is inactive unless the Collector is active.

Default: On
Debugger command: None

SrcDisp Synchronization

Set to allow display of code in the source display from selections made in SourceBrowser, CallGrapher, ClassBrowser, and ClassGrapher. If you issue a source display command from one of these tools, a `list` command is issued, causing the selected code to display in the Debugger, bypassing the SourceBrowser code display pane.

Always: The Debugger responds to an src display message every time you choose a source display command in one of these other tools.

Never: The Debugger ignores all src display messages when a source command is selected in one of these tools.

Default: Never
Debugger command: None, use the Properties window

Executable Cache Size

Set the size of the `a.out` load object cache. Set to <*n*> when debugging <*n*> programs from a single dbx. A <*n*> of zero still allows caching of shared objects.

Default: 1
Debugger command: `dbxenv aout_cache_size <num>`

Log Filename

Rename the Debugger log file.

Default: `/tmp/dbx.log.pid`

Make Arguments

Set the arguments passed to Make. You can also set arguments for Make in the Make window. Choose Make With Argument from the Program Make pull-right menu.

Default: SunOs 5.2 `CC=cc -g` / / ANSI C, with debugging
Debugger command: `dbxenv makeargs "string"`

13.7 Using the Debugger Initialization File

The Debugger initialization file, `.dbxrc,` stores Debugger commands that are executed each time you start the Debugger. Typically, the file contains commands that customize the debugging environment, change the default window pane settings, and add command buttons or Custom menu items to the interface. You may also place Debugger commands in the `.dbxrc` file. Remember, if you customize the Debugger from the command pane, the customized settings apply only to the current debugging session.

During startup, the Debugger searches for `.dbxrc` first (ksh mode, see Chapter 23, "Korn Shell"). The search order is:

1. Current directory `./.dbxrc`
2. Home directory `$HOME/.dbxrc`

If `.dbxrc` is not found, the Debugger searches for `.dbxinit` (dbx mode). The search order is:

1. Current directory `./.dbxinit`
2. Home directory `$HOME/.dbxinit`

13.7.1 A Sample Initialization File

Here is a sample `.dbxrc` file:

```
dbxenv case insensitive
toolenv srclines 35
menu ignore where
button ignore Edit
catch FPE
```

The first line changes the default setting for the case sensitivity control (the Matching control on the Debugging Environment Attributes control panel).

`dbxenv` refers to the set of debugging environment attributes.
`case` refers to the Matching control.
`insensitive` is the control setting.

The second line alters the default value for Window Configuration controls:

`toolenv` refers to the set of Window Configuration controls.
`srclines 35` sets the number of lines in the source display to 35.

The third line creates an item on the Custom menu named where:

`menu` creates the item for the Custom menu.
`ignore` instructs the Debugger to ignore the current mouse selection.
`where` is the name of the new item.

The fourth line creates a new command button, Edit:

`button` creates a button command.
`ignore` instructs the Debugger to ignore the current mouse selection.
`Edit` is the name of the button.

The fourth line is a Debugging command, `catch`, which adds a system signal (`FPE`) to the default list of signals to which the Debugger responds, stopping the program.

13.7.2 Setting the Graphical User Interface (GUI) Resources

Here is a list of the Debugger X resources you can set in the `$HOME/.debugger-init` file.

```
Debugger.CommandWindow.Lines:<int>
Debugger.DataDisplay.Lines:<int>
Debugger.DataDisplay.Width:<int>
Debugger.SourceWindow.Lines:<int>
Debugger.SourceWindow.TopMargin:<int>
Debugger.SourceWindow.BotMargin:<int>
Debugger.Window.Width:<int>
Debugger.Window.FontName:<string>
```

Here is a list of the Debugger X resource defaults you can set in the `$HOME/.Xdefaults` file.

```
vdi*font:<string>
vdi*Node*font:<string>
vdi*Node*EntryValue*font:<string>
vdi*exprInput*font:<string>
```

```
vdi*Node*background:<string>
vdi*Node*borderColor:<string>
vdi*Node*port*background:<string>
vdi*Node*Header*background:<string>
vdi*Node*Header*borderColor:<string>
!
!   custom application resources
!
vdi*labelLength:<int>
vdi*displayCount:<int>
vdi*entryLength:<int>
```

13.8 Adding Buttons

The default interface for the Debugger includes a row of command buttons. This section describes how to add buttons. If you add buttons from the command line, the Debugger discards them when you quit the current session. To have buttons reinserted into the interface each time you start the Debugger, put the commands that create them in the `.dbxrc` file. You can add as many buttons as you like. As you add button commands, the Debugger adds new rows for them, as needed.

13.8.1 The Button Command

The syntax for adding a button command is `button` followed by a selection service modifier and the name of the button:

`button` *selection_service_modifier Name*

The selection service modifier tells the Debugger how to treat the current mouse selection (if there is one) when you click a new button. See Table 13-1 for a description of the selection service modifiers. For some types of commands, the current selection serves as the target of the command. For example, when you select a variable name and then click Print. Other commands or menu items ignore the current selection. For example, if you were to create an Edit button to start your system editor in a Command tool, the current selection would be irrelevant. The button command accepts one or a combination of the following selection service modifiers.

Table 13-1 Selection Service Modifiers for Button Commands

Modifier	Description
`command`	Issue the Debugger command selected in the command pane. This modifier works well as an alternative to using the history facility for reissuing a complex debugging command. You can select the entire debugging command, then click the button you created using the `command` modifier to reissue the command.
`expand`	If the selected characters in either pane begin with an alphanumeric character, dollar sign, or underscore, then first expand the selection, then use the expanded selection as the target for the command button or menu item.
`ignore`	Ignore the current mouse selection.
`lineno`	Use the line number associated with the current selection as the target of the command.
`literal`	Use the selected material exactly as selected for the command target. This modifier works the opposite of `expand`.

13

Editing a Program 14

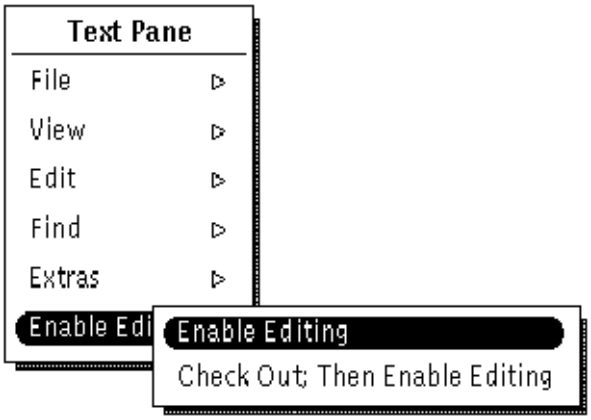
This chapter describes how to edit source code from within the Debugger. You can edit code in the source display after converting the initially read-only pane to an editable pane. To edit the currently displayed file in the source display, choose Enable Edit from the source display floating pop-up menu.

14.1 Enabling Editing in the Source Display

By default, the source display is a browse-only pane.

To edit the file displayed in the source display,

♦ **Choose Enable editing from the source display floating pop-up menu. With the pointer in the source display, press the mouse MENU button.**



Note – When the source display is in editing mode, the debugging annotations (breakpoint and current focus markers) are not displayed.

14.1.1 Checking Out Files Under SCCS

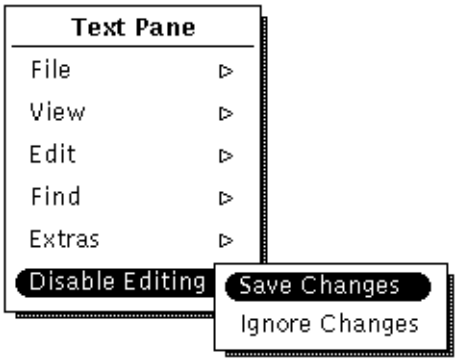
Notice that the Enable Edit item on the floating pop-up menu is a pull-right menu. The second item, Check Out; Then Enable Editing, automatically checks the file out of SCCS, if it is under this version control software. You cannot check it back into SCCS from within the Debugger.

14.1.2 Saving Changes, Disabling Editing

The Enable Editing item toggles to Disable Editing after you make the source display editable.

To save changes:

♦ **Choose Disable Editing from the source display floating pop-up menu.**



14.1.3 Discarding Changes, Disabling Source Display Editing

If you do not want to save changes made to the file currently displayed in the source display:

♦ **Choose Ignore Changes from the Disable Edit item on the floating pop-up menu.**

14

Part 3 — Advanced Debugging

Debugging at the Machine-instruction Level 15

This chapter describes how to use event management and process control commands at the machine-instruction level, how to display the contents of memory at specified addresses, and how to display source lines along with their corresponding machine instructions. The `next`, `step`, `stop` and `trace` commands each support a machine-instruction level variant: `nexti`, `stepi`, `stopi` and `tracei`.

This chapter is organized into the following sections:

15.1 Examining the Contents of Memory

Using addresses, you can examine the content of memory locations as well as print the assembler language instruction performed at each address. Using a syntax derived from `adb`, the assembler language debugger, you can query for:

- The *address*, using the `"="` (equal sign) character; or,
- The *contents* stored at an address, using the `"/"` (slash) character.

You can examine the contents of memory by using the `examine`, `dis`, and `listi` commands.

15.1.1 Using the `examine` Command

Here is the syntax that summarizes the examples shown in this section:

```
examine +
examine <addr>
examine <addr1>,<addr2>
examine <addr1>,<addr2>/<fmt>
examine <addr>/[<count>]<fmt>
examine <addr>=<fmt>
examine <addr>=
```

where

`examine` has a predefined alias, `x`.

`+` displays the contents of the next address in the default format.

addr is any expression resulting in or usable as an address. Examples are:

0xff99	an absolute address
&*main*	address of a function
&*main+20*	offset from a function address
&*errno*	address of a variable
str	a pointer-value variable pointing to a string

Symbolic addresses used to display memory are specified by preceding a name with an ampersand &. Registers are denoted by preceding a name with a dollar sign $. Table 15-2 lists the Sun-4 registers.

count is a repetition count in decimal. The increment size depends on the memory display format.

fmt is the address display format in which the Debugger displays the results of a query as shown in Table 15-1.

The output produced depends on the current display *format*. To change the memory format, you supply a different code. (See “Alternative Memory Display Formats” on page 15-181.)

Here is an example of how to use an address with *count* and *fmt* options to display five successive disassembled instructions starting from the current stopping point:

```
(debugger) stepi
stopped in support at 0x117c8
(debugger) x0x117c8 /5i
support__5blockFv+8:    save    %sp, %g1, %sp
support__5blockFv+0xc:  st      %i0, [%fp + 68]
support__5blockFv+0x10: ld      [%fp + 68], %i3
support__5blockFv+0x14: ld      [%i3 + 24], %o0
support__5blockFv+0x18: ba      support__5blockFv+0x20
```

To print the value stored at the *next* address after the one last displayed by `examine`:

♦ **Type**

```
(debugger) x +/ i
```

Alternative Memory Display Formats

Notice in the previous example the inclusion of the display *fmt* specifier, i. Set the *format* specifier to tell the Debugger how to display information associated with the addresses specified.

The default format set at the start of each Debugger session is `X`: display an address / value as a 32 bit word, in hexadecimal. Table 15-1 lists the possible formats.

Table 15-1 Memory Address Display Formats

Format	Description
`i`	Display as a machine instruction
`d`	Display as a halfword in decimal
`D`	Display as a word in decimal
`o`	Display as a halfword in octal
`O`	Display as a word in octal
`x`	Display as a halfword in hexadecimal
`X`	Display as a word in hexadecimal /* default format */
`b`	Display as a byte in octal
`c`	Display a byte as a character
`w`	Display as a wide character
`s`	Display as a string of characters terminated by a null byte
`W`	Display as a wide-character string
`f`	Display as a single-precision floating point number
`F, g`	Display as a double-precision floating point number
`E`	Display as an extended-precision floating point number

15.1.2 Using the `dis` *Command*

Here is the syntax for the `dis` command. For syntax definitions, see the `examine` command.

`dis` <*addr*> [/<*count*>]
`dis` <*addr1*>, <*addr2*>
`dis`
`dis` /<*count*>

15.1.3 Using the `listi` Command

To display source lines along with their corresponding machine instructions, use `listi`. For example:

```
(debugger) listi 98,100
   98       int i = atoi(argv[1]);
main+0x50:     ld    [fp + 72], %10
main+0x54:     add   %10, 4, %10
main+0x58:     ld    [%10], %10
main+0x5c:     mov   %10, %o0
main+0x60:     call  _PROCEDURE_LINKAGE_TABLE_+0x60 [PLT]
main+0x64:     nop
main+0x68:     mov   %o0, %10
main+0x6c:     st    %10, [%fp + -8]
   99       foo(i);
main+0x70:     ld    [%fp + -8], %10
main+0x74:     mov   %10, %o0
main+0x78:     call  foo
main+0x7c:     nop
   100      exit(0);
main+0x80:     mov   0, %10
main+0x84:     mov   %10, %o0
main+0x88:     call  _PROCEDURE_LINKAGE_TABLE_+0x3C [PLT]
main+0x8c:     nop
```

Command `listi` is equivalent to `list -instr`.

15.2 Stepping and Tracing at Machine-instruction Level

Machine-instruction level commands behave the same as their source level counterparts except that they operate at the level of single instructions instead of source lines.

15.2.1 Single-stepping at the Machine-instruction Level

To single-step from one machine-instruction to the next machine-instruction:

- **Use `nexti` or `stepi` in the command pane.**

`nexti` and `stepi` behave the same as their source-code level counterparts: `nexti` steps *over* functions, `stepi` steps *into* a function called from the "next" instruction (stopping at the first instruction in the called function).

The output from `nexti` and `stepi` differs from the corresponding source level commands in two ways. First, the output includes the *address* of the instruction at which the program is stopped (instead of the source code line number); secondly, the default output contains the *disassembled instruction*. For example:

```
(debugger) func
hand::ungrasp
(debugger) nexti
ungrasp +0x18:  call support
(debugger)
```

15.2.2 Tracing at the Machine-instruction Level

Tracing at the machine instruction level works the same as at the source code level except when you use `tracei`. For `tracei`, the Debugger executes a single instruction only after each check of the address being executed or the value of the variable being traced. `tracei` produces automatic *stepi*-like behavior: that is, the program advances one instruction at a time, stepping into function calls.

The Debugger supports two types of machine-instruction level traces:

- A trace of the execution of a specified address.
- A trace of a change in the value of a variable or expression at a specified address.

When you use `tracei`, it causes the program to stop momentarily after each instruction while the Debugger checks for the address execution or the value of the variable or expression being traced. Using `tracei` can slow execution considerably.

Both types of machine-instruction level traces take a post-break conditional modifier. Here is the syntax:

```
tracei  [address] [if cond]
tracei  [variable] [at address] [if cond]
```

where
address refers to a memory location.

To trace the execution of an address at the machine-instruction level:

- **Type in the command pane,**

  `(debugger)` **`tracei`** *address*

  The default output is the disassembled instruction if the program executes the address.

To trace the value of a variable when the program reaches an address:

- **Type in the command pane,**

  `(debugger)` **`tracei`** *variable* **`at`** *address*

  If the value stored at the specified address changes, the Debugger displays the trace. In this example, `tracei` reports each time the Blocks program "handle" object grasps a different solid object:

```
(debugger) tracei &object at 0x123b4
(debugger) cont
Move block B1 on top of block B2.
First I must get B1 out of the way.
at 0x123b4: : &object = 0xf7ffed78     // tracei output
Moving hand to pick up B1 at location 3:4.
Grasping B1.
Removing support relationship between B1 and B2.
Moving B1 to top of Table at location 10:0.
Adding support relationship between B1 and Table.
Releasing B1.
at 0x123b4: : &object = 0xf7ffef38     / / tracei output
```

15.3 Setting Breakpoints at Machine-instruction Level

To set a breakpoint at machine-instruction level, use one of the following `stopi` variants of the `stop` command:

```
stopi [at address] [if cond]
stopi [variable] [if cond]
stopi in function [if cond]
```

where
address refers to a memory location.

15.3.1 Setting a Breakpoint at an Address

To set a breakpoint at a specified address:

♦ **Type in the command pane,**

`(debugger)` **`stopi at`** *address*

For example,

```
(debugger) nexti
stopped in hand::ungrasp at 0x12638
(debugger) stopi at &hand::ungrasp
(3) stopi at 75320
(debugger)
```

15.3.2 Setting a Breakpoint in a Function in Optimized Code

When working with unoptimized code, you set a breakpoint in a function with the `stop in` *function* command. However, when working with optimized code, you must use the `stopi in` *function* command to assure that the Debugger places the breakpoint at the first instruction.

To set a breakpoint in a function when debugging optimized code:

♦ **Use the** `stopi in` *function* **command.**

`(debugger)` **`stopi in`** *function* [**`if`** *condition*]

Table 15-2 Sun-4 Register Names

Register	Description
`$g0-$g7`	Global registers
`$o0-$o7`	“out” registers
`$i0-$i7`	“in” registers
`$l0-$l7`	“local” registers
`$fp`	Frame pointer, equivalent to register $i6
`$sp`	Stack pointer, equivalent to register $o6
`$y`	Y register
`$psr`	Processor state register
`$wim`	Window invalid mask register
`$tbr`	Trap base register
`$pc`	Program counter
`$npc`	Next program counter
`$f0-$31`	FPU “f” registers
`$fsr`	FPU status register
`$fq`	FPU queue

See the *SPARC Architecture Reference Manual* and the *Sun-4 Assembly Language Reference Manual* for more information on Sun-4 registers and addressing.

15

Debugging Child Processes 16

This chapter describes how to debug a child process. The Debugger has several facilities to help you debug processes which create children via `fork(2)` and `exec(2)`.

This chapter is organized into the following sections:

16.1 Simple Attach

In the simplest case, the child has already been created, so you can attach to it in one of the following ways:

- From the shell, when starting dbx or the Debugger, type

  $ **dbx <progname> <pid>**

- From the command line, type

(dbx) **debug <progname> <pid>**

In both cases, <*progname*> can be substituted with the name "-", in which case the Debugger automatically finds the executable associated with the given process id (pid). After using a "-", a subsequent `run` or `rerun` does not work as the Debugger does not know the full pathname of the executable.

16.2 Follow Exec

If a child process executes (`exec(2)`) a new program, the process id does not change, but the process image does. dbx automatically takes note of an `exec()` and does an implicit reload of the newly executed program.

Because the first argument to `exec(2)` is a relative pathname, and dbx cannot reliably know the working directory of the child at the time of `exec()`, the new program is loaded using the "-" filename and a pid.

16.3 Follow Fork Under dbx (tty Mode)

In analogy to the "Follow Exec" feature, if a child process does `fork(2)`, the process id changes, but the process image stays the same. Depending on how the dbxenv variable "`follow_fork_mode`" is set, dbx does the following:

parent

This is the traditional behavior, dbx ignores the fork and follows the `parent`.

child

In this mode, dbx automatically switches to the forked `child` using "-" and the new pid. All connection and awareness of the original parent is lost.

both

This mode is only available under the graphical user interface (GUI). The GUI mode is described in the following section.

ask

You are prompted to choose a `parent`, `child`, or `both` whenever the Debugger detects a fork.

16.4 Follow Fork Under the Debugger (GUI Mode)

When using the Debugger, in addition to the `follow_fork_modes` of *parent* and *child*, the mode *both* can be used. In this case, a new dbx is cloned (see the DEBUG command option `-clone`). The Debugger can alternate between the two underlying dbx programs.

Dealing with multiple dbx programs attached to multiple processors is simplified through use of the Process/Thread Inspector (PTI). See Chapter 12, "Process/Thread Inspector", for more information. When a new dbx is cloned, a new line is displayed in the Process portion of the PTI window.

You can double-click on a line in the process portion of the PTI window to switch the Debugger to the dbx attached to the selected process.

You can also set `follow_fork_mode` from the Debugger Props button:

- **Choose Debugger Events from the Category menu.**

16.5 Interaction with Events and Other Features

All breakpoints and other events are deleted for any `exec()` or `fork()` process. You can override the deletion for follow fork by setting the dbxenv variable `follow_fork_inherit` to On. (You can set `follow_fork_inherit` to On from the Debugger Events window.)

The Collector and RunTime Checking are disabled for an `exec()` or `fork()` process.

16

Working With System Signals *17*

This chapter describes how to use the Debugger to work with system signals. The Debugger supports a breakpoint command named `catch`. The `catch` command stops a program when the Debugger detects any of the system signals appearing on the catch-list.

Also, the Debugger `cont` command supports the `sig` *signal_name* option, which allows you to resume execution of a program with the program behaving as if it had received the system signal specified in the `cont sig` command.

When a signal is to be delivered to a process that is being debugged, the signal is redirected to the Debugger by the kernel. When this happens, you usually get a prompt. You then have two choices:

1. **"cancel" the signal when the program is resumed. This is the default behavior of `cont`. This default behavior facilitates easy interruption and resumption using `SIGINT` (control c).**

2. **"forward" the signal to the process by using**

   ```
   cont -sig <sig>
   ```

In addition, if a certain signal is received frequently, you can arrange for dbx to automatically forward the signal, by typing

```
ignore <sig> # "ignore" because you do not care to see it.
```

A default set of signals is automatically forwarded in this manner, see `ignore`.

17

This chapter is organized into the following sections:

17.1 Catching System Signals

By default, the catch list contains 22 of the 33 detectable signals. You can change the default catch list by adding or removing signals to or from the default ignore-list.

To see the list of signals currently being trapped,

- **Type** `catch` **with no signal-name argument in the command pane:**

  ```
  (debugger) catch
  ```

To see a list of the signals currently being *ignored* by the Debugger when the program detects them.

- **Type** `ignore` **with no signal-name argument in the command pane:**

  ```
  (debugger) ignore
  ```

17.1.1 *Default* `Catch` *and* `Ignore` *Lists*

The default `catch` and `ignore` lists vary depending on the operating system.

The default `catch` list contains:

INT QUIT ILL TRAP ABRT SEGV SYS PIPE TERM USR1 USR2 PWR URG POLL STOP TTIN TTOU VTARLM PROF XCPU XFSZ

The default `ignore` list contains:

HUP EMT FPE KILL ALRM CLD WINCH TSTP CONT WAITING LWP

17.1.2 *Changing the Default* `Catch` *and* `Ignore` *Signal Lists*

You control which signals cause the program to stop by moving the signal names from one list to the other.

To move signal names from the one list to the other:

- **Supply a signal-name(s) argument that currently appears on one list as an argument(s) to the other list.**
  For example, to move the QUIT and ABRT signals from the `catch` list to the `ignore` list, type:

  `(debugger)` **ignore QUIT ABRT**

17.1.3 Trapping the FPE Signal on a SPARC system Computer

Often programmers working with code that requires floating point calculations want to debug exceptions generated in a program. On a SPARC system computer, when a floating point exception like overflow or divide by zero occurs, the system returns a "reasonable" answer as the result for the operation that caused the exception. Returning a reasonable answer allows the program to continue executing quietly. (SPARC system computers implement the IEEE Standard for Binary Floating Point Arithmetic definitions of "reasonable" answers for exceptions.)

Because a SPARC system returns a reasonable answer for floating point exceptions, exceptions do not automatically trigger the signal `SIGFPE`.

To find the cause of an exception, you need to set up a trap handler so that the exception triggers the signal `SIGFPE`. (See `ieee_handler(3m)` for an example of a trap handler.) When you set up a trap handler using `ieee_handler`, the trap enable mask in the hardware floating point status register is set. This trap enable mask causes the exception to raise `SIGFPE` at run time.

Once you have compiled the program with the trap handler, load the program into the Debugger. Before you can catch the `SIGFPE`, you must add `FPE` to the Debugger signal `catch` list, using the command,

`(debugger)` **catch FPE**

By default, `FPE` is on the ignore-list.

After adding FPE to the catch list, run the program in the Debugger. When the exception you are trapping occurs, SIGFPE is raised and the Debugger stops the program. Now you can trace the call stack (use the Stack menu button or the Debugger where command) to help find the specific line number of the program where the exception occurs.

For more discussion and examples, see the floating point manual, *Numerical Computation Guide*, which comes with the SPARCompilers documentation.

17.2 Sending a System Signal in a Program

The Debugger cont command supports the sig *signal_name* option, which allows you to resume execution of a program with the program behaving as if it had received the system signal specified in the cont sig command.

For example, if a program has an interrupt handler for SIGINT (^c), you can type ^c to stop the application and return control to the Debugger (as discussed in Section 7.4, "Using Cntl-C to Stop a Process," on page 7-103). Now, if you issue a cont command by itself to continue program execution, the interrupt handler never executes. To execute the interrupt handler, you send the signal, sigint, to the program:

```
(debugger) cont sig sigint
```

Collecting Performance Tuning Data 18

This chapter describes how to start the Collector performance tuning tool from the Debugger and how to take a sample manually for use with the Analyzer. The Collector is the Analyzer tool that you use to prepare an application for data collection.

During the execution of an application, the Collector gathers performance and test coverage data on an application of your choice. See the toolset manual entitled, *Performance-Tuning An Application* for full details of the Collector and how to analyze the information it collects.

This chapter is organized into the following sections:

18

18.1 Starting the Collector from the Debugger

To start the Collector:

♦ **Choose Collector from the Execution menu.**

At any one time, you can have several Collector windows displayed, each performing a separate experiment.

.

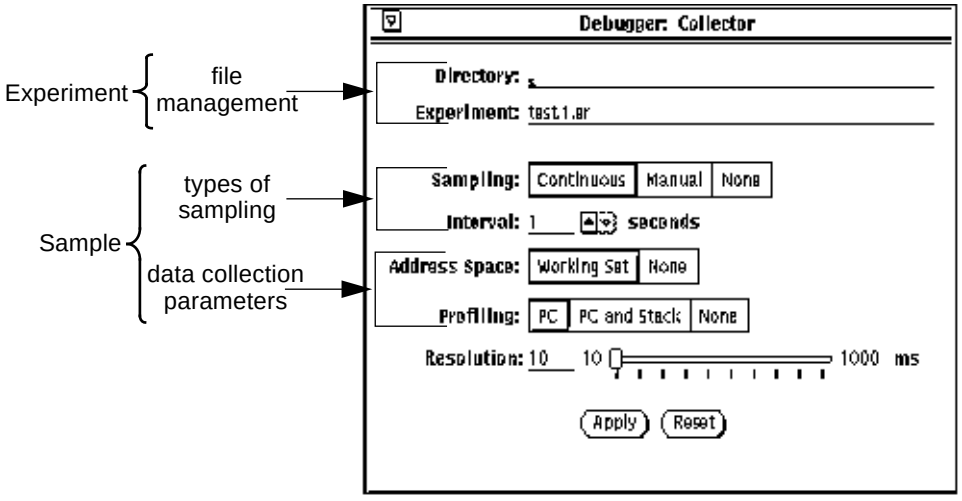


Figure 18-1 Collector Window

The Collector window (Figure 18-1) is displayed with default settings for experiments and samples. You need not change any of the settings or fields in the Collector window to start data collection. However, you can change any of these settings when the default settings do not satisfy your requirements. The settings can only be changed when the program you are debugging is stopped.

The Collector window consists of two parts: experiment and sample.

18.1.1 Experiment

An experiment consists of a set of samples taken on an application. In the experiment you execute the application, observing it with the Collector and storing the performance data into an experiment record. The performance data is collected in one or more samples, each of which is a measurement of a different period of time during the execution of the application. The experiment can contain one or more samples.

The experiment part of the Collector concerns itself with routine file management. You must name the experiment and specify a directory in which it is to be stored. See Figure 18-1.

18.1.2 Sample

A sample contains data collected over a specified period of time during the execution of the application. It provides information about how the application program behaves. You can take one sample or multiple samples.

Multiple samples are useful when the performance of the application varies over time. Instead of examining the aggregate behavior of the application's entire execution, you can take multiple samples to examine the performance behavior at specified intervals of the application's execution.

A sample may include data describing system calls, resource consumption, and referenced and modified pages in the application's address space

The Sample consists of two areas:

- Choosing the type of sampling.

  This area controls the samples that are taken. Each sample contains information on the target application over a specified period of time

- Choosing the types of data to collect.

  This area specifies the types of data to collect (collection parameters). Overview is the default data collection parameter.

18.2 Taking a Sample for Use with the Analyzer

Performance data is collected through the process of sampling. Each sample contains information on the target application over a specified period of time. Within the Collector, you can control the way in which samples are taken by choosing one of the sampling settings:

The default setting is Continuous samples every one second.

18.2.1 Manual Sampling

Manual sampling allows you to mark a sample boundary by issuing the Take Sample command from within the Debugger. Manual sampling with Take Sample is designed mainly so that you can collect data on real time, interactive events, such as displaying a window or choosing a menu item. The Manual sampling mode is especially useful if the application provides a visual response, either in the form of graphics or text.

For example, you can test the performance of an item on a menu as it completes its tasks. To perform this type of experiment, you perform the following list of operations:

1. Run the program in the Debugger; put the user interface into a typical state for choosing the menu item you want to test. Suspend the application.
2. Display the collector and set the sampling control to Manual. (Setting Sampling to Manual in the Collector window also activates the Take Sample item on the Debugger Execution menu.)
3. Continue the application running in the Debugger. *Collection of information starts as soon as the application is re-activated.*
4. Choose the menu item in the application.
5. When the application completes the task(s) invoked by choosing the item, choose Take Sample from the Debugger Execution menu. Take Sample marks the *endpoint* of that particular sample and the start of the next one. The data collected is from the time you started the Collector to the time you chose Take Sample.

To mark a sample boundary in Manual mode,

- **Choose Take Sample from the Execution menu.**

18.2.2 Storing the Collected Data

An experiment consists of a sample or set of samples taken on the application.

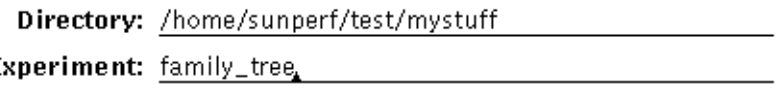


Figure 18-2 Experiment Area of the Collector Window

Experiment Directory

The experiment must be saved to a directory. Use the default directory name or create your own, more descriptive, directory name in which to save the experiment. To specify a different directory, enter the new name in the Experiment text field. Whether you use the default directory or specify another directory, when the Collector is first activated, the default directory is displayed in the Directory text field. If you delete the default directory name and forget to enter in a new name, then the experiment is automatically saved to the current working directory. You must enter a name before you can start data collection.

Experiment Name

All experiment names are derived from the application's name. For example, the experiment name for the Blocks is `blocks.1.er`. The collector assigns names automatically to each experiment, using suffixes and version tag numbers to make each name unique.

The Collector never overwrites an existing file. If there is another file by the same name, then the version tag is incremented each time you run the experiment. For example, if you run the experiment for `blocks.1.er` a total of three times, then the three experiments are named `blocks.1.er`, `blocks.2.er`, and `blocks.3.er`.

18

Runtime Checking 19

Runtime Checking (RTC) allows you to detect automatically run time errors in an application during the development phase. Because RTC is an integral feature of the Debugger, all functions of the Debugger, such as setting breakpoints, examining variables and so on, can be used with RTC. Compiling with the `-g` flag provides source line number correlation in the RTC error messages. RTC can also check programs compiled with the optimization **-**O flag.

No recompiling, relinking, or Makefile changes are required to take advantage of RTC.

The following list briefly describes the features of RTC:

- detects memory access errors
- detects memory leaks
- works with languages other than C and C++
- works on code that you do not have the source for, such as libraries.

This chapter is organized into the following sections:

19

Requirements

Runtime Checking:

- Requires programs to be compiled using SPARCcompiler 3.0 compilers
- Requires dynamic linking with `libc`
- Requires use of the standard `libc malloc/free/realloc` or allocators based on those functions

Limitations

- Does not support attaching to a running process
- RTC does not handle program text areas and data areas larger than 8Mb

19.1 Getting Started

1. To use Runtime Checking with a command line interface:

   Start dbx with the `-C` option:

   `dbx -C` <*yourprog*>

2. To use Runtime Checking with a graphical user interface:

   Start the Debugger with the -C option:

   `debugger -C` <*yourprog*> &

   Alternately, you can set the environment variable `SW_RTC`. This has the effect of specifying the `-C` option every time you invoke dbx or the Debugger:

```
setenv SW_RTC                   # csh
SW_RTC= ; export SW_RTC         # sh or ksh
```

Note – Using the `-C` option does not turn on checking, but it enables the feature to be activated.

If you start dbx or the Debugger without the `-C` option or do not set the environment variable `SW_RTC`, and issue the `check` command, error checking is enabled when the next “run” is issued. However, all the shared libraries needed by the program are reloaded. A warning to that effect is also issued.

3. Batch Utility

   `bcheck [-access | -all | -leaks]` *program[args]*

   `bcheck(1)` is a batch interface to the RTC feature of `dbx(1)`. The default is to perform leaks checking only. Refer to the `bcheck(1)` man page for details on its use.

19.2 Summary of Operation

This section describes how to operate RTC from dbx, the Debugger, and in batch mode.

19.2.1 Operation from dbx

The type of checking desired must be turned on before the program has started running.

To turn on memory leaks checking only, type

```
(dbx) check -leaks
```

To turn on memory access checking only, type

```
(dbx) check -access
```

To turn on both memory leaks checking *and* memory access checking , type

```
(dbx) check -all
```

To turn off memory leaks checking and memory access checking, type

(dbx) **uncheck -all**

Run the program being tested, with or without breakpoints. Here is a simple example showing memory access checking being turned on for a program called “hello”.

```
speedracer$ dbx -C hello
Reading symbolic information for hello
Reading symbolic information for rtld /usr/lib/ld.so.1
Reading symbolic information for
/opt/SUNWspro/bin/../SW3.0/bin/../lib/librtc.so
Reading symbolic information for /usr/lib/libc.so.1
Reading symbolic information for /usr/lib/libintl.so.1
Reading symbolic information for /usr/lib/libdl.so.1
Reading symbolic information for /usr/lib/libw.so.1
(dbx) check -access
access checking - ON
(dbx) run
Running: hello
(process id 14582)
Enabling Error Checking... done
hello
execution completed, exit code is 1
```

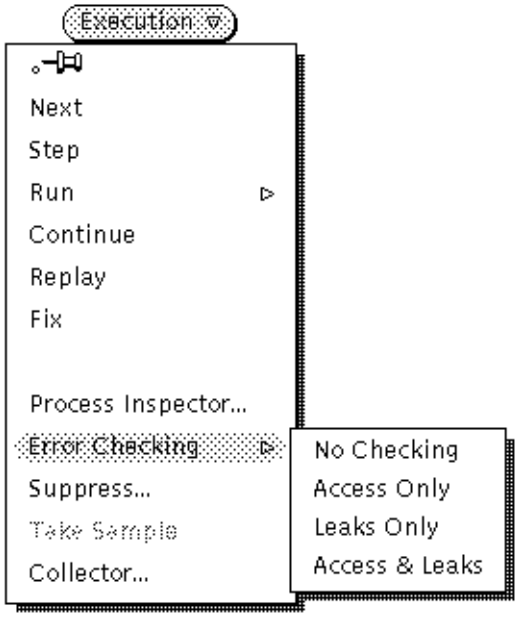
If access checking is on, the program runs as it normally would, except that it runs slower because each memory access is checked for validity. Each memory access is checked just before it actually occurs. If an invalid access is detected, an error is displayed, giving specific information about the error. The program is then suspended and control is returned to you.

You can then issue dbx commands, such as `where`, to get the current stack trace or print to examine variables. If the error is not a fatal error, you can continue execution of the program with the `cont` command. See Section 19.13, “Troubleshooting Tips,” on page 19-232. The program continues to the next error or breakpoint, whichever is detected first.

19.2.2 Operation from the Debugger

To turn on the desired checking mode from the Debugger window:

- **Choose Error Checking from the Execution menu, pull right and make your selection.**



- **Select Run from the Execution menu or click on the Run button to start the program.**

19.2.3 Batch Mode Operation

`bcheck(1)` is a convenient batch interface to the RTC feature of dbx. It runs *program* under dbx, with the arguments specified by *args*, if any. The RTC error output is placed in the file *`program.errs`*. `bcheck` can perform memory leaks checking, memory access checking, or both. The default is to perform leaks checking only.

Examples:

Perform leaks checking only on `hello`:

```
bcheck hello
```

Perform access checking only on `mach` with the argument `5`:

```
bcheck -access mach 5
```

Perform both access checking and leaks checking on `cc`:

```
bcheck -all cc -c prog.c
```

You can also enable batch mode directly from within dbx by setting the following dbx variable:

`(dbx)` **dbxenv autocontinue on**
`(dbx)` **dbxenv errlogfile** *your_logfile_name*

The program does not stop when run time errors are detected in batch mode. All error output is redirected to your error log file *your_logfile_name*. But the program stops when breakpoints are encountered or if the program is interrupted.

In batch mode, the complete stack backtrace is generated and redirected to the errlog file. The number of stack frames can be controlled using the `dbxenv` variable `stackmaxsize`.

Note – If the file *your_logfile_name* already exists, the contents of that file are erased before the batch output is redirected to that file.

You can also enable batch mode from within the Debugger:

- **Click on Props to display the Property sheet.**
- **Select Category: Run Time Check**
- **Select Autocontinue: On**
- **Enter name in Error Log Filename.**

19.3 Error Reporting

When RTC detects an error, it reports the type and location of the error and returns control to the user unless **autocontinue** is set to **On**. If the Debugger GUI is present, RTC shows the location of the error in the source code display.

You can narrow the scope of checking by suppressing a particular *error type* and expand the scope by unsuppressing that *error type* later.

You can perform any of the usual debugging activities; such as setting breakpoints and examining variables. Continue runs the program until the program encounters another error or a breakpoint, or until it terminates.

RTC inserts checkpoints in front of each `ld` or `st` instruction in your program.

A checkpoint leaves program behavior unchanged when a memory access is valid, but acts as a breakpoint when a memory access is invalid. In the case of an invalid memory access, RTC stops on the breakpoint and executes the invalid `ld` or `st` instruction only after you continue the program.

Note – `ld` includes all unprivileged forms of the `ld` instruction: `ldsb`, `ldsh`, `ldub`, `lduh`, `ld`, `ldd`, and `swap`,. Similarly, `st` includes all unprivileged forms of the `st` instruction: `stsb`, `stsh`, `stub`, `stuh`, `st`, and `std`.

19.4 Memory Access Error Checking

RTC checks whether your program accesses memory correctly by monitoring each read, write, and memory free operation.

RTC maintains a table that tracks the state of each block of memory being used by the program. When the program performs a memory operation, RTC checks the operation, against the state of the block of memory it involves, to determine whether the operation is valid. The possible memory states are:

- unallocated—initial state. Memory has not been allocated. It is illegal to read, write, or free this memory because it is not owned by the program.
- allocated, but uninitialized. Memory has been allocated to the program but not initialized. It is legal to write to or free this memory, but is illegal to read it because it is uninitialized. For example, upon entering a function, stack memory for local variables is allocated, but uninitialized.
- read-only. It is legal to read, but not write or free, read-only memory.
- allocated and initialized. It is legal to read, write, or free allocated and initialized memory.

19.5 Memory Access Errors

RTC detects the following memory access errors:

- Read from uninitialized memory (rui)
- Read from unallocated memory (rua)
- Write to unallocated memory (wua)
- Write to read-only memory (wro)
- Misaligned read (mar)
- Misaligned write (maw)
- Duplicate free (duf)
- Bad free (baf)
- Misaligned free (maf)
- Out of memory (oom)

19.5.1 Memory Access Error Reporting

RTC prints the following information for memory access errors:

type	type of error.
access	type of access attempted (read or write).
size	size of attempted access.
addr	address of attempted access.
detail	more detailed information about addr. For example, if addr is in the vicinity of the stack, then its position relative to the current stack pointer is given. If addr is in the heap, then the address, size, and relative position of the nearest heap block is given.
stack	Call stack at time of error.
location	where the error occurred. If line number information is available, this information includes *filename*, *line number*, and *function*. If line numbers are not available, RTC provides *function* and *address*.

The following examples illustrate some typical access error reports:

```
Read from uninitialized (rui):
Attempting to read 4 bytes at address 0xeffff67c
    which is 1268 bytes above the current stack pointer
Variable is ‘i’
Current function is main
    30      j = i
```

```
Read from unallocated (rua):
Attempting to read 4 bytes at address 0x22368
    which is just past heap block of size 16 bytes at 0x22358
Current function is read_out_of_bound
   27    return ptr[index];
```

The following discussion provides a more detailed description of each memory access error checked by RTC.

19.5.2 Read from Uninitialized Memory (rui)

Problem: Attempt to read from uninitialized memory.

Possible causes: Reading local or heap data which has not been initialized.

Example:

```
foo()
{  int i, j;
   j = i;       /* Read from uninitialized memory (rui) */
}
```

19.5.3 Read from Unallocated Memory (rua)

Problem: Attempt to read from non-existent, unallocated, or unmapped memory.

Possible causes: A stray pointer, overflowing the bounds of a heap block, or accessing a heap block that has already been freed.

Example:

```
char c, *a = (char *)malloc(1);
c = a[1];       /* Read from unallocated memory (rua) */
```

19.5.4 Write to Unallocated Memory (wua)

Problem: Attempt to write to non-existent, unallocated, or unmapped memory.

Possible causes: A stray pointer, overflowing the bounds of a heap block, or accessing a heap block that has already been freed.

Example:

```
char *a = (char *)malloc(1);
a[1] = '\0';     /* Write to unallocated memory (wua) */
```

19.5.5 Write to Read-only Memory (wro)

Problem: Attempt to write to read-only memory.

Possible causes: Writing to a text address, writing to a read-only data section (`.rodata`), or writing to a page that has been `mmap`'ed as read-only.

Example:

```
foo()
{  int *foop = (int *) foo;
   *foop = 0;    /* Write to read-only memory (wro) */
}
```

19.5.6 Misaligned Read (mar)

Problem: Attempt to read data from an address without proper alignment.

Possible causes: Reading 2, 4, or 8 bytes from an address which is not half-word-aligned, word-aligned, or double-word-aligned, respectively.

Example:

```
char *s = "hello world";
int *i = (int *)&s[1];
int j;

j = *i;          /* Misaligned read (mar) */
```

19.5.7 Misaligned Write (maw)

Problem: Attempt to write data to an address without proper alignment.

Possible causes: Writing 2, 4, or 8 bytes to an address which is not half-word-aligned, word-aligned, or double-word-aligned, respectively.

Example:

```
char *s = "hello world";
int *i = (int *)&s[1];

*i = 0;          /* Misaligned write (maw) */
```

19.5.8 Duplicate Free (duf)

Problem: Attempt to free a heap block that has already been freed.
Possible causes: Calling `free`() more than once with the same pointer. In C++, using the "delete" operator more than once on the same pointer.

Example:
`char *a = (char *)malloc(1);`
`free(a);`
`free(a);  /* Duplicate free (duf) */`

19.5.9 Bad Free (baf)

Problem: Attempt to free memory that has never been allocated.
Possible causes: Passing a non-heap data pointer to `free`() or `realloc()`.

Example:
`char a[4];`
`char *b = &a[0];`
 	
`free(b);  /* Bad free (baf) */`

Problem: Attempt to free a NULL pointer.
Possible causes: Passing a NULL pointer to `free`().

Example:
`char *b = 0;`
 	
`free(*b);  /* Free NULL ptr (baf) */`

19.5.10 Misaligned Free (maf)

Problem: Attempt to free a misaligned heap block.
Possible causes: Passing an improperly aligned pointer to `free`() or `realloc()`; changing the pointer returned by `malloc`.

Example:
`char *ptr = (char *)malloc(4);`
`ptr++;`
`free(ptr);  /* Misaligned free */`

19.5.11 Out of Memory (oom)

Problem: Attempt to allocate memory beyond physical memory available.
Cause: Program cannot obtain more memory from the system. The **oom** error is useful in tracking down problems that occur when the return value from `malloc()` is not checked for NULL, which is a common programming mistake.

Example:
`char *ptr = (char *)malloc(0x7fffffff);`
`/* Out of Memory (oom), ptr == NULL */`
`*ptr = '\0';  /* Write to unallocated memory */`

19.6 Using Memory Access Checking

The simplest way to find access errors is to turn on access checking and run the program to produce a list of access errors.

Using RTC to find memory access errors is not unlike using a compiler to find syntax errors in your program. In both cases a list of errors is produced, with each error message giving the cause of the error and the location in the program where the error occurred. Also in both cases, you should fix the errors in your program starting at the top of the error list and working your way down. The reason is that one error can cause other errors in a sort of chain reaction. The first error in the chain is therefore the “first cause”, and fixing that error may also fix some subsequent errors. For example, a read from an

uninitialized section of memory can create an incorrect pointer, which when dereferenced can cause another invalid read or write, which can in turn lead to yet another error, and so on.

The simple strategy described above can be used for small- to medium-sized programs because the number of errors is usually relatively small. For the initial run on a large program however, the number of errors may be so large as to be overwhelming. In this case, it may be better to take a phased approach. This can be done by using the `suppress` command to reduce the reported errors to a manageable number, fixing just those errors, and repeating the cycle; suppressing fewer and fewer errors with each iteration.

For example, you could focus on a few error types at one time.The most common error types typically encountered are **rui**, **rua**, and **wua**, usually in that order. **rui** errors are less serious errors (although they can cause more serious errors to happen later), and often a program may still work correctly with these errors. **rua** and **wua** errors are more serious because they are accesses to or from invalid memory addresses, and always indicate a coding error of some sort.

So, you could start by suppressing **rui** and **rua** errors. After fixing all the **wua** errors that occur, run the program again, this time suppressing only **rui** errors. After fixing all the **rua** errors that occur, run the program again, this time with no errors suppressed. Fix all the **rui** errors. Lastly, run the program a final time to ensure there are no errors left.

For more information on error suppression, see Section 19.9, “Error Suppression,” on page 19-222.

Another way to avoid seeing a large number of errors at once is to use RTC earlier in the development cycle, as you are developing the individual modules that make up the program. Write a unit test to drive each module and use RTC incrementally to check each module one at a time. That way, you deal with a smaller number of errors at a time. When you integrate all of the modules into the full program, you are likely to encounter few new errors. When you reduce the number of errors to zero, you need to run RTC again only when you make changes to a module.

19.7 Memory Leaks Checking

Memory Leaks

A memory leak is a dynamically allocated block of memory that has no pointers pointing to it anywhere in the data space of the program. Such blocks are orphaned memory. Because there are no pointers to the blocks, the program cannot even reference them, much less free them. RTC finds and reports such blocks.

Sometimes, the term “memory leak” is used to refer to *any* block that has not been freed. This is a much less useful definition of a memory leak, because it is a common programming practice not to free memory if the program will terminate shortly anyway. RTC does not report a block as a leak if the program still retains one or more pointers to it.

Possible Leaks

There are two cases where RTC may report a “possible” leak. The first case is when no pointers are found pointing to the beginning of the block, but a pointer was found pointing to the *interior* of the block. This case is reported as an “Address in Block (aib)” error. If it was a stray pointer that happened to point into the block, this would be a real memory leak. However, some programs deliberately move the only pointer to an array back and forth as needed to access its entries. In this case it would not be a memory leak. Because RTC cannot distinguish these two cases, it reports it as a Possible Leak, allowing the user to make the determination.

The second type of Possible Leak is when no pointers to a block were found in the data space, but a pointer was found in a register. This case is reported as an “Address in Register (air)” error. If the register happens to point to the block accidentally, or if it is an old copy of a memory pointer that has since been lost, then this is a real leak. However, the compiler can optimize references and place the only pointer to a block in a register without ever writing the pointer to memory. In such cases, this would not be a real leak. Hence, if the program has been optimized *and* the report was the result of the `showleaks` command, it is likely not to be a real leak. In all other cases, it is likely to be a real leak.

To suppress all reports of Possible Leaks, type: `suppress air aib`

Checking for Leaks

If memory leaks checking is turned on, a scan for memory leaks is automatically performed just before the program being tested exits. Any detected leaks are reported. The program should not be killed with the `kill` command. Here is a typical memory leak error message:

```
Memory leak (mel):
Found leaked block at address 0x21718 of size 4
At time of allocation, the call stack was:
[1] foo() at line 63 in test.c
[2] main() at line 47 in test.c
```

To check for leaks in the middle of execution, use the `showleaks` command. The `showleaks` command shows any new leaks since the last `showleaks` command. Showleaks works only when the `check -leaks` command is given before the program starts. After reporting the leaks, if any, a leaks summary is given.

Any particular memory leak is reported only once. If a `showleaks` command is issued, any leaks found are *not* reported again, either by another `showleaks` command, or the automatic leaks scan performed just before the program exits.

UNIX programs have a `main` procedure (called `MAIN` in f77) which is the top-level user function for the program. Normally, a program terminates either by calling `exit(3)` or by simply returning from `main`. In the latter case, all variables local to `main` go out of scope after the return, and any unique heap blocks they pointed to are reported as leaks.

It is a common programming practice not to free heap blocks allocated to local variables in `main`. Because the program is about to terminate anyway, and then return from `main` without calling (`exit()`). To prevent RTC from reporting such blocks as memory leaks, stop the program just before `main` returns by either setting a breakpoint on the last executable source line in `main.` When the program halts there, use the RTC `showleaks` command to report all the true leaks in `main`, omitting the leaks that would result merely from `main`'s variables from going out of scope.

Note – RTC only finds leaks of `malloc` memory. If your program does not use `malloc`, RTC cannot find memory leaks.

19.8 Memory Leak Errors

RTC detects the following memory leak errors:

- Memory Leak (mel)
- Possible leak -- Address in Register (air)
- Possible leak -- Address in Block (aib)

19.8.1 Memory Leak Error Reporting

RTC prints the following information for individual memory leak errors:

location	location where leaked block was allocated.
addr	address of leaked block.
size	size of leaked block.
stack	at least *stackdepth* preceding functions in the call stack at time of allocation.

Because the number of individual leaks can be very large, RTC automatically combines leaks that were allocated at the same place into a single combined leak report. The decision to combine leaks, or report them individually, is controlled by the *number-of-frames-to-match* parameter specified by the `-frames` *n* option on a `check -leaks` or `check -all` command. If the call stack at the time of allocation for two or more leaks matches to *n* frames, then these leaks are reported in a single combined leak report. If the `-frames` option was not given, the default value of *n* is 2.

Consider the following two call sequences:

a()->b()->c()->d()->malloc();

and

e()->f()->c()->d()->malloc();

If both of these sequences lead to memory leaks, the value of <*n*> determines whether the leaks are reported as two separate leaks or as one repeated leak. If <*n*> is 2, they are reported as one repeated leak because the 2 stack frames above `malloc()` are common to both call sequences. `c()->d()->malloc()` is common to both call sequences. For <*n*> greater than 2, RTC reports two separate leaks.

The `-frames` option is available only in conjunction with the `check -leaks` or `check -all` command. `check -all -frames` <*n*> is equivalent to;

```
check -access
check -leaks -frames <n>
```

If `-frames` is not specified, a default value of 2 is used.

In general, the smaller the value of *n*, the fewer individual leak reports and the more combined leak reports are generated. The greater the value of *n*, the fewer combined leak reports and the more individual leak reports are generated. The minimum value of *n* is 1; the maximum value is 8.

RTC prints the following information for combined memory leak reports:

Table 19-1

number	Number of leaked blocks whose call stack matched to *n* frames.
size	Total combined size of all the leaked blocks.
stack	The *n* stack frames that were common to all blocks at the time of allocation

The following discussion provides a more detailed description of each memory leak error RTC reports.

19.8.2 Memory Leak (mel)

Problem: An allocated block has not been freed, and no reference to the block exists anywhere in the program.

Possible causes: Program failed to free a block that is no longer used.

Example:

```
char *ptr;
ptr = (char *)malloc(1);
ptr = 0;

/* Memory leak (mel) */
```

19.8.3 Address in Register (air)

Problem: A possible memory leak. An allocated block has not been freed, and no reference to the block exists anywhere in program memory.

Possible causes: The only reference(s) to an allocated block are contained in registers. This can occur legitimately if the compiler keeps a program variable only in a register instead of in memory.

The compiler often does this for local variables and function parameters when optimization is turned on. If this error occurs when optimization has not been turned on, then this is likely to be an actual memory leak. This can occur, for example, if the only pointer to an allocated block goes out of scope before the block is freed.

Example:

```
       if (i == 0) {
              char *ptr = (char *)malloc(4);
              /* ptr is going out of scope */
       }
    /* Memory Leak or Address in Register */
```

19.8.4 Address in Block (aib)

Problem: A possible memory leak. There is no reference to the start of an allocated block, but there is at least one reference to an address within the block.
Possible causes: The only pointer to the start of the block is incremented.

Example:
`char *ptr;`
`main()`
`{`
`  char *ptr = (char *)malloc(4);`
`  ptr++;  /* Address in Block */`
`}`

19.9 Error Suppression

RTC provides a powerful error suppression facility that allows great flexibility in limiting the number and types of errors reported. If an error occurs that is suppressed, then no report is given, and the program continues as if no error had occurred.

The following kinds of suppression are available:

- Suppression by type

  You can specify which error types should be suppressed.

- Suppression by scope

  You can specify to which parts of the program the suppression should apply. The options are:

  Global — if no scope is specified, it is taken to be global scope and applies to the whole program.

  Load Object — applies to an entire loadobject, such as a shared library.

  File — applies to all functions in a particular file.

  Function — applies to a particular function.

  Line — applies to a particular source line.

  Address — applies to a particular instruction at an address.

- Suppression of last error

  You can tell RTC to suppress the last (most recent) error to prevent repeated reports of the same error. You can also tell RTC to do this automatically, for all errors.

Error suppression is done by using the `suppress` command. Suppression can be undone by using the `unsuppress` command. Suppression is persistent across `run` commands within the same debug session, but not across `debug` commands.

19.9.1 Error Suppression from dbx

From dbx, error suppression is done by typing the `suppress` command directly. See Section 19.10.3, “Command suppress | unsuppress,” on page 19-228, for the complete syntax of the `suppress` and `unsuppress` commands.

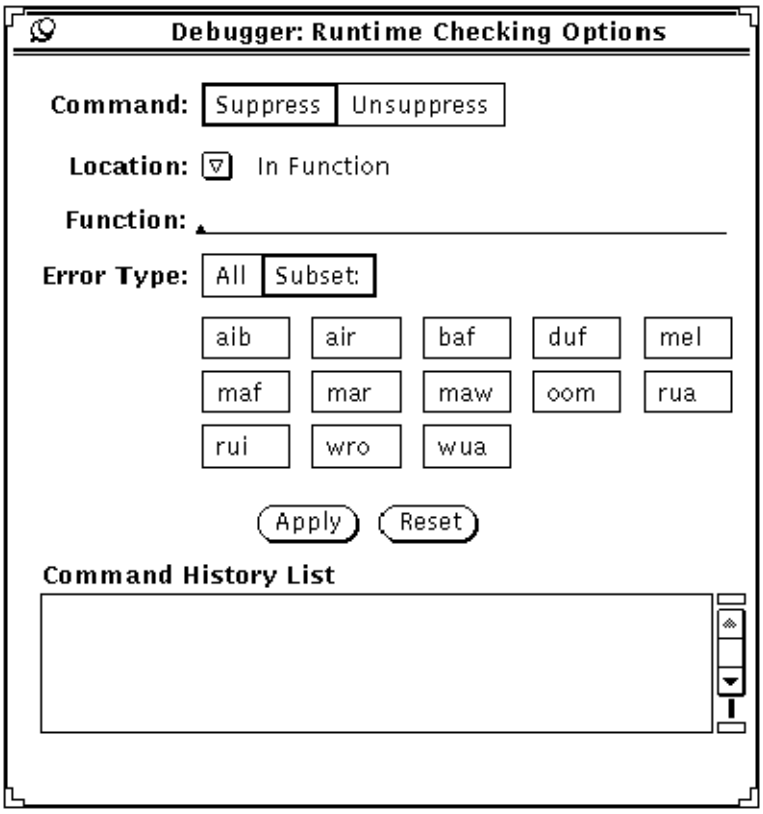
19.9.2 Error Suppression from the Debugger

You can select suppress from the Debugger window.

- **Choose Suppress from the Execution menu to display the Run Time Checking Options window.**

You can select the location specifier from the Run Time Checking Options window.

- **Select the command you want, Suppress or Unsuppress, from the Command choice item.**
- **Press the Location menu button.**



The Location specifier options tell which area of the program to suppress or unsuppress the error:

Last

Suppress / Unsuppress the last (most recent) error.

Everywhere

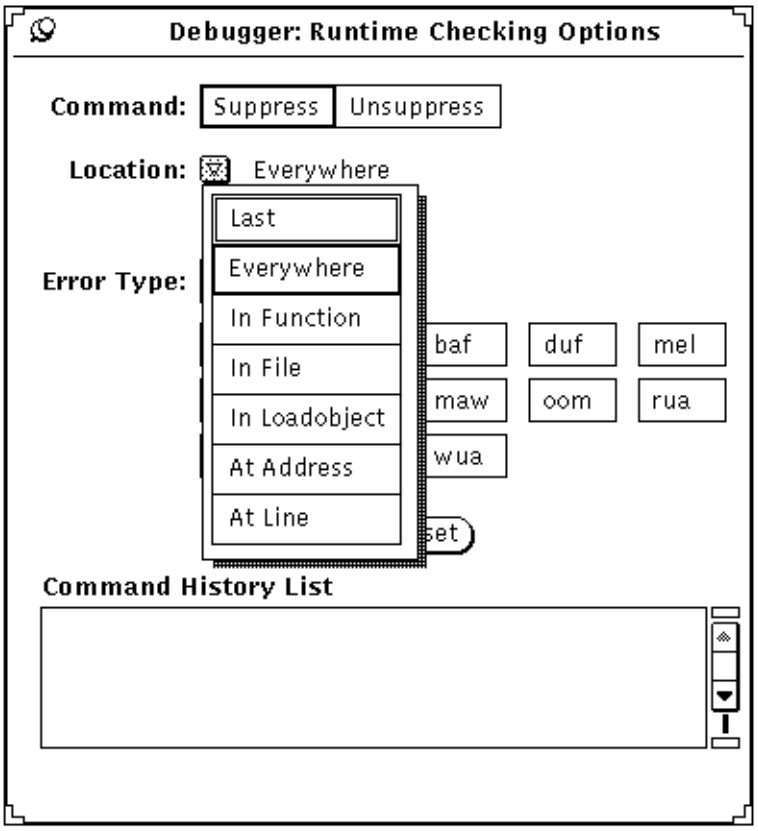
Suppress / Unsuppress the selected Error Types throughout the program.

In Function

Suppress / Unsuppress the selected Error Types in the named function.

In File

Suppress / Unsuppress the selected Error Types in the named file.



In Loadobject

Suppress/Unsuppress the selected Error Types in loadobjects. The Loadobject name given must be valid. The name can be either the complete path or just the basename of the loadobject. To view a list of valid load objects, type

```
(dbx/debugger) loadobjects
```

At Address

Suppress/Unsuppress the selected Error Types at the given address.

At Line

Suppress/Unsuppress the selected Error Types at the given address.

Selecting the Error Type

You can select all error types or a particular error type:

- **Choose All from the Error Type choice setting to include all errors for suppression or unsuppression. -OR-**
- **Choose Subset: from the Error Type choice setting to activate the list of error types from which to make individual selections. Select as many errors as you want to have suppressed or unsuppressed.**

Press the Apply button to activate the selection. Press Reset to change the settings back to the factory defaults.

The Command History list shows the command list you issued in sequential order. Because RTC commands are cumulative, this list helps you to view which suppressions are in effect.

19.10 Command Syntax

19.10.1 Command `check|uncheck`

{ `check` | `uncheck` }
{ `check` | `uncheck` } `-all` [`-frames` [*n*]]
{ `check` | `uncheck` } `-access`
{ `check` | `uncheck` } `-leaks` [`-frames` [*n*]]

- { `check` | `uncheck` }

  Returns the current status of access and leak checking.

- `check -all`

  Current check options are:

```
(dbx) check -all
access checking - ON
leak checking - ON
(dbx) check
access checking - ON
leak checking - ON
```

- `check -leaks`

  Enables or disables memory leak detection. Memory leak detection is a global check; that is, it is either on or off. It is not associated with particular locations in programs.

- `check -leak -frames`

  prints the number of frames to match in combining leak reports.

- `check -leaks -frames` *n*

  where <*n*> is the number of stack frames to check for matches in combining leak reports.

- `check -access`

  Turn on access checking.

- `check` <*function*>* <*file*>* <*loadobject*>*

  This format of the `check` command allows you to turn on checking in specific functions modules, and loadobjects while leaving it turned off for the rest of the program.

  This command is equivalent to:

  ```
  suppress all
  unsuppress all in <function>* <file>* <loadobject>*
  ```

  The command operates cumulatively. For example, the three commands

  ```
  check main
  check foo
  check f.c.
  ```

  are equivalent to:

  ```
  suppress all
  unsuppress all in main
  unsuppress all in foo
  unsuppress all in f.c.
  ```

Notice that the `suppress all` command is only applied once, leaving checking turned on for `main, foo,` and f.c.

`uncheck` <*function*>* <*file*>* <*loadobject*>*

is equivalent to:

`suppress all in` <*function*>* <*file*>* <*loadobject*>*

19.10.2 Command `showleaks`

Show existing memory leaks. Only those created since the last `showleaks` command are displayed.

19.10.3 Command `suppress|unsuppress`

{ `suppress` | `unsuppress` } `-d` [*error type*...[`in` <*loadobject*>]

{ `suppress` | `unsuppress` } `-reset`

{ `suppress` | `unsuppress` } `-last`

{ `suppress` | `unsuppress` }

{ `suppress` | `unsuppress` } [*error type*...[l*ocation specifier*]]

Some, or all files in a loadobject may not be compiled with the `-g` switch. This implies that there is no debugging information available for functions that belong in these files. RTC uses some default suppression in these cases.

- To get a list of these defaults:

  { `suppress` | `unsuppress` } `-d`

- To change the defaults for one loadobject:

  { `suppress` | `unsuppress` } `-d` [`error type`] [`in` <*loadobject*>]

- To change the defaults for all loadobjects:

  { `suppress` | `unsuppress` } `-d` [*error type*]

- To reset these defaults to the original settings:

  `suppress -reset`

- To suppress/unsuppress the most recent error:

  { `suppress` | `unsuppress` } `-last`

This command applies only to access errors and not to leaks errors.

- To display the history of the suppress commands.

  ```
  { suppress | unsuppress }
  ```

- Turn error reports on or off for the specified error types for the specified location.

  ```
  { suppress | unsuppress } [ error type... [location specifier] ]
  ```

error type:

`aib`	- Address in block
`air`	- Address in register
`all`	- all errors
`baf`	- Bad free
`duf`	- Already freed
`maf`	- Misaligned free
`mar`	- Misaligned read
`maw`	- Misaligned write
`mel`	- Memory leak
`mel`	- Memory leak
`oom`	- Out of memory
`rua`	- Read from unallocated memory
`rui`	- Read from write-only memory
`wro`	- Write to read-only memory
`wua`	-Write to unallocated memory

location specifier:

Table 19-2

in loadobject	**all functions in the designated program or library (*)**
in file	all functions in *file*
in function	named *function*
at *line specifier*	at source *line*
addr *address*	at hex *address*

To see a list of the `loadobjects`, type the `loadobjects` command in the Debugger command pane or at the dbx prompt. Either the full pathname or the basename of the loadobject can be used.

If the *location specifier* is blank, the command applies globally to the program.

Only one *location specifier* may be given per command.

line specifier:

line	# - *line* number
file:line	# - particular *line* in designated *file*

19.10.4 dbxenv *Variable*

The following `dbxenv` variables control the operation of RTC:

`dbxenv autocontinue` {on | off}

The default is: `off`

`autocontinue on` causes RTC not to stop upon finding an error, but to continue running, automatically. It also causes all errors to be redirected to the `$errorlogfile`.

`dbxenv autosuppress` {on | off }

The default is: `off`

`autosuppress on` causes a particular error at a particular location to be reported only the first time it is encountered, and suppressed thereafter. This is useful, for example, for preventing multiple copies of the same error report when an error occurs in a loop which is executed many times.

`dbxenv errlogfile` {*filename*}

The default is: `/tmp/dbx.errlog.<pid>`

`errlogfile` redirects RTC error messages to the designated file instead of to the standard output of dbx.

The program does not automatically stop when run time errors are detected in batch mode. All error output is directed to your errlog file, `filename.` The program stops when breakpoints are encountered of if the program is interrupted.

In batch mode, the complete stack backtrace is generated and redirected to the errlog file.

To redirect all errors to the terminal, set the `errorlogfile` to `/dev/tty.`

Note – If the error log file, *filename*, already exists, the contents of that file are erased before the batch output is redirected to that file.

`dbxenv error_limit` *n*

The default is: 1000.

n is the maximum number of errors that RTC reports. The error limit is used separately for access errors and leak errors. For example, if the error limit is set to 5, then a maximum of 5 access errors and 5 memory leaks are shown in both the leaks report at the end of the run and for each `showleaks` command you issue.

If you want to permanently change any of these variables from their default values, the place the `dbxenv` commands in the file, `$HOME/.dbxrc`. That way, your preferred values are used whenever you use RTC.

19.11 Running Commands from a Script

You can put dbx and RTC commands in a script file.

```
% more prog1.rtc
dbxenv autocontinue on
dbxenv errlogfile prog1.errs
check -all
run
exit
% dbx -C prog1 < prog1.rtc
```

19.12 Functions Intercepted by Runtime Checking.

***libc* Functions**

```
free      memcpy    memcmp    malloc    realloc   strlen
strcmp    strcpy    strncmp   strncpy
```

RTC also intercepts all of the standard system calls.

19.13 Troubleshooting Tips

After error checking has been enabled for a program and the program is run, one of the following errors can be detected:

`system error: cannot recover;  Access checking disabled`

This error generally means that a fatal error occurred and error checking has been disabled. This could happen if some system process level information is unavailable. In this case, the problem might be fixed by rebooting the system. Otherwise, call your Software Support representative.

`out of memory;  Access checking disabled`

RTC was unable to obtain memory it needed for correct operation. This indicates there was insufficient memory or swap space available on the system. Try one or more or the following corrective actions and rerun RTC.

Have the SysAdmin increase the amount of swap space available on the system.

Kill some unused or hung processes, or try again when the system is less heavily loaded.

Upgrade the amount of real memory in the system.

Move to another system that has more memory available.

`patch area too far;  Access checking disabled`

RTC was unable to find patch space close enough to a load object for error checking to be enabled.

Make the load object smaller if possible, or try breaking it up into smaller pieces to be linked in as shared libraries.

`librtc.so and dbx version mismatch;  Error checking disabled`

The SysAdmin should reinstall the software.

19

Fix *and* Continue 20

This chapter is organized into the following sections:

20.1 Basic Concepts

The `Fix` and `Continue` feature of the Debugger allows you to modify a source file, and without leaving the Debugger, recompile the file and continue execution of the program. The advantages of using `Fix` and `Continue` are

- You do not have to relink the program.
- You do not have to reload the program into the Debugger.
- You can resume running the program from the fix location.

Note – This feature is not supported by the Pascal compiler.

20.2 *How* `Fix` *and* `Continue` *Operates*

Before applying the `fix` command you need to edit the source. You can modify the source file either by enabling editing in the source display or by editing the file in your system editor. See Chapter 14, “Editing a Program” for an explanation of how to edit in the source display.

After you save your changes to the source, select Fix from the Execution menu. Once `fix` has been invoked, the Debugger calls the Compiler with the appropriate compiler options. The modified files are compiled and shared object (`.so`) files are created. Semantic tests are done comparing the old and new files (the old file is the source file before the latest edits were made; the new file is the source file containing the latest edits).

The new object file is linked to your running process using the run-time linker. The program counter is moved from the old function to the beginning of the same line in the new function (if the function is on top of the stack being fixed). All the breakpoints in the old file are moved to the new file. The modified source is then displayed in the source display and you can resume debugging from the exact point in the source you stopped at.

You can use `fix` and `continue` on files that have been compiled with or without debugging information, but there are some limitations in the functionality of `fix` and `continue` for files originally compiled *without* debugging information. See the `-g` option description in Section 20.6, “Command Summary,” on page 20-239, for more information.

20.3 *Source Modification Using* `Fix` *and* `Continue`

You can modify sources in the following ways when using `Fix` and `Continue`:

- Add, delete, or change lines of code in functions.
- Add or delete functions.
- Add or delete global and static variables.

Restrictions

The Debugger might have problems when functions are mapped from the old file to the new file. To minimize such problems when editing a source file, you should be careful not to:

- Change the name of a function.

- Add, delete, or change the type of arguments to a function.
- Add, delete, or change the type of local variables in functions currently active on the stack (see the `pop` command for more information).

20.4 Precautions

Resuming program execution after performing a `Fix` and `Continue` can cause errors that may not be directly related to the actual modifications to the source. Before resuming program execution after you have modified the source, you should be aware of the following conditions:

- If a function being modified is already instantiated on the stack (not the top frame), the program executes the old code (that is, the unmodified code) when returning to that frame.
- Changes made to global variables are not undone by the `pop` or `fix` command. Use the `assign` command to manually reassign correct values to global variables.
- Values of static variables are normally retained across fixes. However, if the file was not originally compiled with debugging information, static variables in that file are reinitialized after each fix. You can use the `assign` command to manually reassign correct values to static variables.

  A special case is shown in this example code segment:

  ```
  extern   int             x;
  ...
  ...
  static   int             x;
  ```

  In this case, static variable `x` is reinitialized after each fix. You can use the `assign` command to manually reassign correct values to the variable.
- Breakpoints in already instantiated functions on the stack in the old code are lost.
- Breakpoints with absolute addresses, such as those set with the `stop at` command, are not correctly reinstated.
- Breakpoints are moved (not copied) from old files to new files. Therefore, if the number of lines of source code were changed due to your edits, the placement of the breakpoints might be incorrect. The Debugger displays a

warning message telling you that the breakpoints have moved to new lines. You should check the locations of the breakpoints with the `status` command in the new code before running the program.

- The program counter is moved to the beginning of the same line in the new (fixed) function. If the function has been modified, the program counter can end up at the wrong line. In that case, do one of the following:
  - Use the `pop` command. It pops one (or more) frames from the stack and a `continue` re-enters the function.
  - Use the `cont at` <`linenum`> command to continue from another line (effectively moving the pc before executing).
  - Manually repair data structures (use the `assign` command) before continuing.
  - Rerun the program.

20.5 Example

The following example shows how a simple bug can be fixed with `Fix` and `Continue`. The application will get a segmentation violation in line 6 when trying to dereference a NULL pointer:

```
dbx[1] list 1,$
    1   #include <stdio.h>
    2
    3   char *from = "ships";
    4   void copy(char *to)
    5   {
    6       while ((*to++ = *from++) != '\0');
    7       *to = '\0';
    8   }
    9
    10  main()
    11  {
    12      char buf[100];
    13
    14      copy(0);
    15      printf("%s/n", buf)
    16      return 0;
    17  }
(debugger) run
Running: testfix
(process id 4842)
```

```
signal SEGV (no mapping at the fault address) in copy at line 6 in
    file "testfix.cc"
    6       while ((*to++ = *from++) != '\0');
```

Change line 14 to `copy` to `buf` instead of `0` and save the file, then do a fix:

```
    14      copy(buf);  <===  modified line
(debugger) fix
fixing "testfix.cc" .....
pc moved to "testfix.cc":6
stopped in copy at line 6 in file "testfix.cc"
    6       while ((*to++ = *from++) != '\0');
```

If the program is continued from here, it still gets a SEGV because the zero-pointer is still pushed on the stack. Use the '`pop`' command to pop one frame of the stack:

```
(debugger) pop
stopped in main at line 14 in file "testfix.cc"
    14      copy(buf);
```

If the program is continued from here, it will run, but it will not print the correct value because the global variable '`from`' has already been incremented by one. The program prints '`hips`' and not '`ships`'. Use the `assign` command to restore the global variable and then `continue`. Now the program prints the correct string:

```
(debugger) assign from = from-1
(debugger) cont
ships
```

20.6 Command Summary

The `fix` command takes the following options:

`fix [`*option*`s] [`*file*`1,` *file*`2, ...]`

where

`-a` fixes all modified files. This is the default option in the Debugger.

`-d` tells the Debugger not to check the modification date of the source files.

`-c` tells the Debugger to print the compilation line.

`-g` strips `-O` flags from the compilation line and adds the `-g` flag to it.

`-n` sets a no execution mode in the Debugger. Use this option when you want to list the source files to be fixed without actually fixing them.

file1, *file2*,... specifies a list of modified source files to fix.

If `fix` is invoked with an option other than `-a` and without a filename argument, only the current modified source file is fixed.

Note – Sometimes it may be necessary to modify a header (`.h`) file as well as a source file. To be sure that the modified header file is accessed by all source files in the program that include it, you must give as an argument to the `fix` command a list of all the source files that include that header file.

If you do not include the list of source files, only the primary source file is recompiled and only it includes the modified version of the header file. Other source files in the program continue to include the original version of that header file.

Note – C++ template instances cannot be fixed directly. Fix the files with the template definitions instead. You can use the `-d` option to overwrite the data-checking if the template definition file has not changed. dbx looks for template instance `.o` files in the default repository directory "`Templates.DB`". The `-ptr` compiler switch is not supported by dbx.

When `fix` is invoked, the Debugger looks for the current working directory of the file that was current at the time of compilation before executing the compilation line. The Debugger might have problems locating the correct directory due to a change in the file system structure from compilation time to debugging time. To avoid this problem, use the command `pathmap`, which creates a mapping from one pathname to another. Mapping is applied to source paths and object file paths. For detailed information on `pathmap`, see Section 3.2.2, “Setting the Search Path with pathmap,” on page 3-33, the Help file, or the dbx man pages.

Handling Exceptions in the Debugger 21

This chapter describes the commands that are available for handling exceptions and how the Debugger handles exceptions.

This chapter is organized into the following sections:

One reason a program stops running is if an exception occurs. Exceptions signal programming anomalies, such as division by zero or array overflow. To deal with these exceptions, you can set up try blocks to catch exceptions that have been raised by throw expressions defined earlier in the code.

The Debugger can also help you with exception handling. While debugging a program, the Debugger enables you to

- Catch unhandled exceptions before stack unwinding.
- Catch specific exceptions whether handled or not before stack unwinding.
- Determine where a specific throw would be caught if it occurred at a particular point in the program.

If you do a `step` after a handled exception is caught, control is returned at the start of the first destructor that gets executed during stack unwinding. If you do a `step` out of a destructor that is being executed during stack unwinding,

control is returned at the start of the next destructor. When all the destructors have been executed, doing a `step` brings you to the catch block that is handling the throw.

21.1 Commands for Handling Exceptions

This section lists the exception handling commands that you can invoke when debugging a program.

`exception`

Use this command to display the type of an exception (the command is an alias for `print *$exception`). When runtime is processing a current exception (for example, during stack unwinding), the ksh variable `$exception` is set to point to that exception. This variable can be used at any time during debugging.

`intercept [-a |` *exception-type*`]`

You can intercept ("catch") exceptions of a specific type before the stack has been unwound. Use this command to list all the types that are being intercepted (a type can include the pseudo-type `-a` in the list). With the `-a` option, the command intercepts all types. Invoking the `intercept` command with a type adds the specified type to the intercept list.

`unintercept [-a |` *exception-type*`]`

Use this command to remove exception types from the intercept list. With the `-a` option, the command removes the pseudo-type `-a` from the list. Invoking the command with a specific type removes that type from the list. With no arguments, it lists the types being intercepted (same as `intercept`).

`whocatches` *exception-expression*

Reports the location in the source that would catch the exception or informs you that the exception is uncaught. This command helps you to find out what would happen if an exception were thrown from the top frame of the stack.

The next section demonstrates how exception handling is done in the Debugger using a sample program containing exceptions.

21.2 Exception Handling in the Debugger

In the next example, an exception of type `int` is thrown in the function `bar` and is caught in the following catch block:

```
#include <stdio.h>

class c {
    int x;
  public:
    c(int i)  { x = i; }
    ~c()  { printf("destructor for c(%d)\n", x); }
};


void bar()  {
    class c c1(3);
    throw(99);
}


void main()  {
    try {
        class c c1(5);
        bar();
    }
    catch (int i) {
       printf("caught exception\n");
    }
}
```

The following transcript from the example program shows the exception handling features in the Debugger:

```
(debugger) stop in bar
(2) stop in bar(void)
(debugger) run
Running: sparc/a.out
stopped in bar at line 11 in file "test3.cc"
   11      class c c1(3);
(debugger) whocatches int
int is caught at line 18 of function main (frame number 2)
(debugger) whocatches c
class c is unhandled
(debugger) cont
```

```
Exception of type int is caught at line 18 of function main (frame
number 4)
(debugger) where
  ---- hidden frames, use 'where -h' to see them all ----
=>[3] bar(), line 12 in "sparc/test3.cc"
  [4] main(), line 18 in "sparc/test3.cc"
(debugger) stop in c::~c
(3) stop in c::~c(void)
(debugger) cont
stopped in c::~c at line 7 in file "test3.cc"
    7       ~c() {  printf("destructor for c(%d)\n", x); }
(debugger) where
=>[1] c::~c(this = 0xeffffab8, delete = 2), line 7 in
"sparc/test3.cc"
  [2] bar(), line 12 in "sparc/test3.cc"
  [3] main(), line 18 in "sparc/test3.cc"
(debugger) exception
*(int *) 156012 = 99
(debugger) cont
destructor for c(3)
stopped in c::~c at line 7 in file "test3.cc"
    7       ~c() {  printf("destructor for c(%d)\n", x); }
(debugger) where
=>[1] c::~c(this = 0xeffffb28, delete = 2), line 7 in
"sparc/test3.cc"
  [2] main(), line 18 in "sparc/test3.cc"
```

Debugging with Templates 22

This chapter is organized into the following sections:

The Debugger and dbx supports C++ templates. You can load programs containing class and function templates into the Debugger and invoke any of the debugging commands on a template that you would use on a class or function, such as

- Setting breakpoints at class or function template instantiations
- Printing a list of all class and function instantiations
- Displaying the definitions of templates and instances
- Calling member template functions and function instantiations
- Printing the value of function instantiations
- Displaying the source code for function instantiations

A sample code containing function and class templates is provided along with examples of commands called on the templates and the template instantiations.

22.1 Template Example

The following code example shows the class template for `fixedstring` and its instantiations and the function template `square` and its instantiations:

```
#include <stdio.h>


template<class C> void square (C num, C *result)
{
    *result = num * num;
}


template <int length> struct fixedstring {
    char buf[length];
    int compare(fixedstring<length> *);
    fixedstring(char *);
};


template <int length>
    int fixedstring<length>::compare(fixedstring<length> *string2)
{
    int i = length-1;
    while (i >= 0) {
        if (this->buf[i] != string2->buf[i])
            return 0;
        i--;
    }
    return 1;
}


template <int length>
    int fixedstring<length>::fixedstring(char *s)
{
    char *p = s;
    int i = 0;
    while (i < length) {
        this->buf[i] = *p;
        if (*p != '\0')/* null pad if string too short */
            p++;
        i++;
    }
}


main()
{
    int i, j = 3;
    double d, e = 4;
```

```
    fixedstring<5> s1("mumblezoid");
    fixedstring<5> s2("mumble");
    fixedstring<5> s3("mum");

    square(j, &i);
    square(e, &d);

    printf("%d squared is %d, %f squared is %f\n", j ,i, e, d);

    printf("s1.compare(s2) == %d, s1.compare(s3) == %d)\n",
           s1.compare(&s2), s1.compare(&s3));

    return 0;
}
```

where

`fixedstring` is a struct template definition (equivalent to a class template)

`square` is a function template definition

`fixedstring<int>` is a class instantiation (template class)

`fixedstring<5>::compare()`is a class instantiation (template class)

`square(int, int*)` and `square(double, double*)` are function instantiations (template function)

22.2 Debugger Commands on Templates

This section provides a list of Debugger commands you can invoke on templates and template instantiations. Use the `whereis` command to find template instantiations and then use `whatis` to get the definitions of the templates and template instances. Once you know the class or type definitions, you can print values, display source listings, or set breakpoints. For detailed information on each command, see their respective discussions in this manual, the `dbx` man pages, or the Debugger `Help` file.

Displaying Instantiations of Function and Class Templates

Use `whereis` to print a list of all occurrences of function or class instantiations of the specified function or class template:

Class template:

```
(debugger) whereis fixedstring
in loadobject "a.out"
struct template instance: ‘fixedstring<5>
struct template:          ‘test.cc‘fixedstring
```

Function template:

```
(debugger) whereis square
in loadobject "a.out"
function template instance: ‘square(double, double*)
function template instance: ‘square(int, int*)
function template:          ‘square
```

Displaying Template Definitions

Use `whatis` to print the definitions of function and class templates and instantiated functions and classes:

Class template:

```
(debugger) whatis -t fixedstring
 fixedstring {
    int fixedstring::compare( fixedstring *__UNNAMED_ARG__1__);
    fixedstring::fixedstring<const int>(char *__UNNAMED_ARG__1__);
    char buf[1];
};
```

Function template:

```
(debugger) whatis -t square
template<class C> void square(C num, C *result);
```

Class instantiation:

```
(debugger) whatis -t 'fixedstring<5>
struct fixedstring<'5> {
     int fixedstring<5>::compare(signed long long
*string2);
     fixedstring<5>::fixedstring<5>(char *s);
     fixedstring<5>::fixedstring<5>(fixedstring<5>&)
 /* never defined or unused inline function */
     char buf[5];};
};
```

Function instantiation:

```
(debugger) whatis -t square(int, int*)
void square(int num, int *result);
```

Setting Breakpoints in Function and Class Templates

You can set breakpoints at function instantiations, function templates, and class templates.

Use `stop inclass` to set breakpoints at all instances of the specified class template:

```
(debugger) stop inclass 'fixedstring<5>
(6) stop inclass fixedstring<5>
```

Use `stop infunction` to set breakpoints at all instances of the specified function template:

```
(debugger) stop infunction 'square
(9) stop in 'square
```

Use `stop in` to set a breakpoint at a specific class or function instance:

Class instantiation:

```
(debugger) stop in  \
 fixedstring<5>::fixedstring<5>(char *s);
(5) stop in fixedstring<5>::fixedstring<(5>(char*)
```

Function instantiation:

```
(debugger) stop in ‘square(double, double*)
(6) stop in square(double, double*)
```

Calling an Instantiated Function or Class

Use `call` to explicitly call a class function member or function instantiation. If the Debugger is unable to choose the correct instance, a pop-up menu is displayed to allow you to choose the specific instance.

Class instantiation:

```
(debugger) call fixedstring<5>::fixedstring<5>("abc")
dbx: calling member function
fixedstring<5>::fixedstring<5> with bad "this" pointer:
```

Function instantiation:

```
(debugger) call square(3, &i)
```

The source display scrolls to show the definition of the instance:

```
template class C void square(C num, C *result);
{
     *result = num * num;
}
```

Printing Values of Function Instantiations

Use `print` to evaluate a function instantiation:

```
(debugger) print square(j, &i)
(debugger) print num
num = 3
```

Listing Instantiated Functions

Use `list` to print the source listing for the specified function instantiation:

```
list ‘square(int, int*)
```

The source display in the Debugger window shows the source for the instance of `square`.

22.3 Exempting Templates From a Program

If a program cannot be loaded because of a bad template stab, you can include the -notempl option to the `debugger` command. For example,

```
% debugger -notempl file
```

prevents the Debugger from reading the template stabs of file file.

Korn Shell 23

The Debugger command language is based on the syntax of the Korn Shell[1] (ksh 88), including I/O redirection, loops, built-in arithmetic, history, and command-line editing (only in command-line mode; not available from the Debugger).

This chapter lists the differences between ksh-88 and the Debugger command language.

This chapter is organized into the following sections:

1. The Korn Shell Command and Programming Language, Morris I. Bolsky and David G. Korn, Prentice Hall, 1989

23

23.1 Features of ksh-88 not Implemented

The following features of ksh-88 are not implemented in the Debugger:

- `set A name` for assigning values to array name.
- `set -o` particular options: **allexport bgnice gmacs markdirs noclobber nolog privileged protected viraw**.
- `typeset -l -u -L -R -H` attributes.
- backquote (`…`) for command substitution.
- [[*expr*]] compound command for expression evaluation.
- ***@(pattern*[|*pattern*] …)** extended pattern matching.
- co-processes (command or pipeline running in the background that communicates with your program).

23.2 Extensions to ksh-88

The Debugger adds the following features as extensions:

- **$ [*p* –> *flags*]** language expressions.
- `typeset -q` enables special quoting for user-defined functions.
- csh-like `history` and `alias` arguments.
- `set -o path` enables path searching.
- **0xabcd** C syntax for octal and hexadecimal numbers.
- **bind** to change emacs-mode bindings.
- `set -o` hashall.
- `print -e` and `read -e` (opposite of **-r**, “raw”).

23.3 Renamed Commands

Particular dbx commands have been renamed to avoid conflicts with ksh commands.

- The dbx `print` command retains the name `print`. The ksh `print` command has been renamed `kprint`.
- The ksh `kill` command has been merged with the dbx `kill` command.
- The `alias` command is the ksh `alias`, unless in dbx compatibility mode.

These dbx commands have been renamed:

- `addr/fmt` is now `examine addr/fmt`.
- */pattern* is now `search` *`pattern`*.
- **?***pattern* is now `bsearch` *`pattern`*.

23.4 The Debugger Startup Mode

During startup, the Debugger searches for `.dbxrc` first (ksh mode). The search order is:

- current directory `./.dbxrc`
- home directory `$HOME/.dbxrc`

If `.dbxrc` is not found, the Debugger searches for `.dbxinit` (dbx compatibility mode). The search order is:

- current directory `./.dbxinit`
- home directory `$HOME/.dbxinit`

If neither .`dbxrc` nor .`dbxinit` is found, the Debugger assumes ksh mode.

23

Part 4 — Appendixes

Debugger Commands A

This appendix is a reference to the Debugger commands that you can enter in the command pane.

It contains a table of the full set of commands arranged into functional groups.

A.1 On-line Help in the Command Pane.

On-line help for each Debugger command is available in the command pane:

To see the full list of commands by functional group, type:

```
(debugger) help
```

To see the usage formula and a brief description of a particular command, type:

```
(debugger) help command_name
```

The dbx man page contains a description of each command.

A.2 Debugger Commands By Functional Groups

The complete set of Debugger commands are listed below. Note that the groupings are the same as the groups that appear when you type `help` in the command pane with no argument.

Execution and Tracing

```
cancel     catch      clear      cont        delete  event
fix        fixed      ignore     intercept   next    pop
replay     rerun      restore    run         save    status
step       stop       trace      unintercept         when
whocatches
```

Displaying and Naming Data

```
assign     call       demangle   dis         display   down
dump       examine    exists     frame       hide      inspect
print      undisplay  unhide     up          whatis    where
whereami   whereis    which
```

Accessing Source Files

```
bsearch    cd         edit       file        files     func
funcs      line       list       loadobject   loadobjects
module     modules    pathmap    pwd         search    use
```

Debugging Multiple Threads

```
lwp        lwps       thread     threads
```

Run Time Checking

```
check      mark       showleaks  suppress   uncheck
unsuppress
```

Miscellaneous

```
collector  dalias     dbxbugreport          dbxenv   debug
detach     document   help       history    import   kalias
kill       language   make       quit       setenv   sh
source     !          !!
```

Debugger

```
button    menu      toolenv   unbutton  unmenu
```

Machine Level

```
examine   listi     nexti     stepi     stopi    tracei
wheni
```

Language Specific Information

```
C++
```

Other Topics

```
alias     callbacks changes   editing   events
forwardref invocation         ksh       redirection
```

The command ‘`help <cmdname>`’ provides additional help for each command or topic. See ‘`help changes`’ for new and changed features.

A

Operators Recognized By the Debugger

B

This appendix contains two tables:

B

B.1 Operators Recognized by the Debugger

Operator	Description
+	add
-	subtract
* and*	multiply (* logical and, Pascal only)
/	divide
div mod*	divide (* integer remainder, Pascal only)
%	integer remainder
<< or*	left shift (* logical or, Pascal only)
>>	right shift
&	bitwise and
|	bitwise or
^ ^*	exclusive or (*pointer dereference, Pascal only)
~	bitwise complement
&	address of
*	contents of
<	less than
>	greater than
<=	less than or equal to
>=	greater than or equal to
==	equal to
=	equal to (Pascal only)
!=	not equal to
<>	not equal to (Pascal only)
!	not
&&	logical and
||	logical or
sizeof	size of a variable or type
(*type*)	type cast
.	structure field reference
->	pointer to structure field reference
::	C++ doublecolon scope resolution operator
?:	embedded “if-then-else” (C and C++ only)

The operator “**.**” can be used with pointers to records, as well as with records themselves, making the C operator “**->**” unnecessary (though it is supported).

B.2 Precedence and Associativity

Precedence and associativity of operators are the same as in ANSI C, and are described in the table below. Parentheses can be used for grouping.

Operator	Associativity	Precedence
`.  ->`	left to right	highest
`~ !` (*type*) `* & sizeof`	right to left	
`* / % div mod`	left to right	
`+ -`	left to right	
`<< >>`	left to right	
`< <= > >=`	left to right	
`== != = <>`	left to right	
`&`	left to right	
`^`	left to right	
`|`	left to right	
`&& and`	left to right	
`|| or`	left to right	
`?:`	right to left	lowest

If the program being debugged is not active and there is no `core` file, you may only use expressions containing constants. Procedure calls also require that the program be active.

The Debugger attempts to evaluate expressions the same way as the compiler. In some cases, however, this is not possible; for example, when an expression contains a macro.

B

Index

A

B

C

D

E

F

G

H

I

K

L

M

N

O

P

Q

R

S

T

U

V

W