sun microsystems

Debugging Tools

Part Number: 800-1775-10
Revision A, of 9 May 1988

Contents

Tables

Figures

1

Introduction

1

Introduction

1.1. Three Debuggers

This manual describes three debuggers available on Sun Workstations™: dbx, dbxtool, and adb. This document is intended for competent C, assembler, FORTRAN, Modula-2, or Pascal programmers.

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. A detailed description of how to use dbx is found in Chapter 4 .

dbxtool

dbxtool 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 screen. You can use any of the standard dbx commands in the command window. A detailed description of how to use dbxtool is found in Chapter 3 .

adb

adb is an interactive, line-oriented, assembly-level debugger. It can be used to examine core files to determine why they crashed, and provides a controlled environment for program execution. Since it dates back to UNIX† Version 7, it is likely to be available on UNIX systems everywhere. Chapters 5 and 6 are tutorial introductions to adb for the Sun-2 and -3 and the Sun386i, respectively, and Chapter 7 is a reference manual for it.

This manual begins with material about the debuggers of choice, dbxtool and dbx. They are much easier to use than adb, and are sufficient for almost all debugging tasks. adb is most useful for interactive examination of binary files without symbols, patching binary files or object code, debugging programs when the source code is not at hand, and debugging the kernel.

Some programs produce core dumps when an internal bug causes a system fault. You can usually produce a core dump by typing [CTRL-\] while a process is running. If a process is in the background, or originated from a different process group, you can get it to dump core by using the gcore(1) utility.

† UNIX is a registered trademark of AT&T.

2

dbx and dbxtool Compared

2

dbx and dbxtool Compared

2.1. Debugging Modes of dbx and dbxtool

Both dbx and dbxtool support five distinct types of debugging: post-mortem, live-process, multiple-process, and kernel debugging. References to dbx below apply to dbxtool as well.

You can do post-mortem debugging on a program that has created a core file. Using the core file as its image of the program, dbx retrieves the values of variables from it. The most useful operations in post-mortem debugging are getting a stack trace with where, and examining the values of variables with print. Operations such as setting breakpoints, suspending and continuing execution, and calling procedures, are not supported with post-mortem debugging.

In live-process debugging, a process is started under control of dbx. From there, the user can:

- set the process' starting point
- set and clear breakpoints
- restart a stopped process.

The most useful operations are getting a stack trace with where, examining the values of variables with print and display, setting breakpoints with stop, and continuing execution with next, step, and cont.

Multiple-process debugging is most useful when debugging the interaction between two tightly coupled programs. For example, in a networking situation it is common to have server and client processes that use some style of inter-process communication (remote procedure calls, for example). To debug both the client and the server simultaneously, each process must have its own instance of dbx. When using dbx for multiple-process debugging, it is advisable to begin each dbx in a separate window. This gives you a way to debug one process without without losing the context of the other debugging session.

NOTE *This does not mean that either* dbx *or* dbxtool *supports remote debugging. You can debug only processes running on your machine.*

Kernel debugging is a special form of post-mortem debugging. Start kernel debugging by specifying the -k option on the dbx or dbxtool command line (or with the debug command). When debugging the kernel, dbx uses page maps in the kernel's core image to map addresses. The proc command specifies which process' user structure is mapped into the kernel's u area. The `where` command displays the kernel stack associated with the process currently mapped into the u area.

2.2. Common Features of `dbx` and `dbxtool`

The following symbols and conventions apply to both `dbx` and `dbxtool`; as before, references to `dbx` apply to `dbxtool` as well.

Filenames

Filenames within `dbx` may include shell metacharacters. The shell used for pattern matching is determined by the `SHELL` environment variable.

Expressions

Expressions in `dbx` are combinations of variables, constants, procedure calls, and operators. Hexadecimal constants begin with "`0x`" and octal constants with "`0`". Character constants must be enclosed in single quotes. Expressions cannot involve literal strings, structures, or arrays, although elements of structures and arrays may be used. However, the `print` and `display` commands do accept structures or arrays as arguments and, in these cases, print the entire contents of the structure or array. The `call` command accepts literal strings as arguments, and passes them according to the calling conventions of the language of the routine being called.

Table 2-1 *Operators Recognized by* `dbx`

Operators Recognized by `dbx`	
+	add
-	subtract
*	multiply
/	divide
div	integer divide
%	remainder
<<	left shift
>>	right shift
&	bitwise and
|	bitwise or
^	exclusive or
~	bitwise complement
&	address of
*	contents of
<	less than
>	greater than
<=	less than or equal to
>=	greater than or equal to
==	equal to
!=	not equal to
!	not
&&	logical and
||	logical or
sizeof	size of a variable or type
(*type*)	type cast

Table 2-1 *Operators Recognized by* dbx*— Continued*

***Operators Recognized by* dbx**	
.	structure field reference
->	pointer to structure field reference

The operator "." can be used with pointers to records, as well as with records themselves, making the C operator "->" unnecessary (though it is supported).

Precedence and associativity of operators are the same as in C, and are described in Table 2-2 below. Parentheses can be used for grouping.

Table 2-2 *Operator Precedence and Associativity*

<table>
<tr><th>Operator</th><th>Associativity</th></tr>
<tr><td>. -></td><td>left to right</td></tr>
<tr><td>~ ! (type) * & sizeof</td><td>right to left</td></tr>
<tr><td>* / % div</td><td>left to right</td></tr>
<tr><td>+ -</td><td>left to right</td></tr>
<tr><td><< >></td><td>left to right</td></tr>
<tr><td>< <= > >=</td><td>left to right</td></tr>
<tr><td>== !=</td><td>left to right</td></tr>
<tr><td>&</td><td>left to right</td></tr>
<tr><td>^</td><td>left to right</td></tr>
<tr><td>|</td><td>left to right</td></tr>
<tr><td>&&</td><td>left to right</td></tr>
<tr><td>||</td><td>left to right</td></tr>
<tr><td>?:</td><td>right to left</td></tr>
</table>

Of course, 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.

dbx and FORTRAN

Note the following when using dbx with FORTRAN programs:

1) Array elements must be referenced with square brackets [and] rather than with parentheses. So use `print var[3]` instead of `print var(3)`.

2) The main routine is referenced as MAIN (as distinguished from main). All other names in the source file that have upper case letters in them will be lower case in dbx, unless the program was compiled with `f77 -U`. For more information, see the section on `dbxenv case` under Miscellaneous Commands in Chapter 4 .

3) When referring to the value of a logical type in an expression, use the value 0 or 1 rather than `.false.` or `.true.`, respectively.

dbx Scope Rules

dbx uses two variables to resolve scope conflicts: file and func (see Section 4.9). The values of file and func change automatically as files and routines are entered and exited during execution of the user program. They can also be changed by the user. Changing func also changes the value of file; however, changing file does not change func.

The func variable is used for name resolution, as in the command print grab where grab may be defined in two different routines. The search order is:

1) Search for grab in the routine named by func.

2) If grab is not found in the routine named by func, search the file containing the routine named by func.

3) Finally, search the outer levels — the whole program in the case of C and FORTRAN, and the outer lexical levels (in order outward) in the case of Pascal — for grab.

Clearly, if grab is local to a different routine than the one named by func, or is a static variable in a different file than is the routine named by func, it won't be found. Note, however, that print a.grab is allowed, as long as routine a has been entered but not yet exited. Note that the file containing the routine a might have to be specified when the file name (minus its suffix) is the same as a routine name. For example, if routine a is found in module a.c, then print a.grab would not be enough — you would have to use print a.a.grab. If in doubt as to how to specify a name, use the whereis command, as in whereis grab to display the full qualifications of all instances of the specified name — in this case grab.

The variable file is used to:

1) Resolve conflicts when setting func — for example, when a C program has two static routines with the same name.

2) Determine which file to use for commands that take only a source line number — for example, stop at 55.

3) Determine which file to use for commands such as edit, which has optional arguments or no arguments at all.

When dbx begins execution, the initial values of file and func are determined by the presence or absence of a core file or process ID. If there is a core file or process ID, file and func are set to the point of termination. If there is no core file or process ID, func is set to main (or MAIN for FORTRAN) and file is set to the file containing main or (MAIN).

Note that changing func doesn't affect the place where dbx continues execution when the program is restarted.

3

dbxtool

1

dbxtool

dbxtool [**–i**] [**–k**] [**–I** *dir*] [**–kbd**] [*objectfile* [*corefile* | *processID*]]

dbxtool is a source-level debugger with a window and mouse-based user interface, accepting dbx's, commands with a more convenient user interface. Using the mouse, one can set breakpoints, examine variable values, control execution, browse source files, and so on. There are subwindows for viewing source code, entering commands, and several other uses. This debugger functions in the *suntools*(1) environment, so that the standard tool manager actions, such as moving, resizing, mving to the front or back, and so on can be applied to it.

In the usage above, *objectfile* is an object file produced by cc, f77, or pc, or a combination thereof, with the –g flag specified to produce the appropriate symbol information. If no *objectfile* is specified, one may use the debugger's debug command to specify the program to be debugged. The object file contains a symbol table which includes the names of all the source files translated by the compiler to create it. These files are available for perusal while using the debugger.

NOTE *Every stage of the compilation process, including the loading phase, must include the –g option.*

dbxtool can be used to examine the state of the program when it faulted if a file named core exists in the current directory, or a *corefile* is specified on the command line or in the debug command.

Giving a *processID* instead of a *corefile*, halts the process and begins debugging it. Detaching the debugger from the process lets it continue.

Debugger commands in the file .dbxinit are executed immediately after the symbolic information is read, if that file exists in the current directory, or in the user's home directory if it isn't there.

1.1. dbxtool Options

–k Kernel debugging.

–I *dir*

Add *dir* to the list of directories searched when looking for a source file. Normally dbxtool looks for source files in the directory where *objectfile* is located, and if the source files can't be found there or in the current directory, the user must tell todbxtoolwhere –I option or else set the directory search path with the use command. Multiple –I options may be given.

1.2. `dbxtool` Subwindows

A `dbxtool` window consists of five subwindows. From top to bottom they are:

status — Gives the overall status of debugging, including the location where execution is currently stopped, and a description of lines displayed in the *source* subwindow.

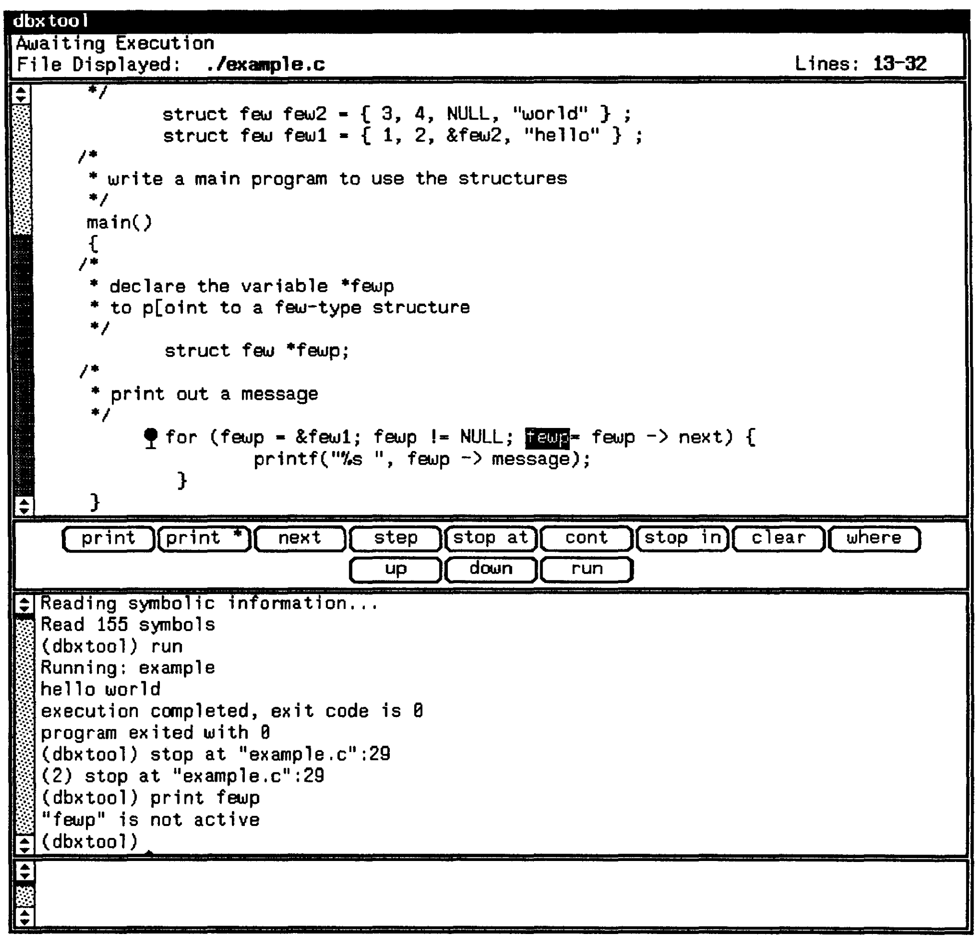
source — Displays source text of the program being debugged, and allows you to move around in the source file.

buttons — Contains buttons for frequently used commands; picking a button with the mouse invokes the corresponding command.

command — Provides a typing interface to supplement the *buttons* subwindow. Also, most command output appears in this subwindow.

display — Display output appears here.

Figure 1-1 *Five* `dbxtool` *Subwindows*



3.3. Scrolling

The *source*, *command*, and *display* windows have scroll bars to facilitate browsing their contents. The scroll bar is at the left edge of each window. The bar is a medium gray background with a darker gray area superimposed over it indicating the portion of the source file, command transcript, or display currently visible in the window. Note that the size of the darker gray area corresponds to the number of characters visible in the *source* window, not the number of lines.

Within the scroll bar, the mouse buttons have the following functions:

left	Scroll forward, moving towards the end of the file.
middle	Scroll to absolute position in the text.
right	Scroll backwards, moving towards the beginning of the file.

Positioning the cursor within the scroll bar next to a given line and clicking the left button causes the line to move to the top of the window. Clicking the right button causes the top line in the window to move to the position of the cursor. The middle button treats the scroll bar as a thumb bar. The top of the thumb bar represents the beginning of the text, and the bottom represents the end of the text. Clicking the middle button in the scroll bar picks a point within the text relative to its entire size. This point is then displayed at the top of the window.

See *Windows and Window-Based Tools: Beginner's Guide* for a more complete description of scroll bars.

3.4. The Source Window

The *source* window displays the text of the program being debugged. Initially, it displays text from either the main routine, if there is no core file, or the point at which execution stopped, if there is a core file. Whenever execution stops during a debugging session, it displays the point at which it stopped. The `file` command can be used to switch the *source* window to another file; the focus of attention moves to the beginning of the new file. Similarly, the `func` command can be used to switch the *source* window to another function; the new focus of attention is the first executable line in the function.

Breakpoints are indicated in the *source* window by a solid stop sign at the beginning of the line. The point at which execution is currently stopped is marked by either a rightward pointing outlined or hollow arrow.

3.5. Constructing Commands

One can either type commands to `dbxtool`, in the *command* window or construct commands with the selection and button mechanism (if a button is provided for the command), but typing and buttons cannot be combined to build a command.

The *command* window is a text subwindow and so uses the text selection facility described in *Windows and Window-Based Tools: Beginner's Guide.*

The software buttons operate in a postfix manner. That is, one first selects the argument, and then clicks the software button with the left mouse button. Each command interprets the selection as appropriate for that command.

There are five ways that dbxtool may interpret a selection:

literal — A selection may be interpreted as exactly representing selected material.

expand — A selection may be interpreted as exactly representing selected material, except that it is expanded if either the first or last character of the selection is an alphanumeric character or underscore. It is expanded to the longest enclosing sequence of alphanumeric characters or underscores. Selections made outside of dbxtool cannot be expanded and are interpreted as exactly the selected text.

lineno — A selection in the *source* window may be interpreted as representing the (line number of the) first source line containing all or some of the selection.

command — A selection in the *command* window may be interpreted as representing the command containing the selection.

ignore — Buttons may ignore a selection.

3.6. Command Buttons

The standard set of command buttons in the *buttons* window is as follows:

`print` — Print the value of a variable or expression. Since this button expands the selection, identifiers can be printed by selecting only one character.

`print *` — Print the value of all variables or expressions. Since this button expands the selection, identifiers can be printed by selecting only one character.

`next` — Execute one source statement and then stop execution, except that if the statement contains a procedure or function call, execute through the called routine before stopping. The `next` button ignores the selection.

`step` — Execute one source line and then stop execution again. If the current source line contains a procedure or function call, stop at the first executable line within the procedure or function. The `step` button ignores the selection.

`stop at` — Set a breakpoint at a given source line. Interpret a selection in the *source* window as representing the line number associated with the first line of the selection.

`cont` — Resume execution from the point where it is currently stopped. The `cont` button ignores the selection.

`stop in` — Set a breakpoint at the first line of a given function or procedure. Since this button expands the selection, identifiers may be printed by selecting only one character.

`clear` — Clear all breakpoints at the currently selected point. `<lineno> clear` clears all breakpoints at the specified line number.

`where` — Prints a procedure traceback. `<number> where` prints `number` top procedures in the traceback.

`up` — Moves up the call stack one level. `<number> up` moves the call stack up `number` levels.

`down` — Moves the call stack down one level. `<number> down` moves the call stack down `number` levels.

`run` — Begins execution of the program. `<arguments> run` begins execution of the program with new arguments.

NOTE *The second form cannot be entered in its standard form with the* `run` *button, only by typing the command.*

3.7. Choosing Your Own Buttons

The `button` command defines buttons in the *buttons* window. It can be used in `.dbxinit` to define buttons not otherwise displayed, or during a debugging session to add new buttons. The first argument to `button` is the selection interpretation for the button, and the remainder is the command associated with it. The default set of buttons can be replicated by the sequence

```
button expand print
button expand print *
button ignore next
button ignore step
button lineno stop at
button ignore cont
button expand stop in
button ignore clear
button ignore where
button ignore up
button ignore down
button ignore run
```

The `unbutton` command may be used in `.dbxinit` to remove a default button from the *buttons* window, or during a debugging session to remove an existing button. The argument to `unbutton` is the command associated with the button.

3.8. The Display Window

The *display* window provides continual feedback of the values of selected variables. The `display` command specifies variables to appear in the *display* window, and `undisplay` removes them. Each time execution of the program being debugged stops, the values of the displayed variables are updated.

3.9. Editing in the Source Window

The *source* window is a standard text subwindow (see *Windows and Window-Based Tools: Beginner's Guide* for details). Initially `dbxtool` puts the source subwindow in browse mode, meaning that editing capabilities are suppressed. `dbxtool` adds a "start editing" entry to the standard text subwindow menu in the *source* window. When this menu item is selected, the file in the *source* window becomes editable, the menu item changes to "stop editing", and any annotations (stop signs and arrows) are removed. The "stop editing" menu item is a pull-right menu with two options: "save changes" and "ignore changes". Selecting either of these menu items disables editing, changes the menu item back to "start editing", and causes the annotations to return.

After editing a source file, it is advisable to rebuild the program, as the source file no longer reflects the executable program.

3.10. Controlling the Environment

The `toolenv` command provides control over several facets of `dbxtool`'s window environment, including the font, the vertical size of the *source*, *command*, and *display* windows, the horizontal size of the tool, and the minimum number of lines between the top or bottom of the *source* window and the arrow. These are chiefly useful in the `.dbxinit` file to control initialization of the tool, but may be issued at any time.

3.11. Other Aspects of `dbxtool`

The commands, expression syntax, scope rules, etc. of `dbxtool` are identical to those of `dbx`. Three of the commands, `toolenv`, `button`, and `unbutton` affect only `dbxtool`, so they are described below. See Chapter 4 for descriptions of the others.

`toolenv`

`toolenv` [*attribute value*]

Set or print attributes of the `dbxtool` window. This command has no effect in `dbx`. The possible *attribute-value* pairs and their interpretations are as follows:

Table 3-1 *Attribute-Value Pairs for* `dbxtool`

Attribute-Value	*Description*
`font` *fontfile*	change the font to that found in *fontfile*; default is taken from the `DEFAULT_FONT` shell variable.
`width` *nchars*	change the width of the tool window to *nchars* characters; default is 80 characters.
srclines *nlines*	make the source subwindow *nlines* high; default is 20 lines.
`cmdlines` *nlines*	make the command subwindow *nlines* high; default is 12 lines.
`displines` *nlines*	make the display subwindow *nlines* high; default is 3 lines.
`topmargin` *nlines*	keep the line with the arrow at least *nlines* from the top of the source subwindow; default is 3 lines.
`botmargin` *nlines*	keep the line with the arrow on it at least *nlines* from the bottom of the source subwindow; default is 3 lines.

The `toolenv` command with no arguments prints the current values of all the attributes.

button

button *selection command-name*

Associate a button in the *buttons* window with a command in dbxtool. This command has no effect in dbx. The argument *selection* may be any of literal, expand, lineno, command and ignore, as described in Section 3.5 . The *command_name* argument may be any sequence of words corresponding to a dbxtool command.

unbutton

unbutton *command-name*

Remove a button from the *buttons* window. The first button with a matching *command-name* is removed.

menu

The menu command defines the menu list in the *buttons* window. It can be used in .dbxinit to define menu items not otherwise displayed, or during a debugging session to add new menu items. The first argument to menu is the selection interpretation for the menu, and the remainder is the command associated with it. The default set of menus can be replicated by the sequence

```
menu expand display
menu expand undisplay
menu expand file
menu expand func
menu ignore status
menu lineno cont at
menu ignore make
menu ignore kill
menu expand list
menu ignore help
```

unmenu

The unmenu command may be used in .dbxinit to remove a default menu from the *menus* window, or during a debugging session to remove an existing menu item. The argument to unmenu is the menu to be removed.

3.12. Bugs

The interaction between scrolling in the *source* subwindow and dbx's regular expression search commands is wrong. Scrolling should affect where the next search begins, but it does not.

4

dbx

4

dbx

dbx [**-r**] [**-k**] [**-kbd**] [**-I** *dir*] [*objectfile* [*corefile* | *processID*]]

dbx is a tool for source-level debugging and execution of programs, that accepts the same commands as dbxtool, but has a line-oriented user interface, which does not use the window system. It is useful when you can't run Sunview. (See also *dbx*(1).)

Table 4-1 dbx *Functions*

dbx *Functions*	
Function	*Commands*
list active procedures	down, proc, up, where
name, display, and set variables	assign, display, dump, print, set, set81, undisplay, whatis, whereis, which
set breakpoints	catch, clear, delete, ignore, status, stop, trace, when
run and trace program	call, cont, next, rerun, run, step
access source files & directories	cd, edit, file, func, list, pwd, use, /, ?
process manipulation	debug, detach, kill
miscellaneous commands	alias, dbxenv, help, sh, source, quit, setenv
machine-level commands	nexti, stepi, stopi, tracei

Although dbx provides a wide variety of commands, there are a few that you will execute most often. You will probably want to

- find out where an error occurred,
- display and change the values of variables,

- display the values of constants,
- set breakpoints,
- and run and trace your program.

4.1. Preparing Files for dbx

When compiling programs with cc, f77, or pc, you must specify the -g option on the command line, so that symbolic information is produced in the object file. Every step of compilation (including linking) must include this option.

WARNING dbx ***won't correctly debug library modules whose names are more than 14 characters long. While*** ar ***emits a warning at the time the library is being created that the name of the file is being truncated,*** dbx ***will offer no warning that there is a problem, other than not working correctly as you attempt to debug the offending module.***

WARNING ***If you use*** ld***'s*** -r ***option when compiling your program, attempts to debug the final load module with*** dbx ***will often fail. This is because*** ld -r ***modifies the symbol table and the resultant load module.***

4.2. Invoking dbx

To invoke dbx, type:

```
% dbx options objfile corefile
```

dbx begins execution by printing:

```
Reading symbolic information...
Read nnn symbols
(dbx)
```

To exit dbx and return to the command level, type:

```
(dbx) quit
%
```

4.3. dbx Options

The *options* to dbx are:

-r Execute *objfile* immediately. Parameters follow the object filename (redirection is handled properly). If the program terminates successfully, dbx exits. Otherwise, dbx reports the reason for termination and waits for your response. When -r is specified and standard input is not a terminal, dbx reads from /dev/tty.

-k Kernel debugging: dbx uses page maps within the kernel's core image to map addresses.

-kbd
Debugs a program that sets the keyboard into up/down translation mode. This flag is necessary if the program you are debugging uses up/down encoding.

-I*dir*

Add *dir* to the list of directories searched when looking for a source file. Normally, `dbx` looks for source files in the directory where *objfile* is located, and if the source files can't be found there or in the current directory, the user must tell `dbx` where to find the source files; either with the `-I` option or else set the directory search path with the `use` command.

The *objfile* contains compiled object code. If it is not specified, one can use the `debug` command to specify the program to be debugged. The object file contains a symbol table, which includes the names of all the source files the compiler translated. These files are available for perusal while using the debugger.

If a file named `core` exists in the current directory, or a *corefile* is specified, `dbx` can be used to examine the state of the program when it faulted. If a *processID* is given instead, `dbx` halts the process and begins debugging it. If you later `detach` the debugger from the it, the process continues to execute.

Debugger commands in the file `.dbxinit` are executed immediately after the symbolic information is read if that file exists in the current directory, or in the user's home directory if it is not found in the current directory.

4.4. Listing Source Code

If you invoked `dbx` on an *objfile*, you can list portions of your program, and associated line numbers in the program's source file. For example, consider the program `example.c`, which you can see by typing:

```
(dbx) list 1,12
    1   #include <stdio.h>
    2
    3   main()
    4   {
    5       printf("goodbye world!\n");
    6       dumpcore();
    7   }
    8
    9   dumpcore()
   10   {
   11       abort();
   12   }
```

If the range of lines starts past the end of file, `dbx` will tell you the program has only so many lines; if the range of lines goes past the end of file, `dbx` will print as many lines as it can, without complaining. You can also list just a single procedure by typing its name instead of a range of lines; for example **`list main`** prints ten lines starting near the top of the `main()` procedure.

4.5. Listing Active Procedures

If your program fails to execute properly, you probably want to find out the procedures that were active when the program crashed. Use the `where` command, like this:

```
where [ n ]
```

`where` displays a list of the top *n* active procedures and functions on the stack, and associated sourcefile line number (if available). If *n* is not specified, all active procedures are displayed.

When debugging a post-mortem dump of the `example.c` program above, `dbx` prints the following:

```
(dbx) where
abort() at 0x80e5
dumpcore(), line 12 in "example.c"
main(0x1, 0xfffd84, 0xfffd8c), line 7 in "example.c"
(dbx)
```

Three other commands useful for viewing the stack are:

`up` [*n*]
Move up the call stack (towards `main`) *n* levels. If *n* is not specified, the default is one. This command allows you to examine the local variables in functions other than the current one. In `dbxtool`, the line containing the call that passes from the *n*th outer level to the *(n–1)*th is highlighted for one second.

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

`proc` [*process_id*]
Specify for kernel debugging which user process is mapped into the *u* area and hence has its kernel stack displayed by the `where` command. If no argument is given, `proc` reports the *process_id* of the process currently mapped into the *u* area .

4.6. Naming and Displaying Data

`print` *expression* [, *expression* ...]
Print the values of specified expressions. An expression may involve function calls if you are debugging an active process. If execution of a function encounters a breakpoint, execution halts and the `dbx` command level is re-entered. A stack trace with the `where` command shows that the call originated from the `dbx` command level.

Variables having the same name as one in the current function may be referenced as *funcname.variable*, or *filename.funcname.variable*. The *filename* is required if *funcname* occurs in several files or is identical to a *filename*. For example, to access variable `i` inside routine `a`, which is declared inside module `a.c`, you would have to use `print a.a.i` to make the name `a` unambiguous. Use `whereis` to determine the fully qualified name of an identifier. See `dbx` Scope Rules in Chapter 2 for more details.

`display` [expression [, *expression* ...]]
Display the values of the expressions each time execution of the debugged program stops. The name qualification rules for `print` apply to `display` as well. With no arguments, the `display` command prints a list of the expressions currently being displayed, and a display number associated with

each expression. In `dbxtool`, the variable names and values are shown in the display subwindow; in `dbx` they are printed automatically whenever execution stops.

`undisplay` *expression* [, *expression* ...]
Stop displaying the expressions and their values each time execution of the program being debugged stops. The name qualification rules for `print` apply to `undisplay` as well. A numeric expression is interpreted as a display number and the corresponding expression is deleted from the display.

`whatis` *identifier*
`whatis` *type*
Print the declaration of the given identifier or type. The identifier may be qualified with block names as above. The *type* argument is useful to print all the members of a structure, union, or enumerated type.

`which` *identifier*
Print the fully qualified form of the given identifier; that is, the outer blocks with which the identifier is associated.

`whereis` *identifier*
Print the fully qualified form of all symbols whose names match the given identifier. The order in which the symbols are displayed is not meaningful.

`assign` *variable = expression*
`set` *variable = expression*
Assign the value of the expression to the variable. Currently no type conversion takes place if operands are of different types.

`set81` *fpreg = word1 word2 word3*
Treat the 96-bit value gotten by concatenating *word1*, *word2*, and *word3* as an IEEE floating-point value, and assign it to the named MC68881 floating-point register *fpreg*. Note that MC68881 registers can also be set with the `set` command, but that the value is treated as double-precision and converted to extended precision. **This command applies to Sun-3 systems only.**

`dump` [*func*]
Display the names and values of all the local variables and parameters in *func*. If not specified, the current function is used.

4.7. Setting Breakpoints

Breakpoints are set with the `stop` and `when` commands, which have the following forms:

`stop at` *source-line-number* [`if` *condition*]
Stop execution at the given line number whenever the *condition* is true. If *condition* is not specified, stop every time the line is reached.

`stop in` *procedure/function* [`if` *condition*]
Stop execution at the first line of the given procedure or function whenever the *condition* is true. If *condition* is not specified, stop every time the line is reached.

`stop` *variable* [`if` *condition*]
Stop execution whenever the value of *variable* changes and *condition* is true. If *condition* is not specified, stop every time the value of *variable* changes. This command performs interpretive execution, and thus is significantly slower than most other commands.

`stop if` *condition*
Stop execution whenever *condition* becomes true. This command performs interpretive execution, and thus is significantly slower than most other commands.

`when in` *procedure/function* **{** *command;* **... }**
Execute the given `dbx` *command(s)* whenever the specified procedure or function is entered.

`when at` *source-line-number* **{** *command;* **... }**
Execute the given `dbx` *command(s)* whenever the specified *source-line-number* is reached.

`when` *condition* **{** *command;* **... }**
Execute the given `dbx` *command(s)* whenever the *condition* is true before a statement is executed. This command performs interpretive execution, and thus is significantly slower than most other commands.

NOTE *In the* `when` *commands, the braces and the semicolons between commands are required.*

The following commands can be used to view and change breakpoints:

`status` [>*filename*]
Display the currently active `trace`, `stop`, and `when` commands. A *command-number* is listed for each command. The *filename* argument causes the output of `status` to be sent to that file.

`delete` *command-number* [, *command-number* ...]
`delete all`
Remove the `trace`, `when`, and/or `stop` commands corresponding to the given *command-numbers*, or all of them. The `status` command explained above displays numbers associated with these commands.

`clear` *source-line-number*
Clear all breakpoints at the given source line number. If no *source-line-number* is given, the current stopping point is used.

Two additional commands can be used to set a breakpoint when a signal is detected by the program, rather than a condition or location.

`catch` [*number* [, *number* ...]]
Start trapping the signals with the given *number*(s) before they are sent to the program being debugged. This is useful when a program handles signals

such as interrupts. Initially all signals are trapped except SIGHUP, SIGCONT, SIGCHILD, SIGALRM, SIGKILL, SIGSTP, and SIGWINCH. If no *number* is given, list the signals being caught.

`ignore` [*number* [, *number* ...]]
Stop trapping the signals with the given *number*(s) before they are sent to the program being debugged. This is useful when a program handles signals such as interrupts. If no *number* is given, list the signals being ignored.

4.8. Running and Tracing Programs

You can run and trace your code using the following commands:

`run` [*args*] [<*filename*] [>*filename*] [>>*filename*]
Start executing *objfile*, specified on the `dbx` command line (or with the most recent `debug` command), passing *args* as command-line arguments; <, >, and >> can be used to redirect input or output in the usual manner. Otherwise, all characters in *args* are passed through unchanged. If no arguments are specified, the argument list from the last `run` command (if any) is used. If *objfile* has been written since the last time the symbolic information was read in, `dbx` reads the new information before beginning execution.

`rerun` [*args*] [<*filename*] [>*filename*] [>>*filename*]
Identical to `run`, except in the case where no arguments are specified. In that case `run` runs the program with the same arguments as on the last invocation, whereas `rerun` runs it with no arguments at all.

`cont` [`at` *source-line-number*] [`sig` *sig-number*]
Continue execution from where it stopped, or, if the clause `at` *source-line-number* is given, at that line number. The *sig-number* causes execution to continue as if that signal had occurred. The *source-line-number* is evaluated relative to the current file and must be within the current procedure/function. Execution cannot be continued if the process has finished (that is, has called the standard procedure `_exit`). `dbx` captures control when the process attempts to exit, thereby letting the user examine the program state.

`trace` *source-line-number* [`if` *condition*]
`trace` *procedure/function* [`if` *condition*]
`trace` [`in` *procedure/function*] [`if` *condition*]
`trace` *expression* `at` *source-line-number* [`if` *condition*]
`trace` *variable* [`in` *procedure/function*] [`if` *condition*]
Display tracing information when the program is executed. A number is associated with the `trace` command, and can be used to turn the tracing off (see the `delete` command).

If no argument is specified, each source line is displayed before it is executed. Execution is substantially slower during this form of tracing.

The clause `in` *procedure/function* restricts tracing information to be displayed only while executing inside the given procedure or function. Note that the *procedure/function* traced must be visible in the scope in which the `trace` command is issued — see the `func` command.

The *condition* is a Boolean expression evaluated before displaying the tracing information; the information is displayed only if *condition* is true.

The first argument describes what is to be traced. The effects of different kinds of arguments are described below:

Table 4-2 *Tracing and its Effects*

source-line-number	Display the line immediately before executing it. Source line numbers in a file other than the current one must be preceded by the name of the file in quotes and a colon, for example, `"mumble.p":17`.
procedure/function	Every time the procedure or function is called, display information telling what routine called it, from what source line it was called, and what parameters were passed to it. In addition, its return is noted, and if it is a function, the return value is also displayed.
expression	The value of the expression is displayed whenever the identified source line is reached.
variable	The name and value of the variable are displayed whenever the value changes. Execution is substantially slower during this form of tracing.

Tracing is turned off whenever the function in which it was turned on is exited. For instance, if the program is stopped inside some procedure and tracing is invoked, the tracing will end when the procedure is exited. To trace the whole program, tracing must be invoked before a `run` command is issued.

When using *conditions* with `trace`, `stop`, and `when`, remember that variable names are resolved with respect to the scope current at the time the command is issued (not the scope of the expression inside the `trace`, `stop`, or `when` command). For example, if you are currently stopped in function `foo()` and you issue the command

```
stop in bar if x==5
```

the variable *x* refers to the *x* in function `foo()`, not in `bar()`. The `func` command can be used to change the scope before issuing a `trace`, `stop`, or `when` command, or the name can be qualified, for example, `bar.x==5`.

`step [`*n*`]`
: Execute through the next *n* source lines and then stop. If *n* is not specified, it is taken to be one. Step into procedures and functions.

`next [`*n*`]`
: Execute through the next *n* source lines and then stop, counting functions as single statements.

`call` *procedure* (*parameters*)

Execute the named *procedure* (or *function*), with the given *parameters*. If any breakpoints are encountered, execution halts and the `dbx` command level is reentered. A stack trace with the `where` command shows that the call originated from the `dbx` command level.

If the source file in which the routine is defined was compiled with the `-g` flag, the number and types of parameters must match. However, if C routines are called that are not compiled with the `-g` flag, `dbx` does no parameter checking. The parameters are simply pushed on the stack as given in the parameter list. Currently, FORTRAN alternate return points are not passed properly.

4.9. Accessing Source Files and Directories

These commands let you access source files and directories without exiting `dbx`:

`edit` [*filename*]
`edit` *procedure/function*

Invoke an editor on *filename* (or on the current source file if none is specified). If a *procedure* or *function* name is specified, the editor is invoked on the file that contains it. The default editor invoked is `vi`. Set the environment variable `EDITOR` to the name of a preferred editor to override the default. For `dbxtool`, the editor comes up in a new window.

`file` [*filename*]

Change the current source file to *filename*, or print the name of the current source file if no *filename* is specified.

`func` [*procedure* / *function* / *objfile*]

Change the current function, or print the name of the current function if none is specified. Changing the current function implicitly changes the current source file variable `file` to the one that contains the function; it also changes the current scope used for name resolution. If the global scope is desired, the argument should be the *objfile*.

`list` [*source-line-number* [, *source-line-number*]]
`list` *procedure/function*

List the lines in the current source file from the first line number through the second. If no lines are specified, the next 10 lines are listed. If the name of a procedure or function is given, lines *n–5* to *n+5* are listed, where *n* is the first statement in the procedure or function. If the `list` command's argument is a procedure or function, the scope for further listing is changed to that routine — use the `file` command to change it back. In `dbxtool`, the region of the file is shown in the source window and extends from the first line number to the end of the window.

`use` [*directory* ...]

Set the list of directories to search when looking for source files. If no *directory* is given, print the current list of directories. Supplying a list of directories replaces the current (possibly default) list. The list is searched from left to right.

`cd` [*dirname*]
Change `dbx`'s notion of the current directory to *dirname*. With no argument, use the value of the `HOME` environment variable.

`pwd`
Print `dbx`'s notion of the current directory.

/*string*[/]
Search downward in the current file for the regular expression *string*. The search begins with the line immediately after the current line and, if necessary, continues until the end of the file. The matching line becomes the current line. In `dbxtool`, the matching line is highlighted for one second.

?*string*[?]
Search upward in the current file for the regular expression *string*. The search begins with the line immediately before the current line and, if necessary, continues until the top of the file. The matching line becomes the current line. In `dbxtool`, the matching line is highlighted for one second.

When `dbx` searches for a source file, the value of `file` and the `use` directory search path are used. The value of `file` is appended to each directory in the `use` search path until a matching file is found. This file becomes the current file.

`dbx` knows the same filenames as were given to the compilers. For instance, if a file is compiled with the command

```
% cc -c -g ../mip/scan.c
```

then `dbx` knows the filename `../mip/scan.c`, but not `scan.c`.

4.10. Machine-Level Commands

These commands are used to debug code at the machine level:

`tracei` [*address*] [`if` *cond*]
`tracei` [*variable*] [`at` *address*] [`if` *cond*]
Turn on tracing of individual machine instructions.

`stopi` [*variable*] [`if` *cond*]
`stopi` [`at` *address*] [`if` *cond*]
Set a breakpoint at the address of a machine instruction.

`stepi`
`nexti`
Single step as in `step` or `next`, but do a single machine instruction rather than a line of source.

address, address / [*mode*]
address / [*count*] [*mode*]

+/ [*count*] [*mode*]
Display the contents of memory starting at the first *address* and continuing up to the second *address*, or until *count* items have been displayed. If a + is specified, the address following the one displayed most recently is used. The *mode* specifies how memory is displayed; if omitted, the last specified

mode is used. The initial mode is X. The following modes are supported:

Mode	*Does*
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
b	display as a byte in octal
c	display a byte as a character
s	display as a string of characters terminated by a null byte
f	display as a single-precision real number
g	display as a double-precision real number
E	display as an extended-precision real number

Symbolic addresses used in this context are specified by preceding a name with an ampersand &. Registers are denoted by preceding a name with a dollar sign $. Here is a list of MC680x0 register names:

Register	*Name*
$d0-$d7	data registers
$a0-$a7	address registers
$fp	frame pointer (same as $a6)
$sp	stack pointer (same as $a7)
$pc	program counter
$ps	program status

The following registers apply only to Sun-3s:

Register	*Name*
$fp0-$fp7	MC68881 data registers
$fpc	MC68881 control register
$fps	MC68881 status register
$fpi	MC68881 instruction address register
$fpf	MC68881 flags (unused, idle, busy)
$fpg	MC68881 floating-point signal type

For example, to print the contents of the data and address registers in hex on a Sun-2 or Sun-3, type `&$d0/16X` *or* `&$d0,&$a7/X`. To print the contents of register `d0`, type `print $d0` (one cannot specify a range with `print`). Addresses may be expressions made up of other addresses and the operators + (plus), – (minus), * (multiply), and indirection (unary *). The address may be a + alone, which causes the next location to be displayed.

See the *SPARC Architecture Reference Manual* and the *Sun-4 Assembly Language Reference Manual* for information about Sun-4 registers and addressing.

Here is the list of Sun386i registers:

Register	*Name*
`$ss`	stack segment register
`$eflags`	flags
`$cs`	code segment register
`$eip`	instruction pointer
`$eax`	general register
`$ebx`	general register
`$ecx`	general register
`$edx`	general register
`$esp`	stack pointer
`$ebp`	frame pointer
`$esi`	source index register
`$edi`	destination index register
`$ds`	data segment register
`$es`	alternate data segment register
`$fs`	alternate data segment register
`$gs`	alternate data segment register

On the Sun386i, to print the contents of the data and address registers in hex, type `&$eax/16X` or `&$eax,&$edi/X`. To print the contents of register `eax`, type `print $eax`.

You can also access parts of the Sun386i registers. Specifically, the lower halves (16 bits) of these registers have separate names, as follows:

Register	*Name*
`$ax`	general register
`$cx`	general register
`$dx`	general register
`$bx`	general register
`$sp`	stack pointer
`$bp`	frame pointer
`$si`	source index register
`$di`	destination index register
`$ip`	instruction pointer, lower 16 bits
`$flags`	flags, lower 16 bits

Furthermore, the first four of these 16 bit refisters can be split into two 8-bit parts, as follows:

Register	*Name*
`$al`	lower (right) half of register $ax
`$ah`	higher (left) half of register $ax
`$cl`	lower (right) half of register $cx
`$ch`	higher (left) half of register $cx
`$dl`	lower (right) half of register $dx
`$dh`	higher (left) half of register $dx
`$bl`	lower (right) half of register $bx
`$bh`	higher (left) half of register $bx

The registers for the Sun386i math coprocessor are the following:

Register	*Name*
`$fctrl`	control register
`$fstat`	status register
`$ftag`	tag register
`$fip`	instruction pointer offset
`$fcs`	code segment selector
`$fopoff`	operand pointer offset
`$fopsel`	operand pointer selector
`$st0 - $st7`	data registers

4.11. Miscellaneous Commands

`sh` *command-line*

Pass the command line to the shell for execution. The `SHELL` environment variable determines which shell is used.

`alias` *new-command-name character-sequence*

Respond to *new-command-name* as though it were *character-sequence*. Special characters occurring in *character-sequence* must be enclosed in double quotation marks. Alias substitution as in the C shell also occurs. For example, `!:1` refers to the first argument. The command

```
alias mem "print (!:1)->mem1->mem2"
```

creates a `mem` command that takes an argument, evaluates its `mem1->mem2` field, and prints the result.

`help` [*command*]
`help`

Print a short message explaining *command*. If no argument is given, display a synopsis of all `dbx` commands.

`source` *filename*

Read `dbx` commands from the given *filename*. This is especially useful when that file was created by redirecting a `status` command from an earlier debugging session.

`quit`
Exit `dbx`.

`dbxenv`
`dbxenv stringlen` *num*
`dbxenv case [sensitive | insensitive ]`
`dbxenv speed` *seconds*
Set `dbx` attributes. The `dbxenv` command with no argument prints the attributes and their current values. The keyword `stringlen` controls the maximum number of characters printed for a `char *` variable in a C program (default 512). The keyword `case` controls whether upper and lower case letters are considered different. The default is `sensitive`; `insensitive` is most useful for debugging FORTRAN programs. The keyword `speed` determines the interval between execution of source statements during tracing (default 0.5 seconds).

`debug [-k ]` [*objfile* [*corefile* / *process-id*]]
Terminate debugging of the current program (if any), and begin debugging the one found in *objfile* with the given *corefile* or live process, without incurring the overhead of reinitializing `dbx`. If no arguments are specified, the name of the program currently being debugged and its arguments are printed. The `-k` flag specifies kernel debugging. You must have both the *objfile* and *corefile* or live process available to perform debugging.

`kill`
Terminate debugging of the current process and kill the process, but leave `dbx` ready to debug another. This can eliminate remains of a window program you were debugging without exiting the debugger, or allow the object file to be removed and remade without incurring a "text file busy" error message.

`detach`
Detach a process from `dbx` and let it continure to execute. The process is no longer under the control of `dbx`.

`setenv` *name string*
Set the environment variable *name* to the value of *string*. (See `csh`(1)).

4.12. Debugging Processes that Fork

Debugging a process that creates a new process (using *fork*(2)) introduces unique problems. `dbx` uses *ptrace*(2) to fetch from and store into the program being debugged.

After a fork, there are two processes sharing the same text (code) space. The kernel does not allow `ptrace()` to write into a text space that is being used by more than one process. This means that the debugged program must not encounter any breakpoints while the child of the fork is still sharing its text space. In most cases, the child of the fork spawns a new program almost immediately, using *exec*(2). After the `exec()`, it is safe for the debugged program to encounter breakpoints. Therefore, it is recommended that a *sleep*(2) of two or three seconds be placed in the debugged code immediately after the fork. This gives the child of the fork time to execute a new program and get out of the way.

4.13. dbx FPA Support

Release of the Floating Point Accelerator (FPA) for Sun-3 systems also necessitated some changes to dbx, in order to support debugging of programs that use the FPA. Here are changes made to dbx in Release 3.1 and later:

1. There is a new fpaasm debugger variable to control disassembly of FPA instructions. This variable may be set or displayed using the dbxenv command, for which the syntax is:

   ```
   dbxenv fpaasm <on|off>
   ```

   If the value of fpaasm is off, all FPA instructions are disassembled as moves. If the value is on, FPA instructions are disassembled with FPA assembler mnemonics. Defaults: on a machine with an FPA, fpaasm is initially set to on; on machines without an FPA, it is initially set to off.

2. The fpabase debugger variable has been added. It designates a 68020 address register for FPA instructions that use base+short displacement addressing to address the FPA. The syntax is:

   ```
   dbxenv fpabase <a[0-7]|off>
   ```

   If FPA disassembly is disabled (if fpaasm is off) its value is ignored. Otherwise, its value is interpreted as follows:

   value in [a0..a7]:
   Long move instructions that use the designated address register in base+short displacement mode are assumed to address the FPA, and are disassembled using FPA assembler mnemonics. Note that this is independent of the actual run-time value of the register.

   value = off0:
   All based-mode FPA instructions are disassembled and single-stepped as move instructions.

   The default value of fpabase is off, which designates no FPA base register.

3. The FPA registers $fpa0..$fpa31 are recognized and can be used in arithmetic expressions or modified in set commands. This extension only applies on a machine with an FPA. Note that if an FPA register is used in an expression or assignment, its type is assumed to be double precision.

4. FPA registers can be displayed in single precision using the /f display format. Double precision values are displayed using the /F display format.

NOTE *Note that FPA support does not apply to the Sun386i.*

4.14. Example of FPA Disassembly

Consider the following simple FORTRAN program:

```
program example
print *,f(1.0,1.0)
end

function f(x,y)
f = atan(x/y)
return
end
```

Assume that this program has been compiled with the `-g` option into the file `example`. On a Sun-3 with an FPA, we could disassemble the function `f` as shown below. Note that the FORTRAN intrinsic `ATAN` is directly supported by the FPA instruction set and the FORTRAN compiler.

```
% dbx a.out
(dbx) stop in f
(1) stop in f
(dbx) run
Running: a.out
stopped in f at line 5 in file "example.f"
    5           f = atan(x/y)
(dbx) &$pc/8i
f+0x12:         movl    a6@(0xc),a0
f+0x16:         fpmoves a0@,fpa0
f+0x1c:         movl    a6@(0x8),a0
f+0x20:         fprdivs a0@,fpa0
f+0x26:         fpmoves fpa0,a6@(-0xc)
f+0x2e:         fpmoves a6@(-0xc),fpa1
f+0x36:         fpatans fpa1,fpa1
f+0x40:         fpmoves fpa1,a6@(-0x8)
    ...
```

FPA disassembly can be disabled by setting the debugger variable `fpaasm` to `off`. This causes `dbx` to disassemble FPA instructions as long moves to addresses on the FPA page:

```
(dbx) dbxenv fpaasm off
(dbx) &f+0x12/10i
f+0x12:         movl    a6@(0xc),a0
f+0x16:         movl    a0@,0xe0000c00:l
f+0x1c:         movl    a6@(0x8),a0
f+0x20:         movl    a0@,0xe0000600:l
f+0x26:         movl    0xe0000e00:l,a6@(-0xc)
f+0x2e:         movl    a6@(-0xc),0xe0000c08:l
f+0x36:         movl    #0x41,0xe0000818:l
f+0x40:         movl    0xe0000e08:l,a6@(-0x8)
```

When tracing a more complex program, one may occasionally want to step into a routine that has been compiled with optimization on. In such routines, it is often the case that the compiled code addresses the FPA page by using base+short offset addressing. Such code can be difficult to recognize unless it is known ahead of time that a particular address register is being used to address the FPA. This situation can be identified by the presence of an instruction that loads the address of the FPA page (0xe0000000) into an address register before doing any floating-point arithmetic.

For example, here is a disassembly of the beginning of an optimized FORTRAN routine compiled with the -O and -ffpa options:

```
(dbx) &ddot_/7i
ddot_:        link     a6,#-0x2a0
ddot_+0x4:    moveml   #<d2,d3,d4,d5,d6,d7,a2,a3,a4,a5>,sp@
ddot_+0x8:    lea      e0000000:l,a2
ddot_+0xe:    movl     a2@(0xe20),a6@(-0x278)
ddot_+0x14:   movl     a2@(0xe24),a6@(-0x274)
ddot_+0x1a:   movl     a2@(0xe28),a6@(-0x270)
ddot_+0x20:   movl     a2@(0xe2c),a6@(-0x26c)
```

dbx does not know which register (if any) is being used to address the FPA in a given sequence of machine code. However, you may set the dbxenv variable fpabase to designate an MC68020 address register as an FPA base register. In this example, we note that the compiler has loaded the address of the FPA page into register a2, and so we designate a2 as the FPA base register to obtain the following:

```
(dbx) dbxenv fpabase a2
(dbx) &ddot_/7i
ddot_:        link     a6,#-0x2a0
ddot_+0x4:    moveml   #<d2,d3,d4,d5,d6,d7,a2,a3,a4,a5>,sp@
ddot_+0x8:    lea      e0000000:l,a2
ddot_+0xe:    fpmoved@2        fpa4,a6@(-0x278)
ddot_+0x1a:   fpmoved@2        fpa5,a6@(-0x270)
ddot_+0x26:   fpmoved@2        204ce:l,fpa5
ddot_+0x36:   fpmoved@2        204ce:l,fpa4
```

4.15. Examples of FPA Register Use

FPA data registers can be displayed using a syntax similar to that used for the MC68881 co-processor registers. Note that unlike the MC68881 registers, FPA registers may contain either single-precision (32-bit) or double-precision (64-bit) values; MC68881 registers always contain an extended-precision (96-bit) value.

For example, if fpa0 contains the single-precision value 2.718282, we may display it as follows:

```
(dbx) &$fpa0/f
fpa0      0x402df855    +2.718282e+00
```

Note that the value is displayed in hexadecimal as well as in floating point notation.

A double-precision value may be displayed using the /F format. For example, if fpa0 contains the double-precision value 2.718281828, we may display it as follows:

```
(dbx) &$fpa0/F
fpa0      0x4005bf0a 0x8b04919b    +2.71828182800000e+00
```

Note that it is important to use the correct display format; attempting to display a double-precision value in single precision (and vice versa) will usually produce meaningless results.

FPA registers can also be used in set commands and in arithmetic expressions. Since dbx cannot tell whether the value in an FPA register is single or double precision, dbx provides two sets of names to refer to FPA registers. The names {$fpa0..$fpa31} always cause the contents of the register to be interpreted as a double precision value; the names {$fpa0s..$fpa31s} cause interpretation as a single precision value. Thus, the commands

```
(dbx) set $fpa0s = 1.0

(dbx) set $fpa0 = 1.0
```

cause different bit patterns to be stored in fpa0.

5

adb Tutorial

5

adb Tutorial

5.1. A Quick Survey

Available on most UNIX systems, adb is a debugger that permits you to examine core files resulting from aborted programs, display output in a variety of formats, patch files, and run programs with embedded breakpoints. This document provides examples of the more useful features of adb. The reader is expected to be familiar with basic SunOS commands, and with the C language.

NOTE *This chapter describes* adb *use on Sun-2, -3, and Sun-4s only. Chapter 6 describes* adb *use on the Sun386i.*

Starting adb

Start adb with a shell command of the form

```
% adb [objectfile] [corefile]]
```

where *objectfile* is an executable SunOS file and *corefile* is a core dump file. If the object file is named a.out, then the invocation is

```
% adb
```

If you place object files into a named *program*, then the invocation is

```
% adb program
```

The filename minus (–) means ignore the argument, as in:

```
% adb - core
```

This is for examining the core file without reference to an object file. The adb program provides requests for examining locations in either file: **?** examines the contents of *objectfile*, while **/** examines the contents of *corefile*. The general form of these requests is:

```
address ? format
```

or

```
address / format
```

Current Address

adb maintains a current address, called **dot**. When an address is entered, the current address is set to that location, so that

```
0126?i
```

sets dot to octal 126 and displays the instruction at that address. The request

```
.,10/d
```

displays 10 decimal numbers starting at dot. Dot ends up referring to the address of the last item displayed. When used with the **?** or **/** requests, the current address can be advanced by typing newline; it can be decremented by typing **^**.

Addresses are represented by expressions. Expressions are made up of decimal integers, octal integers, hexadecimal integers, and symbols from the program under test. These may be combined with the operators **+** (plus), **-** (minus), ***** (multiply), **%** (integer divide), **&** (bitwise and), **|** (bitwise inclusive or), **#** (round up to the next multiple), and **~** (not). All arithmetic within adb is 32 bits. When typing a symbolic address for a C program, you can type name. On a Sun-2, Sun-3, or Sun-4 you could alternatively type L _name ; adb recognizes both forms on these systems, only the first on Sun386i.

Formats

To display data, specify a collection of letters and characters to describe the format of the display. Formats are remembered, in the sense that typing a request without a format displays the new output in the previous format. Here are the most commonly used format letters:

Table 5-1 *Some* adb *Format Letters*

Letter	*Description*
b	one byte in octal
B	one byte in hex
c	one byte as a character
o	one word in octal
d	one word in decimal
f	one long word in single-precision floating point
i	MC68000 instruction on Sun-2 and Sun-3, SPARC instuction on Sun-4, and 80386 instruction on Sun386i.
s	a null terminated character string
a	the value of dot
u	one word as an unsigned integer
n	print a newline
r	print a blank space
^	backup dot (not really a format)
+	advance dot (not really a format)

Format letters are also available for long values: for example, D for long decimal, and F for double-precision floating point. Since integers are long-words on the Sun-2 and Sun-3, capital letters are used more often then not. For other formats see Chapter 7 .

General Command Meanings

The general form of a command is:

```
[address [, count]] command [modifier]
```

which sets dot to *address* and executes *command count* times. The following table illustrates some general adb command meanings:

Table 5-2 *Some* adb *Commands*

Some* adb *Commands	
Command	*Meaning*
?	Print contents from a.out file
/	Print contents from core file
=	Print value of "dot"
:	Breakpoint control
$	Miscellaneous requests
;	Request separator
!	Escape to shell

Since adb catches signals, a user cannot use a quit signal to exit from adb. The request $q or $Q (or CTRL-D) must be used to exit from adb.

5.2. Debugging C Programs

If you use adb because you are accustomed to it, you will want to compile programs with the -go or -g option, to produce old-style symbol tables. This will make debugging proceed according to expectations. If you don't compile programs with -go (or -g), and the -O option is set, the object code will be optimized, and may not so readily be understood as the same thing that was written in the source file.

Debugging A Core Image

Consider the C program below, which illustrates a common error made by C programmers. The object of the program is to change the lower case t to an upper case T in the string pointed to by ch, and then write the character string to the file indicated by the first argument.

```
#include <stdio.h>

char *cp = "this is a sentence.";

main(argc, argv)
int argc;
char **argv;
{
    FILE *fp;
    char c;

    if (argc == 1) {
        fprintf(stderr, "usage: %s file\n", argv[0]);
        exit(1);
    }
    if ((fp = fopen(argv[1], "w")) == NULL) {
        perror(argv[1]);
        exit(2);
    }
    cp = 'T';
    while (c = *cp++)
        putc(c, fp);
    fclose(fp);
    exit(0);
}
```

The bug is that the character T is stored in the pointer cp instead of in the string pointed to by cp. Compile the program as follows:

```
% cc -go example1.c
% a.out junk
Segmentation fault (core dumped)
```

Executing the program produces a core dump caused by an illegal memory reference. Now invoke adb by typing:

```
% adb
core file = core -- program "a.out"
memory fault
```

Commonly the first debugging request given is

```
$c
_main[8074](2,fffd7c,fffd88) + 92
```

which produces a C backtrace through the subroutines called. The output from adb tells us that only one function — main — was called, and the arguments argc and argv have the hexadecimal values 2 and fffd7c respectively. Both these values look reasonable — 2 indicates two arguments, and fffd7c equals the stack address of the parameter vector. The next request:

```
$C
_main[8074](2,fffd7c,fffd88) + 92
    fp:         10468
    c:          104
```

generates a C backtrace plus an interpretation of all the local variables in each function, and their values in hexadecimal. The value of the variable c looks incorrect since it is outside the ASCII range. The request

```
$r
d0    54        frame+24
d1    77        frame+47
d2    2         man1
d3    0         exp
d4    0         exp
d5    0         exp
d6    0         exp
d7    0         exp
a0    54        frame+24
a1    0         exp
a2    0         exp
a3    fffd7c
a4    fffd88
a5    0         exp
a6    fffd64
sp    fffd5c
pc    8106      _main+92
ps    0         exp
_main+92:               ???
```

displays the registers, including the program counter, and an interpretation of the instruction at that location. The request

```
$e
_environ:   fffd88
_sys_nerr:  48
__ctype_:   202020
__exit_nhandlers:       0
__exit_tnames:          9b06
```

```
__lastbuf:  10684
__root:     0
__lbound:   0
__ubound:   0
curbrk:     12dd4
__d_pot:    8000
__d_big_pot:            8000
__d_r_pot:  8000
__d_r_big_pot:          8000
_errno:     0
_end:       0
```

displays the values of all external variables.

A map exists for each file handled by adb. The map for a.out files is referenced by ? whereas the map for core files is referenced by /. Furthermore, a good rule of thumb is to use ? for instructions and / for data when looking at programs. To display information about maps, type:

```
$m
b1 = 2000           e1 = b000           f1 = 800
b2 = 10000          e2 = 11000          f2 = 3800
/ map       'core'
b1 = 10000          e1 = 13000          f1 = 1800
b2 = fff000         e2 = 1000000        f2 = 4800
```

This produces a report of the contents of the maps. More about these maps later.

In our example, we might want to see the contents of the string pointed to by cp. We would want to see the string pointed to by cp in the core file:

```
*cp/s
55:
data address not found
```

Because the pointer was set to 'T' (hex 54) and then incremented, it now equals hex 55. On the Sun-2 and Sun-3, there are no symbols below address 2000 (8000 on a Sun-2), so the data address 55 cannot be found. We could also display information about the arguments to a function. To get the decimal value of the argc argument to main, which is a long integer, type:

```
main.argc/D
fffd6c:         2
```

To display the hex values of the three consecutive cells pointed to by argv in the function main, type:

```
*main.argv,3/X
fffd7c:         fffdc0          fffdc6          0
```

Note that these values are the addresses of the arguments to `main`. Therefore, typing these hex values should yield the command-line arguments:

```
fffdc0/s
fffdc0:         a.out
```

The request:

```
.=
                fffdc0
```

displays the current address (not its contents) in hex, which has been set to the address of the first argument. The current address, dot, is used by `adb` to remember its current location. It allows the user to reference locations relative to the current address. For example

```
fffdc6:         zzz
```

prints the first command-line argument.

Setting Breakpoints

Set breakpoints in a program with the `:b` instruction, which has this form:

```
address :b [ request ]
```

Consider the C program below, which changes tabs into blanks, and is adapted from *Software Tools* by Kernighan and Plauger, pp. 18-27.

```
#include <stdio.h>

#define MAXLIN  80
#define YES 1
#define NO  0
#define TABSP   8

int tabs[MAXLIN];

main()
{
    int *ptab, col, c;

    ptab = tabs;
    settab(ptab);    /* set initial tab stops */
    col = 1;
    while ((c = getchar()) != EOF) {
        switch (c) {
        case '\t':
            while (tabpos(col) != YES) {
                putchar(' ');
                col++;
            }
            putchar(' ');
```

```
            col++;
            break;
        case '\n':
            putchar('\n');
            col = 1;
            break;
        default:
            putchar(c);
            col++;
        }
    }
    exit(0);
}

tabpos(col) /* return YES if col is a tab stop, NO if not */
int col;
{
    if (col > MAXLIN)
        return(YES);
    else
        return(tabs[col]);
}

settab(tabp)     /* set initial tab stops every TABSP spaces */
int *tabp;
{
    int i;

    for (i = 0; i <= MAXLIN; i++)
        (i % TABSP) ? (tabs[i] = NO) : (tabs[i] = YES);
}
```

Run the program under the control of adb, and then set four breakpoints as follows:

```
% adb a.out -
settab:b
tabpos:b
```

This sets breakpoints at the start of the two functions. Sun compilers generate statement labels only with the −g option, which is incompatible with adb. Therefore it is impossible to plant breakpoints at locations other than function entry points using adb. To display the location of breakpoints, type:

```
$b
breakpoints
count   bkpt            command
1       _tabpos
1       _settab
```

A breakpoint is bypassed *count*–1 times before causing a stop. The *command* field indicates the adb requests to be executed each time the breakpoint is encountered. In this example no command fields are present.

Display the instructions at the beginning of function settab() in order to observe that the breakpoint is set after the link assembly instruction:

```
settab,5?ia
_settab:
_settab:                 link     a6,#0
_settab:                 addl     #-4,a7
_settab+a:               moveml   #<>,sp@
_settab+e:               clrl     a6@(-4)
_settab+12:              cmpl     #50,a6@(-4)
_settab+1a:
```

This request displays five instructions starting at settab with the address of each location displayed. Another variation is

```
settab,5?i
_settab:
_settab:                 link     a6,#0
                         addl     #-4,a7
                         moveml   #<>,sp@
                         clrl     a6@(-4)
                         cmpl     #50,a6@(-4)
```

which displays the instructions with only the starting address. Note that we accessed the addresses from a.out with the **?** command. In general, when asking for a display of multiple items, adb advances the current address the number of bytes necessary to satisfy the request; in the above example, five instructions were displayed and the current address was advanced 26 bytes.

To run the program, type:

```
:r
```

To delete a breakpoint, for instance the entry to the function tabpos(), type:

```
tabpos:d
```

Once the program has stopped, in this case at the breakpoint for settab(), adb requests can be used to display the contents of memory. To display a stack trace, for example, type:

```
$c
_settab[8250](10658) + 4
_main[8074](1,fffd84,fffd8c) + 1a
```

And to display three lines of eight locations each from the array called `tabs`, type:

```
tabs,3/8X
_tabs:
_tabs:      0     0     0     0     0     0     0     0
            0     0     0     0     0     0     0     0
            0     0     0     0     0     0     0     0
```

At this time (at location `settab`) the `tabs` array has not yet been initialized. If you just deleted the breakpoint at `tabpos`, put it back by typing:

```
tabpos:b
```

To continue execution of the program from the breakpoint type:

```
:c
    x
```

You will need to give the `a.out` program a line of data, as in the figure above. Once you do, it will encounter a breakpoint at `tabpos+4` and stop again. Examine the `tabs` array once more: now it is initialized, and has a one set in every eighth location:

```
tabs,3/8X
_tabs:
_tabs:      1     0     0     0     0     0     0     0
            1     0     0     0     0     0     0     0
            1     0     0     0     0     0     0     0
```

You will have to type `:c` eight more times in order to get your line of output, since there is a breakpoint at every input character. Type [CTRL-D] to terminate the `a.out` process; you are back in command-level of `adb`.

Advanced Breakpoint Usage

The quit and interrupt signals act on `adb` itself, rather than on the program being debugged. If such a signal occurs, then the program being debugged is stopped and control is returned to `adb`. The signal is saved by `adb` and passed on to the test program if you type:

```
:c 0
```

Now let's reset the breakpoint at `settab()` and display the instructions located there when we reach the breakpoint. This is accomplished by:

```
settab+4:b settab,5?ia
:r
_settab:
_settab:                link     a6,#0
_settab+4:              addl     #-4,a7
_settab+a:              moveml   #<>,sp@
_settab+e:              clrl     a6@(-4)
_settab+12:             cmpl     #50,a6@(-4)
_settab+1a:
breakpoint      _settab+4:               addl     #-4,a7
```

It is possible to stop every two breakpoints, if you type `,2` before the breakpoint command. Variables can also be displayed at the breakpoint, as illustrated below:

```
tabpos+4,2:b main.col?X
:c
    x
fffd64:         1
fffd64:         2
breakpoint      _tabpos+4:               addl     #0,a7
```

This shows that the local variable `col` changes from 1 to 2 before the occurrence of the breakpoint.

WARNING ***Setting a breakpoint causes the value of dot to be changed. However, executing the program under*** `adb` ***does not change the value of dot.***

A breakpoint can be overwritten without first deleting the old breakpoint. For example:

```
settab+4:b main.ptab/X; main.c/X
:r
fffd68:         10658
fffd60:         0
breakpoint      _settab+4:               addl     #-4,a7
```

The semicolon is used to separate multiple `adb` requests on a single line.

Other Breakpoint Facilities

Arguments and change of standard input and output are passed to a program as follows. This request kills any existing program under test and starts `a.out` afresh:

```
:r arg1 arg2 ... <infile >outfile
```

The program being debugged can be single stepped as follows. If necessary, this request starts up the program being debugged and stops after executing the first instruction:

```
:s
```

You can enter a program at a specific address by typing:

```
address:r
```

The count field can be used to skip the first *n* breakpoints, as follows:

```
,n:r
```

This request may also be used for skipping the first *n* breakpoints when continuing a program:

```
,n:c
```

A program can be continued at an address different from the breakpoint by:

```
address:c
```

The program being debugged runs as a separate process, and can be killed by:

```
:k
```

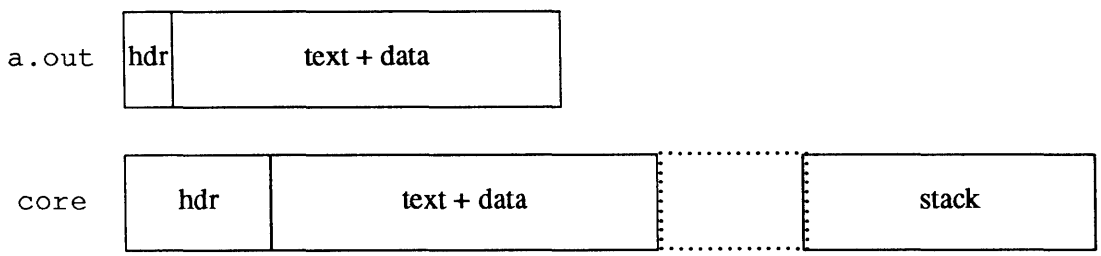
5.3. File Maps

SunOS supports several executable file formats. Executable type 407 is generated by the cc (or ld) flag –N. Executable type 410 is generated by the flag –n. An executable type 413 is generated by the flag –z; the default is type 413. adb interprets these different file formats, and provides access to the different segments through a set of maps. To display the maps, type **$m** from inside adb.

407 Executable Files

In 407-format files, instructions and data are intermixed. This makes it impossible for adb to differentiate data from instructions, but adb will display in either format. Furthermore, some displayed symbolic addresses look incorrect (for example, data addresses as offsets from routines). Here is a picture of 407-format files:

Figure 5-1 *Executable File Type 407*



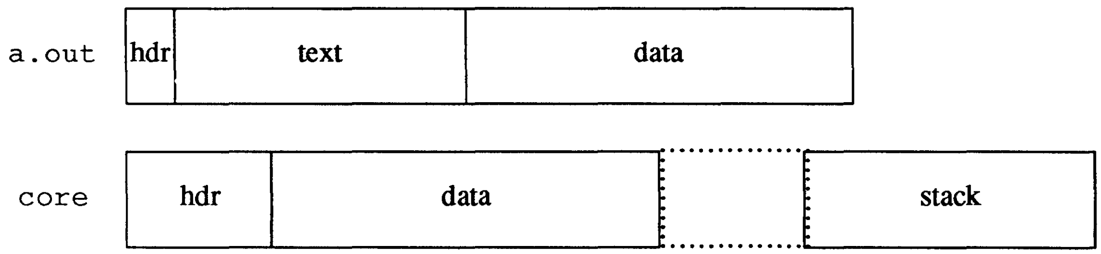
Here are the maps and variables for 407-format files:

```
$m
? map        'a.out'
b1 = 2000              e1 = 8f28              f1 = 20
b2 = 8000              e2 = 9560              f2 = 20
/ map        'core'
b1 = 8000              e1 = b800              f1 = 1800
b2 = fff000            e2 = 1000000           f2 = 5000
$v
variables
b = 0100000
d = 03070
e = 0407
m = 0407
s = 010000
t = 07450
```

410 Executable Files

In 410-format files (pure executable), instructions are separate from data. The ? command accesses the data part of the `a.out` file, telling `adb` to use the second part of the map in that file. Accessing data in the `core` file shows the data after it was modified by the execution of the program. Notice also that the data segment may have grown during program execution. Here is a picture of 410-format files:

Figure 5-2 *Executable File Type 410*



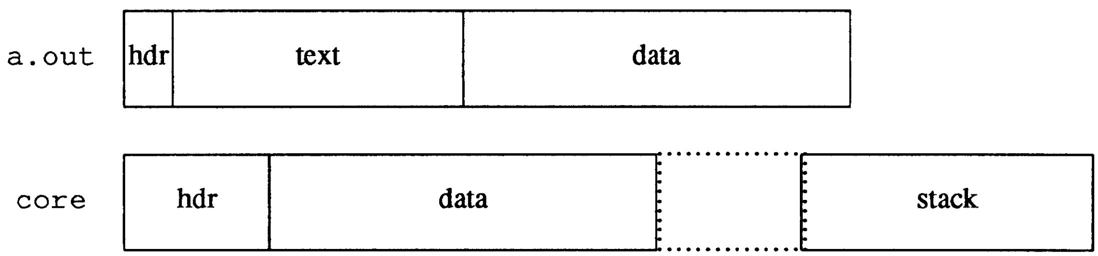
Here are the maps and variables for 410-format files:

```
$m
? map       'a.out'
b1 = 2000            e1 = 8f28              f1 = 20
b2 = 10000           e2 = 10638             f2 = f48
/ map       'core'
b1 = 10000           e1 = 12800             f1 = 1800
b2 = fff000          e2 = 1000000           f2 = 4000
$v
variables
b = 0200000
d = 03070
e = 0410
m = 0410
s = 010000
t = 07450
```

413 Executable Files

In 413-format files (pure demand-paged executable) the instructions and data are also separate. However, in this case, since data is contained in separate pages, the base of the data segment is also relative to address zero. In this case, since the addresses overlap, it is necessary to use the `?*` operator to access the data space of the `a.out` file. In both 410 and 413-format files the corresponding `core` file does not contain the program text. Here is a picture of 413-format files:

Figure 5-3 *Executable File Type 413*



The only difference between a 410 and a 413-format file is that 413-format segments are rounded up to page boundaries. Here are the maps and variables for 413-format files:

```
$m
? map        'abort'
b1 = 2000                e1 = 9000                f1 = 800
b2 = 10000               e2 = 10800               f2 = 1800
/ map        'core'
b1 = 10000               e1 = 12800               f1 = 1800
b2 = fff000              e2 = 1000000             f2 = 4000
$v
variables
b = 0200000
d = 04000
e = 0413
m = 0413
s = 010000
t = 010000
```

NOTE *In the example above,* `b1 = 2000` *would be* `b1 = 8000` *for a Sun-2.*

Variables

The `b`, `e`, and `f` fields are used to map addresses into file addresses. The `f1` field is the length of the header at the beginning of the file — 020 bytes for an `a.out` file and 02000 bytes for a `core` file. The `f2` field is the displacement from the beginning of the file to the data. For a 407-format file with mixed text and data, this is the same as the length of the header; for 410-format and 413-format files, this is the length of the header plus the size of the text portion. The `b` and `e` fields are the starting and ending locations for a segment. Given the address *A*, the location in the file (either `a.out` or `core`) is calculated as:

```
b1<A<e1    file address = (A-b1)+f1
b2<A<e2    file address = (A-b2)+f2
```

You can access locations by using the adb-defined variables. The $v request displays the variables initialized by adb:

b base address of data segment,

d length of the data segment,

s length of the stack,

t length of the text,

m execution type (407, 410, 413).

Those variables not presented are zero. Use can be made of these variables by expressions such as

```
<b
```

in the address field. Similarly, the value of a variable can be changed by an assignment request such as

```
02000>b
```

which sets b to octal 2000. These variables are useful to know if the file under examination is an executable or core image file.

The adb program reads the header of the core image file to find the values for these variables. If the second file specified does not seem to be a core file, or if it is missing, then the header of the executable file is used instead.

5.4. Advanced Usage

One of the uses of adb is to examine object files without symbol tables since dbx cannot handle this kind of task.

With adb, you can combine formatting requests to provide elaborate displays. Several examples are given below.

Formatted Dump

The following adb command line displays four octal words followed by their ASCII interpretation from the data space of the core file:

```
<b,-1/4o4^8Cn
```

Broken down, the various requests mean:

<b The base address of the data segment.

<b,-1 Print from the base address to the end-of-file. A negative count is used here and elsewhere to loop indefinitely or until some error condition (like end-of-file) is detected.

The format `4o4^8Cn` is broken down as follows:

`4o` Print 4 octal locations.

`4^` Back up the current address 4 locations (to the original start of the field).

`8C` Print 8 consecutive characters using an escape convention; each character in the range 0 to 037 is displayed as followed by the corresponding character in the range 0140 to 0177. An `@` is displayed as `@@`.

`n` Print a newline.

The following request could have been used instead to allow the displaying to stop at the end of the data segment. (The request `<d` provides the data segment size in bytes.)

```
<b,<d/4o4^8Cn
```

Because `adb` can read in scripts, you can use formatting requests to produce image dump scripts. Invoke `adb` as follows:

```
% adb a.out core < dump
```

This reads in a script file, `dump`, containing formatting requests. Here is an example of such a script:

```
120$w
4095$s
$v
=3n
$m
=3n"C Stack Backtrace"
$C
=3n"C External Variables"
$e
=3n"Registers"
$r
0$s
=3n"Data Segment"
<b,-1/8ona
```

The request `120$w` sets the width of the output to 120 characters (normally, the width is 80 characters). `adb` attempts to display addresses as:

```
symbol + offset
```

The request `4095$s` increases the maximum permissible offset to the nearest symbolic address from the default 255 to 4095. The request = can be used to display literal strings. Thus, headings are provided in this dump program with requests of the form:

```
=3n"C Stack Backtrace"
```

This spaces three lines and displays the literal string. The request `$v` displays all non-zero `adb` variables. The request `0$s` sets the maximum offset for symbol matches to zero, thus suppressing the display of symbolic labels in favor of octal values. Note that this is only done for displaying the data segment. The request

```
<b,-1/8ona
```

displays a dump from the base of the data segment to the end-of-file with an octal address field and 8 octal numbers per line.

Accounting File Dump

As another illustration, consider a set of requests to dump the contents `/etc/utmp` or `/usr/adm/wtmp`, both of which are composed of 8-character terminal names, 8-character login names, 16-character host names, and a 4-byte integer representing the login time.

```
% adb /etc/utmp -
0,-1?cccccccc8tcccccccc8tcccccccccccccccc16tYn
```

The `c` format is repeated 8 times, 8 times, and 16 times. The `8t` means go to align on an 8-character-position boundary, and `16t` means to align on a 16-character-position boundary. `Y` causes the 4-byte integer representing the login time to print in *ctime*(3) format.

Converting Values

You can use `adb` to convert values from one representation to another. For example, to print the hexadecimal number `ff` in octal, decimal, and hexadecimal, type:

```
ff = odx
    072 58  #3a
```

The default input radix of `adb` is hexadecimal. Formats are remembered, so that typing subsequent numbers will display them in the same format. Character values may be converted as well:

```
'a' = oc
    0141    a
```

This technique may also be used to evaluate expressions, but be warned that all binary operators have the same precedence, which is lower than for unary operators.

5.5. Patching

Patching files with adb is accomplished with the write requests w or W. This is often used in conjunction with the locate requests l or L. In general, the syntax for these requests is as follows:

```
?l value
```

The l matches on two bytes, whereas L matches four bytes. The w request writes two bytes, whereas W writes four bytes. The value field in either locate or write requests is an expression. Either decimal and octal numbers, or character strings, are permitted.

In order to modify a file, adb must be invoked as follows:

```
% adb -w file1 file2
```

When invoked with this option, *file1* and *file2* are created if necessary, and opened for both reading and writing.

Note: The $W command has the same effect during an adb session as the –w option used on the command line.

For example, consider the following C program, zen.c: We will change the word "Thys" to "This" in the executable file.

```
char    str1[]  = "Thys is a character string";
int one = 1;
int number  = 456;
long    lnum    = 1234;
float   fpt = 1.25;
char    str2[]  = "This is the second character string";

main()
{
    one = 2;
}
```

Use the following requests:

```
% adb -w zen -
<b?l 'Th'
?W 'This'
```

The request <b?l starts at the start of the data segment and stops at the first match of "Th", having set dot to the address of the location found. Note the use of **?** to write to the a.out file. The form **?*** would be used for a 410-format file.

More frequently the request is typed as:

```
?l 'Th'; ?s
```

which locates the first occurrence of "Th", and display the entire string. Execution of this `adb` request sets dot to the address of those characters in the string.

NOTE *Be careful when using the `?l` or `?L` cammands of gaps in the address range that you want to search.*

As another example of the utility of the patching facility, consider a C program that has an internal logic flag. The flag could be set using `adb`, before running the program. For example:

```
% adb a.out -
:s arg1 arg2
flag/w 1
:c
```

The `:s` request is normally used to single step through a process or start a process in single step mode. In this case it starts `a.out` as a subprocess with arguments arg1 and arg2. If there is a subprocess running, `adb` writes to it rather than to the file so the `w` request caused flag to be changed in the memory of the subprocess.

5.6. Anomalies

Below is a list of some strange things that users should be aware of.

1) When displaying addresses, `adb` uses either text or data symbols from the `a.out` file. This sometimes causes unexpected symbol names to be displayed with data (for example, `savr5+022`). This does not happen if **?** is used for text (instructions) and **/** for data.

2) The `adb` debugger cannot handle C register variables in the most recently activated function.

6

Sun386i adb Tutorial

6

Sun386i adb Tutorial

6.1. A Quick Survey

Available on most UNIX systems, adb is a debugger that permits you to examine core files resulting from aborted programs, display output in a variety of formats, patch files, and run programs with embedded breakpoints. This document provides examples of the more useful features of adb. The reader is expected to be familiar with basic SunOS commands, and with the C language.

Starting adb

Start adb with a shell command like

```
% adb objectfile corefile
```

where *objectfile* is an executable SunOS file and *corefile* is a core dump file. If you leave object files in a.out, then the invocation is simple:

```
% adb
```

If you place object files into a named *program*, then the invocation is a bit harder:

```
% adb program
```

The filename minus (–) means ignore the argument, as in:

```
% adb - core
```

This is for examining the core file without reference to an object file. The adb program provides requests for examining locations in either file: **?** examines the contents of *objectfile*, while **/** examines the contents of *corefile*. The general form of these requests is:

```
address ? format
```

or

```
address / format
```

Current Address

adb maintains a current address, called **dot**. When an address is entered, the current address is set to that location, so that

```
0126?i
```

sets dot to octal 126 and displays the instruction at that address. The request

```
.,10/d
```

displays 10 decimal numbers starting at dot. Dot ends up referring to the address of the last item displayed. When used with the **?** or **/** requests, the current address can be advanced by typing newline; it can be decremented by typing ^.

Addresses are represented by expressions. Expressions are made up of decimal integers, octal integers, hexadecimal integers, and symbols from the program under test. These may be combined with the operators **+** (plus), **-** (minus), ***** (multiply), **%** (integer divide), **&** (bitwise and), **|** (bitwise inclusive or), **#** (round up to the next multiple), and **~** (not). All arithmetic within adb is 32 bits. When typing a symbolic address for a C program, you can type name. On a Sun-2, Sun-3, or Sun-4 you could alternatively type _name; adb recognizes both forms on these systems, only the first on Sun386i.

Formats

To display data, specify a collection of letters and characters to describe the format of the display. Formats are remembered, in the sense that typing a request without a format displays the new output in the previous format. Here are the most commonly used format letters:

Table 6-1 *Some* adb *Format Letters*

Letter	*Description*
b	one byte in octal
B	one byte in hex
c	one byte as a character
o	one word in octal
d	one word in decimal
f	one long word in single-precision floating point
i	MC68000 instruction on Sun-2 and Sun-3, SPARC instuction on Sun-4, and Sun386i instruction on Sun386i.
s	a null terminated character string
a	the value of dot
u	one word as an unsigned integer
n	print a newline
r	print a blank space
^	backup dot (not really a format)
+	advance dot (not really a format)

Format letters are also available for `long` values: for example, `D` for long decimal, and `F` for double-precision floating point. Since integers are long-words on the Sun, capital letters are used more often then not. For other formats see the Chapter 5.

General Request Meanings

The general form of a request is:

```
address, count command modifier
```

which sets dot to *address* and executes *command count* times. The following table illustrates some general adb command meanings:

Table 6-2 *Some* adb *Commands*

Some adb *Commands*	
Command	*Meaning*
?	Print contents from a.out file
/	Print contents from core file
=	Print value of expression
:	Breakpoint control
$	Miscellaneous requests
;	Request separator
!	Escape to shell

Since adb catches signals, a user cannot use a quit signal to exit from adb. The request `$q` or `$Q` (or CTRL-D) must be used to exit from adb.

6.2. Debugging C Programs on Sun386i

If you use adb because you are accustomed to it, you will want to compile programs with the -go option, to produce old-style symbol tables. This will make debugging proceed according to expectations.

Debugging A Core Image

Consider the C program below, which illustrates a common error made by C programmers. The object of the program is to change the lower case t to an upper case T in the string pointed to by ch, and then write the character string to the file indicated by the first argument.

```
#include <stdio.h>

char *cp = "this is a sentence.";

main(argc, argv)
int argc;
char **argv;
{
    FILE *fp;
    char c;

    if (argc == 1) {
        fprintf(stderr, "usage: %s file\n", argv[0]);
        exit(1);
    }
    if ((fp = fopen(argv[1], "w")) == NULL) {
        perror(argv[1]);
        exit(2);
    }
    cp = 'T';
    while (c = *cp++)
        putc(c, fp);
    fclose(fp);
    exit(0);
}
```

The bug is that the character T is stored in the pointer cp instead of in the string pointed to by cp. Compile the program as follows:

```
% cc -go example1.c
% a.out junk
Segmentation fault (core dumped)
```

Executing the program produces a core dump because of an out-of-bounds memory reference. Now invoke adb by typing:

```
% adb
core file = core -- program "a.out"
memory fault
```

Commonly the first debugging request given is

```
$c
main[8074](2,fffd7c,fffd88) + 92
```

which produces a C backtrace through the subroutines called. The output from adb tells us that only one function — main — was called, and the arguments argc and argv have the hexadecimal values 2 and fffd7c respectively. Both these values look reasonable — 2 indicates two arguments, and fffd7c equals the stack address of the parameter vector. The next request:

```
$C
main[8074](2,fffd7c,fffd88) + 92
    fp:          10468
    c:           104
```

generates a C backtrace plus an interpretation of all the local variables in each function, and their values in hexadecimal. The value of the variable c looks incorrect since it is outside the ASCII range. The request

```
$r
gs       0xfbff0000                          ecx      0x28680
fs       0xfbff0000                          eax      0x54
es       0xfcff0083                          retaddr  0xfc06e38e
ds       0x83                                trapno   0xe
edi      0x30890                             err      0x4
esi      0x28680                             eip      0x120b        main+0x10f
ebp      0xfbfffec8                          cs       0x7b
esp      0xfcff97e0                          efl      0x10206       end+0x7202
ebx      0x2a0c0                             uesp     0xfbfffec0
edx      0xfbfffe6a                          ss       0x83
main+0x10f:      movb    (%eax),%al
```

displays the registers, including the program counter, and an interpretation of the instruction at that location. The request

```
$e
cp:            0x55
_exit_nhandlers:         0x0
_exit_tnames:            0x35dc
_ctype_:       0x20202000
_smbuf:        0x65c0
_iob:          0x0
__mallinfo:    0x0
_root:         0x0
_lbound:       0x0
_ubound:       0x0
curbrk:        0x9004
errno:         0x0
environ:       0xfbfffef4
end:           0x0
```

displays the values of all external variables.

A map exists for each file handled by adb. The map for a.out files is referenced by **?** whereas the map for core files is referenced by **/**. Furthermore, a good rule of thumb is to use **?** for instructions and **/** for data when looking at programs. To display information about maps, type:

```
$m
b1 = 8000              e1 = b000              f1 = 800
b2 = 10000             e2 = 11000             f2 = 3800
/ map        `core'
b1 = 10000             e1 = 13000             f1 = 1800
b2 = fff000            e2 = 1000000           f2 = 4800
```

This produces a report of the contents of the maps. More about these maps later.

In our example, we might want to see the contents of the string pointed to by cp. We would want to see the string pointed to by cp in the core file:

```
*cp/s
55:
data address not found
```

Because the pointer was set to 'T' (hex 54) and then incremented, it now equals hex 55. On the Sun386i, there is nothing mapped at this address, so the data at address 55 cannot be found. We could also display information about the arguments to a function. To get the decimal value of the argc argument to main, which is a long integer, type:

```
main.argc/D
fffd6c:         2
```

To display the hex values of the three consecutive cells pointed to by argv in the function main, type:

```
*main.argv,3/X
fffd7c:         fffdc0          fffdc6          0
```

Note that these values are the addresses of the arguments to main. Therefore, typing these hex values should yield the command-line arguments:

```
fffdc0/s
fffdc0:         a.out
```

The request:

```
.=
                fffdc0
```

displays the current address (not its contents) in hex, which has been set to the address of the first argument. The current address, dot, is used by adb to remember its current location. It allows the user to reference locations relative to the current address. For example

```
.+6/s
fffdc6:         zzz
```

prints the first command-line argument.

Setting Breakpoints

You set breakpoints in a program with the :b instruction, which has this form:

```
address :b [ request ]
```

Consider the C program below, which changes tabs into blanks, and is adapted from *Software Tools* by Kernighan and Plauger, pp. 18-27.

```
#include <stdio.h>

#define MAXLIN  80
#define YES 1
#define NO  0
#define TABSP   8

int tabs[MAXLIN];

main()
{
    int *ptab, col, c;

    ptab = tabs;
    settab(ptab);    /* set initial tab stops */
    col = 1;
    while ((c = getchar()) != EOF) {
        switch (c) {
        case '\t':
            while (tabpos(col) != YES) {
                putchar(' ');
                col++;
            }
            putchar(' ');
            col++;
            break;
        case '\n':
            putchar('\n');
            col = 1;
            break;
        default:
            putchar(c);
            col++;
        }
    }
    exit(0);
```

```
}

tabpos(col) /* return YES if col is a tab stop, NO if not */
int col;
{
    if (col > MAXLIN)
        return(YES);
    else
        return(tabs[col]);
}

settab(tabp)    /* set initial tab stops every TABSP spaces */
int *tabp;
{
    int i;

    for (i = 0; i <= MAXLIN; i++)
        (i % TABSP) ? (tabs[i] = NO) : (tabs[i] = YES);
}
```

Run the program under the control of adb, and then set two breakpoints as follows:

```
% adb a.out -
settab+5:b
tabpos+5:b
```

This sets breakpoints at the start of the two functions. Sun compilers generate statement labels only with the -g option, which is incompatible with adb. In adb, you can set breakpoints anywhere, but you can only refer to a breakpoint as a function entry point plus an offset. To display the location of breakpoints, type:

```
$b
breakpoints
count   bkpt            command
1       tabpos+5
1       settab+5
```

A breakpoint is bypassed *count*–1 times before causing a stop. The *command* field indicates the adb requests to be executed each time the breakpoint is encountered. In this example no command fields are present.

Display the instructions at the beginning of function settab() in order to observe that the breakpoint is set after the link assembly instruction:

```
settab,5?ia
settab:
settab:          jmp     settab+0x58
settab+5:        movl    $0,-4(%ebp)
settab+0xc:      jmp     settab+0x48
settab+0x11:     movl    -4(%ebp),%eax
settab+0x14:     movl    $8,%ecx
settab+0x19:
```

This request displays five instructions starting at settab with the address of each location displayed. Another variation is

```
settab,5?i
settab:
settab:                  jmp     settab+0x58
                 movl    $0,-4(%ebp)
                 jmp     settab+0x48
                 movl    -4(%ebp),%eax
                 movl    $8,%ecx
```

which displays the instructions with only the starting address. Note that we accessed the addresses from a.out with the **?** command. In general, when asking for a display of multiple items, adb advances the current address the number of bytes necessary to satisfy the request; in the above example, five instructions were displayed and t he current address was advanced 26 bytes.

To run the program, type:

```
:r
```

To delete a breakpoint, for instance the entry to the function tabpos(), type:

```
tabpos:d
```

Once the program has stopped, in this case at the breakpoint for settab(), adb requests can be used to display the contents of memory. To display a stack trace, for example, type:

```
$c
settab[8250](10658) + 4
main[8074](1,fffd84,fffd8c) + 1a
```

And to display three lines of eight locations each from the array called `tabs`, type:

```
tabs,3/8X
tabs:
tabs:     0     0     0     0     0     0     0     0
           0     0     0     0     0     0     0     0
           0     0     0     0     0     0     0     0
```

At this time (at location `settab`) the `tabs` array has not yet been initialized. If you just deleted the breakpoint at `tabpos`, put it back by typing:

```
tabpos:b
```

To continue execution of the program from the breakpoint type:

```
:c
    x
```

You will need to give the `a.out` program a line of data, as in the figure above. Once you do, it will encounter a breakpoint at `tabpos+4` and stop again. Examine the `tabs` array once more: now it is initialized, and has a one set in every eighth location:

```
tabs,3/8X
tabs:
tabs:     1     0     0     0     0     0     0     0
           1     0     0     0     0     0     0     0
           1     0     0     0     0     0     0     0
```

You will have to type `:c` eight more times in order to get your line of output, since there is a breakpoint at every input character. Type [CTRL-D] to terminate the `a.out` process; you are back in command-level of `adb`.

Advanced Breakpoint Usage

The quit and interrupt signals act on `adb` itself, rather than on the program being debugged. If such a signal occurs, then the program being debugged is stopped and control is returned to `adb`. The signal is saved by `adb` and passed on to the test program if you type:

```
:c 0
```

Now let's reset the breakpoint at `settab()` and display the instructions located there when we reach the breakpoint. This is accomplished by:

```
settab+5:b settab,5?ia
:r
settab,5?ia
settab:
settab:         jmp    settab+0x58
settab+5:       movl   $0,-4(%ebp)
settab+0xc:     jmp    settab+0x48
settab+0x11:    movl   -4(%ebp),%eax
settab+0x14:    movl   $8,%ecx
settab+0x19:
breakpoint      settab+5:      movl   $0,-4(%ebp)
```

It is possible to stop every two breakpoints, if you type `,2` before the breakpoint command. Variables can also be displayed at the breakpoint, as illustrated below:

```
tabpos+4,2:b main.col?X
:c
    x
fffd64:         1
fffd64:         2
breakpoint      tabpos+5:      movl    $0x50,%eax
```

This shows that the local variable `col` changes from 1 to 2 before the occurrence of the breakpoint.

WARNING ***Setting a breakpoint causes the value of dot to be changed. However, executing the program under*** `adb` ***does not change the value of dot.***

A breakpoint can be overwritten without first deleting the old breakpoint. For example:

```
settab+4:b main.ptab/X; main.c/X
:r
fffd68:         10658
fffd60:         0
breakpoint      settab+5:      movl   $0,-4(%ebp)
```

The semicolon is used to separate multiple `adb` requests on a single line.

Other Breakpoint Facilities

Arguments and change of standard input and output are passed to a program as follows. This request kills any existing program under test and starts `a.out` afresh:

```
:r arg1 arg2 ... <infile >outfile
```

The program being debugged can be single stepped as follows. If necessary, this request starts up the program being debugged and stops after executing the first instruction:

```
:s
```

You can enter a program at a specific address by typing:

```
address:r
```

The count field can be used to skip the first *n* breakpoints, as follows:

```
,n:r
```

This request may also be used for skipping the first *n* breakpoints when continuing a program:

```
,n:c
```

A program can be continued at an address different from the breakpoint by:

```
address:c
```

The program being debugged runs as a separate process, and can be killed by:

```
:k
```

6.3. File Maps

Sun SunOS supports several executable file formats.

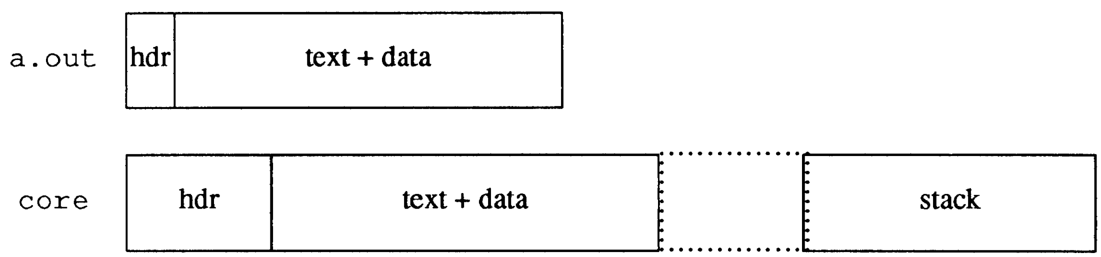
NOTE *On the Sun386i, all executable files are COFF files. An additional COFF header precedes the a.out header; this* `a.out` *header is slightly different than the Sun-2, Sun-3, or Sun-4* `a.out` *header. However, the executable file types are identical.*

Executable type 407 is generated by the `cc` (or `ld`) flag `–N`. Executable type 410 is generated by the flag `–n`. An executable type 413 is generated by the flag `–z`; the default is type 413. `adb` interprets these different file formats, and provides access to the different segments through a set of maps. To display the maps, type **$m** from inside `adb`.

407 Executable Files

In 407-format files, instructions and data are intermixed. This makes it impossible for `adb` to differentiate data from instructions, but `adb` will happily display in either format. Furthermore, some displayed symbolic addresses look incorrect (for example, data addresses as offsets from routines). Here is a picture of 407-format files:

Figure 6-1 *Executable File Type 407*



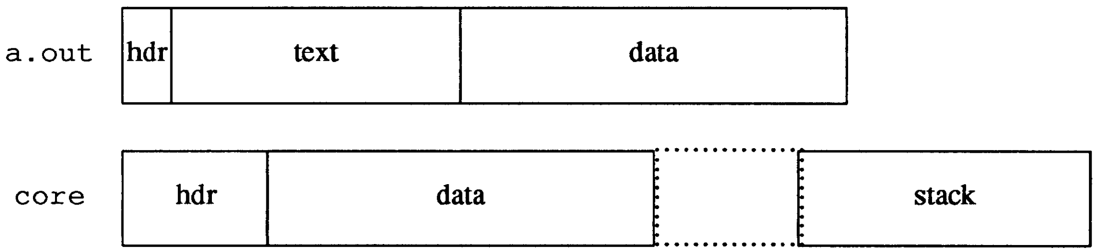
Here are the maps and variables for 407-format files:

```
$m
? map        'a.out'
b1 = 8000              e1 = 8f28              f1 = 20
b2 = 8000              e2 = 9560              f2 = 20
/ map        'core'
b1 = 8000              e1 = b800              f1 = 1800
b2 = fff000            e2 = 1000000           f2 = 5000
$v
variables
b = 0100000
d = 03070
e = 0407
m = 0407
s = 010000
t = 07450
```

410 Executable Files

In 410-format files (pure executable), instructions are separate from data. The `?` command accesses the data part of the `a.out` file, telling `adb` to use the second part of the map in that file. Accessing data in the `core` file shows the data after it was modified by the execution of the program. Notice also that the data segment may have grown during program execution. Here is a picture of 410-format files:

Figure 6-2 *Executable File Type 410*



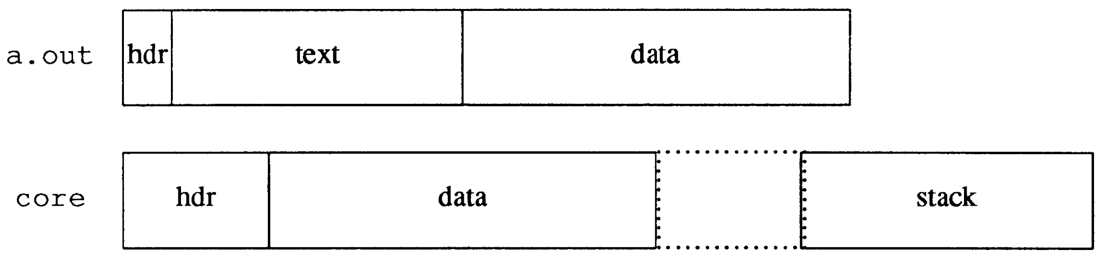
Here are the maps and variables for 410-format files:

```
$m
? map          'a.out'
b1 = 8000                e1 = 8f28                f1 = 20
b2 = 10000               e2 = 10638               f2 = f48
/ map          'core'
b1 = 10000               e1 = 12800               f1 = 1800
b2 = fff000              e2 = 1000000             f2 = 4000
$v
variables
b = 0200000
d = 03070
e = 0410
m = 0410
s = 010000
t = 07450
```

413 Executable Files

In 413-format files (pure demand-paged executable) the instructions and data are also separate. However, in this case, since data is contained in separate pages, the base of the data segment is also relative to address zero. In this case, since the addresses overlap, it is necessary to use the ?* operator to access the data space of the a.out file. In both 410 and 413-format files the corresponding core file does not contain the program text. Here is a picture of 413-format files:

Figure 6-3 *Executable File Type 413*



The only difference between a 410 and a 413-format file is that 413 segments are rounded up to page boundaries. Here are the maps and variables for 413-format files:

```
$m
? map         'abort'
b1 = 8000              e1 = 9000              f1 = 800
b2 = 10000             e2 = 10800             f2 = 1800
/ map         'core'
b1 = 10000             e1 = 12800             f1 = 1800
b2 = fff000            e2 = 1000000           f2 = 4000
$v
variables
b = 0200000
d = 04000
e = 0413
m = 0413
s = 010000
t = 010000
```

Variables

The b, e, and f fields are used to map addresses into file addresses. The f1 field is the length of the header at the beginning of the file — 020 bytes for an a.out file and 02000 bytes for a core file. The f2 field is the displacement from the beginning of the file to the data. For a 407-format file with mixed text and data, this is the same as the length of the header; for 410 and 413-format files, this is the length of the header plus the size of the text portion. The b and e fields are the starting and ending locations for a segment. Given the address *A*, the location in the file (either a.out or core) is calculated as:

```
b1<A<e1    file address = (A-b1)+f1
b2<A<e2    file address = (A-b2)+f2
```

You can access locations by using the adb-defined variables. The $v request displays the variables initialized by adb:

- b base address of data segment,
- d length of the data segment,
- s length of the stack,
- t length of the text,
- m execution type (407, 410, 413).

Those variables not presented are zero. Use can be made of these variables by expressions such as

```
<b
```

in the address field. Similarly, the value of a variable can be changed by an assignment request such as

```
02000>b
```

which sets b to octal 2000. These variables are useful to know if the file under examination is an executable or core image file.

The adb program reads the header of the core image file to find the values for these variables. If the second file specified does not seem to be a core file, or if it is missing, then the header of the executable file is used instead.

6.4. Advanced Usage

One of the uses of adb is to examine object files without symbol tables; dbx cannot handle this kind of task. With adb, you can even combine formatting requests to provide elaborate displays. Several examples are given below.

Formatted Dump

The following adb command line displays four octal words followed by their ASCII interpretation from the data space of the core file:

```
<b,-1/4o4^8Cn
```

Broken down, the various requests mean:

<b The base address of the data segment.

<b,-1 Print from the base address to the end-of-file. A negative count is used here and elsewhere to loop indefinitely or until some error condition (like end-of-file) is detected.

The format 4o4^8Cn is broken down as follows:

4o Print 4 octal locations.

4^ Back up the current address 4 locations (to the original start of the field).

8C Print 8 consecutive characters using an escape convention; each character in the range 0 to 037 is displayed as followed by the corresponding character in the range 0140 to 0177. An @ is displayed as @@.

n Print a newline.

The following request could have been used instead to allow the displaying to stop at the end of the data segment.

```
<b,<d/404^8Cn
```

The request <d provides the data segment size in bytes. Because adb can read in scripts, you can use formatting requests to produce image dump scripts. Invoked adb as follows:

```
% adb a.out core < dump
```

This reads in a script file, dump, containing formatting requests. Here is an example of such a script:

```
120$w
4095$s
$v
=3n
$m
=3n"C Stack Backtrace"
$C
=3n"C External Variables"
$e
=3n"Registers"
$r
0$s
=3n"Data Segment"
<b,-1/8ona
```

The request 120$w sets the width of the output to 120 characters (normally, the width is 80 characters). adb attempts to display addresses as:

```
symbol + offset
```

The request `4095$s` increases the maximum permissible offset to the nearest symbolic address from the default 255 to 4095. The request = can be used to display literal strings. Thus, headings are provided in this dump program with requests of the form:

```
=3n"C Stack Backtrace"
```

This spaces three lines and displays the literal string. The request `$v` displays all non-zero `adb` variables. The request `0$s` sets the maximum offset for symbol matches to zero, thus suppressing the display of symbolic labels in favor of octal values. Note that this is only done for displaying the data segment. The request

```
<b,-1/8ona
```

displays a dump from the base of the data segment to the end-of-file with an octal address field and 8 octal numbers per line.

Accounting File Dump

As another illustration, consider a set of requests to dump the contents `/etc/utmp` or `/usr/adm/wtmp`, both of which are composed of 8-character terminal names, 8-character login names, 16-character host names, and a 4-byte integer representing the login time.

```
% adb /etc/utmp -
0,-1?cccccccc8tcccccccc8tcccccccccccccccc16tYn
```

The `c` format is repeated 8 times, 8 times, and 16 times. The `8t` means go to the 8th tab stop, and `16t` means to to the 16th tab stop. `Y` causes the 4-byte integer representing the login time to print in *ctime*(3) format.

Converting Values

You can use `adb` to convert values from one representation to another. For example, to print the hexadecimal number `ff` in octal, decimal, and hexadecimal, type:

```
ff = odx
    072 58  #3a
```

The default input radix of `adb` is hexadecimal. Formats are remembered, so that typing subsequent numbers will display them in the same format. Character values may be converted as well:

```
'a' = oc
    0141    a
```

This technique may also be used to evaluate expressions, but be warned that all binary operators have the same precedence, which is lower than for unary operators.

6.5. Patching

Patching files with adb is accomplished with the write requests w or W. This is often used in conjunction with the locate requests l or L. In general, the syntax for these requests is as follows:

```
?l value
```

The l matches on two bytes, whereas L matches four bytes. The w request writes two bytes, whereas W writes four bytes. The value field in either locate or write requests is an expression. Either decimal and octal numbers, or character strings, are permitted.

In order to modify a file, adb must be invoked as follows:

```
% adb -w file1 file2
```

When invoked with this option, *file1* and *file2* are created if necessary, and opened for both reading and writing.

For example, consider the following C program, zen.c: We will change the word "Thys" to "Thys" in the executable file.

```
char    str1[]  = "Thys is a character string";
int one = 1;
int number  = 456;
long    lnum    = 1234;
float   fpt = 1.25;
char    str2[]  = "This is the second character string";

main()
{
    one = 2;
}
```

Use the following requests:

```
% adb -w zen -
?l 'Th'
?W 'This'
```

The request ?l starts a dot and stops at the first match of "Th", having set dot to the address of the location found. Note the use of **?** to write to the a.out file. The form **?*** would be used for a 411 file.

More frequently the request is typed as:

```
?l 'Th'; ?s
```

which locates the first occurrence of "Th", and display the entire string. Execution of this adb request sets dot to the address of those characters in the string.

As another example of the utility of the patching facility, consider a C program that has an internal logic flag. The flag could be set using adb, before running the program. For example:

```
% adb a.out -
:s arg1 arg2
flag/w 1
:c
```

The :s request is normally used to single step through a process or start a process in single step mode. In this case it starts a.out as a subprocess with arguments arg1 and arg2. If there is a subprocess running, adb writes to it rather than to the file so the w request caused flag to be changed in the memory of the subprocess.

6.6. Anomalies

Below is a list of some strange things that users should be aware of.

1) When displaying addresses, adb uses either text or data symbols from the a.out file. This sometimes causes unexpected symbol names to be displayed with data (for example, savr5+022). This does not happen if **?** is used for text (instructions) and **/** for data.

2) The adb debugger cannot handle C register variables in the most recently activated function.

7

adb Reference

7

adb Reference

adb [**-w**] [**-k**] [**-I** *dir*] [*objectfile* [*corefile*]]

adb is an interactive, general-purpose, assembly-level debugger, that examines files and provides a controlled environment for executing SunOS programs.

Normally *objectfile* is an executable program file, preferably containing a symbol table. If the file does not contain a symbol table, it can still be examined, but the symbolic features of adb cannot be used. The default *objectfile* is a.out.

The *corefile* is assumed to be a core image file produced after executing *objectfile* and having a problem causing the core image to be dumped to the file *core*. The default *corefile* is core.

7.1. adb Options

-w Create both *objectfile* and *corefile* if necessary and open them for reading and writing so they can be modified using adb.

-k Do SunOS kernel memory mapping; should be used when *corefile* is a SunOS crash dump or /dev/mem.

-I Specifies a directory where files to be read with $< or $<< (see below) will be sought; the default is /usr/lib/adb.

7.2. Using adb

adb reads commands from the standard input and displays responses on the standard output, ignoring QUIT signals. An INTERRUPT signal returns to the next adb command.

adb saves and restores terminal characteristics when running a sub-process. This makes it possible to debug programs that manipulate the screen. See *tty*(4).

In general, requests to adb are of the form

[*address*] [, *count*] [*command*] [;]

The symbol **dot** (.) represents the current location. It is initially zero. If *address* is present, then **dot** is set to *address*. For most commands *count* specifies how many times the command will be executed. The default *count* is 1 (one). Both *address* and *count* may be expressions.

7.3. adb Expressions

. The value of **dot**.

\+ The value of **dot** incremented by the current increment.

^ The value of **dot** decremented by the current increment.

& The last *address* typed; this used to be ".

integer
A number. The prefixes 0o and 0O (zero oh) force interpretation in octal radix; the prefixes 0t and 0T force interpretation in decimal radix; the prefixes 0x and 0X force interpretation in hexadecimal radix. Thus 0o20= 0t16= 0x10= sixteen. If no prefix appears, then the *default radix* is used; see the $d command. The default radix is initially hexadecimal. Hexadecimal digits are 0123456789abcdefABCDEF with the obvious values. Note that if a hexadecimal number starts with a letter, but does not duplicate a defined symbol, it is accepted as a hexadecimal value. To enter a hexadecimal number that is the same as a defined symbol, precede it by 0, 0x, or 0X.

'cccc'
The ASCII value of up to 4 characters. A backslash (\) may be used to escape a '.

<name
The value of *name*, which is either a variable name or a register name; adb maintains a number of variables (see VARIABLES) named by single letters or digits. If *name* is a register name, then the value of the register is obtained from the system header in *corefile*. The register names are those printed by the $r command.

symbol
A *symbol* is a sequence of upper or lower case letters, underscores or digits, not starting with a digit. The backslash character (\) may be used to escape other characters. The value of the *symbol* is taken from the symbol table in *objectfile*. An initial _ will be prepended to *symbol* if needed.

_symbol
In C, the true name of an external symbol begins with underscore (_). It may be necessary to use this name to distinguish it from internal or hidden variables of a program.

NOTE *_symbol applies only to Sun-2, Sun-3, and Sun-4. It is not used on Sun386i.*

routine.name
The address of the variable *name* in the specified C routine. Both *routine* and *name* are *symbols*. If *name* is omitted the value is the address of the most recently activated C stack frame corresponding to *routine*. Works only if the program has been compiled using the -go flag. See *cc*(1).

e *s* Sun386i only. Like *s*, but steps over subroutine calls instead of into them.

(*expr*) The value of the expression *expr*.

Unary Operators

**expression*
The contents of the location addressed by *exp* in *corefile*.

%*expression*
The contents of the location addressed by *exp* in *objectfile* (used to be @).

–expression
Integer negation.

~*expression*
Bitwise complement.

#*expression*
Logical negation.

^F*expression*
(Control–f) Translates program addresses into source file addresses. Works only if the program has been compiled using the –go flag. See *cc*(1).

^A*expression*
(Control–a) Translates source file addresses into program addresses. Works only if the program has been compiled using the –go flag. See *cc*(1).

`*name*
(Back–quote) Translates a procedure name into a source file address. Works only if the program has been compiled using the –go flag. See *cc*(1).

"*filename*"
A filename enclosed in quotation marks (for instance, `main.c`) produces the source file address for the zero-th line of that file. Thus to reference the third line of the file main.c, we say: `"main.c"+3`. Works only if the program has been compiled using the –go flag. See *cc*(1).

Binary Operators

Binary operators are left associative and are less binding than unary operators.

expression-1 + *expression-2*
Integer addition.

expression-1 – *expression-2*
Integer subtraction.

expression-1 * *expression-2*
Integer multiplication.

expression-1 % *expression-2*
Integer division.

expression-1 & *expression-2*
Bitwise conjunction.

expression-1 | *expression-2*
Bitwise disjunction.

expression-1 # *expression-2*
Expression1 rounded up to the next multiple of *expression2*.

7.4. adb Variables

adb provides several variables. Named variables are set initially by adb but are not used subsequently. Numbered variables are reserved for communication as follows:

0 The last value printed.

1 The last offset part of an instruction source.

2 The previous value of variable 1.

9 The count on the last $< or $<< command.

On entry the following are set from the system header in the *corefile*. If *corefile* does not appear to be a **core** file then these values are set from *objectfile*.

b The base address of the data segment.

d The data segment size.

e The entry point.

m The 'magic" number (0407, 0410 or 0413), depending on the file"s type. (See Section 5.3 .)

s The stack segment size.

t The text segment size.

7.5. adb Commands

Commands to adb commands consist of a *verb* followed by a *modifier* or list of modifiers.

adb Verbs

The verbs are:

? Print locations starting at *address* in *objectfile*.

/ Print locations starting at *address* in *corefile*.

= Print the value of *address* itself.

@ Interpret *address* as a source file address, and print locations in *objectfile* or lines of the source text. Works only if the program has been compiled using the -go flag. See *cc*(1).

: Manage a subprocess.

$ Execute miscellaneous commands.

> Assign a value to a variable or register.

RETURN
Repeat the previous command with a *count* of 1. *Dot* is incremented by its current increment.

! Call the shell to execute the following command.

Each verb has a specific set of **modifiers**, these are described below.

?, /, @, and = Modifiers

The first four verbs described above take the same *modifiers*, which specify the format of command output. Each modifier consists of a format letter (*fletter*) preceded by an optional *repeat* count (*rcount*). Verb can take one or more modifiers.

{ ?, /, @, = } [[*rcount*] *fletter* ...]

Each modifier specifies a format that increments *dot* by a certain amount, which is given below. If a command is given without a modifier, the last specified format is used to display output. The following table shows the format letters, the amount they increment *dot*, and a description of what each letter does. Note that all octal numbers output by adb are preceded by 0.

Format	*Dot+=*	*Description*
o	2	Print 2 bytes in octal.
O	4	Print 4 bytes in octal.
q	2	Print in signed octal.
Q	4	Print long signed octal.
d	2	Print in decimal.
D	4	Print long decimal.
x	2	Print 2 bytes in hexadecimal.
X	4	Print 4 bytes in hexadecimal.
h	2	Sun386i only. Print 2 bytes in hexadecimal in reverse order.
H	4	Sun386i only. Print 4 bytes in hexadecimal in reverse order.
u	2	Print as an unsigned decimal number.
U	4	Print long unsigned decimal.
f	4	Print the 32 bit value as a floating point number.
F	8	Print double floating point.
b	1	Print the addressed byte in octal.
B	1	Sun386i only. Print the addressed byte in hexadecimal.
c	1	Print the addressed character.
C	1	Print the addressed character using the standard escape convention. Print control characters as ^X and the delete character as ^?.

Format	*Dot+=*	*Description*
`s`	*n*	Print the addressed characters until null character is reached; *n* is the length of the string including its zero terminator.
`S`	*n*	Print string using the escape conventions of `C`; *n* is the length of the string including its zero terminator.
`Y`	4	Print 4 bytes in *ctime*(3) format.
`i`	*n*	Print as machine instructions; *n* is the number of bytes occupied by the instruction. In this format, variables 1 and 2 are set to the offset parts of the source and destination respectively.
`M`	*n*	Sun386i only. Print as machine instructions along with machine code; *n* is the number of bytes occupied by the instruction. In this format, variables 1 and 2 are set to the offset parts of the source and destination, respectively.
`z`	*n*	Print as machine instructions with MC68010 instruction timings; *n* is the number of bytes occupied by the instruction. In this format, variables 1 and 2 are set to the offset parts of the source and destination respectively.
`I`	0	Print the source text line specified by *dot* (@ command), or most closely corresponding to *dot* (? command).
`a`	0	Print the value of *dot* in symbolic form. Symbols are checked to ensure that they have an appropriate type as indicated below. / local or global data symbol ? local or global text symbol = local or global absolute symbol
`p`	4	Print the addressed value in symbolic form using the same rules for symbol lookup as with `a`.
`A`	0	Print the value of *dot* in source file symbolic form, that is: `"file"+nnn`. Works only if the program has been compiled with the `-go` flag. See *cc*(1).
`P`	4	Print the addressed value in source file symbolic form, that is: *"file"+nnn*. Works only if the program has been compiled using the `-go` flag. See *cc*(1).
`t`	0	When preceded by an integer, tabs to the next appropriate tab stop. For example, `8t` moves to the next 8-space tab stop.
`r`	0	Print a space.
`n`	0	Print a newline.
`"..."`	0	Print the enclosed string.

Format	*Dot+=*	*Description*
^	0	*Dot* decremented by current increment; nothing is printed.
+	0	*Dot* incremented by 1; nothing is printed.
–	0	*Dot* decremented by 1; nothing is printed.

? and / Modifiers

Only the verbs ? and / take the following modifiers:

[?/]l *value mask*
: Words starting at *dot* are masked with *mask* and compared to *value* until a match is found. If the command is L instead of l, the match is for 4 bytes at a time instead of 2. If no match is found *dot* is unchanged; otherwise *dot* is set to the matched location. If *mask* is omitted then –1 is used.

[?/]w *value ...*
: Write the 2-byte *value* into the addressed location. If the command is W instead of w, write 4 bytes instead of 2. If the command is v, write only 1 byte. Odd addresses are not allowed when writing to the sub-process address space.

[?/]m *b1 e1 f1* [?/]
: New values for (*b1, e1, f1*) are recorded. If fewer than three expressions are given, then the remaining map parameters are left unchanged. If the ? or / is followed by *, then the second segment (*b2, e2, f2*) of the address mapping is changed (see *Address Mapping* below). If the list is terminated by ? or /, then the file, *objectfile* or *corefile* respectively, is used for subsequent requests. For example, /m? causes / to refer to *objectfile*.

: Modifiers

Only the verb : takes the following modifiers:

a *cmd* — Sun386i only. Set a data access breakpoint at *address*. Like *b* except that the breakpoint is hit when the program reads or writes to *address*.

b *cmd* — Set breakpoint at *address*. The breakpoint is executed *count*–1 times before causing a stop. Each time the breakpoint is encountered the command *cmd* is executed. If this command is omitted or sets *dot* to zero, then the breakpoint causes a stop.

w — Sun386i only. Set a data write breakpoint at *address*. Like *b* except that the breakpoint is hit when the program writes to *address*.

B — *Like b but takes a source file address. Works only if the program has been compiled using the* –go *flag. See cc(1).*

d — Delete breakpoint at *address*.

D — Like *d* but takes a source file address. Works only if the program has been compiled using the –go flag. See *cc*(1).

`z` Sun386i only. Delete all breakpoints.

`r` Run *objectfile* as a subprocess. If *address* is given explicitly, then the program is entered at this point; otherwise, the program is entered at its standard entry point. An optional *count* specifies how many breakpoints are to be ignored before stopping. Arguments to the subprocess may be supplied on the same line as the command. An argument starting with < or > causes the standard input or output to be established for the command. All signals are enabled on entry to the subprocess.

`c` *s* The subprocess is continued with signal *s*; see *sigvec*(2). If *address* is given then the subprocess is continued at this address. If no signal is specified, then the signal that caused the subprocess to stop is sent. Breakpoint skipping is the same as for `r`.

`s` *s* Same as for `c` except that the subprocess is single stepped *count* times. If there is no current subprocess, then *objectfile* is run as a subprocess as for `r`. In this case no signal can be sent; the remainder of the line is treated as an argument list for the subprocess.

`S` Like s but single steps by source lines, rather than by machine instructions. This is achieved by repeatedly single-stepping machine instructions until the corresponding source file address changes. Thus procedure calls cause stepping to stop. Works only if the program has been compiled using the `-go` flag. See *cc*(1).

`u` Sun386i only. Continue uplevel, stopping after the current routine has returned. Should only be given after the frame pointer has been pushed on the stack.

`i` Add the signal specified by *address* to the list of signals that are passed directly to the subprocess with the minimum of interference. Normally, `adb` intercepts all signals destined for the subprocess, and the `:c` command must be issued to continue the process with the signal. Signals on this list are handed to the process with an implicit `:c` commands as soon as they are seen.

`t` Remove the signal specified by *address* from the list of signals that are implicitly passed to the subprocess.

`k` Terminate (kill) the current subprocess, if any.

`A` Sun386i only. Attach the process whose process ID is given by *address*. The PID is generally preceded by `0t` so that it will be interpreted in decimal.

`R` Sun386i only. Release (detach) the current process.

`$` Modifiers

Only the verb `$` takes the following modifiers:

<*file* Read commands from *file*. If this command is executed in a file, further commands in the file are not seen. If *file* is omitted, the current input stream is terminated. If a *count* is given, and it is zero, the

command will be ignored. The value of the count will be placed in variable *9* before the first command in *file* is executed.

<< *file* Similar to <, but can be used in a file of commands without closing the file. Variable *9* is saved during the execution of this command, and restored when it completes. There is a small, finite limit to the number of << files that can be open at once.

> *file* Append output to *file*, which is created if it does not exist. If *file* is omitted, output is returned to the terminal.

? Print the process id, the signal that stopped the subprocess, and the registers. Produces the same response as $ used without any modifier.

r Print the general registers and the instruction addressed by `pc`; *dot* is set to `pc`.

b Print all breakpoints and their associated counts and commands.

c C stack backtrace. If *address* is given, it is taken as the address of the current frame instead of the contents of the frame-pointer register. If *count* is given, only the first *count* frames are printed.

C Similar to `c`, but in addition prints the names and 32-bit values of all automatic and static variables for each active function. Works only if the program has been compiled using the `-go` flag. See *cc*(1).

d Set the default radix to *address* and report the new value. Note that *address* is interpreted in the (old) current radix. Thus `10$d` never changes the default radix. To make the default radix decimal, use `0t10$d`.

e Print the names and values of external variables.

w Set the page width for output to *address* (default 80).

s Set the limit for symbol matches to *address* (default 255).

o Regard all input integers as octal.

q Exit `adb`.

v Print all non-zero variables in octal.

m Print the address map.

f Print a list of known source file names.

p Print a list of known procedure names.

p For kernel debugging. Change the current kernel memory mapping to map the designated *user structure* to the address given by the symbol `_u`. The *address* argument is the address of the user"s `proc` structure.

i Show which signals are passed to the subprocess with the minimum of `adb` interference. Signals may be added to or deleted from this list using the `:i` and `:t` commands.

W — Re-open *objectfile* and *corefile* for writing, as though the -w command-line argument had been given.

l — Sun386i only. Set the length in bytes (1, 2, or 4) of the object referenced by :a and :w to address. Default is 1.

7.6. adb Address Mapping

The interpretation of an address depends on its context. If a subprocess is being debugged, addresses are interpreted in the usual way (as described below) in the address space of the subprocess. If the operating system is being debugged, either post-mortem or by using the special file /dev/mem to interactively examine and/or modify memory, the maps are set to map the kernel virtual addresses, which start at zero. For some commands, the address is not interpreted as a memory address at all, but as an ordered pair representing a file number and a line number within that file. The @ command always takes such a source file address, and several operators are available to convert to and from the more customary memory locations.

The address in a file associated with a written address is determined by a mapping associated with that file. Each mapping is represented by two triples ($b1, e1, f1$) and ($b2, e2, f2$), and the *file address* corresponding to a written *address* is calculated as follows.

$$b1 \leq address < e1 \Rightarrow file\ address = address + f1 - b1$$

otherwise

$$b2 \leq address < e2 \Rightarrow file\ address = address + f2 - b2$$

Otherwise, the requested *address* is not legal. If a ? or / request is followed by an *, only the second triple is used.

The initial setting of both mappings is suitable for normal a.out and core files. If either file is not of the kind expected then, for that file, $b1$ is set to 0, $e1$ is set to the maximum file size, and $f1$ is set to 0. This way, the whole file can be examined with no address translation.

7.7. See Also

For more information, read *dbx*(1), *ptrace*(2), *a.out*(5), and *core*(5) in the man-pages.

7.8. Diagnostic Messages from adb

After startup, the only prompt adb gives is

```
adb
```

when there is no current command or format. On the other hand, adb supplies comments about inaccessible files, syntax errors, abnormal termination of commands, etc. Exit status is 0, unless the last command failed or returned non-zero status.

7.9. Bugs

There is no way to clear all breakpoints with a single command, except on the Sun386i.

Since no shell is invoked to interpret the arguments of the `:r` command, the customary wildcard and variable expansions cannot occur.

Since there is little type checking on addresses, using a source file address in an inappropriate context may lead to unexpected results.

7.10. Sun-3 FPA Support in adb

Release of the floating point accelerator (FPA) for the Sun-3 required some changes to adb, in order to support assembly language debugging of programs that use the FPA. Here are changes made to adb in Release 3.1 and later:

1. The new debugger variables `A` through `Z` are reserved for special use by adb. They should not be used in adb scripts.

2. The FPA registers `fpa0` through `fpa31` are recognized and can be used or modified in debugger commands. This extension only applies to a machine with an FPA.

3. The debugger variable `F` governs FPA disassembly. This is equivalent to the dbx environment variable `fpaasm`. A value of 0 indicates that all FPA instructions are to be treated as move instructions. A nonzero value is used to indicate that FPA instruction sequences are to be disassembled and single stepped using FPA assembler mnemonics. On a machine with an FPA, the default value is 1; on other machines, the default value is 0.

4. The debugger variable `B` is used to designate an FPA base register. This is equivalent to the dbx environment variable `fpabase`. If FPA disassembly is disabled (the `F` flag = 0) its value is ignored. Otherwise, its value is interpreted as follows:

   0 through 7:
   Based-mode FPA instructions that use the corresponding address register in `[a0..a7]` to address the FPA are also disassembled using FPA assembler mnemonics. Note that this is independent of the actual run-time value of the register.

   otherwise:
   All based-mode FPA instructions are disassembled and single-stepped as move instructions.

   The default value of the FPA base register number is –1, which designates no FPA base register.

5. The command `$x` has been added to display the values of FPA registers `fpa0` through `fpa15`, along with FPA control registers and the current contents of the FPA instruction pipeline. All registers are displayed in the format:

```
<low word> <high word> <double precision> <single precision>
```

   This verbose display is used because FPA registers are typeless; in particular, they may contain either single or double precision floating point values. If a single precision value is stored, it is always stored in the high-order word. Machines without an FPA display the message "no FPA .

6. The command `$X` is similar to `$x`, but displays the FPA registers `fpa16` through `fpa31` instead of `fpa0` through `fpa15`. This is done as a separate command because `adb` cannot display the contents of all FPA registers in a single standard-size window.

7. The command `$R` displays the contents of the data and control registers of the standard mc68881 floating point coprocessor. *Note: this is a change from release 3.0.*

7.11. Examples of FPA Disassembly

As an example, consider the following assembly source fragment:

```
% cat foo.s
foo:
fpadds  d0,fpa0
fpadds@0    d0,fpa0
fpadds@5    d0,fpa0
%
```

On machines without an FPA, the default mode is to disassemble all FPA instructions as moves. For the example program, the following output is produced (except the parenthesized comments added here for explanation):

```
% as foo.s -o foo.o
% adb foo.o
<F=d
    0       (default value of "F" on a machine without FPA)
foo?ia
foo:        movl    d0,0xe0000380    (normal disassembly)
```

FPA disassembly can be enabled by setting the debugger variable `F` to 1. For example:

```
% adb foo.o
1>F
<F=d
    1       (new value of "F")
foo?ia
foo:        fpadds  d0,fpa0      (FPA disassembly)
```

On machines with an FPA, FPA disassembly is on by default, so the above output is produced without having to set the value of `F`.

Some FPA instructions may address the FPA using a base register in `[a0..a7]`. In practice, only `[a0..a5]` are used by the compilers.

`adb` does not know which register (if any) is being used to address the FPA in a given sequence of machine code. However, another debugger variable (`B`) may be set by the user to designate a register as an FPA base register. By default, this variable has the value –1, which means that no register should be assumed to point at the FPA, so only instructions that access the FPA using absolute addressing are recognized as FPA instructions.

For the example program, a machine with an FPA produces the following output:

```
% adb foo.o
<F=d
    1        (default value of "F" on a machine with FPA)
<B=d
   -1        (default value of "B")
foo,3?ia
foo:         fpadds  d0,fpa0      (FPA disassembly)
0x6:         movl    d0,a0@(0x380)   (normal disassembly)
0xa:         movl    d0,a5@(0x380)   (normal disassembly)
0xe:
```

Note that the second and third instructions are still disassembled as moves, since adb cannot assume that they access the FPA. Continuing this example, if the FPA base register number is set to 5, the following output is produced:

```
% adb foo.o
5>B
<B=d
    5
foo,3?ia
foo:         fpadds  d0,fpa0      (FPA disassembly)
0x6:         movl    d0,a0@(0x380)   (normal disassembly)
0xa:         fpadds@5    d0,fpa0 (FPA disassembly)
0xe:
```

Note that the second instruction is still disassembled as a move, since a5, the register designated as the FPA base, is not used.

7.12. Examples of FPA Register Use

FPA data registers can be displayed using a syntax similar to that used for the 68881 co-processor registers. Note that unlike the 68881 registers, FPA registers may contain either single precision (32-bit) or double precision (64-bit) values; 68881 registers always contain an extended precision (96-bit) value.

For example, if fpa0 contains the value 2.718282, we may display it as follows:

```
<fpa0=f
          fpa3      0x402df855     +2.718282e+00
```

Note that the value is displayed in hexadecimal as well as in floating point notation. Unfortunately, an FPA register can only be set to a hexadecimal value. To set fpa0 to 1.0, for example, you must know that this is represented as 0x3f800000 in IEEE single-precision format:

```
0x3f800000>fpa0
<fpa0=X
        3f800000
<fpa0=f
        +1.0000000e+00
```

8

Debugging SunOS Kernels with adb

8

Debugging SunOS Kernels with adb

This document describes the use of extensions made to the SunOS debugger adb for the purpose of debugging the SunOS kernel. It discusses the changes made to allow standard adb commands to function properly with the kernel and introduces the basics necessary for users to write adb command scripts that may be used to augment the standard adb command set. The examination techniques described here may be applied to running systems, as well as the post-mortem dumps automatically created by *savecore*(8) after a system crash. The reader is expected to have at least a passing familiarity with the debugger command language.

8.1. Introduction

Modifications have been made to the standard UNIX debugger adb to simplify examination of the post-mortem dump generated automatically following a system crash. These changes may also be used when examining SunOS in its normal operation. This document serves as an introduction to the use of these facilities, but should not be construed as a description of how to debug the kernel.

Getting Started

Use the -k option of adb when you want to examine the SunOS kernel:

```
% adb -k /vmunix /dev/mem
```

The -k option makes adb partially simulate the Sun virtual memory management unit when accessing the *core* file. In addition, the internal state maintained by the debugger is initialized from data structures maintained by the SunOS kernel explicitly for debugging.† A post-mortem dump may be examined in a similar fashion:

```
% adb -k vmunix.? vmcore.?
```

Supply the appropriate version of the saved operating system image, and its core dump, in place of the question mark.

† If the -k flag is not used when invoking adb, the user must explicitly calculate virtual addresses. With the -k option, adb interprets page tables to automatically perform virtual to physical address translation.

Establishing Context

During initialization `adb` attempts to establish the context of the currently active process by examining the value of the kernel variable `panic_regs`. This structure contains the register values at the time of the call to the `panic()` routine. Once the stack pointer has been located, this command generates a stack trace:

```
$c
```

An alternate method may be used when a trace of a particular process is required; see Section 6.3 for details.

8.2. `adb` Command Scripts

This section supplies details about writing `adb` scripts to debug the kernel.

Extended Formatting Facilities

Once the process context has been established, the complete `adb` command set is available for interpreting data structures. In addition, a number of `adb` scripts have been created to simplify the structured printing of commonly referenced kernel data structures. The scripts normally reside in the directory `/usr/lib/adb`, and are invoked with the `$<` operator. Standard scripts are listed below in Table 6-1.

As an example, consider the listing that starts on the next page. The listing contains a dump of a faulty process"s state.

```
% adb -k vmunix.3 vmcore.3
sbr 50030 slr 51e
physmem  3c0
$c
_panic[10fec](5234d) + 3c
_ialloc[16ea8](d44a2,2,dff) + c8
_maknode[1d476](dff) + 44
_copen[1c480](602,-1) +    4e
_creat() + 16
_syscall[2ea0a]() + 15e
level5() + 6c
5234d/s
_nldisp+175:  ialloc:  dup alloc
u$<u
_u:
_u:       pc
          4be0
_u+4:         d2        d3        d4        d5
          13b0      0         0         0
_u+14:        d6        d7
          0         2604
_u+1c:        a2        a3        a4        a5
          0         c7800          5a958        d7160
_u+2c:        a6        a7
          3e62      3e48
_u+34:        sr
          27000000
_u+38:        p0br      p0lr      p1br      p1lr
```

```
         105000         40000022 fd7f4          1ffe
_u+48:        szpt      sswap
         1        0
_u+50:        procp          ar0      comm
         d7160          3fb2     dtime^@^@^@^@^@
_u+158:       arg0      arg1     arg2
         1001c          -1       ffffa4
_u+178:       uap       qsave                  error
         2958     2eb46          1        0
_u+1b2:       rv1       rv2      eosys
         0        14cac          0
_u+1bc:       uid gid
         49   10
_u+1c0:       groups
         10       -1       -1       -1
         -1       -1       -1       -1
_u+1e0:       ruid rgid
         49   10
_u+1e4:       tsize          dsize         ssize
         7        1b       2
_u+344:       odsize         ossize        outime
         0        0        0
_u+350:       signal
         0        0        0        0
         0        0        0        0
         0        0        0        0
         0        0        0        0
         0        0        0        0
         0        0        0        0
         0        0        0        0
         0        0        0        0
         sigmask
         0        0        0        0
         0        0        0        0
         0        0        0        0
         0        0        0        0
         0        0        0        0
         0        0        0        0
         0        0        0        0
         0        0        0        0
_u+450:       onstack        oldmask       code
         0        80002          0
_u+45c:       sigstack onsigstack
         0        0
_u+464:       ofile
         d66b4          d66b4          d66b4          0
         0        0        0        0
         0        0        0        0
         0        0        0        0
         0        0        0        0

         pofile
         0    0    0    0    0    0    0    0
```

```
        0    0    0    0    0    0    0    0
        0    0    0    0
_u+4c8:      cdir      rdir      ttyp      ttyd cmask
        d44a2          0         5c6c0          0    12

        ru & cru
_u+4d8:      utime                          stime
        0         0         0         35b60
_u+4e8:      maxrss         ixrss          idrss          isrss
        9         35        43
_u+4f8:      minflt         majflt         nswap
        0         5         0
_u+504:      inblock        oublock        msgsnd         msgrcv
        3         7         0         0
_u+514:      nsignals nvcsw            nivcsw
        0         12        4
_u+520:      utime                          stime
        0         0         0         0
_u+530:      maxrss         ixrss          idrss          isrss
        0         0         0
_u+540:      minflt         majflt         nswap
        0         0         0
_u+54c:      inblock        oublock        msgsnd         msgrcv
        0         0         0         0
_u+55c:      nsignals nvcsw            nivcsw
        0         0         0
0d7160$<proc
d7160:       link      rlink          addr
        590e0          0         1057f4
d716c:       upri pri  cpu  stat time nice slp
        066  024  020  03   01   024  0
d7173:       cursig         sig
        0         0
d7178:       mask      ignore         catch
        0         0         0
d7184:       flag      uid  pgrp pid  ppid
        8001      31   2f   2f   23
d7190:       xstat          ru        poip szpt tsize
        0         0         0    1    7
d719e:       dsize          ssize          rssize         maxrss
        1b        2         5         fffff
d71ae:       swrss          swaddr         wchan          textp
        0         0         0         d8418
d71be:       p0br      xlink          ticks
        105000         0         15
d71c8:       %cpu                     ndx  idhash    pptr
        0                   6    2    d70d4
d71d4:       real itimer
        0         0         0         0
d71e4:       quota          ctx
        0         5f236
0d8418$<text
d8418:       daddr
```

```
284     0       0       0
0       0       0       0
0       0       0       0

ptdaddr         size        caddr           iptr
184     7       d7160           d47e0

rssize  swrss   count   ccount  flag slptim  poip
4   0   01  01  042 0   0
```

The cause of the crash was a `panic` (see the stack trace) due to a duplicate `inode` allocation detected by the `ialloc()` routine. The majority of the dump was done to illustrate the use of command scripts used to format kernel data structures. The `u` script, invoked by the command `u$<u`, is a lengthy series of commands to pretty-print the user vector. Likewise, `proc` and `text` are scripts to format the obvious data structures. Let"s quickly examine the `text` script, which has been broken into a number of lines for readability here; in actuality it is a single line of text.

```
./"daddr"n12Xn\
"ptdaddr"16t"size"16t"caddr"16t"iptr"n4Xn\
"rssize"8t"swrss"8t"count"8t"ccount"8t"flag"8t"slptim"8t"poip"n2x4bx
```

The first line produces the list of disk block addresses associated with a swapped out text segment. The `n` format forces a newline character, with 12 hexadecimal integers printed immediately after. Likewise, the remaining two lines of the command format the remainder of the text structure. The expression `16t` tabs to the next column which is a multiple of 16.

The majority of the scripts provided are of this nature. When possible, the formatting scripts print a data structure with a single format to allow subsequent reuse when interrogating arrays of structures. That is, the previous script could have been written:

```
./"daddr"n12Xn
+/"ptdaddr"16t"size"16t"caddr"16t"iptr"n4Xn
+/"rssize"8t"swrss"8t"count"8t"ccount"8t"flag"8t"slptim"8t"poip"n2x4bx
```

But then, reuse of the format would have invoked only the last line of the format.

Traversing Data Structures

The `adb` command language can be used to traverse complex data structures. One such data structure, a linked list, occurs quite often in the kernel. By using `adb` variables and the normal expression operators it is a simple matter to construct a script which chains down the list, printing each element along the way.

For instance, the queue of processes awaiting timer events, the callout queue, is printed with the following two scripts:

callout:
```
    calltodo/"time"16t"arg"16t"func"
    *(.+0t12)$<callout.nxt
```

callout.nxt:
```
    ./D2p
    *+>l
    ,#<l$<
    <l$<callout.nxt
```

The first line of the script `callout` starts the traversal at the global symbol `calltodo` and prints a set of headings. It then skips the empty portion of the structure used as the head of the queue. The second line then invokes the script `callout.nxt` moving *dot* to the top of the queue — `*+` performs the indirection through the link entry of the structure at the head of the queue. The script `callout.nxt` prints values for each column, then performs a conditional test on the link to the next entry. This test is performed as follows:

```
*+>l
```

This means to place the value of the *link* in the `adb` variable `<l`. Next:

```
,#<l$<
```

This means if the value stored in `<l` is non-zero, then the current input stream (from the script `callout.nxt`) is terminated. Otherwise, the expression `#<l` is zero, and the `$<` operator is ignored. That is, the combination of the logical negation operator `#`, `adb` variable `<l`, and operator `$<`, in effect, creates a statement of the form:

```
if (!link)
    exit;
```

The remaining line of `callout.nxt` simply reapplies the script on the next element in the linked list. A sample `callout` dump is shown below:

```
% adb -k /vmunix /dev/mem
sbr 50030 slr 51e
physmem 3c0
$<callout
_calltodo:
_calltodo:  time        arg     func
d9fc4:      5       0       _roundrobin
d9f94:      1       0       _if_slowtimo
d9fd4:      1       0       _schedcpu
d9fa4:      3       0       _pffasttimo
d9fe4:      0       0       _schedpaging
d9fb4:      15      0       _pfslowtimo
d9ff4:      12      0       _arptimer
da044:      736     d7390       _realitexpire
da004:      206     d6fbc       _realitexpire
da024:      649     d741c       _realitexpire
da034:      176929      d7304       _realitexpire
```

Supplying Parameters

A command script may use the address and count portions of an adb command as parameters. An example of this is the setproc script, used to switch to the context of a process with a known process ID:

```
0t99$<setproc
```

The body of setproc is:

```
.>4
*nproc>l
*proc>f
$<setproc.nxt
```

The body of setproc.nxt is:

```
(*(<f+0t42)&0xffff)="pid "D
,#(((*(<f+0t42)&0xffff))-<4)$<setproc.done
<l-1>l
<f+0t140>f
,#<l$<
$<setproc.nxt
```

The process ID, supplied as the parameter, is stored in the variable <4, the number of processes is placed in <l, and the base of the array of process structures in <f. Then setproc.nxt performs a linear search through the array until it matches the process ID requested, or until it runs out of process structures to check. The script setproc.done simply establishes the context of the process, then exits.

Standard Scripts

Here are the command scripts currently available in `/usr/lib/adb`:

Table 8-1 *Standard Command Scripts*

Name	*Use*	*Description*
buf	*addr*$<buf	format block I/O buffer
callout	$<callout	print timer queue
clist	*addr*$<clist	format character I/O linked list
dino	*addr*$<dino	format directory inode
dir	*addr*$<dir	format directory entry
file	*addr*$<file	format open file structure
filsys	*addr*$<filsys	format in-core super block structure
findproc	*pid*$<findproc	find process by process id
ifnet	*addr*$<ifnet	format network interface structure
inode	*addr*$<inode	format in-core inode structure
inpcb	*addr*$<inpcb	format internet protocol control block
iovec	*addr*$<iovec	format a list of *iov* structures
ipreass	*addr*$<ipreass	format an ip reassembly queue
mact	*addr*$<mact	show active list of mbuf's
mbstat	$<mbstat	show mbuf statistics
mbuf	*addr*$<mbuf	show next list of mbuf's
mbufs	*addr*$<mbufs	show a number of mbuf's
mount	*addr*$<mount	format mount structure
pcb	*addr*$<pcb	format process context block
proc	*addr*$<proc	format process table entry
protosw	*addr*$<protosw	format protocol table entry
rawcb	*addr*$<rawcb	format a raw protocol control block
rtentry	*addr*$<rtentry	format a routing table entry
rusage	*addr*$<rusage	format resource usage block
setproc	*pid*$<setproc	switch process context to *pid*
socket	*addr*$<socket	format socket structure
stat	*addr*$<stat	format stat structure
tcpcb	*addr*$<tcpcb	format TCP control block
tcpip	*addr*$<tcpip	format a TCP/IP packet header
tcpreass	*addr*$<tcpreass	show a TCP reassembly queue
text	*addr*$<text	format text structure
traceall	$<traceall	show stack trace for all processes
tty	*addr*$<tty	format tty structure
u	*addr*$<u	format user vector, including pcb
uio	*addr*$<uio	format uio structure
vtimes	*addr*$<vtimes	format vtimes structure

8.3. Generating adb Scripts with adbgen

You can use the adbgen program to write the scripts presented earlier in a way that does not depend on the structure member offsets of referenced items. For example, the text script given above depends on all printed members being located contiguously in memory. Using adbgen, the script could be written as follows (again it is really on one line, but broken apart for ease of display):.PL FULL

```
#include "sys/types.h"
#include "sys/text.h"

text
./"daddr"n{x_daddr,12X}n\
"ptdaddr"16t"size"16t"caddr"16t"iptr"n\
{x_ptdaddr,X}{x_size,X}{x_caddr,X}{x_iptr,X}n\
"rssize"8t"swrss"8t"count"8t"ccount"8t"flag"8t"slptim"8t"poip"n\
{x_rssize,x}{x_swrss,x}{x_count,b}{x_ccount,b}\
{x_flag,b}{x_slptime,b}{x_poip,x}{END}
```

The script starts with the names of the relevant header files, while the braces delimit structure member names and their formats. This script is then processed through adbgen to get the adb script presented in the previous section. See Chapter 7 of this manual for a complete description of how to write adbgen scripts. The real value of writing scripts this way becomes apparent only with longer and more complicated scripts (the u script for example). When scripts are written this way, they can be regenerated if a structure definition changes, without requiring people to calculate the offsets.

8.4. Summary

The extensions made to adb provide basic support for debugging the SunOS kernel by eliminating the need for a user to carry out virtual-to-physical address translation. A collection of scripts has been written to format the major kernel data structures, and aid in switching between process contexts. This was carried out with only minimal changes to the debugger.

9

Generating adb Scripts with adbgen

9

Generating adb Scripts with adbgen

/usr/lib/adb/adbgen *file*.adb ...

This program makes it possible to write adb scripts that do not contain hard-coded dependencies on structure member offsets. After generating a C program to determine structure member offsets and sizes, adbgen proceeds to generate an adb script.

The input to adbgen is a file named *file*.adb containing adbgen header information, then a null line, then the name of a structure, and finally an adb script. The adbgen program only deals with one structure per file; all member names occurring in a file are assumed to be in this structure. The output of adbgen is an adb script in *file* (without the .adb suffix).

The header lines, up to the null line, are copied verbatim into the generated C program. These header lines often have #include statements to read in header files containing relevant structure declarations.

The second part of *file*.adb specifies a structure.

The third part contains an adb script with any valid adb commands (see Chapter 6 of this manual), and may also contain adbgen requests, each enclosed in braces. Request types are:

1) Print a structure member. The request form is {*member*,*format*} where *member* is a member name of the structure given earlier, and *format* is any valid adb format request. For example, to print the p_pid field of the proc structure as a decimal number, say {p_pid,d}.

2) Reference a structure member. The request form is {**member*, *base*} where *member* is the member name whose value is wanted, and *base* is an adb register name containing the base address of the structure. For example, to get the p_pid field of the proc structure, get the proc structure address in an adb register, such as <f, and say {*p_pid,<f}.

3) Tell adbgen that the offset is OK. The request form is {OFFSETOK}. This is useful after invoking another adb script which moves the adb *dot*.

4) Get the size of the *structure*. The request form is {SIZEOF}; adbgen simply replaces this request with the size of the structure. This is useful for incrementing a pointer to step through an array of structures.

5) Get the offset to the end of the structure. The request form is {END}. This is useful at the end of a structure to get adb to align *dot* for printing the next structure member.

By keeping track of the movement of *dot*, adbgen emits adb code to move forward or backward as necessary before printing any structure member in a script. The model of *dot*"s behavior is simple: adbgen assumes that the first line of the script is of the form *struct_address/adb text* and that subsequent lines are of the form +/*adb text*. This causes *dot* to move in a sane fashion. Unfortunately, adbgen does not check the script to ensure that these limitations are met. However, adbgen does check the size of the structure member against the size of the adb format code, and warns you if they are not equal.

9.1. Example of adbgen

If there were an include file x.h like this,

```
struct x {
    char    *x_cp;
    char    x_c;
    int x_i;
};
```

then the adbgen file (call it script.adb) to print it would be:

```
#include "x.h"

x
./"x_cp"16t"x_c"8t"x_i"n{x_cp,X}{x_c,C}{x_i,D}
```

After running adbgen, the output file script would contain:

```
./"x_cp"16t"x_c"8t"x_i"nXC+D
```

To invoke the script, type:

```
x$<script
```

9.2. Diagnostic Messages from adbgen

The adbgen program generates warnings about structure member sizes not equal to adb format items, and complaints about badly formatted requests. The C compiler complains if you reference a non-existent structure member. It also complains about & before array names; these complaints may be ignored.

9.3. Bugs in adbgen

Structure members that are bit fields cannot be handled, because C will not give the address of a bit field; the address is needed to determine the offset.

Index

Notes

Notes

Notes

Notes

Notes