VMS Software

VSI OpenVMS

VSI DECset for OpenVMS Performance and Coverage Analyzer Command-Line Interface Guide

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VSI DECset for OpenVMS Performance and Coverage Analyzer Command-Line Interface Guide

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Preface

This guide explains how to use the command-line interface to the Performance and Coverage Analyzer (PCA). It describes the two components of PCA, as follows:

- The Collector, which gathers various kinds of performance and test coverage data on your program.
- The Analyzer, which processes and displays that data in histograms and tables.

1. About VSI

VMS Software, Inc. (VSI) is an independent software company licensed by Hewlett Packard Enterprise to develop and support the OpenVMS operating system.

2. Intended Audience

This guide is intended for experienced programmers and technical managers who are concerned with the performance of their application programs. PCA serves as a flexible and reliable tool that you can use to:

- Analyze the performance characteristics of your applications
- Analyze the text coverage characteristics of the tests you run on your applications to determine what code paths and tests are executing.

3. Document Structure

This guide is divided into five chapters and three appendixes:

- *Chapter 1, "Introduction"* provides an overview of PCA and briefly describes how to use the Collector and the Analyzer to gather and manipulate data.
- *Chapter 2, "Using the Collector"* explains how to invoke the Collector and how to specify what kinds of data you want to gather.
- *Chapter 3, "Using the Analyzer"* explains how to invoke the Analyzer and how to generate performance histograms and tables.
- *Chapter 4, "Productivity Enhancements with PCA"* offers solutions to complex problems through practical examples. This chapter also introduces screen mode, discusses how to create and use screen displays, and how to use the predefined keypad definitions.
- *Chapter 5, "Using VAX Vectors with PCA"* describes how to do performance analysis on applications containing vector instructions.
- *Appendix A, "Sample Programs"* contains the sample program used for many of the examples throughout this file. It also contains the programs that are used in the examples in *Chapter 4, "Productivity Enhancements with PCA"*.
- *Appendix B, "PCA Reference Tables"* contains information on Collector and Analyzer logical names, node specifications, and data kinds. Also, this appendix contains keypad figures used in screen mode.

- *Appendix C, "Questions and Answers"* answers questions that are commonly asked about this tool.

4. Related Documents

The following documents might also be helpful when using PCA:

- The *VSI DECset for OpenVMS Performance and Coverage Analyzer Reference Manual* describes all the commands available in PCA.
- The *Guide to Performance and Coverage Analyzer for OpenVMS Systems* provides a tutorial description of the use of PCA from the windows interface, and contains other important user information.
- *VSI DECset for OpenVMS Installation Guide* gives instructions for installing PCA on OpenVMS Alpha and OpenVMS VAX systems.
- *VSI Fortran Performance Guide* details the performance features of the VSI Fortran High Performance Option, and discusses ways to improve the run-time performance of VSI Fortran programs.

5. References to Other Products

Some older products that DECset components previously worked with might no longer be available or supported by VSI. Any reference in this manual to such products does not imply actual support, or that recent interoperability testing has been conducted with these products.

Note

These references serve only to provide examples to those who continue to use these products with DECset.

Refer to the *Software Product Description* for a current list of the products that the DECset components are warranted to interact with and support.

6. OpenVMS Documentation

The full VSI OpenVMS documentation set can be found on the VMS Software Documentation webpage at https://docs.vmssoftware.com.

7. VSI Encourages Your Comments

You may send comments or suggestions regarding this manual or any VSI document by sending electronic mail to the following Internet address: `<docinfo@vmssoftware.com>`. Users who have VSI OpenVMS support contracts through VSI can contact `<support@vmssoftware.com>` for help with this product.

8. Typographical Conventions

Table 1, "Typographical Conventions" lists the conventions used in this guide.

Table 1. Typographical Conventions

Convention	**Description**
$	A dollar sign ($) represents the OpenVMS DCL system prompt.
Ctrl/*x*	The key combination Ctrl/*x* indicates that you must press the key labeled Ctrl while you simultaneously press another key, for example, Ctrl/Y or Ctrl/Z.
KP*n*	The phrase KP*n* indicates that you must press the key labeled with the number or character *n* on the numeric keypad, for example, KP3 or KP-.
file-spec, ...	A horizontal ellipsis following a parameter, option, or value in syntax descriptions indicates additional parameters, options, or values you can enter.
. . .	A horizontal ellipsis in a figure or example indicates that not all of the statements are shown.
. . .	A vertical ellipsis indicates the omission of items from a code example or command format; the items are omitted because they are not important to the topic being described.
( )	In format descriptions, if you choose more than one option, parentheses indicate that you must enclose the choices in parentheses.
[ ]	In format descriptions, brackets indicate that whatever is enclosed is optional; you can select none, one, or all of the choices.
{ }	In format descriptions, braces surround a required choice of options; you must choose one of the options listed.
bold text	Bold text represents the introduction of a new term.
italic text	Italic text represents book titles, parameters, arguments, and information that can vary in system messages (for example, Internal error *number*).
UPPERCASE	Uppercase indicates the name of a command,routine, file, file protection code, or the abbreviation of a system privilege.
lowercase	Lowercase in examples indicates that you are to substitute a word or value of your choice.

Chapter 1. Introduction

This chapter presents an overview of the Performance and Coverage Analyzer (PCA). It includes a demonstration of a sample program used with PCA.

1.1. Overview

PCA is one of the DECset software development tools. It helps you produce efficient and reliable applications by analyzing your program's dynamic behavior. PCA also measures codepath coverage within your program so that you can devise tests that exercise all parts of your application.

Components

PCA has two operational components:

- **The Collector**. The Collector gathers performance or test coverage data on a running program and writes that data to a performance data file.
- **The Analyzer**. The Analyzer reads the performance data file produced by the Collector and processes the data to produce performance or coverage histograms and tables.

You can run the Collector and the Analyzer in batch as well as interactively.

Online Help

To get help with PCA commands, or any of the qualifiers or parameters used with these commands, type HELP, followed by the command or topic.

For the DECwindows interface, you can obtain help on any screen object by positioning the pointer on the desired object, pressing and holding the HELP key while you press MB1, and releasing both keys. You can also obtain help by choosing a menu item from the Help pull-down menu.

1.2. The Collector

The Collector collects that data you request and deposits the data into a data file during the program run. Afterward, you can use the Analyzer to display and filter the collected data.

There are three aspects of Collector operation:

- Image selection
- Measurement and control selection
- Output to data file

Image Selection

You may select either the main image or one of the shareable images in the program address space. PCA measures the dynamic behavior of the image you have selected. The image must be in the address space when the application program is activated.

Measurement and Control Selection

You may select one or more of the following measurements to be collected during the program's execution:

- **Program counter (PC) sampling data**. PCA samples the program counter at an interval you specify (by default, every 10 milliseconds).
- **CPU sampling data**. This is the same as PC sampling data, except that PCA uses the virtual-process time instead of the system or wall clock time as the basis for sampling. Data counts reflect only the CPU time usage, and not the time spent by the program waiting for the completion of I/O operations, page faulting, and so on.
- **Counters**. PCA counts the exact number of times that specified program locations execute.
- **Coverage data**. PCA collects information that indicates which portions of your program are or are not executed during each test run.
- **Page fault data**. PCA shows you where a page fault occurs and which program address caused it.
- **System services data**. PCA counts which system services your program calls, how often it calls them, and which program segments do the calling.
- **Input/Output services data**. PCA counts information about all I/O service calls that your program makes.
- **Ada tasking data**. PCA collects information on all context switches in Ada multi-tasking applications.
- **Events data**. PCA collects data from a specified phase of your program.
- **Vector program counter (VPC) sampling data**. PCA samples the program counter at intervals you specify to show where the wall-clock time is being spent in the application performing vector instructions.
- **Vector CPU (VCPU) sampling data**. This is the same as VPC sampling data, except that PCA uses the virtual-process time instead of the system or wall clock time.
- **Vector counters data**. PCA counts all the vector instructions in all or part of your application containing vector instructions.

You must set controls on the following measurements before collecting the data to be deposited into the data file:

- You must set a control to define the length of the sampling interval for PC sampling, CPU sampling, vector PC sampling, and vector CPU sampling. The fastest timer on the system is 10 milliseconds, the default.
- You must set a program address control for gathering counters, vector counters, and coverage data.
- You must define an event name and set program address controls for gathering events data.

Output to Data File

The data file receives the collected data and can then be passed to the Analyzer for analysis and filtering.

1.3. The Analyzer

The Analyzer lets you analyze and filter the data produced by the Collector and creates views of the specified data.

There are three aspects of Analyzer operation:

- Data file selection
- Data specification
- View selection

Data File Selection

The Analyzer operates on data produced by the Collector. You may choose one data file or merge several from different collections.

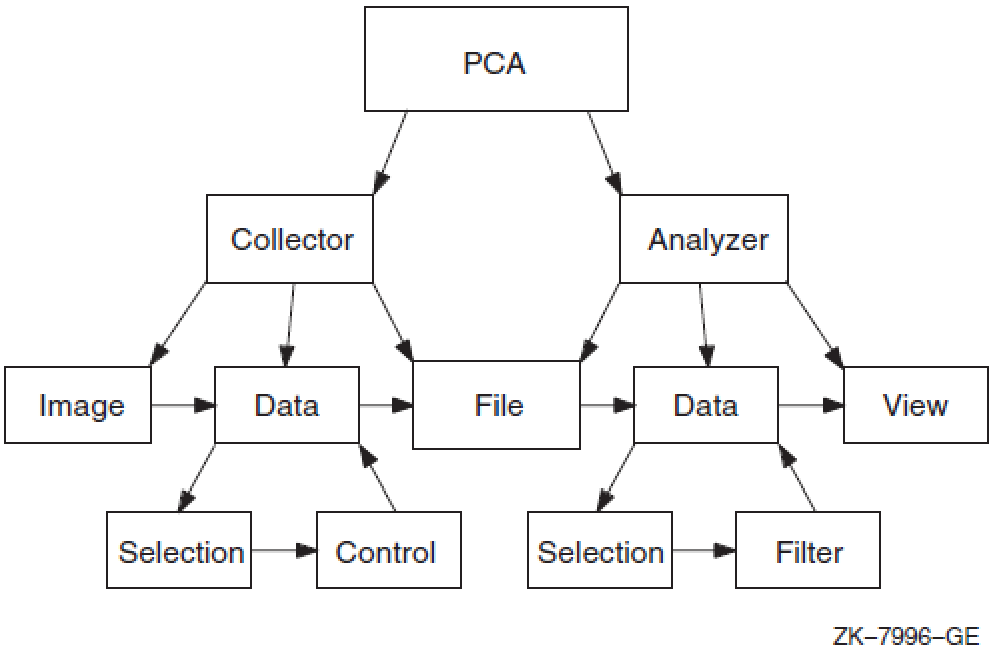
Data Specification

After selecting the data file, you must specify the data to be viewed. There are three interrelated kinds of data specification:

- Data kind
- Domain
- Filters

The Collector gathers many data kinds. In the Analyzer,you select which ones to analyze. Each data kind has one or more **domains** associated with it. For example, if you collected PC sampling, you can choose to view the following domains in the Analyzer: the program address, the call tree, the task, the task priority, and the task type. You can further restrict the data to be viewed with a filter. Any of the domains can be chosen and the value of the domain can be tested to be within a range of values. If it is within the range, then the selected domain value is passed along to be viewed. The general flow of control in PCA is shown in *Figure 1.1, "The PCA Model"*.

Figure 1.1. The PCA Model



One way to think of PCA performance data is to consider each data kind as a record with one or more domains as fields in the record. As another example, the I/O data kind has these domains associated with it:

- The program counter (PC) of the I/O call
- The file name
- The virtual block number
- Record size
- I/O service name

Choosing the I/O data kind means you want to know the frequency of I/O calls. Choosing the Program Address domain indicates that you want to know where in the program the I/O calls occur. The Analyzer creates a view of the I/O data kind with the value of the PC from each I/O "record". The Analyzer uses the data to construct a view of the program, which shows where the I/O calls originate.

Filter selection differs from other selections because it is based on the values in the domain, not on the larger class of the data kind. For example, if you choose the I/O data kind with the Program Address Domain, set the filter for the Virtual Block Number domain, and specify a range of 1 to 5, the Program Address domain values then passed to the View are those which have Virtual Block Number domain values in the range of 1 to 5. In other words, you are asking where in my program are the I/O calls for Virtual Block number 1 to 5.

Selecting data kinds and domains can be thought of as progressively refining selected data from the data file before passing it on to be viewed.

View Selection

After you select one or more data kinds and specify domains, the Analyzer produces a view of the data. A view is a graphic representation, displayed on the screen in one of the following formats:

- Histograms (Plot/Tables)
- Source listings annotated with bars or numbers
- Lists
- Trees

You may alter the appearance of a view by performing any of the following operations allowed by the Analyzer:

- Selecting the appearance of the view
- Defining the granularity or size of each bucket
- Defining the complete range
- Setting the upper, lower, no zeros limits
- Setting or canceling acceptable noncoverage (ANC)
- Traversing the table
- Expanding to source
- Scaling
- Scrolling
- Selecting vertical versus horizontal views
- Selecting numbers versus bars
- Changing the title

1.4. Getting Started

This section uses as an example a FORTRAN program called PCA$PRIMES, which generates all the prime numbers in a given integer range. The program's source code has the file name PCA$PRIMES.FOR. The complete program is included in *Appendix A, "Sample Programs"* and is supplied with the PCA kit. (After installation, you can find PCA demonstration programs in the directory PCA$EXAMPLES.)

1.4.1. Using the Collector

The Collector gathers performance or test coverage data on applications programs as they run. In the example in the following sections, the Collector gathers program counter sampling data on the FORTRAN program PCA$PRIMES.

1.4.1.1. Invoking the Collector

You must perform the following steps to invoke the Collector:

1. **Compile the source file**. Use the /DEBUG qualifier with a compilation command to create a Debug Symbol Table (DST) in the object module. The DST contains all of the symbol and line number

information PCA needs to specify user program locations. Enter the following DCL command to compile the FORTRAN program PCA$PRIMES.FOR for use with the Collector:

```
$ FORTRAN/DEBUG PCA$PRIMES.FOR
```

This command creates the file PCA$PRIMES.OBJ.

2. **Link the user program**. The /DEBUG qualifier passes the DST information generated by the compiler to the executable image file where it can be accessed by the Collector. Type the following DCL command to link PCA$PRIMES.OBJ for running under Collector control:

```
$ LINK/DEBUG PCA$PRIMES.OBJ
```

3. **Run the program**. Invoke the Collector on an image linked for debugging by defining the LIB$DEBUG logical to be PCA$COLLECTOR.EXE. This causes the OpenVMS image activator to invoke the Collector as a debugger. You can then enter Collector commands. Type the following commands to define the LIB$DEBUG logical:

```
$ DEFINE LIB$DEBUG SYS$LIBRARY:PCA$COLLECTOR.EXE
$ RUN PCA$PRIMES.EXE
```

When the Collector product header and the Collector prompt (PCAC>) appear on your terminal, you have successfully invoked the Collector.

```
                      PCA Collector Version 4.6
PCAC>
```

1.4.1.2. Collecting the Data

At the Collector prompt, use the SET DATAFILE command to specify a name for the performance data file to contain the collected data. To specify the data file PCA$PRIMES.PCA, type the following:

```
PCAC> SET DATAFILE PCA$PRIMES
```

The default file type for the Collector data file is .PCA. Next, enter a data collection command to specify the kind of performance or coverage data you want to collect. For example, to collect program counter sampling data, enter the following command:

```
PCAC> SET PC_SAMPLING
```

The GO command tells the Collector to start your program, to collect data according to the current data collection settings, and to write that data to the performance data file:

```
PCAC> GO
```

After you enter the GO command, the Collector does not return you to the Collector prompt; instead, your program runs to completion and returns you to the DCL ($) prompt. The following information is displayed on the screen:

```
%PCA-I-BEGINCOL, data collection begins
 169 prime numbers generated between   1 and 1000
FORTRAN STOP
%PCA-I-ENDCOL, data collection ends$
```

1.4.1.3. Exiting the Collector

To end the Collector session at any time prior to saying GO, or to suspend data collection, enter the EXIT command or press Ctrl/Z.

Repeat the RUN command to invoke the Collector again and to collect additional data on your program's performance or coverage. If you want the same file to contain data collections from many executions of the same program, use the /APPEND qualifier with the SET DATAFILE command:

```
PCAC>  SET DATAFILE/APPEND PCA$PRIMES.PCA
```

You can run your program without collecting data by entering the GO command with the /NOCOLLECT qualifier.

The Collector allows you to collect different kinds of data in the same collection run, but you should be cautious in doing so. Values may be distorted if different kinds of data are collected in the same collection run. The Collector provides informational messages warning about potential conflicts. *Section 1.2, "The Collector"* contains a listing of the different kinds of data you can collect.

1.4.2. Using the Analyzer

The Analyzer reads the performance data file written by the Collector and uses the data to produce histograms, tables, and other reports that help you evaluate your program's performance or coverage. In the example in the following sections, the Analyzer is used on the data file previously produced by the Collector to create histograms and tables, to display the source code and the summary page, and to print, file, and append Analyzer output.

1.4.2.1. Invoking the Analyzer

To invoke the Analyzer, type the PCA command and specify the name of a performance data file at DCL level. For example:

```
$ PCA PCA$PRIMES

         Performance and Coverage Analyzer Version 5.0

PCAA>
```

The data file in the previous example, PCA$PRIMES.PCA, contains the performance or coverage data and all symbol table information required by the Analyzer.

You can use the /COMMAND qualifier to specify a list of commands to execute after the Analyzer executes the initialization file (if any) and before it prompts you for interactive commands. The list of commands used with /COMMAND must be enclosed in quotation marks. To list more than one command, use semicolons to separate them. For example:

```
$ PCA/COMMAND="SHOW DATAFILE; SHOW LANGUAGE"  PCA$PRIMES.PCA

         Performance and Coverage Analyzer Version 5.0

Performance Data File: SYS$DISK01:[SMITH]PCA$PRIMES.PCA;1
Language: FORTRAN
PCAA>
```

In this example, SHOW DATAFILE and SHOW LANGUAGE are executed before the Analyzer prompt appears.

1.4.2.2. Creating the Default Plot

After invoking the Analyzer and specifying the data file, you can enter a *traverse* command (NEXT, BACK, FIRST,CURRENT), and let the Analyzer default settings create a useful plot for you. The traverse commands walk you through your program's structure, pointing out the most significant portions of your application.

Entering the NEXT command at the first Analyzer prompt creates a source plot with the PC sampling data kind. A pointer is positioned at the line with the most data points in the routine with the most data points, that is, the place where the most PC samples were gathered and most of the time was spent. Subsequent NEXT commands traverse the program structure to show you the most-to-least significant line in the program.

The Analyzer supplies the default data kind. The default data kind is the last data kind collected by the Collector. If CPU sampling was the last data kind collected, then CPU sampling is the default data kind. You can change the default with the SET PLOT or PLOT commands.

1.4.2.3. Scrolling Through the Display on Your Terminal

A histogram or table is displayed on your terminal one page at a time. To see the next page, press the Return key. You can keep pressing Return to see successive pages until you reach the summary page. The **summary page** contains various summary statistics and lists all qualifiers and node specifications used to generate the Analyzer display. It can be more than one page. *Section 1.4.2.4, "Interpreting the Summary Page"* provides a detailed interpretation of the summary page. If you press Return at the end of the summary, the Analyzer brings you back to the first page of the histogram or table.

You can use the PAGE command to page through the histogram or table. You can also use the FIND command to look for a page with a specific label or line number.

When you have a histogram or table that you want to print or save in a file, you can do so with the PRINT, FILE, and APPEND commands (see *Section 1.4.2.6, "Printing, Filing and Appending Analyzer Output"*).

1.4.2.4. Interpreting the Summary Page

The last few terminal pages of every histogram or table display are called the summary page. The summary page gives various summary statistics and lists all qualifiers, node specifications, and filters used to generate the histogram or table. This section explains the various parts of the summary page for histograms or tables with one data kind (*Example 1.1, "Summary Page for a Single Data-Kind Plot"*), and for those with multiple data kinds (*Example 1.2, "Summary Page for a Multiple Data-Kind Plot"*). These two examples have numbered callouts to the right, which are explained in the following lists.

Example 1.1. Summary Page for a Single Data-Kind Plot

```
                       Performance and Coverage Analyzer        Page 2
            Program Counter Sampling Data (27546 data points total) - "*" ❶
                PCA Version 5.0       20-OCT-2006 14:13:18 ❷
PLOT Command Summary Information:
Number of buckets tallied:                              17 ❸
Program Counter Sampling Data - "*"
Data count in largest defined bucket:                27477    99.7% ❹
Data count in all defined buckets:                   27539   100.0% ❺
Data count not in defined buckets:                       0     0.0% ❻
Portion of above count in P0 space:                      0     0.0% ❼
Number of PC values in P1 space:                         0     0.0% ❽
Number of PC values in system space:                     0     0.0% ❾
Data points failing /STACK_DEPTH or /MAIN_IMAGE:         7     0.0% ❿
Total number of data values collected:               27546   100.0% ⓫
```

```
Command qualifiers and parameters used: ⓬
  Qualifiers:
    /PC_SAMPLING /DESCENDING /NOMINIMUM /NOMAXIMUM
    /NOCUMULATIVE /NOSOURCE /ZEROS /NOSCALE /NOCREATOR_PC
    /NOPATHNAME /NOCHAIN_NAME /WRAP /NOPARENT_TASK /NOKEEP /NOTREE
    /FILL=("*","O","x","@",":","#","/","+")
    /NOSTACK_DEPTH /MAIN_IMAGE
  Node specifications:
    PROGRAM_ADDRESS BY MODULE
No filters are defined ⓭
PCAA>
```

❶ **Data-kind line**. This line tells you what kind of data was tallied to form the histogram or table and the total number of data points collected. The count does not include data points removed by filtering. This line, in conjunction with the line beginning with *Command qualifiers and parameters used*, described at the end of this list, tells you what command generated the histogram or table associated with this summary page.

❷ **Version number and current date**. This line tells you the version number of the Analyzer and the date the plot was created.

❸ **Number of buckets in histogram or table**. This line tells you how many buckets the current histogram or table has. For source listings, this count includes only those source lines that generated object code.

❹ **Data count in largest defined bucket**. This line shows the largest data count found for any bucket in the histogram or table. Used to scale the histogram bars, this number tells you how many data counts correspond to a full-length histogram bar.

❺ **Data count in all defined buckets**. This line shows the total number of data points tallied in the buckets of this histogram or table. Data points that fall outside all buckets and data points removed by filters are not counted. Data points that fall in more than one bucket are only counted once.

❻ **Data count not in defined buckets**. This line gives the number of data points that do not fall in the buckets you specified for this histogram or table. Data points removed by filtering are not included.

❼ **Portion of above count in P0 space**. This line tells you how many of the data points counted in the previous line (data count not in defined buckets) have addresses in P0 space. P0 space is the virtual address range from address 0 to address 3FFFFFFF hexadecimal and contains all code and static data in your program.

❽ **Number of PC values in P1 space**. This line tells you how many program counter values (code addresses) fell in P1 space. P1 space is the virtual address range from address 40000000 to address 7FFFFFFF hexadecimal and contains the stack, various VMS tables, and the system service vector. PC values in P1 space reflect activity in the system service vector. In particular, PC sampling data in P1 space reflects the amount of I/O or other system service wait time your program experiences.

❾ **Number of PC values in system space**. This line tells you how many program counter values fell in system space. System space is the virtual address range from address 80000000 to address FFFFFFFF hexadecimal and contains all system code. You see only system code that executes in user mode. Such code includes some condition handler code and certain system services (such as SYS$FAO) that execute in user mode. System services that execute in more privileged modes enter system code by means of a change-mode instruction in the system service vector, so the PC values you observe are in P1 space.

⑩ **Data points failing /STACK_DEPTH or /MAIN_IMAGE**. This line tells you the total number of data points that could not be tallied because the address specified with the /STACK_DEPTH or the /MAIN_IMAGE qualifier could not be found on the stack.

⑪ **Total number of data values collected**. This line tells you the total number of data points tallied in this histogram or table that were found in the performance data file. This count excludes data points eliminated by any filters you specified. This total count is used to compute the percentage shown for each bucket in the histogram or table.

⑫ **Command qualifiers and parameters used**. The lines that follow this one show all qualifiers and node specifications used to create this histogram or table. By looking at this output, you can see what defaults were applied. This line, in conjunction with the line beginning with *Data-kind line*, described at the beginning of this list,tells you what command generated the histogram or table associated with this summary page.

⑬ **Filter definition line**. This line either tells you that no filters are defined (as in this example), or lists the filters that are defined. Filters cause the Analyzer to include or exclude in the histogram or table only selected data points from the performance data file.

Not all of the lines shown in the example appear in all summary pages. For example, the summary page does not display the lines showing the number of PC values in P0, P1, or system space unless you have tallied program addresses.

Some summary pages have additional lines. For test coverage data, the summary page shows the number of buckets covered, not covered, and acceptably not covered, along with the corresponding percentages. Also, if you use the /CUMULATIVE qualifier, a line stating the cumulative count in all defined buckets is added. This count may be larger than the data count in all defined buckets because some data points maybe included more than once in the cumulative count.

Example 1.2. Summary Page for a Multiple Data-Kind Plot

```
                      Performance and Coverage Analyzer       Page 3
              I/O System Service Calls (3581 data points total) - "*"
         Page Fault Program-Counter Data (121 data points total) - "O" ❶
         Program Counter Sampling Data (27546 data points total) - "x"
               PCA Version 5.0       20-OCT-2006 14:15:32
PLOT Command Summary Information:
Number of buckets tallied:                             17
I/O System Service Calls - "*" ❷
Data count in largest defined bucket:                3581   100.0%
Data count in all defined buckets:                   3581   100.0%
Data count not in defined buckets:                      0     0.0%
Portion of above count in P0 space:                     0     0.0%
Number of PC values in P1 space:                        0     0.0%
Number of PC values in system space:                    0     0.0%
Data points failing /STACK_DEPTH or /MAIN_IMAGE:        0     0.0%
Total number of data values collected:               3581   100.0%
Command qualifiers and parameters used: ❸
  Qualifiers:
    /IO_SERVICES /DESCENDING /NOMINIMUM /NOMAXIMUM
    /NOCUMULATIVE /NOSOURCE /ZEROS /NOSCALE /NOCREATOR_PC
    /NOPATHNAME /NOCHAIN_NAME /WRAP /NOPARENT_TASK /NOKEEP /NOTREE
    /FILL=("*","O","x","@",":","#","/","+")
    /NOSTACK_DEPTH /MAIN_IMAGE
  Node specifications:
    PROGRAM_ADDRESS BY MODULE
```

```
Filter definitions: ❹
  Filter F1:
    RUN_NAME = 2

Page Fault Program-Counter Data - "O"
Data count in largest defined bucket:                    46    38.0%
Data count in all defined buckets:                      121   100.0%
Data count not in defined buckets:                        0     0.0%
Portion of above count in P0 space:                       0     0.0%
Number of PC values in P1 space:                          0     0.0%
Number of PC values in system space:                     24    19.8%
Total number of data values collected:                  121   100.0%
Qualifiers applied to this datakind:
    /NOCUMULATIVE     /NOSTACK_DEPTH      /NOPARENT_TASK   /NOCREATOR_PC
    /NOMAIN_IMAGE
Filter definitions:
  Filter F1:
    RUN_NAME = 1

Program Counter Sampling Data - "x"
Data count in largest defined bucket:                 27477    99.7%
Data count in all defined buckets:                    27539   100.0%
Data count not in defined buckets:                        0     0.0%
Portion of above count in P0 space:                       0     0.0%
Number of PC values in P1 space:                          0     0.0%
Number of PC values in system space:                      0     0.0%
Data points failing /STACK_DEPTH or /MAIN_IMAGE:          7     0.0%
Total number of data values collected:                27546   100.0%
Qualifiers applied to this datakind: ❺
    /NOCUMULATIVE     /NOSTACK_DEPTH      /NOPARENT_TASK   /NOCREATOR_PC
    /MAIN_IMAGE
No filters are defined
```

❶ **Data kind lines.** Each line of this header information names one of the data kinds plotted, in the order that they were plotted.

❷ **Summary information by data kind.** The summary information is repeated for each data kind, and is presented in the order that they were plotted.

❸ **Qualifier information.** This list includes all qualifiers used by the Analyzer. Subsequent qualifier information lists only those applied to the data kind.

❹ **Filters applied to this data kind.** This line includes only the filters that were defined for this data kind.

❺ **Qualifiers applied to this data kind.** This list includes only the qualifiers applied to this data kind.

Information that does not vary among the data kinds (such as the number of buckets, the qualifier list, and node specification) is only displayed once.

1.4.2.5. Viewing the Currently Active Plot

The plot or table resulting from the last PLOT or TABULATE command you entered is known as the **currently active plot**. The currently active plot is the source of all default qualifiers and parameters for a subsequent PLOT or TABULATE command. Use the SHOW PLOT command to view all the attributes of the currently active plot.

1.4.2.6. Printing, Filing and Appending Analyzer Output

The PRINT, FILE, and APPEND commands act on the output from the last PLOT, TABULATE, INCLUDE, EXCLUDE, LIST or traverse command you entered. You can use PRINT, FILE, APPEND commands to print or file raw performance data in addition to histograms and tables. Also, with the FILE/DDIF command, you can store your output in a DDIF file to process for a specified printing device.

To print a hard copy of a histogram or table that is displayed on your terminal, use the PRINT command. The PRINT command accepts no parameters as follows:

```
PCAA> PRINT
%PCA-I-FILQUE, print file queued to SYS$PRINT
PCAA>
```

To be notified on your terminal when the print job has completed, use the /NOTIFY qualifier with the PRINT command. No other qualifiers are accepted.

To save the current plot or table in a file, use the FILE command. The default file type is .PCALIS. The following command sequence writes the full text of the current plot or table, including its summary page, to the specified file:

```
PCAA> FILE OUTFILE
%PCA-I-CREFILE, creating file SYS$DISK01:[LEE]OUTFILE.PCALIS;1
PCAA>
```

To append the current histogram or table to an existing text file, use the APPEND command. This command allows you to add as many plots or tables as you wish to a single text file. It is not necessary to specify the name of the file to which the PCA output will be appended. The default file specification is taken from the most recent FILE or APPEND command. The following command appends the current plot or table, including its summary page, to the file created in the previous example:

```
PCAA> APPEND
%PCA-I-APPFILE, appending to file SYS$DISK01:[LEE]OUTFILE.PCALIS;1
PCAA>
```

1.4.2.7. Stopping Terminal Output or Exiting the Analyzer Session

To stop the Analyzer's terminal output, such as long output from a SHOW or LIST command, press Ctrl/C. The Analyzer aborts the current output operation and prompts for a new command.

To end the Analyzer session, enter the EXIT command or press Ctrl/Z.

Chapter 2. Using the Collector

This chapter explains how to invoke the Collector, how to set up the Collector environment, and how to specify and filter the data you want to collect on your application's performance.

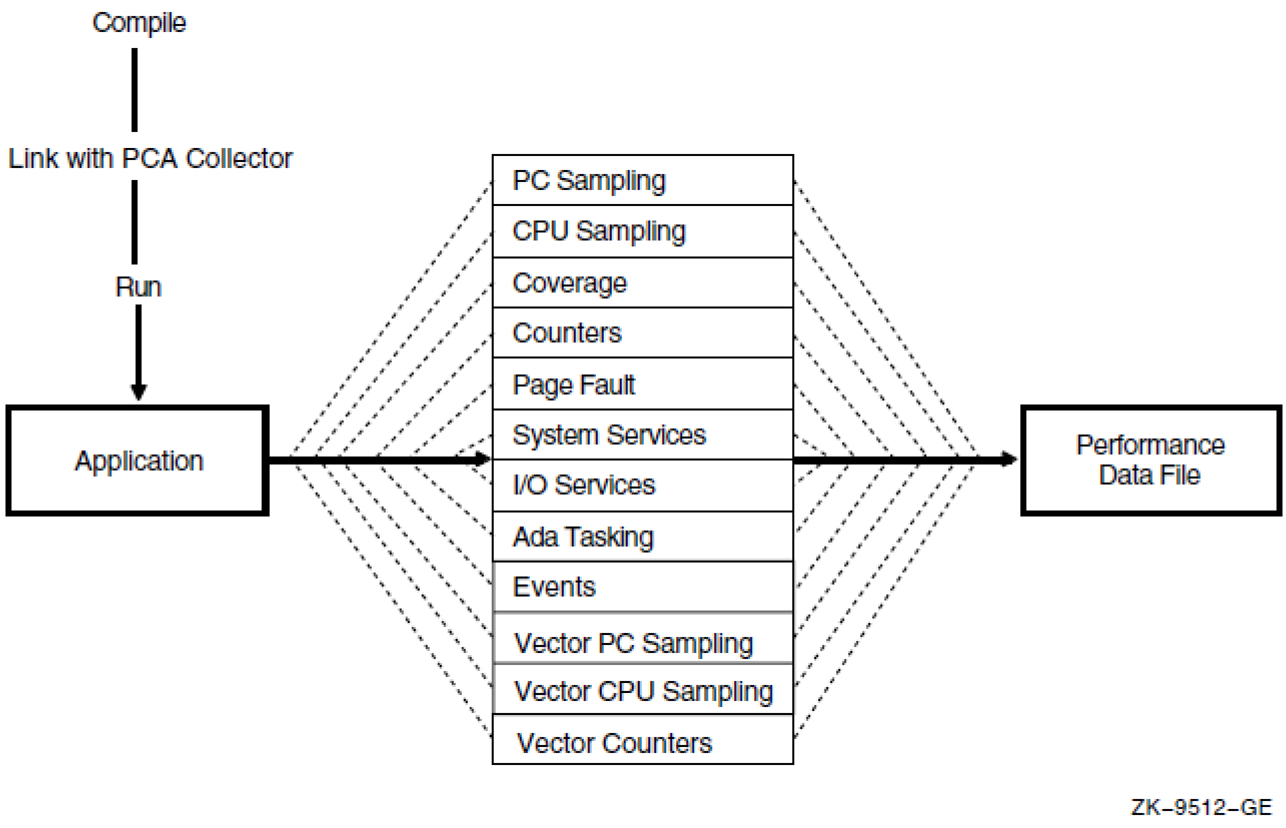
2.1. Overview

As your application runs, the Collector gathers data to discover performance bottlenecks or lack oftest coverage. To collect performance data on your application,perform the following steps:

1. Invoke the Collector by compiling, linking and running your application.
2. Specify the name of the performance data file.
3. Specify the data kinds to collect.
4. Select the language of your application.
5. Name the collection run.
6. Type GO to start the collection run and store the data in the performance data file.

Figure 2.1, "The PCA Collector" shows how the Collector interacts with your application to collect data.

Figure 2.1. The PCA Collector



2.2. Invoking the Collector

To invoke the Collector on an image linked for debugging, define the LIB$DEBUG logical to be PCA$COLLECTOR.EXE. This causes the OpenVMS image activator to invoke the Collector as a debugger. You can then enter Collector commands. Type the following commands to define the LIB$DEBUG logical:

```
$ LINK/DEBUG PCA$PRIMES.OBJ
$ DEFINE LIB$DEBUG PCA$COLLECTOR.EXE
$ RUN PCA$PRIMES.EXE

        PCA Collector Version 4.6
PCAC>
```

To return to the debugger, deassign the logical name LIB$DEBUG, as follows:

```
$ DEASSIGN LIB$DEBUG
$ RUN PCA$PRIMES.EXE

          OpenVMS Debugger Version 7.0
DBG>
```

When collecting coverage data, use the /NOOPTIMIZE qualifier during compilation.

2.3. Specifying the Performance Data File

After you invoke the Collector, use the SET DATAFILE command to specify the performance data file that is to contain the gathered data. Give the data file a mnemonic name that tells you something about the collection run. For example, you could expand the data file name from PCA$PRIMES to PCA$PRIMES_PC_SMPL with the following command:

```
PCAC> SET DATAFILE PCA$PRIMES_PC_SMPL
```

If you do not specify a data file,the Collector names the data file after the executable image file of the program you are measuring with a default file type of .PCA.

To direct the gathered data to a new data file with each run,enter a new SET DATAFILE command for each collection run.

Appending a New Data Collection to an Existing File

To append a new data collection to an existing datafile with the default file name, use both the /APPEND and the /EXECUTABLE qualifiers. For example:

```
PCAC> SET DATAFILE/APPEND/EXECUTABLE
```

This example sets the data file to the default data file. When using the /EXECUTABLE qualifier, omit the file specification parameter.

2.4. Specifying Data Collection

When you invoke the Collector and name the data file,you must specify the kinds of data you want to gather.

Use the Collector SET commands to specify collection of the following data kinds:

- PC Sampling
- CPU Sampling
- Coverage
- Counters
- Page fault
- System services
- I/O services
- Ada tasking
- Events
- Vector PC sampling
- Vector CPU sampling
- Vector counters

By default, PCA collects PC sampling and stack data when you enter a GO command without specifying a data kind.

PCA supports the following data collection commands on both OpenVMS VAX and OpenVMS Alpha:

Set PC_Sampling	(see *Section 2.4.1, "Program Counter Sampling Data: System Time"*)
Set PCU_Sampling	(see *Section 2.4.2, "Program Counter Sampling Data: CPU Time"*)
Set Page_Faults	(see *Section 2.4.1.4, "Interpreting Page-Faulting Data"*)
Set Services	(see *Section 2.4.6, "System Services Data"*)
Set IO_Services	(see *Section 2.4.7, "Input/Output Data"*)
Set Tasking	(see *Section 2.4.8, "Tasking Data"*)

2.4.1. Program Counter Sampling Data: System Time

PC sampling provides a broad measure of where your program is spending its time. For this reason, PC sampling is the single most useful way to measure program performance. You can sample the program counter (PC) of your running program to determine which parts consume the most time. The program counter contains the address of the next machine instruction to be executed. Specify collection of PC sampling data with the following command:

```
PCAC> SET PC_SAMPLING
```

The Collector samples the PC by setting up an **asynchronous system trap** (AST) timer routine in supervisor mode. By default, the AST timer routine is activated every 10 milliseconds. Each time the routine is activated, the Collector retrieves the current PC value for output to the data file. Because the timer operates in supervisor mode, it samples the PC in all user-mode and user AST-mode that your program executes. The Collector cannot collect data on programs that run in other modes.

PC sampling data collection is efficient. The extra overhead of gathering this data is typically no more than 5 percent of the total run time of the user program. However, run times of a minute or more are required to gather enough PC values for statistically significant results. You can gather at most 100 values per second, and you usually need to gather thousands of values to get significant results.

2.4.1.1. PC Sampling Data Distortion

PC sampling provides correct and repeatable results if the Collector supplies enough PC values for statistically significant results. When collecting PC values under ideal conditions, the chances of finding the PC in a given address range is proportional to the amount of time the program actually spends in that address range. However, when less than ideal conditions exist, the results of PC sampling may be distorted. This section discusses those situations that can distort PC sampling data and lead you to draw incorrect conclusions about the behavior of your program.

The overall system load at the time of collection affects the number of program counter values the Collector gathers, because program execution slows down as more demands are made on the system CPU. When program execution slows, the 10-millisecond timer (which is relatively unaffected by the CPU load) gathers more PC values per program run than when your system is lightly loaded and processing faster. The actual number of PC values collected is not important as long as the number is large enough to establish a representative sample. Only the *proportion* of PC values found in a given address range is significant and repeatable.

A less than ideal condition exists when the system load changes markedly during the PC sampling session. This condition may force the program you are measuring to share the system with a CPU-intensive process. This would cause the program to run more slowly in real time, produce more 10-millisecond ticks, and collect a greater number of PC values. Now, consider that the other process may terminate at some point through the PC sampling run. If this occurs, then the rest of the PC sampling run executes at full speed, experiences fewer 10-millisecond ticks, and collects fewer PC values than it did before the other process terminated. Under these conditions, the PC sampling data would be misleading because the program was not run on an evenly loaded system. There could be a skew of PC sampling data toward the beginning of the run.

Synchronizing your code with the 10-millisecond timer can also cause PC sampling data distortion. For example, if your program sets up a user-mode timer AST routine, then that routine normally gains control as soon as the Collector's supervisor-mode timer AST routine runs to completion. The AST routine starts early in the Collector's timer interval and probably finishes before the next 10-millisecond tick occurs. Therefore, no PC values are likely to be collected from such an AST routine, and you may wrongly conclude that no time is consumed in that routine. An example of this situation is an Ada multi-tasking program that is time slicing at every 10 milliseconds.

2.4.1.2. Interpreting System Service Wait Times

Interpreting system service wait times can also be deceiving. When your program calls a system service that runs in executive or kernel mode, the PC points to the first byte following a change-mode instruction in the system service vector in P1 space. However, as long as the system service is running in that higher mode, the Collector's supervisor-mode timer AST routine cannot gain control. When the higher-mode code has finished executing, the Collector's AST routine gains control and collects only one PC value, even if many 10-millisecond ticks occur in that time frame. Therefore, the amount of CPU time consumed in system services may not be properly represented in the PC sampling data.

2.4.1.3. Interpreting I/O Services Wait Times

In comparison to system service wait times, I/O services wait times are properly represented in PC sampling data. The CPU time used by the I/O system services may be under represented, but once the physical I/O operation is queued or started, the Collector's timer AST routine can continue to collect PC values. Therefore, I/O-bound programs may result in large numbers of PC values occurring in P1 space. These values represent I/O system service wait times.

Under some circumstances, I/O wait times should be evaluated cautiously. For example, if your program is accessing an overloaded disk, much of the wait time may be due to competition from other processes accessing the same device. In such cases, the best way to reduce program I/O wait time is to reduce the load on that disk, perhaps by spreading its files over several disks. Before you decide to code your program to make it faster, you should consider both the internal and external factors that can be causing poor I/O performance.

Because terminals are inherently slow devices, terminal I/O is likely to cause many PC values to be collected in P1 space. A terminal-bound application can easily spend 80 to 90 percent of its time waiting for the terminal. Collecting many PC values in P1 space is a normal characteristic of terminal-bound programs.

2.4.1.4. Interpreting Page-Faulting Data

PC sampling data measures page faulting time in addition to CPU and I/O time. When a page fault occurs, the Collector gathers the PC value of the instruction that caused the page fault. If you find a big PC sampling peak in a routine or in a code segment, the peak could be due to page faulting rather than to CPU usage. If you are in doubt about the PC data, collect page fault data or collect CPU sampling data to see if that can explain the PC sampling peak in that code segment.

2.4.1.5. Collecting PC Sampling Data and Other Data in the Same Run

You can collect different kinds of data in the same collection run. However, some kinds of data impose a high collection overhead that can substantially alter the run-time behavior of your program. For this reason, the Collector provides an informational message warning about possible conflicts. For example, execution counters can slow your program down several hundred times. If you try to collect execution counts and PC sampling data at the same time, the overhead of collecting execution counts may make the PC sampling data meaningless.

Although you should avoid collecting PC sampling data and execution count data at the same time, there are exceptions. For example, an execution counter that is “hit” only half a dozen times in a long collection run may have no appreciable effect on the PC sampling process.

Usually, you can collect page fault data and PC sampling data at the same time with little or no distortion in either kind of data. However, avoid collecting system services data, I/O data, CPU sampling data, execution counts,or test coverage data at the same time that you collect PC sampling data.

2.4.2. Program Counter Sampling Data: CPU Time

The SET CPU_SAMPLING command collects PC values in the same way that SET PC_SAMPLING does, with one important difference. The CPU sampling interval is based on virtual process time, not system time. When you enter the SET CPU_SAMPLING command, PCA collects PC values whenever there has been one or more clock ticks on the process clock. Specify the collection of CPU sampling data with the following command:

```
PCAC> SET CPU_SAMPLING
```

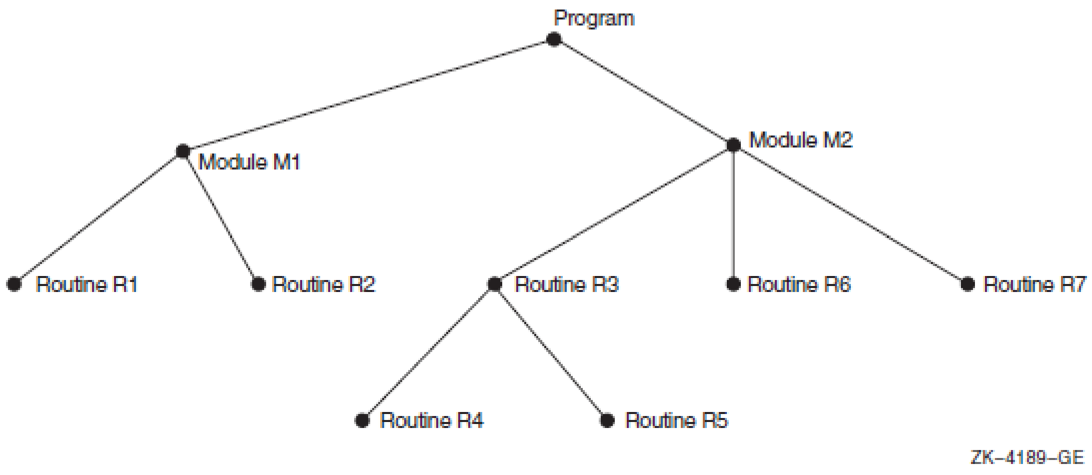
There are many external factors that can affect the behavior of a program in relation to the system clock (for example, page faulting and system service wait time, including I/O wait time). These conditions make it difficult to determine whether the program counter contains a specific location because of the structure of the program's algorithm or because of other external factors occurring in that interval. Under these conditions, sampling the PC values based on the CPU time is more effective and reproducible because the effects caused by contending processes are eliminated.

2.4.3. Test Coverage Data

If you want to see which parts of your application are covered or not covered by your test suite, use the SET COVERAGE command. You must use **node specifications** to specify program locations on which to place **breakpoints** so that test coverage data or execution counts can be gathered for that area of the program. Node specifications refer to those elements of your application that can be defined as a program address, a module, a routine, a code path, or a line.

Figure 2.2, "A Program Represented as a Tree" depicts the different elements of a program as a tree structure. Many of the examples used in the following sections refer to its modules and routines by name.

Figure 2.2. A Program Represented as a Tree



A breakpoint is a location in a program in which that program's execution may be suspended so that partial results can be examined. For example, to measure test coverage for every code path in your program and collect stack PC values, type the following:

```
PCAC>  SET COVERAGE/STACK_PCS PROGRAM BY CODEPATH
```

By default, the Collector removes each breakpoint the first time the code executes. This allows the program to run faster because it does not collect counts at locations that have already been covered. Therefore, frequently executed code runs at full speed after the first execution.

The complete syntax of node specifications, as used with the SET COUNTERS, SET COVERAGE, and SET EVENT commands, is shown in *Table B.3, "Node Specification Parameter Syntax"*.

2.4.3.1. Codepaths

When you use the SET COVERAGE command, the most useful node specification is one with a BY CODEPATH clause. This nodespec causes the Collector to examine the program's object code in order to find all relevant codepaths. The term **codepath** is any piece of object code that the executing program enters only at the beginning (at the first instruction) and exits only at the end.

The codepath search starts at all entry points and labels. The Collector puts breakpoints at the entry points of the routines and at all possible destinations of conditional branches. In this regard, you can think of the codepath source as being a basic block within a high level language. In the Analyzer, you can plot or tabulate the collected data to see which codepaths are not covered by your tests.

The following command selects all codepath nodes in module M2, and puts coverage breakpoints on all corresponding program locations:

```
PCAC> SET COVERAGE MODULE M2 BY CODEPATH
```

Similarly, the following command places test coverage counters on all codepaths in the entire program:

```
PCAC> SET COVERAGE PROGRAM_ADDRESS BY CODEPATH
```

Because the MACRO assembler does not provide adequate symbol table information, the Collector may not be able to find all codepaths in MACRO programs. To minimize this problem, you should declare all MACRO routines with .ENTRY directives. Even then, constructs such as indexed jump instructions or passing code addresses as parameters may cause codepaths to be missed.

You can specify comma lists of node specifications with these commands. *Figure 2.2, "A Program Represented as a Tree"* shows a program with its elements represented in a tree structure and is used in the following example. To specify the collection of tests coverage on routines R6 and R7, and all the routines in module M1, enter the following command line:

```
PCAC> SET COVERAGE ROUTINE R6, ROUTINE R7, MODULE M1 BY ROUTINE
```

Codepath measurement has one drawback. If the generated code contains dynamically determined destination addresses (for example, self-modifying code or jump table constructs), those codepaths are not measured. To ensure covering as many points as possible, enter the following command:

```
PCAC> SET COVERAGE PROG BY LINE, PROG BY CODE
```

This covers the union of addresses specified in the nodespec but may create an inordinate number of buckets.

Although the SET COVERAGE command causes the Collector to remove test coverage breakpoints after the first execution, you can order the breakpoints removed after any specified number of executions by using the /UNTIL:*n* qualifier. The following command specifies placement of test coverage breakpoints on every codepath of routine FINDSUM, and removal of them after the third execution:

```
PCAC> SET COVERAGE/UNTIL:3 ROUTINE FINDSUM BY CODEPATH
```

When compiling your program to gather coverage data, use the/NOOPTIMIZE qualifier to prevent the compiler from optimizing code and gathering incorrect results.

2.4.3.2. Modules

You can specify a type of program location by providing a formal nodename followed by a BY clause. For example, to test coverage on every routine in Module M1, enter the following command:

```
PCAC> SET COVERAGE MODULE M1 BY ROUTINE
```

If the subtree with Module M1 as its root has routine nodes for both R1 and R2, coverage breakpoints are placed on those two routine nodes, but not on root node Module M1.

2.4.3.3. Routines

To specify an individual program location with a nodespec, you must providethe formal name of the corresponding node in the program tree. For example, to get test coverage on Routine R3, use the nodespec ROUTINE R3:

```
PCAC> SET COVERAGE ROUTINE R3
```

2.4.3.4. Lines

In addition to modules and routines, a program contains nodes for all lines in a program. You can specify all lines in a given program unit by using a BYLINE clause. For example, you can test for coverage on every line in Routine R3 by entering the following command:

```
PCAC> SET COVERAGE ROUTINE R3 BY LINE
```

You can also use the PROGRAM_ADDRESS BY LINE nodespec. Measuring test coverage at that many program locations is reasonable because test coverage data is collected only once for each line.

You can use the SEARCH and TYPE commands to display specific lines, or a range of lines. See *Section 4.7.4.1, "Viewing Displays with TYPE and SEARCH Commands"* for information on these commands.

2.4.3.5. Path-Name Qualification

If the name of a routine or line is not unique, you must specify its formal name with a partial or full path-name qualification. A **path name** for a program unit is either the formal name of that unit or an expansion of the name that specifies the unit's nesting within other program units. In a path name, the name of the program unit is preceded by the name of its root node; backslashes (\) separate the names. (If the language is set to Ada, you can also use the period (.) as a separator.) For example, if the name of Routine R2 is not unique, you would have to specify it as M1\R2. R2 is still the routine name, but it is prefixed with M1\ to indicate that the desired routine is Routine R2 in Module M1:

```
PCAC> SET COVERAGE ROUTINE M1\R2 BY LINE
```

If a routine is nested within other routines, further qualification may be required in the routine's path name. Routine R4, for example, is nested within Routine R3, which is nested in Module M2. Its full path name is M2\R3\R4.

Specifying Path Names for Source Lines

Path names also apply to source lines. A source line is identified by a name of the form %LINE *n*, where *n*is the line number. Because line numbers are generally not unique in programs with multiple modules, line numbers usually require path-name qualification. For example, line 25 in Routine R4 might have path names such as `R4\%LINE 25`, `R3\R4\%LINE 25`, or `M2\R3\R4\%LINE 25`. However, specifying only the module name and line number is sufficient because line numbers are always unique within a separately compiled module. For example:

```
PCAC> SET COVERAGE LINE M2\%LINE 25
```

2.4.3.6. Collecting Coverage Data from Multiple Test Runs

Generally, a series of executions is necessary to test all parts of a large program. To collect coverage data from multiple test runs, use the /APPEND qualifier on the SET DATAFILE command. Then, to avoid gathering redundant data for commonly used code, use the /PREVIOUS qualifier with the SET COVERAGE command, as in the following example:

```
PCAC> SET DATAFILE/APPEND MY_DATAFILE.PCA
PCAC> SET COVERAGE/PREVIOUS PROGRAM_ADDRESS BY CODEPATH
```

The /PREVIOUS qualifier causes the Collector to measure coverage at each designated program location only once during the entire set of program executions (collection runs). If a location has been covered in a prior execution, the Collector does not attempt to measure coverage of that location in subsequent executions of the program.

If the SET DATAFILE command creates a new data file, it then places test coverage breakpoints on all program locations that you specified on the SET COVERAGE command. When the collection run ends, all breakpoint locations not hit (or not hit *n* times if /UNTIL:*n* was also specified) are recorded in the data file as not covered.

If the SET DATAFILE command finds an existing file, then the breakpoint locations recorded by the previous collection run (those that were requested but not hit) are used. In this case, if you specify node specifications, they are ignored. When the collection run ends, all breakpointl ocations still not hit are once again recorded in the data file as not covered. Thus, each collection run starts with the breakpoint locations remaining from the previous collection run and passes on a reduced breakpoint table to the next collection run.

If you intend to use the Analyzer MERGE/ANC command (see *Section 3.4.1, "Merging PCA Performance and Software Performance Monitor (SPM) Files"*) to write acceptable noncoverage information to a table, use the /ANC qualifier. This qualifier instructs the Collector to save the codepaths of the current version of the program for comparison with codepaths from another version of the program. This information is comprised of all codepath information in the modules that were specified by the nodespec in the SETCOVERAGE/ANC command. The Analyzer can tell which routines have changed from this saved information. See *Section 3.6, "Using Acceptable Noncoverage (ANC)"* for information on acceptable noncoverage (ANC).See *Section 4.5, "Determining Acceptable Noncoverage (ANC)"* for an example of collecting, merging and setting ANC data.

2.4.3.7. Gathering Test Coverage Without Optimization

When gathering information on how completely a given set of test data covers your program, you may find it helpful to first compile your program with the /NOOPTIMIZE qualifier. Compiling the program without optimization makes the program run slower, but may make it easier to relate the coverage points in the object module back to the original source code. If you measure test coverage over fully optimized code, then simple one-to-one correspondence between the coverage points in the optimized object code and the constructs in your source program may be lost.

2.4.4. Execution Count Data

The SET COUNTERS command determines the exact number of times that various parts of your program execute by placing breakpoints at specified program locations. Each time a breakpoint executes, the Collector records a count for that location. The Collector lets you specify these locations either individually or collectively. For example, an individual location could be line 6 of routine FINDSUM in your program, whereas a type of program locations could be every routine in the whole program or every line in a given routine.

Specify these code locations by using node specifications on the SET COUNTERS command. (See *Section 2.4.3, "Test Coverage Data"* for a full explanation of Collector node specifications.) The following example specifies placement of an execution counter on line 6 of routine FINDSUM:

```
PCAC> SET COUNTERS LINE FINDSUM\%LINE 6
```

The nodespec FINDSUM\%LINE 6 specifies an individual program location for an execution counter. In the next example, the PROGRAM_ADDRESS BYROUTINE nodespec causes execution counters to be placed on every routine in the entire program:

```
PCAC> SET COUNTERS PROGRAM_ADDRESS BY ROUTINE
```

Note

Counting the number of times that program locations execute greatly increases CPU overhead. Therefore, you should be selective in using execution counters.

Placing an execution counter on every line in a program may make the program run a hundred times slower. Place execution counters at the entry point to each routine in your program, or for all lines in one routine, or for only strategic program locations.

It is practical to use execution counters when you need more exact data than you can get from PC sampling. Because execution count results are repeatable (provided the program and its input are fixed), useful data can be collected in short collection runs.

2.4.5. Page Fault Data

The SET PAGE_FAULTS command collects the following kinds of data for each page fault the user program generates:

- The address of the instruction that caused the fault
- The faulting virtual address
- The current CPU time

Specify the collection of this data with the following command:

```
PCAC> SET PAGE_FAULTS
```

Collecting page fault data alters your program's page faulting behavior. The Collector requires some code and data to collect page fault data and therefore produces paging of its own. This reduces your program's working set, which increases the program's paging. This usually has little or no effect on the sites of the page faulting peaks in your program; the small disruptions introduced by the Collector can usually be ignored when you are trying to discover where your program is producing the most page faults.

Distortions introduced by collecting page fault data and other data at the same time can be significant. The process of collecting these other kinds of data may in itself cause page faulting, which distorts the page fault data. Avoid collecting call stack return addresses when collecting page fault data because the Collector can affect your program's page faulting behavior as it traverses the call stack. Call stack return addresses cannot be collected for the page fault data itself, but can be collected for other kinds of data during the run.

PCA supports this command on both OpenVMS VAX and OpenVMS Alpha.

2.4.6. System Services Data

The SET SERVICES command determines exactly how many times your program calls each system service. For each system service call, PCA command gathers the following data:

- The system service index
- The PC address of the system service call
- The current CPU time

Specify the collection of this data with the following command:

```
PCAC> SET SERVICES
```

PCA supports this command on both OpenVMS VAX and OpenVMS Alpha.

For more information on system services and a list of the available system services, see the *VSI OpenVMS System Services Reference Manual*.

2.4.7. Input/Output Data

Use the SET IO_SERVICES command when you want to collect more information on I/O data than you can collect with the SET SERVICES command. For example:

```
PCAC> SET IO_SERVICES
```

The SET IO_SERVICES command measures several Record Management Services (RMS). See *Appendix B, "PCA Reference Tables"* for a listing of both RMS and non-RMS services measured by this command. For more information on RMS services, see the *VSI OpenVMS Record Management Services Reference Manual*.

The data gathered for each I/O system service depends on the service, but, where appropriate, includes the following information:

- The I/O system service index
- The PC address of the I/O call
- The current CPU time
- The file name
- The physical I/O read count
- The physical I/O write count
- The file access block (FAB)
- The record access block (RAB)

PCA supports this command on both OpenVMS VAX and OpenVMS Alpha.

2.4.8. Tasking Data

For multi-task applications, you can determine how much time or other resource is spent in a particular task. Use the following command to instruct the Collector to gather tasking information:

```
PCAC> SET TASKING
```

The Collector records the following:

- The context switch
- The task priority
- The task type

- The PC value of the address where the task was created
- The CPU time
- The parent task

PCA supports this command on both OpenVMS VAX and OpenVMS Alpha.

2.4.9. Events Data

You can filter your data so that the Analyzer creates histograms or tables using only data from a specified phase of your program. Place **event markers** in the datafile using the Collector SET EVENT command. An event marker is a record that the Collector inserts into the data file whenever control passes to a specified program location during program execution.

The SET EVENT command uses two parameters to identify an event. The first parameter is the event name you want to use, and the second parameter is a list of one or more node specifications whose execution constitutes the actual event. Each program location is specified by a node specification. For more information on node specifications, see *Section 2.4.3, "Test Coverage Data"*. The second parameter may specify multiple node specifications separated by commas. The following is an example of a valid SET EVENT command:

```
PCAC> SET EVENT COMPUTE LINE  M1\R2\%LINE 25
```

In this example, the event name is COMPUTE and the event breakpoint location is line 25 of Routine R2 in Module M1. Whenever line 25 executes, an event marker for event COMPUTE is written to the data file. If you specify more than one breakpoint location for the event COMPUTE, execution of any of the designated locations would mark that event in the file.

You can use event markers to limit analysis of performance data to data collected between any two events occurring in your program's execution. The event marked is the execution of code at that program location.

The SET EVENT command causes the Collector to insert breakpoints at specified program locations. When the breakpoint location executes, all currently accumulated data is written to the data file followed by a time-stamped event marker record. The event marker record signifies that the indicated event occurred. You must specify an event name for each event. The Collector records all event names in your data file. Event markers, in effect, partition the collected data by time.

For example, if your program consists of three main phases—an input phase,a compute phase, and an output phase, executed in that order—you may want to look at the data from only one of these phases. If you want to investigate how often your program calls a particular utility routine during the compute phase of your program, place an event marker at the beginning of the compute phase and at the beginning of the output phase. Then, you can examine the data that is collected between these event markers. Data gathered between two event markers is associated with the event name given to the first of the two markers.

2.4.10. Collecting Vector Instruction Data

The Collector provides the following three commands to allow you to gather information on the execution of vector instructions in your programs:

- SET VCOUNTERS
- SET VCPU_SAMPLING

- SET VPC_SAMPLING

This section summarizes each of these commands. *Chapter 5, "Using VAX Vectors with PCA"* contains a complete discussion of using VAX Vectors with PCA.

2.4.10.1. Vector Program Counter Sampling Data

The SET VPC_SAMPLING Collector command lets you collect PC values for random vector instructions based on the wall clock. The collected data lets you determine the scalar/vector parallelism throughout your entire program.

When you collect vector PC samples, you set a sampling interval timer that includes all idle time associated with the current run of the program. This form of sampling shows you where the time is being spent in the program with little cost to the time of actually running the program.

2.4.10.2. Vector CPU Time Data

The SET VCPU_SAMPLING Collector command allows you to collect PC values for random vector instructions based on the processor clock. The collected data lets you determine the scalar/vector parallelism throughout your entire program.

When you collect vector CPU samples, you set a sampling interval timer that includes only the time when the program is actually running the processor. This form of sampling allows you to focus on the particular area of the program's algorithm where the time is being spent, and not on the areas where outside influences consume time.

2.4.10.3. Vector Instruction Execution Count Data

The SET VCOUNTERS command determines the exact number of times that vector processor instructions are executed in all or part of your program. You must specify at least one nodespec on the command line to indicate one of the following domains of the data to be collected:

- PROGRAM ADDRESS by VINSTRUCTION
- MODULE module-name by VINSTRUCTION
- ROUTINE routine-name by VINSTRUCTION

2.4.11. Collecting PC Values from the Call Stack

For some forms of data collection, the Collector records the current value of the program counter, along with the other data collected. The Analyzer uses the program counter to associate the collected data with the particular module, routine, line, or other program unit that generate the data.

Sometimes the value of the program counter may not be the most meaningful program address to collect. For example, if you gather I/O data on your FORTRAN program, the PC values of all the I/O system service calls are within the address range of the FORTRAN Run-Time Library. What you really need to know is what sections of your FORTRAN program are causing the I/O calls. To discover what program code is calling the Run-Time Library, you must gather all subroutine return addresses stored on the stack for each collected data point.

The SET STACK_PCS command allows you to gather stack PC values, consisting of the original PC value and all subroutine return addresses on the Call Stack, for the following kinds of data:

- PC sampling data

- CPU sampling data
- System services data
- I/O services data
- Exact execution counts
- Test coverage data
- Vector PC sampling data
- Vector CPU sampling data
- Vector counters data

The Call Stack return addresses cannot be gathered for page fault data. Page fault data is collected within the OpenVMS operating system at a point where it is not possible to traverse the call stack to gather return addresses. (Walking the stack at that point can generate page faults.)

To collect additional PC values from the Call Stack for all data collections, enter the following command:

```
PCAC> SET STACK_PCS
```

Collecting this data adds to the amount of data gathered and to the processing overhead of gathering the data. However, you can gather exactly the data you need and minimize PCA's overhead by selectively collecting desired data kinds with the /STACK_PCS qualifier.

2.4.11.1. Collecting Stack PCs by Data Kind

Call Stack return addresses can be gathered selectively by data kind with the /STACK_PCS qualifier. The /STACK_PCS qualifier allows you to collect only the data that you need, thus minimizing PCA's overhead.

The /STACK_PCS qualifier causes the collection of stack PC values. The /NOSTACK_PCS qualifier prevents the collection of stack PC values.

For example, the following command disables the collection of stack PC values for the current CPU_SAMPLING collection. Further CPU_SAMPLING requests assume a default of /NOSTACK_PCS.

```
PCAC> SET CPU_SAMPLING/NOSTACK_PCS
```

Note that canceling a collection does not affect the present /STACK_PCS default value. For example, enter the following commands to collect stack PC values:

```
PCAC>  SET IO_SERVICE/STACK_PCS
PCAC>  CANCEL IO_SERVICE
PCAC>  SET IO_SERVICE
```

You can collect stack PC values for all nodespecs of a measurement,or for none. If you enter the following command sequence, then stack PC values are not collected:

```
PCAC>  SET COUNTERS/STACK_PCS MODULE A BY LINE
PCAC>  SET COUNTERS/NOSTACK MODULE B BY LINE
PCAC>  SET COUNTERS MODULE A BY LINE
```

The SET STACK_PCS command overrides all previously set /NOSTACK_PCS qualifiers and causes a new default of /STACK_PCS. The CANCEL STACK_PCS command overrides all previously set /STACK_PCS qualifiers and causes a new default of /NOSTACK_PCS. For information on data kind collection in vector applications, see *Chapter 5, "Using VAX Vectors with PCA"*.

2.5. Selecting the Language of Your Application

The language setting determines how PCA parses symbol names in command input. If the language is set to C, PCA treats symbol names as case sensitive. If the language is set to anything other than C or C++, symbol names are assumed to be case insensitive.

When you use the SET DATAFILE command, the language setting is determined by the language of the main routine in the program. Typically, you need not change this setting. However, if you have a mixed-language program that includes C or C++ modules, you may have to change the language setting before you can reference symbols that include lowercase letters. You can change the language setting by using the SET LANGUAGE command. For example:

```
PCAC>  SET LANGUAGE C
```

This command changes the language setting to C. Symbol names are then parsed by the C language rules.

2.6. Naming the Collection Run

Each program execution run under Collector control is called a **collection run**. The data collected from each collection run is recorded separately in the performance data file. Collection run numbers are assigned sequentially by the Collector, starting at 1.

You may assign a name of your choice to each collection run with the Collector SET RUN_NAME command, as follows:

```
PCAC> SET RUN_NAME name-of-run
```

If name-of-run does not start with an alphabetic character, you must enclose it in quotation marks.

If you assign the same collection run name to more than one collection run in the same data file, data from all those runs passes the filter specified by that name. Thus, you can assign the same collection run name to a whole group of collection runs when you intend to filter that group of runs as a unit in the Analyzer.

If you do not use the SET RUN_NAME command, you get a null run name; the Collector assigns a number as a run name. To show collection run names, use the SHOW RUN_NAME command.

2.7. Starting and Terminating Data Collection

After you invoke the Collector and optionally set the data file and collection type, enter the GO command to start data collection.

To stop a Collector session before you enter the GO command, enter the EXIT command or press Ctrl/Z. If the data collection has already started, you cannot enter an EXIT command; you must press Ctrl/Y to stop the collection run.

If you press Ctrl/Y, do not use the DCL STOP command immediately afterward. If Ctrl/Y interrupts the Collector when the Collector is executing supervisor-mode code, a subsequent STOP command may cause a supervisor-mode exception that kills your entire process and logs you out. To avoid this, execute another program after pressing Ctrl/Y, or type EXIT. The Collector's exit handlers then successfully close out the data collection.

To stop Collector output to your terminal, such as SHOW command output, press Ctrl/C. The Collector aborts the command and returns to DCL level.

To run your program without collecting data, use the /NOCOLLECT qualifier with the GO command.

2.8. Using Collector Command Procedures

If you repeatedly enter the same group of commands to the Collector, then place those commands into a **command procedure**. This makes command entry more efficient and less error prone.

A command procedure is a text file of commands that substitute for an interactively entered sequence of commands. The default file type is .PCAC. Add SET VERIFY to the procedure to view the commands as they are executed from the procedure.

When the Collector encounters a GO command in a command procedure, it starts collecting data and does not accept additional commands from the terminal or from the command procedure. If a command procedure does not contain a GO command, the Collector interactively prompts for further commands after executing the commands in the command procedure.

When the Collector encounters an EXIT command in a command procedure, that command procedure terminates and control returns to the command stream (either the terminal or a previous command procedure) that invoked the command procedure.

You can also create a special type of command procedure called an **initialization file** that is automatically read and executed every time the Collector is initialized for a new collection run. A Collector initialization file allows you to collect the same performance or coverage data in many separate collection runs, and to collect data in a batch run. Define the Collector initialization file by defining the logical name PCAC$INIT to be the file specification for the initialization file. The following DCL command defines the file COLLECTOR_STARTUP.PCAC as an initialization file:

```
$ DEFINE PCAC$INIT SYS$LOGIN:COLLECTOR_STARTUP.PCAC
```

An initialization file often includes a SET DATAFILE command (usually with the /APPEND qualifier), some data collection commands, and a GO command. For example:

```
SET DATAFILE/APPEND PRIMES_IO    ! Append data to existing file
SET IO_SERVICES                  ! Collect I/O services data
GO                               ! Start collection
```

2.9. Using Collector Logical Names

The Collector checks for a number of logical names which, if defined, modify the activity of the Collector in various ways. These names perform functions such as defining input and output streams and defining the name of the performance data file to use. In *Section 2.8, "Using Collector Command Procedures"*, PCAC$INIT was used to define an initialization file. As a convenience, use logical names rather than repeated commands to pass information to the Collector.

The Collector accepts the following logical names:

PCAC$DATAFILE	PCA$RUN_NAME
PCA$INHIBIT_MSG	PCAC$INIT
PCAC$INPUT	PCAC$OUTPUT
PCAC$DECW$DISPLAY	

For a more detailed description of these logical names, see *Table B.4, "Collector Logical Names"*.

2.10. Gathering Shareable Image Data

To measure the performance of a shareable image, use the /SHAREABLE qualifier with the SET DATAFILE command. When you measure the performance of a program, some of the data you collect may come from shareable images called by your program.

Note

There are two classes of shareable images: those that are user written, and those that are provided. The Analyzer can report symbolically only on user-written shareable images. See the *VSI OpenVMS Linker Utility Manual* for more information on shareable images.

The Collector writes all shareable image names and address ranges to the performance data file. The Analyzer uses this information to report on each shareable image.

User-Written Shareable Images

Before you can collect data, you must build a shareable image on which to collect that data. Next, you must link an executable image that uses that shareable image. The following steps are necessary:

1. Compile all sources for the shareable image with /DEBUG to gather performance data on a shareable image. To do symbolic performance analysis on the shareable image, first compile the sources:

   ```
   $ FORTRAN/DEBUG SHARE
   ```

   In this example, MAIN.FOR is the source file for your main image, and SHARE.FOR is the source file for the shareable image to be called by other programs. Assume that SHARE.FOR has a single universal symbol called SHARED_ROUTINE, which isa routine called from the main program MAIN.FOR.

2. Enter LINK/SHAREABLE/DEBUG to create a version of the shareable image that contains the DST information the Collector needs and enter the universal symbol:

   ```
   $ LINK/SHARE/DEBUG SHARE,SYS$INPUT/OPTION-
   _$ UNIVERSAL=SHARED_ROUTINE Ctrl/Z
   ```

   This command builds the shareable image SHARE.EXE in your current directory.

3. Link the program /DEBUG to link the programs that use the shareable image. Because it is a shareable image, you cannot run SHARE.EXE directly. Instead, you have to link your main image against it, then point the logical name SHARE to your copy of SHARE.EXE:

   ```
   $ LINK/DEBUG MAIN,SYS$INPUT/OPTION SHARE.EXE/SHARE Ctrl/Z
   $ DEFINE SHARE SYS$DISK:[]SHARE.EXE
   ```

   Point LIB$DEBUG to PCA Collector:

```
$ DEFINE LIB$DEBUG PCA$COLLECTOR
```

4. Run the programs that use your shareable image, as follows:

   ```
   $ RUN MAIN

                   PCA Collector Version 4.6

   PCAC>
   ```

5. Enter the SET DATAFILE/SHAREABLE=img-name command. This command specifies the shareable image to be measured.(The /SHAREABLE=(img-name,dst-file) form of the /SHAREABLE qualifier is supported, but only for the sake of compatibility with PCA Version 1.0.) When you get the Collector prompt, enter the SET DATAFILE command:

   ```
   PCAC> SET DATAFILE/SHAREABLE=SHARE MY_DATAFILE.PCA
   ```

   SHARE is the name of the shareable image to be measured, and MY_DATAFILE.PCA is the file specification for the performance data file.

   The Collector creates the performance data file, extracts the required symbol table information from the shareable image, and writes it to the data file. The Collector then prompts for additional commands.

6. Specify your remaining data collection commands and enter a GO command to start the data collection. After the collection run ends, you can process the performance data by running the Analyzer.

You can measure the performance of one shareable image averaged over many executions of different programs. Use the /APPEND qualifier to collect data from several program executions into one data file.

Chapter 3. Using the Analyzer

This chapter describes the Analyzer, explains the steps you must follow to use the Analyzer, and provides examples of tasks you can perform while using the Analyzer.

3.1. Overview

The Analyzer provides a graphical representation of the performance data gathered by the Collector. To display and analyze the data in your performance data file, you perform the following general steps:

1. Invoke the Analyzer, which then reads the performance datafile that the Collector has built.
2. View the performance data results as tabular and graphical reports, filtering and refining the data to get a more detailed view.
3. Analyze and pinpoint the bottlenecks in your application or evaluate the thoroughness of your testing environment.

Each of these steps is described fully in this chapter.

You can use the Analyzer to produce the following kinds of reports:

- Performance histograms showing how much time or other resource is consumed by various parts of your program
- Tables showing information in the form of raw data counts and percentages
- Annotated source listings showing performance or coverage data
- Histograms and tables for other data domains, such as the number of calls per system service, or the amount of I/O per file used by your program
- Listings of your raw performance data
- Dynamic call trees that show the frequency of each call chain

3.2. Invoking the Analyzer

To invoke the Analyzer, type the PCA command and specify the name of a performance data file at DCL level. For example:

```
$ PCA PCA$PRIMES

         Performance and Coverage Analyzer Version 5.0

PCAA>
```

The data file in the previous example, PCA$PRIMES.PCA, contains the performance or coverage data and all symbol table information required by the Analyzer.

See *Chapter 1, "Introduction"* for complete information on invoking the Analyzer, creating the default plot, scrolling through your display, interpreting the summary page, and printing, filing, and appending Analyzer output.

3.3. Generating Histograms and Tables

The PLOT and TABULATE commands display performance and coverage data in an understandable form. The PLOT command produces performance histograms that plot the distribution of resource usage over your program or over other data domains. The TABULATE command presents the same information in the form of tables so you can see the actual data counts, instead of scaled histogram bars.

The PLOT and TABULATE command qualifiers specify the kind of data to analyze, and the format and display of the output.

When you enter a PLOT command, use the qualifiers to specify what kind of data to tally and how to partition the histogram into buckets. These two elements define the meanings of the horizontal and vertical axes of the histogram.

If you do not specify a data-kind qualifier on a PLOT or TABULATE command, then a default data kind is used based on the data collected in the data file. See the online PCA Command Dictionary for detailed information on the PLOT and TABULATE commands.

3.3.1. Specifying the Kind of Data to Tally in the Histogram or Table

In order to plot or tabulate a certain kind of data, you must have already collected the data in the Collector. The Analyzer data kind directly corresponds to the data gathered in the Collector. *Table B.7, "The SET Command with Corresponding Data-Kind Qualifiers"* shows the correspondence of the Collector SET commands to the Analyzer data-kind qualifiers.

Use the data-kind qualifiers on the PLOT or TABULATE command to specify which kind of performance or coverage data to tally in the histogram. For example, if coverage data has been collected in the Collector, then the Analyzer data kind can have coverage, noncoverage, and acceptable noncoverage (ANC) information in the performance data file. To display coverage data, enter the following command:

```
PCAA> PLOT/COVERAGE
```

The initial default data-kind qualifier is /PC_SAMPLING.

3.3.2. Partitioning Histograms into Buckets

The node specifications on PLOT and TABULATE commands define how the vertical axis of a histogram or table is partitioned into **buckets**. Each bucket is defined by a value range and corresponds to one histogram bar. Each data-point in the data file is tallied in the bucket whose value range includes the value of that data point. For example, the node specification PROGRAM_ADDRESS BY ROUTINE selects the program address domain, the domain of all possible program addresses. From this domain, it selects the address ranges of the routines in the program. Each of these address ranges defines a bucket. When the Analyzer tallies data points from the performance file, it compares each program address data point value to the value ranges of the buckets and puts the data point in the bucket for the appropriate routine. The resulting plot or table shows the resource usage for each routine in the program. To do this, enter the following command:

```
PCAA> PLOT/PC_SAMPLING PROGRAM_ADDRESS BY ROUTINE
```

Buckets are defined by attributes of the data points in the data file. Depending on the data kind, these attributes can be the program address value, the CPU time stamp, the system service name, the file name, the record size, the physical I/O count, and so on. You can partition many different kinds of data domains along the vertical axis of the plot,not just the program address domain. For example, you can partition the system services domain so that each histogram bar represents the number of calls on one system service.

The PLOT and TABULATE node specifications are similar to those on the Collector SET command. However, the Analyzer accepts a wider range of nodespecs than the Collector does, because the Analyzer nodespecs can cover domains other than the program address domain. Node specifications are discussed in *Section 2.4.3, "Test Coverage Data"*, but some simple examples are presented here. *Example 3.1, "Displaying PC Sampling Data in a Histogram"* shows how to plot program counter sampling data against the whole program partitioned by module.

Example 3.1. Displaying PC Sampling Data in a Histogram

```
PCAA> PLOT/PC_SAMPLING PROGRAM_ADDRESS BY MODULE

                     Performance and Coverage Analyzer        Page 1
          Program Counter Sampling Data (386 data points total) - "*"
Bucket Name         +----+----+----+----+----+----+----+----+----+
PROGRAM_ADDRESS\    |
 PRIMES . . . . . . |*                                             0.8%
 PRIME  . . . . . . |********************************************* 61.9%
 READ_RANGE . . . . |****                                          4.7%
 READ_END_OF_FILE . |                                              0.0%
 READ_ERROR . . . . |                                              0.0%
 OUTPUT_TO_DATAFILE |                                              0.3%
 SHARE$FORRTL . . . |****                                          5.4%
 SHARE$LIBRTL . . . |**                                            2.6%
 SHARE$PCA$COLLECTOR|                                              0.0%
 SHARE$DBGSSISHR  . |                                              0.0%
 SHARE$PCA$PRVSHR . |                                              0.0%
 SHARE$LBRSHR . . . |                                              0.0%
 SHARE$SMGSHR . . . |                                              0.0%
                    |
                    |
                    |
                    +----+----+----+----+----+----+----+----+----+
PCAA>
```

The /PC_SAMPLING qualifier defines the meaning of the horizontal axis of the previous plot;the number of PC sampling data points in each bucket is plotted along that dimension. The node specification defines the meaning of the vertical axis; modules are plotted along that dimension. In this case, each bucket is defined by a module address range and is labeled by a module name.

The scale of the histogram is adjusted so that the longest bar occupies the full width of the plot. You can adjust this scale with the /SCALE qualifier to make the comparison of histograms more convenient.

If you prefer a table to a histogram, use the TABULATE command. *Example 3.2, "Displaying PC Sampling Data in Tabular Form"* displays the same information contained in *Example 3.1, "Displaying PC Sampling Data in a Histogram"* in tabular form.

Example 3.2. Displaying PC Sampling Data in Tabular Form

```
PCAA> TABULATE/PC_SAMPLING PROGRAM_ADDRESS BY MODULE

                    Performance and Coverage Analyzer        Page 1
            Program Counter Sampling Data (386 data points total) - "*"
                            Data             95% Conf
Bucket Name                Count   Percent   Interval
PROGRAM_ADDRESS\ PRIMES . . . . . . . . . .    3     0.8%
 PRIME  . . . . . . . . . .  239    61.9% +/-  4.8%
 READ_RANGE . . . . . . . .   18     4.7% +/-  2.2%
 READ_END_OF_FILE . . . . .    0     0.0%
 READ_ERROR . . . . . . . .    0     0.0%
 OUTPUT_TO_DATAFILE . . . .    1     0.3%
 SHARE$FORRTL . . . . . . .   21     5.4% +/-  2.3%
 SHARE$LIBRTL . . . . . . .   10     2.6% +/-  1.6%
 SHARE$PCA$COLLECTOR  . . .    0     0.0%
 SHARE$DBGSSISHR  . . . . .    0     0.0%
 SHARE$PCA$PRVSHR . . . . .    0     0.0%
 SHARE$LBRSHR . . . . . . .    0     0.0%
 SHARE$SMGSHR . . . . . . .    0     0.0%

PCAA>
```

This example shows that most of the time is consumed in module PRIME. To focus on the area that consumes the most time in module PRIME, examine that module at a finer level of detail.

Example 3.3, "Node Specs Used to Focus on Program Elements" shows how to use nodespecs to reduce data by focusing on certain parts of your program.

Example 3.3. Node Specs Used to Focus on Program Elements

```
PCAA> PLOT MODULE PRIME BY LINE

                      Performance and Coverage Analyzer        Page 1
          Program Counter Sampling Data (386 data points total) - "*"

Percent    Count  Line
PRIME\
                     1:
                     2: C       Function to identify whether a given
                                                          number is p
                     3: C       If it is prime, the returned function
                                                           value is T
                     4: C
  0.0%               5:         LOGICAL FUNCTION PRIME(NUMBER)
  0.0%               6:         PRIME = .TRUE.
  0.3%               7:         DO 10 I = 2, NUMBER/2
 60.4%  ********     8:         IF ((NUMBER - ((NUMBER / I) * I)) .EQ.
                                                               0) THEN
                     9:             PRIME = .FALSE.
  0.0%              10:             RETURN
  0.0%              11:         ENDIF
  1.3%              12:    10   CONTINUE
  0.0%              13:         RETURN
                    14:

ENDPCAA>
```

This example shows that line 8 of module PRIME consumes about 60% of the total time in the program. To improve performance, concentrate on the algorithm that contains line 8 or calls routine PRIME.

3.3.2.1. Filtering Performance Data

You can filter performance or coverage data before the data is used to generate histograms or tables. This is useful when you wantonly a certain part of that data to be considered in a given data reduction. For example, you may only want the data associated with a certain event marker to be included in your histogram.

Setting Filters

To filter data, you must establish filter definitions with the SET FILTER command. The SET FILTER command takes two parameters: a filter name that you define and a comma-delimited list of filter restrictions (see the online PCA Command Dictionary). The filter restrictions specify limits or conditions that any given data point must satisfy in order to pass the filter. You can filter data on all attributes that are used to plot or tabulate data.

For example, if you want all data points that are tallied in a certain plot to come from collection run 3 or collection run 5, use the following SETFILTER command before entering the PLOT command:

```
PCAA> SET FILTER F1 RUN_NAME=3, RUN_NAME=5
```

Any data point that comes from collection run 3 or collection run 5 passes filter F1.

Similarly, if you want to tally all data points from all collections other than collection run 8, use the following SET FILTER command before entering the PLOT command:

```
PCAA> SET FILTER F2 RUN_NAME<>8
```

Specifying Multiple Filter Restrictions

By specifying multiple restrictions for a single filter, you can logically OR the restrictions. Also, by declaring more than one filter, each with a separate SET FILTER command and name,you can logically AND the restrictions. That is, if you have several filters, data points must pass every one of those filters to be included in a plot or table. These capabilities give you considerable flexibility in filtering your performance or coverage data. See the description of the SET FILTER command in the online PCA Command Dictionary for examples of specifying multiple filter restrictions.

Multiple filters are applied in the order that they are specified. There are no precedence rules.

Filtering Data by Event Name

You can filter data by event name. To do this, use the following filter declaration:

```
PCAA> SET FILTER F2 TIME=EVENT_NAME
```

EVENT_NAME is the name of an event marker whose data you want to include in subsequent plots or tables. Event markers are declared with the SET EVENT command in the Collector.

You can also filter data by chain_name, as in the following example:

```
PCAA> SET FILTER CHAIN_NAME=(ROUTINE1,*)
```

(ROUTINE1,*) filters all the data points with the call chains that have ROUTINE1 at the bottom of the stack. If you specified (*,ROUTINE1,*,ROUTINE2,*), the filter would apply to data points that have the call chain of ROUTINE1 calling ROUTINE2 directly or indirectly. Note that you can only use wildcards for program unit names as a whole, but not for portions of their identifiers. For example, (ROUT*) does not mean all of the routines that begin with ROUT. Rather, the meaning is for the program unit name of ROUT*.

The SET FILTER command, described in the online PCA Command Dictionary, contains the filter restrictions that specify the conditions that any given data point must satisfy in order to pass the filter. You can filter data on all attributes that are used to plot or tabulate data.

The following command selects only the data points that have ROUTINE_1 on their stack:

```
PCAA> SET FILTER/CUMULATIVE F1 PROG_ADDR=ROUTINE_1
```

PROG_ADDR=ROUTINE_1 indicates that the PC used must be in the address range of ROUTINE_1. /CUMULATIVE indicates that every PC on the stack should be looked at, and any PC that passes the data point passes the filter.

The following command selects only those data points where ROUTINE_2 called ROUTINE_1 directly:

```
PCAA> SET FILTER/MAIN=ROUTINE_1/STACK=1 F1 PROG_ADDR=ROUTINE_2
```

/MAIN=ROUTINE_1 indicates a step down the stack until the return PC is in ROUTINE_1. /STACK=1 indicates a step one frame further down. PROG=ROUTINE2 indicates that the PC must be in the range of ROUTINE_2.

The following command selects only those data points where ROUTINE_2 called ROUTINE_1 indirectly:

```
PCAA> SET FILTER/MAIN=ROUTINE_1/STACK=2/CUM F1 PROG_ADDR=ROUTINE_2
```

/MAIN=ROUTINE_1 indicates a step down the stack until the return PC is in ROUTINE_1. /STACK=2 indicates a step two frames further down the stack. /CUMULATIVE specifies to look at all the remaining addresses. PROG=ROUTINE_2 specifies that if the address is in the range of ROUTINE_2, the PC passes the filter.

Rules for Applying Filter Specifications

After you have defined a filter, that filter remains in effect for all subsequent PLOT and TABULATE commands. However, that does not mean that the filter will always be applied to the current plot. If the data kind is inconsistent with the specified filter because of the data collected, then the filter is ignored and the data point is included in the histogram. *Table B.9, "Filter Specification by Data Kind"* shows when the filter specification is applied and when it is not.

Canceling a Filter

You can cancel a filter with the CANCEL FILTER command or enter another SETFILTER command with the same filter name. The CANCEL FILTER command takes as a parameter the name of the filter to cancel. If you want to cancel all current filters, use the CANCEL FILTER/ALL command.

Showing Filters

To show what filters you currently have defined, use the SHOW FILTER command. The summary page from any PLOT or TABULATE command also lists the current filters.

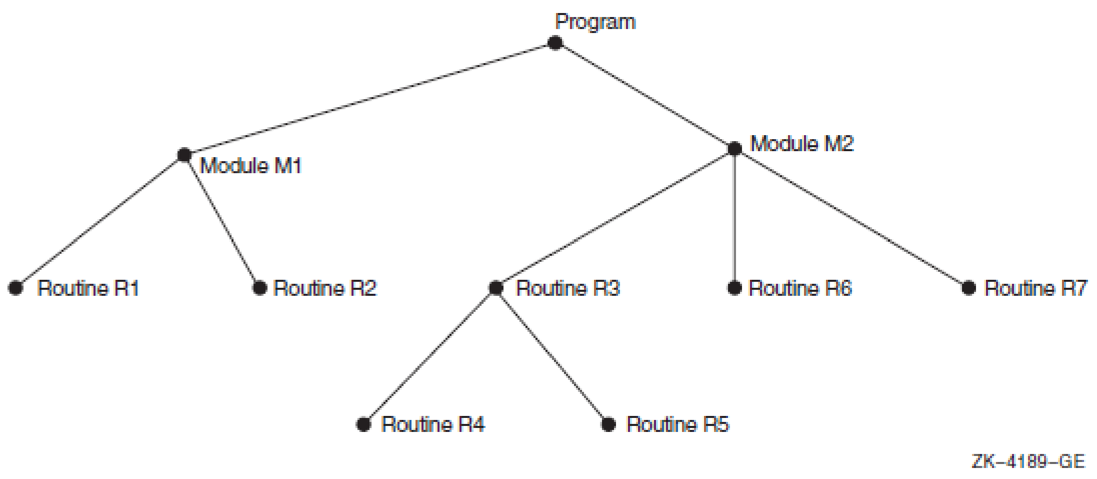
3.3.2.2. Specifying Modules and Routines

Each node in a program tree has an associated address range. The address range for each routine is the first code address of the routine through the last code address. Each module also has, as an address range, the sum of all the routine address ranges within that module. (A module may have several disjoint address ranges since the routines within that module may not be contiguous in memory.) All such address range information is derived from the program's Debug Symbol Table (DST) and stored in the performance data file. For example, to plot the address ranges of routines in a specific module, use the formal name for the module and the BY ROUTINE nodespec:

```
PCAA> PLOT MODULE M1 BY ROUTINE
```

Figure 3.1, "A Program Represented as a Tree" shows the relationship of modules and routines to each other within a program's tree structure.

Figure 3.1. A Program Represented as a Tree



3.3.2.3. Specifying Individual Buckets

When you want to specify an individual routine or module in a node specification, you must specify the formal name of the corresponding node in the program tree. For example, if you want one bucket (and one histogram bar) for Routine R3, use the nodespec ROUTINE R3:

```
PCAA> PLOT ROUTINE R3
```

This command does not give you a significant histogram because it requests only a single bucket. However, you can specify a comma list of buckets:

```
PCAA> PLOT ROUTINE R3, ROUTINE R4, MODULE M1
```

This command results in a histogram with three buckets: one for Routine R3, one for Routine R4, and one for Module M1. Each histogram bar is labeled with the name of the corresponding routine or module.

3.3.2.4. Specifying a Set of Buckets

You can specify a whole set of buckets by using node specifications that consist of a formal node name and a BY clause. If you want a bucket in your histogram for every routine in Module M1, specify the MODULE M1 BY ROUTINE nodespec with the following command:

```
PCAA> PLOT MODULE M1 BY ROUTINE
```

Module M1 specifies a node in the program tree, and that node is the root of a subtree. The BYROUTINE clause selects each routine node in the Module M1 subtree and creates a bucket for each one.

The subtree that has Module M1 at its root has routine nodes for routines R1 and R2. The Analyzer creates one histogram bar for each of these two routines.

The formal node name also can be the name of the rootnode for the whole tree: PROGRAM_ADDRESS. If you want a histogram where every routine in your program gets one histogram bar, use the following command:

```
PCAA> PLOT PROGRAM_ADDRESS BY ROUTINE
```

This command creates buckets for routines R4 and R5 (which are nested within routine R3) as well as for all the top-level routines. All routine nodes in the tree are therefore included, even if they are nested below other routine nodes. Similarly, the nodespec MODULE M2 BY ROUTINE includes routines R4 and R5 as well as R3, R6, and R7.

The following command breaks the tree down by module:

```
PCAA> PLOT PROGRAM_ADDRESS BY MODULE
```

This command is useful if your program uses shareable images,such as the run-time library, for your language. The Analyzer creates module nodes for all shareable images and assigns them the appropriate address ranges. Each such module has a formal name of the form MODULE SHARE$imgname, where imgname is the shareable image name. This PLOT command lets you see how much time or other resource is consumed in each shareable image your program calls. You can break down provided shareable images by module only.

3.3.2.5. Specifying Lines

The program tree contains nodes for all lines in the program. Using a BY LINE clause, you can create a bucket for each line in a given program unit. The BYLINE clause in *Example 3.4, "BY LINE Clause Output"* selects all line nodes in the subtree that have Routine R3 as their root.

Example 3.4, "BY LINE Clause Output" shows the output of the previous command.

Example 3.4. BY LINE Clause Output

```
PCAA> PLOT/NOSOURCE ROUTINE R3 BY LINE

                      Performance and Coverage Analyzer        Page 2
          Program Counter Sampling Data (386 data points total) - "*"
Bucket Name        +----+----+----+----+----+----+----+----+----+
 %LINE    37  . . .|                                              0.0%
 %LINE    38  . . .|                                              0.0%
 %LINE    45  . . .|                                              0.0%
 %LINE    46  . . .|                                              0.0%
 %LINE    48  . . .|                                              0.0%
PRIME\             |
 %LINE     5  . . .|                                              0.0%
 %LINE     6  . . .|                                              0.0%
 %LINE     7  . . .|                                              0.3%
 %LINE     8  . . .|********************************************* 60.4%
 %LINE    10  . . .|                                              0.0%
 %LINE    11  . . .|                                              0.0%
 %LINE    12  . . .|*                                             1.3%
 %LINE    13  . . .|                                              0.0%
READ_RANGE\        |
 %LINE     5  . . .|                                              0.0%
 %LINE     8  . . .|**                                            1.8%
```

```
                   +----+----+----+----+----+----+----+----+----+
PCAA>
```

In the previous histogram, each line in Routine R3 gets one histogram bar. Only lines that generate object code appear in the plot. The /NOSOURCE qualifier causes the generation of a histogram instead of an annotated source listing.

You can group several lines per bucket in the histogram or table by using the BY *n* LINES clause. For example:

```
PCAA> PLOT ROUTINE R3 BY 10 LINES
```

Such a clause shortens the histogram or table by a factor of *n*, but gives less resolution.

When plotting or tabulating by line, it is best to use the /SOURCE qualifier to see the annotated listing of your program's source.

Example 3.5, "Using /SOURCE with BY LINE" shows what an annotated source listing looks like when the /SOURCE qualifier and a BY LINE node specification are used.

Example 3.5. Using /SOURCE with BY LINE

```
PCAA> PLOT/SOURCE ROUTINE PRIME BY LINE

                      Performance and Coverage Analyzer        Page 4
            Program Counter Sampling Data (386 data points total) - "*"
Percent     Count  Line
                      4: C  0.0%
                      5:         LOGICAL FUNCTION PRIME(NUMBER)
  0.0%                6:         PRIME = .TRUE.
  0.3%                7:         DO 10 I = 2, NUMBER/2
 60.4%  ********      8:         IF ((NUMBER - ((NUMBER / I) * I)) .EQ.
                                                               0) THEN
                      9:             PRIME = .FALSE.  0.0%
                     10:             RETURN
  0.0%               11:         ENDIF
  1.3%               12:    10   CONTINUE
  0.0%               13:         RETURN
                     14:         END

PCAA>
```

You can also use a node specification such as PROGRAM_ADDRESS BY LINE, but because a large program may have thousands or tens of thousands of lines, you may generate a very large plot that is time-consuming to create and difficult to read. A better strategy is to locate the areas of high resource usage at the module or routine level first; then investigate, line by line, those modules or routines that have high resource usage.

The formal name of a line number node has the following form:

```
LINE [module-name\]%LINE n
```

In this context, module-name is the name of the module containing the line, and *n* is the line number. You can specify the appropriate routine name instead of the module name if the routine name is unique. The line number is always the compiler-assigned listing line number; it is the same line number that the OpenVMS Debugger uses. You can use line number node specifications on PLOT and TABULATE commands, although a BY LINE clause is usually more practical.

You can also use the SEARCH or TYPE commands to determine specific line numbers for desired sections of source. See *Section 4.7.4.1, "Viewing Displays with TYPE and SEARCH Commands"* for information.

3.3.2.6. Specifying Codepaths

If you collect test coverage data or other information by codepath in the Collector, you can use the BY CODEPATH clause when plotting or tabulating such data. Like line nodes, codepath nodes are part of the program tree and are attached to the appropriate routine nodes. Codepath nodes do not have formal names, and therefore cannot be listed individually in node specifications. However, you can use the BY CODEPATH clause to specify all codepaths in a given program unit. *Example 3.6, "Showing Noncovered Codepaths"* shows which codepaths in Module M1 are not covered by your tests.

Example 3.6. Showing Noncovered Codepaths

```
PCAA> PLOT/NONCOVERAGE/SOURCE MODULE M1 BY CODEPATH

                       Performance and Coverage Analyzer        Page 3
               Test Noncoverage Data (48 data points total) - "*"
Percent     Count  Line
                     28:
                     29: C       Verify that the numbers in PRIMES_TABLE
                                                                really a
                     30: C
  2.2%               31:         ERROR_COUNT = 0
                     32:         DO 20 I = 1, COUNT
  2.2%            %LINE 32 + 7
  2.2%               33:         IF (.NOT. PRIME(PRIMES_TABLE(I))) THEN
  2.2%            %LINE 33 + 0C
  0.0%   ********    34:             ERROR_COUNT = ERROR_COUNT + 1
                     35:         END IF
  2.2%               36:    20   CONTINUE
  2.2%               37:         IF (ERROR_COUNT .NE. 0) THEN
  0.0%   ********    38:             TYPE 30, ERROR_COUNT
  0.0%   ******** %LINE 38 + 10
  0.0%   ******** %LINE 38 + 19
                     39:    30       FORMAT (I5, ' wrong prime numbers
                                                            generated')
                     40:         END IF
                     41:

PCAA>
```

Example 3.6, "Showing Noncovered Codepaths" shows histogram bars next to codepaths that are not covered. These noncovered codepaths contain code to handle various error conditions that did not arise when this particular program test was run. In addition, the /SOURCE qualifier displays the source line that starts or contains each codepath.

Codepaths that do not begin on line boundaries are given names of the form %LINE *n* + *offs*. Here *n* is a line number, and *offs* is the hexadecimal byte offset of the codepath from the start of line *n*. For example, %LINE 38 + 10 means that the codepath begins 16 bytes after the start of the code for line 38.

Once you have decided which noncovered program addresses do not need to be tested, that is, those that are acceptably noncovered (ANC), you can save that information for the next test run. See *Section 3.6, "Using Acceptable Noncoverage (ANC)"* for a discussion of acceptable noncoverage.

3.3.2.7. Specifying Bytes

The program tree can also be partitioned by byte. You can use a nodespec such as ROUTINE R1 BY BYTE when you want to create one bucket per byte of address space in Routine R1. This means that you can see how much time (or other resource) is spent at each individual instruction in your program. Not every byte starts an instruction, but those that do show histogram bars proportional to the resource usage of that instruction. Bytes that do not start instructions do not show any resource usage.

Partitioning program units by byte is useful if you have access to machine listings for those units.

A useful variant of the BY BYTE clause is the BY n BYTES clause. This clause causes the Analyzer to generate a histogram with buckets that represent *n*-byte address ranges. For example:

```
PCAA> PLOT ROUTINE R1 BY 10 BYTES
```

Each bucket represents a 10-byte address range within routine R1. Hence, the histogram has one-tenth as many buckets as the full address range of the routine, giving a more compact and more easily understood histogram. By selecting an appropriate *n* value, you can make your own choice between compactness and expanded detail.

You can look at the performance of a shareable image by entering the following command:

```
PCAA> PLOT/PC_SAMPLING MODULE SHARE$LIBRTL BY 100 BYTES
```

3.3.2.8. Omitting Node Specifications

If you omit the node specifications on a PLOT or TABULATE command, that command inherits all qualifier settings and node specifications from the previous PLOT or TABULATE command. Any qualifiers you specify with the new command override the corresponding qualifiers from the previous command. Using this feature, you can first display a plot or table that is approximately what you want, and then modify the qualifiers on that plot or table until you get exactly what you want. You can also change from a plot to a table and vice versa.

For example, suppose you generate a plot with the following command:

```
PCAA> PLOT/PC_SAMPLING/NOSORT PROGRAM_ADDRESS BY MODULE
```

After examining this plot, you may decide that you would rather see the corresponding table, and you may want that table sorted in descending order. You then enter the following TABULATE command:

```
PCAA> TABULATE/DESCENDING
```

Because no parameters are specified with this command, it inherits the qualifiers and node specifications from the previous PLOT command. The /DESCENDING qualifier, however, overrides the previous sorting qualifier, NOSORT, when the histogram changes to a table.

After seeing this table, you may decide that you prefer a plot after all, but you want all buckets with zero data counts suppressed. Enter the following command:

```
PCAA> PLOT/NOZEROS
```

The resulting plot inherits the PROGRAM_ADDRESS BY MODULE node specification and the /PC_SAMPLING and /DESCENDING qualifiers from the TABULATE command. However, the /NOZEROS qualifier applies when your histogram is displayed. Entering additional commands without parameters lets you see more variations on this particular histogram without requiring you to enter a full PLOT or TABULATE command each time.

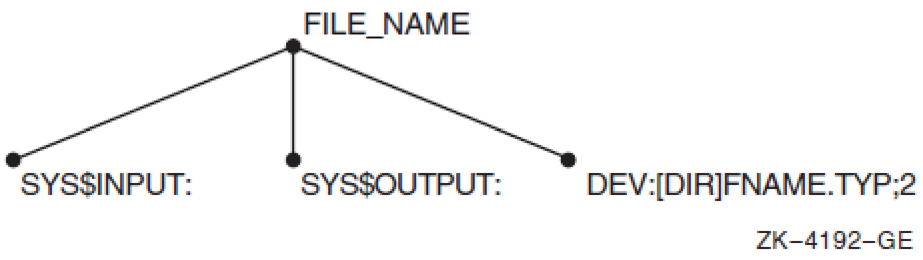
3.3.3. Using Nonaddress Domains

Domains that do not have a value for the program address are grouped together in a class of nonaddress domains. The following sections describe these nonaddress domains.

3.3.3.1. File Name Domain

The Analyzer defines the file name domain in the same way as system services, described in *Section 3.3.3.4, "I/O System Services Domain"*. When you collect I/O data, the Collector collects data values for each I/O system service call,including the file name, the record size, and the I/O system service index for the call. The Analyzer defines a tree for each such domain. *Figure 3.2, "The File Name Domain"* shows what the nodespec tree for the file name domain may look like.

Figure 3.2. The File Name Domain



The rootnode is named FILE_NAME, and the other nodes represent the files the program uses.

3.3.3.2. File Key Domain

The file key domain is useful when you are using indexed sequential files. This domain consists of file keys such as file key 0, the primary key(no key used in I/O call), file key 1 (secondary key used), and file key 2. Use the following command to partition the file key domain by key number:

```
PCAA> PLOT/IO_SERVICES FILE_KEY BY KEY
```

If your program is using the secondary key more than the primary key for I/O access, you can switch key positions; primary key access is more efficient.

For RMS services that the Analyzer can plot, see *Table B.1, "RMS Services Measured by the Collector"*.

3.3.3.3. File Virtual Block Number Domain

You can plot data against the file virtual block number domain. This domain has a rootnode with the formal name FILE_VBN. You can partition this domain by block or by *n* blocks, as in the following examples:

```
PCAA> PLOT/PHYSICAL_IO_COUNT FILE_VBN BY BLOCK
PCAA> PLOT/IO_SERVICES FILE_VBN BY 3 BLOCKS
```

3.3.3.4. I/O System Services Domain

A tree similar to the system services domain exists for the I/O services domain, described in *Section 3.3.3.4, "I/O System Services Domain"*. This tree has the rootnode IO_SYSTEM_SERVICES and a node for each I/O service, with a formal name such as IO_SERVICE SYS$PUT or IO_SERVICE SYS$GET. Based on *Figure 3.2, "The File Name Domain"*, you can plot the number of I/O system service calls per file with the following command:

```
PCAA> PLOT/IO_SERVICES FILE_NAME BY FILE
```

The formal node name FILE_NAME specifies the root of a tree, and the BY clause specifies that all FILE nodes in that tree define the buckets of the histogram.

3.3.3.5. Physical Read Count Domain

You can plot data against the physical read count domain. This domain has a rootnode with the formal name READ_COUNT. You can partition the physical read count domain by block or by *n* blocks, as in the following examples:

```
PCAA> PLOT/IO_SERVICES READ_COUNT BY COUNT
PCAA> PLOT/IO READ BY 10 COUNTS
```

Note that /IO_SERVICES is the only data-kind qualifier that can be used with this domain.

3.3.3.6. Physical Write Count Domain

You can plot data against the physical write count domain. This domain has a rootnode with the formal name WRITE_COUNT. You can partition the physical write count domain by block or by *n* blocks, as in the following examples:

```
PCAA> PLOT/IO_SERVICES WRITE_COUNT BY COUNT
PCAA> PLOT/IO WRITE BY 10 COUNTS
```

Note that /IO_SERVICES is the only data-kind qualifier that can be used with this domain.

3.3.3.7. Total Physical I/O Count Domain

You can plot data against the total physical I/O count domain. This domain has a rootnode with the formal name PHYSICAL_IO_COUNT. You can partition this domain by count or by *n* counts, as in the following examples:

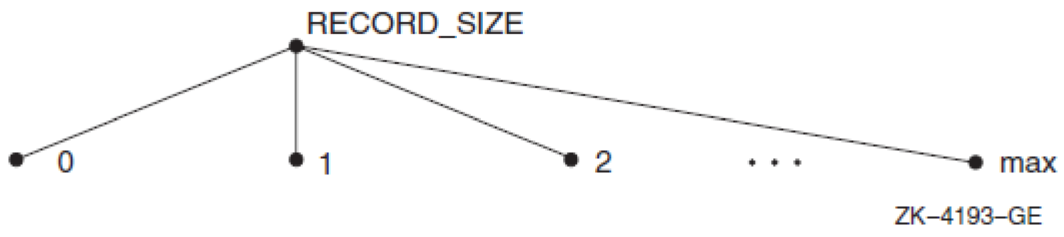
```
PCAA> PLOT/IO_SERVICES PHYSICAL_IO BY COUNT
PCAA> TAB/IO PHYS BY 10 COUNTS
```

Note that /IO_SERVICES is the only data-kind qualifier that can be used with this domain.

3.3.3.8. Record Size Domain

For the record size domain, the root node is called RECORD_SIZE and the nodes represent different record sizes: zero-byte records, one-byte records, two-byte records, up to the maximum record size recorded. *Figure 3.3, "The Record Size Domain"* shows the record size tree.

Figure 3.3. The Record Size Domain



The only node specification for the record size domain is the whole domain partitioned by byte, as follows:

```
PCAA> PLOT/IO_SERVICES RECORD_SIZE BY BYTE
```

The resulting histogram has one bucket per record size, given in bytes. It displays the distribution of record sizes characteristic of this program's I/O, showing how many short records, long records, or in-between records the program has read or written.

You can modify the record size nodespec to specify a range of record sizes for each bucket, as in the following command:

```
PCAA> PLOT/IO_SERVICES RECORD_SIZE BY 10 BYTES
```

In this case, each histogram bar represents a 10-byte range of record sizes, giving a less detailed but more compact histogram.

3.3.3.9. System Services Domain

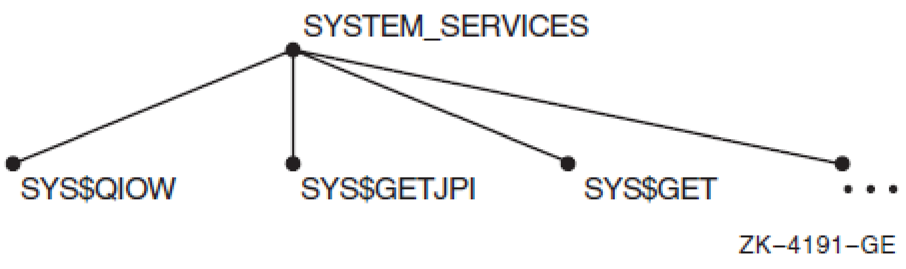
When you collect system services data, the Collector records both the address of the system service call and the system service index. To partition the system services domain into buckets, use a PLOT command to produce a histogram where each bar corresponds to one system service.

```
PCAA> PLOT/SERVICES SYSTEM_SERVICES BY SERVICE
```

This plot tells you how many times each system service is called.

Figure 3.4, "System Services Domain" shows how this node specification is constructed. The system services domain is represented as a tree very similar to the program tree shown in *Figure 3.1, "A Program Represented as a Tree"*.

Figure 3.4. System Services Domain



Attached to the SYSTEM_SERVICES rootnode are nodes for all the individual system services, such as SYS$QIO and SYS$GETJPI. The system service nodes have formal names, such as SERVICE SYS$QIO and SERVICE SYS$GETJPI. These formal names can be listed in the nodespecs of a PLOT or TABULATE command. For example:

```
PCAA> PLOT/SERVICES SERVICE SYS$QIO, SERVICE SYS$GETJPI
```

Each nodespec creates one bucket whose value range is defined by the corresponding system service index.

The most useful node specification for the system services domain applies the BY SERVICE clause to the rootnode, as in the following example:

```
PCAA> PLOT/SERVICES/NOZEROS/DESCENDING SYSTEM_SERVICES BY SERVICE
```

In this case, every system service gets one histogram bar. The /NOZEROS qualifier shortens this plot by eliminating all system services that are not called. Sorting the services in descending order of use lets you examine the most-used service first.

3.3.3.10. Task Domains

You can plot data against the following task domains, expressed as node specifications:

Domain	**Node Specification**
TASK	TASK BY TASK_IDENTIFIER
	TASK_IDENTIFIER task_id
TASK_TYPE	TASK_TYPE BY TASK_TYPE_NAME
	TASK_TYPE_NAME task_type
TASK_PRIORITY	TASK_PRIORITY BY n PRIORITY_UNITS

The TASK domain consists of all the **instances** of a task. Eachinstance is a label composed of an integer identifying the run and a label and integer identifying the task. The following string is an example of a typical identifier for the instance of a task:

```
RUN 3\%TASK 2
```

Although this label identifies each instance of the task, it lacks a symbolic meaning. For this reason, the TASK_TYPE domain is available. The task type is the declared type of the task object. Several instances of a task may have the same type. The TASK_PRIORITY domain is the RTL priority at which each of the tasks run. The range of task priority is between 0 and 15 (this is the dynamic priority).

3.3.3.11. Time Domain

You can also plot data against the time domain. The time domain has a rootnode with the formal name TIME. You can partition the time domain by event, as follows:

```
PCAA> PLOT TIME BY EVENT
```

Each bar of the resulting histogram shows the amount of data collected after event markers for one event name in your collection run. (The Collector SETEVENT command sets event markers.) You can specify individual event names in node specifications by using the following command line.

```
PCAA> PLOT EVENT INPUT, EVENT COMPUTE, EVENT OUTPUT
```

You can also partition the time domain by millisecond ranges. For page fault, system services, task_switch, and I/O data, you can use node specifications of the form TIME BY *n* MSECS, where *n* specifies the number of milliseconds of CPU time per bucket. For example:

```
PCAA> PLOT/PAGE_FAULTS TIME BY 100 MSECS
```

You cannot specify a value of *n* less than 10 in a BY *n* MSECS clause because the CPU measures time in 10-millisecond increments.

3.3.4. Sorting the Histogram or Table

Sorting qualifiers gives you the option of displaying only buckets that are within a certain region of the histogram or table. This helps you reduce the size of the output. The sorting qualifiers specify how to sort the buckets before a histogram or table is displayed. The available sorting qualifiers are /ALPHABETICALLY, /ASCENDING, /DESCENDING, and /NOSORT.

The initial default sorting qualifier is /DESCENDING. The /NOSORT qualifier specifies no sorting at all. In that case, the Analyzer selects an order.

Sorting qualifiers are ignored for source displays. If you use the /SOURCE qualifier and a BY LINE or BY CODEPATH node specification on a PLOT or TABULATE command, the source lines are always presented in line number order regardless of the sorting qualifier.

You can specify that only the first *n* buckets be included in the histogram by adding =*n* to the sorting qualifier, or you can specify that only the buckets numbered *n* through *m* be included by adding =*n:m* to the sorting qualifier. The bucket numbers are assigned sequentially after sorting, and the first bucket is bucket number 1.

The following example shows how to select the first 20 buckets after a histogram has been sorted in descending order:

```
PCAA> PLOT/DESCENDING=20 PROGRAM BY MODULE
```

Similarly, the following command generates a table where the buckets are first sorted alphabetically. After that, the first 10 buckets are discarded, buckets 11 through 20 are kept, and all remaining buckets are discarded:

```
PCAA> TABULATE/ALPHABETICALLY=11:20 PROGRAM BY MODULE
```

If the =*n* or =*n:m* parameters are omitted, all buckets are kept in the histogram or table.

3.3.5. Omitting Buckets of Certain Values

The bucket selection qualifiers let you remove unwanted buckets from your histogram or table. The initial default bucket selection qualifiers are /ZEROS, /NOMINIMUM, and /NOMAXIMUM.

The /NOZEROS qualifier omits buckets with a data count of zero from the histogram or table. Because buckets with a count of zero are frequently insignificant, the /NOZEROS qualifier allows you to condense a histogram or table to only those buckets that contain data. The /ZEROS qualifier retains buckets with zero data counts.

The /MINIMUM=*n*qualifier causes the Analyzer to omit buckets whose percentage falls below the given minimum from the histogram or table. For example, /MINIMUM=10 signifies that the Analyzer should drop all buckets whose data count is less than 10% of the total number of data points. If you use the / NOMINIMUM qualifier, no minimum threshold applies. The /NOMINIMUM and the /MINIMUM=0 qualifiers are equivalent.

Similarly, the /MAXIMUM= *n* qualifier deletes buckets whose percentage exceeds the given maximum from the histogram or table. The /MAXIMUM=30 qualifier omits all buckets whose data count is more than 30% of the total number of data points. If you use the /NOMAXIMUM qualifier, no maximum threshold applies. The /NOMAXIMUM and the /MAXIMUM=100 qualifiers are equivalent.

Bucket selection qualifiers are ignored for source displays. f you use the /SOURCE qualifier and a BY LINE or BY CODEPATH node specification on a PLOT or TABULATE command, the source lines are always presented in line number order regardless of the bucket selection qualifier.

3.3.6. Showing Source Code in BY LINE and BY CODEPATH Histograms and Tables

Source code display qualifiers specify whether the Analyzer displays source code next to the bars in histograms or next to the data counts in tables that are generated with BY LINE or BY CODEPATH node specifications.

The initial default source code display qualifier is /SOURCE. Use the PLOT/NOSOURCE command if you do not want to display source code in the histogram or table.

The /SOURCE qualifier has no effect if you use any node specification other than BY LINE or BY CODEPATH. When /SOURCE is in effect, the sorting qualifiers and the /NOZEROS, /MINIMUM, and /MAXIMUM qualifiers also have no effect. You always see the full source context around each source line.

3.3.7. Using CALL_TREE Node Specifications

With the PROGRAM_ADDRESS domain,you can perform specific call stack analysis by using CALL_TREE node specifications on a PLOT or TABULATE command. This results in a **call tree plot** that displays the call stack relationship of program units by name. As with the /STACK_DEPTH qualifier, in order to perform any kind of call stack analysis, you must first collect stack PC values in the Collector. You cannot use the /ANC, /NONCOVERAGE, /PAGE_FAULT, and /FAULT_ADDRESS qualifiers with the CALL_TREE node specification because no call stack information can be collected for them.

A call tree plot allows you to pinpoint the set of subroutine calls that is consuming most of the system's time. This is particularly useful for programs that utilize commonly-called subroutines that are known to be time-consuming. As an example, suppose your program consists of routines FILE$LOAD, FILE$UPDATE, and FILE$WRITE. The PROG BY ROUTINE nodespec may create a plot that shows most of your time being spent in FILE$WRITE. However, the CALL_TREEBY CHAIN_ROUTINE nodespec may show that most of the time was spent performing the FILE$WRITE routine when called from the FILE$LOAD routine.

Each bucket in the plot is a **call chain**. A call chain is the set of return addresses found on the call stack associated with each data point. The Analyzer attempts to match each PC value on the call stack to a program unit. Any PC value that cannot be matched to a program address unit is resolved to a “best guess,” such as a shareable image or the hexadecimal representation.

The Analyzer creates the call tree plot by scanning the data file once to determine all the measured call chains, then again to match the data points to the specified buckets. The set of measured call chains is the domain. The CALL_TREE node specification represents that domain.

The following node specifications can be given on a PLOT or TABULATE command to provide the domain:

- CALL_TREE BY CHAIN_MODULE
- CALL_TREE BY CHAIN_ROUTINE
- CALL_TREE BY CHAIN_LINE
- CHAIN_MODULE chain_name
- CHAIN_ROUTINE chain_name
- CHAIN_LINE chain_name

A **chain_name** is represented as a comma list of program unit names. The list must be delimited by parentheses. Preceding the chain_name is any one of the identifiers CHAIN_MODULE, CHAIN_ROUTINE, or CHAIN_LINE. The Analyzer interprets each of these identifiers in the same way. The list of program unit names can be line numbers, routines, modules, and hexadecimal numbers.

Note

For case-sensitive languages, use the SET LANGUAGE command to permit the correct parsing. For example, to handle C identifiers and FORTRAN identifiers in the same call chain, set the language to C and use uppercase for all the FORTRAN identifiers.

Example 3.7, "Indented Call Tree Plot" shows an indented call tree plot.

Example 3.7. Indented Call Tree Plot

```
PCAA> PLOT/NOCHAIN_NAME CALL_TREE BY CHAIN_ROUTINE

              Performance and Coverage Analyzer      Page 1
    Program Counter Sampling Data (1156 data points total) - "*"
Percent    Count            Call Chain Name
  1.2%             Chain : MAIN_PROGRAM
  5.5%     **      Chain : . ROUTINE_A
  6.5%     **      Chain : . . UTILITY_ROUTINE_A
 12.5%     *****   Chain : . ROUTINE_B
  3.5%     *       Chain : . ROUTINE_C
  1.4%             Chain : . . SHARE$FORRTL
 15.5%     ******* Chain : . . UTILITY_ROUTINE_A
  2.3%     *       Chain : . . ROUTINE_D
  0.4%             Chain : . . ROUTINE_E
```

In *Example 3.7, "Indented Call Tree Plot"*, a routine name is indented by two characters if that routine was called by another routine. The call levels are hierarchical. That is, MAIN_PROGRAM called ROUTINE_A, ROUTINE_B, and ROUTINE_C directly. ROUTINE_A in turn called UTILITY_ROUTINE_A. ROUTINE_B did not call any other routines, and so on.

The counts and percentages shown are those that occurred in the routines. The /CUMULATIVE qualifier can be used to find the data counts in a given routine, plus all of its calls. The /MAIN_IMAGE and /STACK_DEPTH qualifiers will start the call chains that begin at the specified point on the call stack. The /ALPHABETICALLY[=[*n*:]*m*] qualifier provides an alphabetical sort on the first 255 characters of each call chain in a call tree plot.

If you specify /NOCHAIN_NAME, then the PLOT command's maximum,minimum, and sorting qualifiers are ignored. If you specify /CHAIN_NAME, then these qualifiers are in effect.

Using the comma list form of a call tree plot results in the same output as the previous PLOT command except that each call chain is represented by comma list instead of by indentation. This is useful when specifying sorting options. *Example 3.8, "Comma List Form of a Call Tree Plot"* shows the comma list form of a call tree plot.

Example 3.8. Comma List Form of a Call Tree Plot

```
PCAA> PLOT/CHAIN_NAME CALL_TREE BY CHAIN ROUTINE

              Performance and Coverage Analyzer      Page 1
  Program Counter Sampling Data (1156 data points total) - "*"
Percent    Count              Call Chain Name
  1.2%             Chain : MAIN_PROGRAM
  5.5%     **      Chain : MAIN_PROGRAM,ROUTINE_A
  6.5%     **      Chain : MAIN_PROGRAM,ROUTINE_A,
                                UTILITY_ROUTINE_A
```

```
 12.5%     *****   Chain : MAIN_PROGRAM,ROUTINE_B
  3.5%     *       Chain : MAIN_PROGRAM,ROUTINE_C
  1.4%             Chain : MAIN_PROGRAM,ROUTINE_C,
                                 UTILITY_ROUTINE_A
 15.5%     ******* Chain : MAIN_PROGRAM,ROUTINE_C,SHARE$FORRTL
  2.3%     *       Chain : MAIN_PROGRAM,ROUTINE_C,ROUTINE_D
  0.4%             Chain : MAIN_PROGRAM,ROUTINE_C,ROUTINE_E
```

The comma list form of a call tree plot is useful when specifying sorting options.

3.3.8. Specifying Which Program Counter Values to Tally

Program address selection qualifiers determine which program addresses the Analyzer selects before tallying them in a histogram or table. The initial default program address selection qualifiers are /NOSTACK_DEPTH and /NOCUMULATIVE.

The /[NO]MAIN_IMAGE default depends on the data kind being plotted. If stack PCs have been collected, then /MAIN_IMAGE is the default. In all other cases, /NOMAIN_IMAGE is the default. For example, SETPC_SAMPLING in the Collector defaults to collecting stack PCs, and therefore /MAIN_IMAGE is the default in the Analyzer's PLOT command. SET COUNTERS does not default to collecting stack PCs, and therefore the Analyzer uses /NOMAIN_IMAGE as the default.

3.3.8.1. Performing Call Stack Analysis

To perform any kind of call stack analysis, you must first collect stack PC values in the Collector. The /MAIN_IMAGE[=prog-unit], /STACK_DEPTH=*n*, and /CUMULATIVE[=*n*] qualifiers use call stack return addresses (**stack PC values**) when creating histograms and tables.

The /MAIN_IMAGE qualifier causes the Analyzer to tally the first program address on the call stack that falls within the program's address range. (This value may be the original PC value.) If much of your data falls in shareable images, use the /MAIN_IMAGE qualifier to instruct the Analyzer to charge back that data to the places in your program (the main image) that call the shareable images.

The /NOMAIN_IMAGE qualifier causes the Analyzer to use the original PC value for each data point.

3.3.8.2. Defining the Program Unit as the Main Image

You can define the main image by specifying a program unit with the /MAIN_IMAGE=prog-unit qualifier. By default, the program unit is the entire user program but it can be a module, routine, or line. Specifying the program unit you want starts the call stack at that point. If no program address on the stack is within the program unit's address range, then it does not appear in any of the buckets and is added to the total of "Data points failing /STACK_DEPTH or /MAIN_IMAGE" that appears on the summary page.

Note that the SYSTEM$SERVICE and the SYSTEM$SPACE program units that represent the system service vector and the system space can be used in the /MAIN_IMAGE=prog-unit qualifier.

3.3.8.3. Performing Specific Call Stack Analysis

You can accomplish more specific call stack analysis with the /STACK_DEPTH qualifier. With the /STACK_DEPTH=*n* qualifier, the Analyzer selects data points that are *n* call frames lower than the return address you specified with the /MAIN_IMAGE qualifier. You must specify an integer that is greater than or equal to one. Each increment in the integer represents going one more call frame lower in the stack. The /STACK_DEPTH=1 qualifier causes the address of the caller to be charged, /STACK_DEPTH=2 causes the address of the caller's caller to be charged, and so on. If you specify a number that is greater than the number of call frames on the stack, then the corresponding program address will not appear in any of the buckets; rather, it will be added to the summary total of "Data points failing /STACK_DEPTH or /MAIN_IMAGE" that appears on the summary page.

The /NOSTACK_DEPTH qualifier, the initial default, specifies that no stack depth analysis be performed and causes the original PC to be used.

3.3.8.4. Tallying Program Counter Values

The /CUMULATIVE qualifier determines whether all program counter values on the call stack are tallied or if only one is tallied. The /CUMULATIVE qualifier causes the Analyzer to tally all stack PC values. You can use the/CUMULATIVE=*n* qualifier to request that only *n* return addresses down the stack be tallied. Thereby, the Analyzer adds each data point in many buckets of the histogram or table. The effect is that each bucket shows how much time or other resource is consumed not only by the corresponding program unit but also by all return addresses (or *n* return addresses if /CUMULATIVE=*n* that call that unit directly or indirectly).

For example, if you plot program counter sampling data by routine for the whole program, using the /CUMULATIVE qualifier, then each data point is tallied in the buckets for the routine in which it was collected, for the caller of that routine, for the caller of the caller, and so on (or for the number of calls specified with /CUMULATIVE=*n*). All data points are tallied in the bucket for the main routine because the main routine is always the ultimate caller; the main routine contains 100% of the data points. The histogram bar for each routine shows how much time is consumed in that routine and in all routines it calls.

The /NOCUMULATIVE qualifier causes only the first program counter value to be tallied; other stack PC values are not used.

3.3.8.5. Using Program Address Selection Qualifiers

If you use all the program address selection qualifiers together, they are applied in the following order: /MAIN_IMAGE, /STACK_DEPTH, then /CUMULATIVE. Therefore, if you specify the /MAIN_IMAGE=prog-unit and /STACK_DEPTH=*n*qualifiers, the Analyzer searches the stack for the first address within the specified program unit. However, it does not charge the data point to this address, but to the address *n* call frames on the stack from the main image address. If you include /CUMULATIVE on that command, the same action occurs, but the Analyzer also charges the data point to every caller (or *n* callers if /CUMULATIVE=*n*) below the address that was charged.

The following command causes the Analyzer to charge all the calls that Routine 1 made to the caller of Routine 1, and to every caller below it:

```
PCAA> TABULATE/MAIN=ROUTINE_1/STACK=1/CUM PROG BY ROUTINE
```

Note the acceptable abbreviated forms of /STACK_DEPTH, /MAIN_IMAGE, and /CUMULATIVE that are used.

3.3.9. Filling and Scaling the Histogram

Design qualifiers let you determine the character fill to be used for the histogram bar, to adjust the scale of the histogram, and to wrap plot output that is too long. Each of these features is useful in controlling the appearance of the plot. The design qualifiers are /FILL, /SCALE, /[NO]WRAP, /[NO]KEEP, and /[NO]TREE. The /FILL and /SCALE qualifiers are described in the following sections. See the *VSI DECset for OpenVMS Performance and Coverage Analyzer Reference Manual* for more information on them, as well as complete descriptions for the /[NO]WRAP, /[NO]KEEP, and /[NO]TREE qualifiers.

3.3.9.1. Defining the Character String for the Histogram Bar

Use the /FILL qualifier to define the character string that makes up the histogram bar. This is useful when building a multiple data-kind plot. /FILL= “a”, where “a” is a character string delimited by double or single quotation marks, specifies a fill of character string “a” for the data kind in the first position in the plot. /FILL=(“a”, “b”, ...) specifies a fill of character string “a” for the first data kind, a fill of character string “b” for the second data kind, and so on. A series of character string specifications are enclosed within parentheses. A maximum of eight character strings can be defined. Note that blanks, spaces, and other nonprinting ASCII characters should not be used in this string because it will be used as the fill in a plot. The standard default fill for each of the eight positions is listed in the online PCA Command Dictionary under the PLOT command.

3.3.9.2. Setting the Range for the Histogram Bar

By default, histogram scales are adjusted so that the longest bar occupies the full width of the plot. This adjusted scale is convenient for viewing individual histograms, but can make comparing histograms with each other difficult. When comparing histograms, you can set the range of the histogram bar with the /SCALE=*n*qualifier on the PLOT, TABULATE, and SET PLOT commands. /SCALE=*n* selects a fixed scale, set to *n* percent, where *n* is an integer value from 1 to 100. To restore the default scale, specify the /NOSCALE qualifier on the PLOT, TABULATE, or SET PLOT command.

For example, assume that the longest bar shown in a histogram represents 40% of the total data points. The default scale will set the histogram range to 40%, causing that bar to occupy the full width of the histogram. To override the default and to set the histogram range to 75%,enter the following command:

```
PCAA> PLOT/SCALE=75
```

This command will cause the longest bar to occupy about half of the histogram width.

Fixed scaling can cause histogram bars to represent percentages that are larger than the histogram range. In plots produced with /NOSOURCE, these bars are truncated to equal the specified range, and the right-angle character (>) appears in the rightmost position of the bar. In plots produced with /SOURCE, the left-angle character (<)appears in the leftmost position of the truncated bar.

The fixed scaling option can be useful when comparing multiple data kinds in one histogram. In multiple data-kind plots, the scaling option used for the first data kind also applies to subsequent data kinds included in the plot.

3.3.10. Performing Multi-tasking Analysis

You can gather tasking information with the SET TASKING Collector command,and then in the Analyzer use task qualifiers to perform multi-tasking analysis.

The /TASK_SWITCH qualifier selects a data kind that represents the number of times there was a task context switch. It can be applied to the following domains: TIME BY *n* MSECs, TASK, TASK_PRIORITY, and TASK_TYPE. This qualifier will only work with the TIME, TASK, TASK_PRIORITY, and TASK_TYPE filter specifications.

The /CREATOR_PC qualifier selects a program address that charges a data point to the location in the program that created the task, rather than to the PC value of the measurement. This qualifier can only be used when the PROGRAM_ADDRESS domain is in effect, and when tasking data has been collected. It overrides /MAIN_IMAGE, /STACK_DEPTH, and /CUMULATIVE.

The /PARENT_TASK qualifier charges a data point to the parent of the current task, rather than to the current task. It can only be used when the TASK or the TASK_TYPE domain is in effect, and when tasking data has been collected.

3.3.11. Interpreting TABULATE Confidence Intervals

When you use the TABULATE command to display either PC sampling data or CPU sampling data, for each bucket you get a data count column, a percentage column, and a 95% confidence interval column as shown in *Example 3.9, "Interpreting Confidence Intervals"*.

Example 3.9. Interpreting Confidence Intervals

```
PCAA> TABULATE/PC PROGRAM BY ROUTINE

                     Performance and Coverage Analyzer        Page 1
             Program Counter Sampling Data (386 data points total)
                           Data             95% Conf
Bucket Name               Count   Percent   Interval
PROGRAM_ADDRESS\
 PRIMES . . . . . . . . . .    3     0.8%
 PRIME  . . . . . . . . . .  239    61.9% +/-  4.8%
 READ_RANGE . . . . . . . .   18     4.7% +/-  2.1%
 READ_END_OF_FILE . . . . .    0     0.0%
 READ_ERROR . . . . . . . .    0     0.0%
 OUTPUT_TO_DATAFILE . . . .    1     0.3%
 SHARE$FORRTL . . . . . . .   21     5.4% +/-  2.3%
 SHARE$LIBRTL . . . . . . .   10     2.6% +/-  1.6%
 SHARE$PCA$COLLECTOR  . . .    0     0.0%
 SHARE$DBGSSISHR  . . . . .    0     0.0%
 SHARE$PCA$PRVSHR . . . . .    0     0.0%
 SHARE$LBRSHR . . . . . . .    0     0.0%
 SHARE$SMGSHR . . . . . . .    0     0.0%

PCAA>
```

The Analyzer computes the percentage of PC values that fall in each bucket by dividing the data count on the same line by the total number of PC values collected (the sample size) and multiplying by 100. This yields the percentage of the total execution time consumed in the corresponding routine or other program unit.

However, these measurements are random sampling processes. This means that the number of PC values collected in a given routine may not be exactly proportional to the amount of time consumed in that routine. Random variations in the sampling process may cause more PC values to be collected from one routine than from another, even if the two routines take exactly the same amount of time. Unpredictable variations in system load, interrupt processing, and disk access times are among the causes of random variation in the PC sampling process.

Obtaining the true percentage of time spent in each routine (or whatever program units you are tabulating) based on PC sampling data is impossible. The computed percentage is only an estimate of the true percentage. However, using this estimated percentage and the sample size, you can compute a confidence interval for the true percentage. To help understand how close the estimate is likely to be to the true percentage, the Analyzer computes a 95%confidence interval around the estimated percentage, assuming a normal distribution.

The interpretation of the confidence interval is as follows. If the computed percentage (the estimate) is 13.0% and the 95% confidence interval is expressed as +/– 2.0%, then the confidence interval is 11% to 15%.This means you can be 95% confident that the true percentage is in this range.

If the data count is within 3 of zero or within 3 of the total sample size, noconfidence interval is computed. For such small deviations from 0% or from 100%, the formula used to compute the confidence interval may not be statistically valid. Therefore, the confidence interval is left blank in the TABULATE output.

3.4. Creating a Multiple Data-Kind Plot

You can compare more than one data kind in the same plot. For example, you can plot PC sampling hits, page fault addresses, and I/O service calls in the same histogram to determine if the PC sampling spikes are caused by page faults or by I/O service calls.

You must build a multiple data-kind plot incrementally. Enter a PLOT or TABULATE command containing the first data-kind qualifier. The first data-kind qualifier remains permanent to the plot. *Example 3.10, "Creating a Multiple Data-Kind Plot"* shows how to start creating a multiple data-kind plot.

Example 3.10. Creating a Multiple Data-Kind Plot

```
PCAA> PLOT/PC_SAMPLING/FILL=("pc") PROGRAM BY ROUTINE

                      Performance and Coverage Analyzer        Page 1
         Program Counter Sampling Data (11236 data points total) - "pc"
Bucket Name     +----+----+----+----+----+----+----+----+----+----+
SYSTEM$SERVICE\ |
 SYSTEM$SERVICE.|pcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpc  40.2%
SYSTEM$SPACE\   |
 SYSTEM$SPACE . |pcpcpcpcpc                                          7.9%
BUCKETS\        |
 BUCKETS  . . . |pc                                                  1.4%
AVERAGES\       |
 AVERAGES . . . |                                                    0.2%
CODLNS\         |
 CODLNS . . . . |                                                    0.2%
MATCHREC\       |
 MATCHREC . . . |                                                    0.1%
MATCHST1\       |
 MATCHST1 . . . |                                                    0.0%
                |
                |
                |
                +----+----+----+----+----+----+----+----+----+----+
                                  Performance and Coverage Analyzer
  Page 1
```

Use the INCLUDE and EXCLUDE commands to add and delete different data kinds to and from the plot. *Example 3.11, "Adding Data Kinds to Plots"* demonstrates how to add several data kinds to your plot. The heading lines indicate the data kinds, the total number of data points for each data kind, and the fill for each data kind. Each bucket in a multiple data-kind plot contains a line for each data kind in the plot, and each line shows the percentage of the total data points for that bucket. If you create a multiple data-kind plot with the TABULATE command, the number of hits in each bucket is represented by a decimal integer instead of a histogram bar.

Example 3.11. Adding Data Kinds to Plots

```
PCAA> INCLUDE/IO_SERVICES/MAIN_IMAGE

                     Performance and Coverage Analyzer        Page 1
          Program Counter Sampling Data (138 data points total) - "pc"
            I/O System Service Calls (108 data points total) - "io"
Bucket Name      ----+----+----+----+----+----+----+----+----+----+
PRIMES\          |
 WRITELN  . . . |pcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpc   87.7%
                |ioioioioioioioioioioioioioioioioioioioioioio   94.4%
 OPENIN . . . . |pc                                             4.3%
                |i                                              1.9%
 PUTINT . . . . |pc                                             2.9%
                |                                               0.0%
 LISTPRIMES . . |p                                              2.2%
                |                                               0.0%
 CLOSEIN  . . . |                                               0.7%
                |                                               0.9%
 OPENOUT  . . . |                                               0.7%
                |i                                              1.9%
 PRIME  . . . . |                                               0.7%
                |                                               0.0%
 PUTSTR . . . . |                                               0.7%
                |                                               0.0%
 CLOSET . . . . |                                               0.0%
                |                                               0.9%
 READING  . . . |                                               0.0%
                |                                               0.0%
 READLN . . . . |                                               0.0%
                |                                               0.0%
SYSTEM$SERVICE\ |
 SYSTEM$SERVICE |                                               0.0%
                |                                               0.0%
SYSTEM$SPACE\   |
 SYSTEM$SPACE . |                                               0.0%
                |                                               0.0%
                +----+----+----+----+----+----+----+----+----+----+

PCAA> INCLUDE/PAGE_FAULTS/FILL="pf"

                     Performance and Coverage Analyzer        Page 1
         Program Counter Sampling Data (11236 data points total) - "pc"
            I/O System Service Calls (3581 data points total) - "io"
         Page Fault Program-Counter Data (121 data points total) - "pf"
Bucket Name      ----+----+----+----+----+----+----+----+----+----+
SYSTEM$SERVICE\ |
 SYSTEM$SERVICE |pcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpc 40.2%
                |                                               0.0%
                |                                               0.0%
SYSTEM$SPACE\   |
 SYSTEM$SPACE . |pcpcpcpcpc                                     7.9%
                |                                               0.0%
                |pfpfpfpfpfpfpfpfpfpfpfpfpfpf                  19.8%
BUCKETS\        |
 BUCKETS  . . . |pc                                             1.4%
                |ioioioioioioioioioioioioioioioioioioioioioioio 97.7%
                |pfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpf 38.0%
                |
                |
                |
                +----+----+----+----+----+----+----+----+----+----+

PCAA> INCLUDE/MAIN_IMAGE

                      Performance and Coverage Analyzer        Page 1
         Program Counter Sampling Data (11236 data points total) - "pc"
            I/O System Service Calls (3581 data points total) - "io"
         Page Fault Program-Counter Data (121 data points total) - "pf"
         Program Counter Sampling Data (11236 data points total) - "@"
Bucket Name     ----+----+----+----+----+----+----+----+----+----+
SYSTEM$SERVICE\ |
 SYSTEM$SERVICE.|pcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpc  40.2%
                |                                                    0.0%
                |                                                    0.0%
                |                                                    0.0%
SYSTEM$SPACE\   |
 SYSTEM$SPACE . |pcpcpcpcpc                                          7.9%
                |                                                    0.0%
                |pfpfpfpfpfpfpfpfpfpfpfpfpfpf                       19.8%
                |                                                    0.0%
                |
                |
                |
                |
                +----+----+----+----+----+----+----+----+----+----+
```

The INCLUDE command uses a subset of PLOT qualifiers and parameters. See the online PCA Command Dictionary for a listing of qualifiers and parameters for the INCLUDE command. The default qualifiers are taken from the currently active plot.

The use of INCLUDE command qualifiers does not affect the qualifiers of the currently active plot. The INCLUDE command adds new data kinds to the present plot with the following conditions:

- There is a maximum of eight data kinds per plot.
- The data kinds must be compatible with the node specifications for the current plot.
- There is an active plot available.

A different filter or restriction can be applied to the data kind for every INCLUDE command, by entering SET FILTER commands between the INCLUDE commands. The current filters are applied to all data kinds when the INCLUDE command is entered. The newly created plot will appear after you enter the INCLUDE command.

Each EXCLUDE command eliminates one data kind from the plot, and is immediately followed by the newly created plot. *Example 3.12, "Excluding Data Kinds from a Plot"* demonstrates the EXCLUDE command. This command deletes the last data kind included and creates a new plot.

Example 3.12. Excluding Data Kinds from a Plot

```
PCAA> EXCLUDE

                      Performance and Coverage Analyzer        Page 1
         Program Counter Sampling Data (11236 data points total) - "pc"
            I/O System Service Calls (3581 data points total) - "io"
         Page Fault Program-Counter Data (121 data points total) - "pf"
```

```
Bucket Name      +----+----+----+----+----+----+----+----+----+----+
SYSTEM$SERVICE\  |
 SYSTEM$SERVICE.|pcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpc  40.2%
                |                                                     0.0%
                |                                                     0.0%
SYSTEM$SPACE\   |
 SYSTEM$SPACE . |pcpcpcpcpc                                           7.9%
                |                                                     0.0%
                |pfpfpfpfpfpfpfpfpfpfpfpfpfpf                        19.8%
BUCKETS\        |
 BUCKETS  . . . |pc                                                   1.4%
                |ioioioioioioioioioioioioioioioioioioioioioioioioio  97.7%
                |pfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpfpf  38.0%
                |
                |
                |
                +----+----+----+----+----+----+----+----+----+----+
```

When you switch data files, any information that depends on the symbol table in the current data file is lost. This information includes the currently active plot, the current default node specifications, and any filters you may have set.

3.4.1. Merging PCA Performance and Software Performance Monitor (SPM) Files

The Software Performance Monitor (SPM) is a collection of individually executed utilities. SPM is run by entering DCL commands. To analyze data contained in several files, you can use the Analyzer MERGE command. The MERGE command allows you to:

- Merge data from one or more performance data files into another performance data file, where all the files have been created in succession for the same image. While this may sometimes be convenient, it is usually simpler and more efficient to use the SET DATAFILE/APPEND command in the Collector.
- Merge data from one or more SPM data files into a performance data file. This is the only way to make SPM data available for analysis with PCA. You must ensure that the merged SPM data pertains to the image for which the output performance data file has been created. This is because PCA cannot perform all the necessary checks for SPM data.
- Merge ANC information from an old performance data file to a newer one that was created for the same program. Note that all coverage set information (no tjust ANC information) is merged for each unchanged routine. This preserves the proper context for the ANC information.
- Merge data from one or more performance data files into another performance data file, where all the files have been created simultaneously for the same image, and have been executed in a parallel processing environment. Note that the MERGE operation preserves collection run names. After all the data has been merged, you can use the original collection run names to analyze any subset of the parallel collections. Thereby, important insight can be gained into the performance of the parallel processing itself, in addition to the performance of the image being run.

Note that only input files are specified on the MERGE command. The output file is implicit; it is the currently open performance data file. Therefore, MERGE requires that a current performance data file be set. Enter the following command to collect SPM's PC sampling data.

```
$ PERFORMANCE[/INTERVAL=ticks] [/IDENTIFICATION=process-id]-
_$ COLLECT=SYSTEM_PC
```

PC values are then sampled at a specified interval. You can specify the interval in the range of 1 to 100 ticks with the /INTERVAL qualifier, where each tick equals 10 milliseconds. The resulting PC log file includes the PC values for all processes on the system, unless you select a single process with the /IDENTIFICATION qualifier. The MERGE command accepts SPM data only from system-wide PC log files, hereafter referred to as SPM data files.

Data merged from SPM data files must have been gathered for the same image as the image for the currently open performance data file. To prepare the image for data collection with SPM and with the Collector, you may link the image with the /DEBUG qualifier. Then, to collect data with SPM, run the image with /NODEBUG.

3.5. Listing the Raw Performance Data

To view the raw data gathered by the Collector, use the LIST command to display a list of the raw performance data.

To input the raw performance data to a reduction program of your own:

1. Enter the FILE command.
2. Use the PRINT command to print the output.

The simplest form of the LIST command takes the ALL keyword as its parameter and lists all performance and coverage data. For example:

```
PCAA> LIST ALL
```

To see data records of several different kinds, specify the corresponding keywords in a comma list. For example:

```
PCAA> LIST SERVICES, IO_SERVICES, PAGE_FAULTS
```

To see a complete list of the LIST qualifiers, refer to the LIST command in the Command Dictionary section of the *VSI DECset for OpenVMS Performance and Coverage Analyzer Reference Manual*.

Use the SHOW RUN_DESCRIPTION command to display a list of the kinds of data gathered in the data file for each collection run. The SHOW RUN_DESCRIPTION command shows an abbreviated version of what the SHOW ALL command would have shown in the original Collector sessions. The SHOW RUN_DESCRIPTION command takes one parameter that specifies which collection run or range of collection runs you want described. For example, to see what data you collected for runs 2 through 4, use the following command:

```
PCAA> SHOW RUN_DESCRIPTION 2:4
```

Use the parameter /START_TIME with the LIST command to display system service CPU start times in the LIST output. For example:

```
PCAA> LIST/START_TIME
```

The parameter default is NOSTART_TIME.

You can specify a run name as the parameter. If you use the SET RUN_NAME EVENT1 command in the Collector, you can use the SHOW RUN_DESCRIPTION EVENT1 in the Analyzer.

Use asterisks (*) as wildcard characters. Each asterisk matches zero or more characters in the run name. For example, to see descriptions of all the collection runs in the data file, use the following command:

```
PCAA> SHOW RUN_DESCRIPTION *
```

Here the asterisk matches all possible run names.

3.6. Using Acceptable Noncoverage (ANC)

Most programs have portions of code that you would not expect to be tested; for example, internal error paths, difficult-to-test paths, and so on. These portions of code are considered acceptably noncovered, or ANC.

Once you have decided which portions of a program are acceptably noncovered, you can save that information for the next test run.

If you have modified the program and you want to preserve the ANC information from a previous version of the program, then you can use the MERGE/ANC command to copy the ANC information from the old data file to the new one. The information will only be copied for those routines in the program that have not changed. PCA decides if a routine has changed by looking at two sets of codepath information for each routine. One set is from the current version of the program, and the other (saved) set is from a previous version. If the codepath information has not changed, then the ANC information is considered valid, and is merged. If the codepath information has changed, then the ANC information is disregarded by MERGE/ANC for the given routine. See the online PCA Command Dictionary for complete information about the MERGE command.

There are two ways to specify ANC information. One is to generate a noncoverage plot or tabulation, then use a traverse command (such as NEXT) or the FIND command to pinpoint a particular noncovered point. Then, enter the SET ANC command at the Analyzer prompt. The SET ANC command declares all the noncovered points within the selected bucket's address range as acceptably noncovered. If you use the SET ANC command in this manner when the FIND pointer is pointing to a routine bucket, then all the lines or codepaths within the routine are flagged as ANC, whether they are covered or not. You can continue traversing the plot in this manner until you have reviewed all the noncovered points. Use the NEXT command to move the pointer from one noncovered point to another.

Another way to save ANC information is to provide a nodespec on a SET ANC command. The following command will declare all noncovered lines for routines R2 and R4 as acceptably noncovered:

```
PCAA> SET ANC ROUTINE R2 BY LINE, ROUTINE R4 BY LINE
```

The nodespec must specify one or more program address locations.

ANC information is stored in the coverage-set table section in the performance data file. You can list the full contents of that table with the LIST/COVERAGE_SET command. The SHOW ANC command displays the current status of ANC information.

If you want to remove ANC information from the coverage-set table, use the CANCEL ANC command. If you enter the CANCEL ANC command without a nodespec, then it pertains to all the ANC points within the bucket pointed to with a FIND or traverse arrow. You can provide a nodespec on this command to specify which ANC points to remove. You can also use the CANCEL ANC/ALL command to remove all the ANC information from the current data file.

You can specify a filter restriction that will pass a data point only if it is an ANC point, as in the following example:

```
PCAA> SET FILTER F1 PROGRAM_ADDRESS=%ANC
```

See the online PCA Command Dictionary for complete information on the SET FILTER command.

Section 4.5, "Determining Acceptable Noncoverage (ANC)" contains an example of the complete cycle of merging, setting, and using ANC information.

3.7. Editing Source Code from Within the Analyzer

If you want to edit the source code displayed by the most recent PLOT or TABULATE command, you can use the EDIT command to invoke an editor directly from the Analyzer. The Language-Sensitive Editor (LSE) is the default editor. To use the EDIT command,you must have an editor installed on your system. For more information on LSE, see the *Guide to VSI Language-Sensitive Editor for OpenVMS Systems*.

The editor you select must be one you can access from DCL level. Use the Analyzer SET EDITOR command to specify the editor you want to use. This will cause subsequent EDIT commands to invoke the editor you chose.

The SET EDITOR command accepts the following qualifiers: /CALLABLE_EDT, /CALLABLE_LSEDIT, /CALLABLE_TECO, and /CALLABLE_TPU.

Enter the SHOW EDITOR command to display the current setting of the editor and its command line. For example:

```
PCAA> SET EDITOR/CALLABLE_TPU
PCAA> SHOW EDITOR
The editor is CALLABLE_TPU having the command line:
      "TPU"
```

You can specify a command line if you use the /CALLABLE_LSEDIT or the /CALLABLE_TPU qualifiers, but not if you use the /CALLABLE_EDT or the /CALLABLE_TECO qualifiers.

If you are positioned at a source listing produced by the /SOURCE qualifier on a PLOT or TABULATE command, use the EDIT command without parameters to invoke the editor, as follows:

```
PCAA> EDIT
```

This command spawns a subprocess to run the editor. The Analyzer automatically positions the editor at the point in the source file displayed by the PLOT or TABULATE command. When you exit from the editor, the Analyzer session resumes.

If you use the /EXIT qualifier on the EDIT command, you terminate the Analyzer session and invoke the editor in the same process.

If you want to position the editor at a different line or file than you get by default, the EDIT command can take a module name and a line number as a parameter. In this example, MODNAME is a module name and 25 is a line number:

```
PCAA> EDIT MODNAME\25
```

If you omit the module name and backslash, the editor defaults to the module referenced by the PLOT or TABULATE command currently in effect.

The following SET EDITOR command causes subsequent EDIT commands to invoke callable LSEDIT with the default command line of LSEDIT/READ_ONLY:

```
PCAA> SET EDITOR/CALLABLE_LSEDIT/START_POS "LSED/READ_ONLY"
```

Also, the /START_POSITION qualifier will be appended to the command line, causing the editing session to start on the source line that the Analyzer is currently pointing to. Note the abbreviated form of /START_POSITION. Also note that the command line is enclosed in quotation marks.

3.8. Using Initialization Files and Command Procedures

The Analyzer **initialization file** is automatically read and executed at the start of each session. It is useful for defining frequently used keypad keys or command abbreviations, establishing mode settings, such as screen mode or SET PLOT defaults, or setting up a SET SOURCE command.

Define the Analyzer initialization file by defining the logical name PCAA$INIT to be the file specification for the initialization file. The following DCL command defines ANL_STARTUP.PCAA as the Analyzer initialization file:

```
$ DEFINE PCAA$INIT ANL_STARTUP.PCAA
```

After reading the initialization file, the Analyzer solicits additional command input from the terminal until you enter the EXIT command.

To make command entry more efficient, you can place often-used commands into a **command procedure**. For example, you can use command procedures for lengthy but frequently used filter specifications.

Analyzer command procedures are similar to Collector command procedures discussed in *Section 2.8, "Using Collector Command Procedures"*.

3.8.1. Using Analyzer Logical Names

The Analyzer checks for several logical names that can be defined before invocation. The logical names can specify the Analyzer initialization file, the Analyzer input stream, the Analyzer output stream, or the line printer page size. The Analyzer recognizes the following logical names:

- PCAA$INIT
- PCAA$INPUT
- PCAA$OUTPUT
- SYS$LP_LINES
- SYS$PRINT
- PCAA$DECW$DISPLAY

Table B.5, "Analyzer Logical Names" describes the logical names the Analyzer accepts.

Chapter 4. Productivity Enhancements with PCA

The examples in this chapter demonstrate how to use PCA to solve common problems and improve the performance of your applications. *Section 4.7, "Using PCA in Screen Mode"* shows how to use the Analyzer in screen mode.

The examples in this chapter include the following:

- *Section 4.1, "Example 1: Reducing Execution Time"* demonstrates how to find where most of the time is being spent in a typical application, then applies a change that improves that program's performance.
- *Section 4.2, "Example 2: Analyzing Call Stack Data"* demonstrates the analysis of call stack data.
- *Section 4.3, "Example 3: Using Multiple Data Kinds"* demonstrates how a multiple data-kind plot can isolate the reason a program statement takes the most time.
- *Section 4.4, "Example 4: Using Event Markers for Selective Analysis"* demonstrates the use of event markers for selective analysis.
- *Section 4.5, "Determining Acceptable Noncoverage (ANC)"* demonstrates the collection and analysis of coverage data,and shows how you can determine acceptable noncoverage.
- *Section 4.6, "Example 6: Measuring Ada Tasking Data"* demonstrates the measurement of Ada tasks.

Some of the programs used in this chapter are compiled with the /NOOPTIMIZE qualifier because they are so simple the compiler would otherwise optimize away the effect that the examples are intended to show.

4.1. Example 1: Reducing Execution Time

This example demonstrates a simple method of finding out where most of the time is being spent in a typical application.

PCA is used on a FORTRAN program that counts the prime numbers within a given range. The Collector gathers PC sampling data. Then the Analyzer is invoked specifying the performance data file PCA$PRIMES. When you enter the NEXT command, the Analyzer creates a source plot, pointing to the most significant line.

To compile, link, and run the program, enter the following commands:

```
$ FOR/NOOPTIMIZE/DEBUG PCA$PRIMES.FOR
$ LINK/DEBUG PCA$PRIMES
$ DEFINE LIB$DEBUG PCA$COLLECTOR.EXE
$ RUN PCA$PRIMES

        PCA Collector Version 5.0

PCAC> GO

%PCA-I-DEFDATFIL, set datafile required in this context, creating
```

```
'[]PCA$PRIMES.PCA'
%PCA-I-BEGINCOL, data collection begins
%PCA-I-DATADEFPC, defaulting to collecting PC sampling data
 169 prime numbers generated between    1 and 1000
FORTRAN STOP
%PCA-I-ENDCOL, data collection ends

$ PCA PCA$PRIMES

        Performance and Coverage Analyzer Version 5.0

PCAA> NEXT

                    Performance and Coverage Analyzer                Page 1
           Program Counter Sampling Data (93 data points total) - "*"
                              Routine PRIME\PRIME
Percent   Count       Line
PRIME\PRIME\
  0.0%                   5:         LOGICAL FUNCTION PRIME(NUMBER)
  0.0%                   6:         PRIME = .TRUE.
  0.0%                   7:         DO 10 I = 2, NUMBER/2
 33.3%  ******* ->       8:         IF ((NUMBER - ((NUMBER / I) * I)) .EQ.
                                                                   0) THE
                         -: N
  0.0%                   9:             PRIME = .FALSE.
  0.0%                  10:             RETURN
                        11:         ENDIF
  2.2%                  12:    10   CONTINUE
  0.0%                  13:         RETURN
```

The resulting source plot shows that 33.3% of the time is spent at line 8. This is expected,because this is where the calculation that determines the prime is done. To reduce the time spent at line 8, you must either make the calculation more efficient or reduce the number of times the calculation is done. At this point, confirm that the time being spent is caused by CPU consumption.

Gathering and Analyzing CPU Sampling Data

Use the /APPEND and /EXECUTABLE qualifiers on the SET DATAFILE command to gather and analyze the CPU sampling data. The /APPEND qualifier adds the CPU sampling data to the file already created for the PC sampling data, and the /EXECUTABLE qualifier uses the default data file specification. For example:

```
$ RUN PCA$PRIMES

        PCA Collector Version V5.0

PCAC> SET DATAFILE/APPEND/EXE
PCAC> SET CPU_SAMPLING
%PCA-I-PCDISTORT, PC sampling data may be distorted by collection of other
 data
%PCA-I-CPUDISTOR, CPU sampling data may be distorted by collection of other
 data
PCAC> GO
%PCA-I-BEGINCOL, data collection begins
 169 prime numbers generated between    1 and 1000
FORTRAN STOP
%PCA-I-ENDCOL, data collection ends
```

```
$
```

Analyze the CPU sampling data. You can use this sequence of collection and analysis with any data kind. The buckets in the resulting plot are partitioned by routine (by default). For example:

```
$ PCA PCA$PRIMES

         Performance and Coverage Analyzer Version V5.0

PCAA> PLOT/CPU

                Performance and Coverage Analyzer               Page 1
                CPU Sampling Data (114 data points total) - "*"
Bucket Name              +----+----+----+----+----+----+----+----+
PRIME\                   |
 PRIME  . . . . . .      |***************************************** 62.3%
OUTPUT_TO_DATAFILE\      |
 OUTPUT_TO_DATAFILE      |***************                          19.3%
READ_RANGE\              |
 READ_RANGE . . . .      |********                                 10.5%
PCA$PRIMES\              |
 PCA$PRIMES . . . .      |******                                    7.9%
READ_END_OF_FILE\        |
 READ_END_OF_FILE .      |                                          0.0%
READ_ERROR\              |
 READ_ERROR . . . .      |                                          0.0%
SYSTEM$SERVICE\          |
 SYSTEM$SERVICE . .      |                                          0.0%
SYSTEM$SPACE\            |
 SYSTEM$SPACE . . .      |                                          0.0%
                         |
                         |
                         +----+----+----+----+----+----+----+----+
```

Now you can use Ctrl/N (defined as NEXT) to find the most significant line, as in the following example:

```
PCAA> CTRL/N

                    Performance and Coverage Analyzer               Page 1
                CPU Sampling Data (114 data points total) - "*"
                          Routine PRIME\PRIME
Percent   Count       Line
PRIME\PRIME\
  0.0%                   5:         LOGICAL FUNCTION PRIME(NUMBER)
  0.0%                   6:         PRIME = .TRUE.
  0.0%                   7:         DO 10 I = 2, NUMBER/2
 58.8%  ******* ->       8:         IF ((NUMBER - ((NUMBER / I) * I)) .EQ.
                                                                 0) THE
                        -: N
  0.0%                   9:             PRIME = .FALSE.
  0.0%                  10:             RETURN
                        11:         ENDIF
  3.5%                  12:    10   CONTINUE
  0.0%                  13:         RETURN
```

This confirms that CPU consumption, caused by a CPU-intensive instruction, is the problem.

Editing and Modifying the Program

Now you can use the EDIT command to invoke an editor (see *Section 3.7, "Editing Source Code from Within the Analyzer"*) to modify the program:

```
PCAA> EDIT
```

In this example, the program is modified by making the loop in the subroutine PRIME go from two to the square root of the number, instead of the number divided by two. Compile, link, and run the program again, gather the data, and look at the most significant line:

```
$ FOR/NOOPT/DEBUG PCA$PRIMES.FOR
$ LINK/DEBUG PCA$PRIMES
$ DEFINE LIB$DEBUG PCA$COLLECTOR.EXE
$ RUN PCA$PRIMES

        PCA Collector Version V5.0

PCAC> GO
%PCA-I-DEFDATFIL, set datafile required in this context, creating
'[]PCA$PRIMES.PCA'
%PCA-I-BEGINCOL, data collection begins
%PCA-I-DATADEFPC, defaulting to collecting PC sampling data
1000 prime numbers generated between     1 and 1000
FORTRAN STOP
%PCA-I-ENDCOL, data collection ends

$ PCA PCA$PRIMES

         Performance and Coverage Analyzer Version V5.0

PCAA> CTRL/N

                  Performance and Coverage Analyzer             Page 1
            Program Counter Sampling Data (90 data points total) - "*"
Percent   Count   Line
PRIME\
                     1: C       Function to identify whether the number in
                     2: C       in the given range is prime number or not.
                     3: C       If so, returned function value is TRUE.
                     4: C
  3.3%        *      5:         LOGICAL FUNCTION PRIME(NUMBER)
                     6: C
                     7:         REAL*8 R
  0.0%               8:         PRIME = .TRUE.
  0.0%               9:         R = NUMBER
  4.4%        *     10:         DO 10 I = 2, (SQRT(R))
                    11: C
 46.7% ********     12:             IF ((NUMBER - ((NUMBER / I) *
                                                 I)) .EQ. 0) THEN
  1.1%              13:                 PRIME = .FALSE.
  0.0%              14:                 RETURN
                    15:             ENDIF
                    16: C
  6.7%        *     17: 10      END DO
                    18: C
  0.0%              19:         RETURN
                    20:         END
```

The percentage of time spent at the calculation is smaller now, but some of the other percentages are larger. The modification has reduced the *relative* time spent at one line, causing the same amount of time at another line to be a *larger portion* of the total time.

Relative measures do not always confirm that performance has been improved. Actual timing of the execution is used to confirm that a program performs better (particularly if the changes are extensive). Sometimes, changes only move a “bottleneck” to another place in the program.

4.2. Example 2: Analyzing Call Stack Data

In this example, the Collector gathers PC sampling data and I/O services data on the Pascal program PCA$8QUEENS. Both data kinds are gathered with calls tack return addresses. Then, the data is analyzed to find out what portions of the program are causing the I/O calls. This example runs optimized code so you can go directly to the real “hot spots”, avoiding sections of code that can be optimized by the compiler.

Compile, link, and run program PCA$8QUEENS and collect PC sampling data and I/O services data. Two separate runs are necessary because I/O data-gathering can distort the PC sampling data. The two runs must have the same input because they are going to be compared with each other. For example:

```
$ PASCAL/DEBUG PCA$8QUEENS.PAS
$ LINK/DEBUG PCA$8QUEENS
$ DEFINE LIB$DEBUG PCA$COLLECTOR.EXE
$ RUN PCA$8QUEENS

        PCA Collector Version V5.0

PCAC> SET PC_SAMPLING/STACK_PCS
PCAC> GO
%PCA-I-DEFDATFIL, set datafile required in this context, creating
'[]PCA$PCA$8QUEENS.PCA'
%PCA-I-BEGINCOL, data collection begins
%PCA-I-ENDCOL, data collection ends

$ RUN PCA$8QUEENS

        PCA Collector Version V5.0

PCAC> SET IO_SERVICES/STACK_PCS
PCAC> GO
%PCA-I-DEFDATFIL, set datafile required in this context, creating
'[]PCA$PCA$8QUEENS.PCA'
%PCA-I-BEGINCOL, data collection begins
%PCA-I-ENDCOL, data collection ends

$
```

The /STACK_PCS qualifier, although used in this example, is the default setting for both kinds of data being gathered.

The following plot shows that most of the PC sampling hits occur within the system space, and that most I/O service calls are made within the Pascal Run-Time Library (RTL):

```
$ PCA PCA$8QUEENS.PCA;1

         Performance and Coverage Analyzer Version V5.0
```

```
PCAA> MERGE PCA$8QUEENS
PCAA> PLOT/PC_SAMPLING/NOMAIN_IMAGE PROGRAM_ADDRESS BY MODULE
PCAA> INCLUDE/IO_SERVICES

                    Performance and Coverage Analyzer                Page 1
           Program Counter Sampling Data (35 data points total) - "*"
             I/O System Service Calls (97 data points total) - "O"
Bucket Name            ----+----+----+----+----+----+----+----+----+
 PROGRAM_ADDRESS\       |
  SYSTEM$SPACE . . .    |********************************************  42.9%
                        |                                               0.0%
  PCA$8QUEENS  . . .    |***************************************       40.0%
                        |                                               0.0%
  SHARE$PASRTL . . .    |****************                              14.3%
                        |OOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOO   100.0%
  SHARE$LIBRTL . . .    |***                                            2.9%
                        |                                               0.0%
                         ----+----+----+----+----+----+----+----+
```

It is interesting to see which portions of the program caused these effects. Instead of charging the data points to where the measurements were made,use the /MAIN_IMAGE qualifier to charge the data points to the first address on the stack within the program's main image. For example:

```
PCAA> PLOT/PC_SAMPLING/MAIN_IMAGE PROGRAM_ADDRESS BY ROUTINE
PCAA> INCLUDE/IO_SERVICES


                 Performance and Coverage Analyzer           Page 1
     Program Counter Sampling Data (35 data points total) - "*"
        I/O System Service Calls (97 data points total) - "O"
Bucket Name                ----+----+----+----+----+----+----+
EIGHTQUEENS\EIGHTQUEENS\
   TRYCOL . . . . . .      |*******************************  93.8%
                           |OOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOO  99.0%
EIGHTQUEENS\EIGHTQUEENS\TRYCOL\
   SETQUEEN . . . . .      |*                                  3.3%
                           |                                   0.0%
   REMOVEQUEEN  . . .      |*                                  2.8%
                           |                                   0.0%
  EIGHTQUEENS\             |
   EIGHTQUEENS  . . .      |                                   0.0%
                           |                                   1.0%
  EIGHTQUEENS\EIGHTQUEENS\
   PRINT  . . . . . .      |                                   0.0%
                           ----+----+----+----+----+----+----+
```

Most of the time is spent doing I/O in routine TRYCOL. To check the performance of this routine alone, use routine TRYCOL as the main image. Now all data points resulting from calls made by routine TRYCOL are charged to the address within routine TRYCOL that made the call.

For example:

```
PCAA> PLOT/PC_SAMPLING/MAIN_IMAGE=TRYCOL ROUTINE TRYCOL BY LINE
PCAA> INCLUDE/IO_SERVICES

                    Performance and Coverage Analyzer                Page 1
           Program Counter Sampling Data (35 data points total) - "*"
             I/O System Service Calls (97 data points total) - "O"
Percent   Count     Line
```

```
PCA$8QUEENS\PCA$8QUEENS\TRYCOL\
                      21: end ; (* print *)
                      22:
                      23:
  0.0%                24: procedure trycol( j : integer ) ;
  0.0%
                      25:
                      26: var
                      27:    i : integer ;
                      28:
                      29:
                      30: procedure setqueen ;
                      31:
                      32: begin (* setqueen *)
                      33:    a[i] := false ;
                      34:    b[i + j] := false ;
                      35:    c[i - j] := false ;
                      36: end ; (* setqueen *)
                      37:
                      38:
                      39: procedure removequeen ;
                      40:
                      41: begin (* removequeen *)
                      42:    a[i] := true ;
                      43:    b[i + j] := true ;
                      44:    c[i - j] := true ;
                      45: end ; (* removequeen *)
                      46:
                      47:
                      48: begin (* trycol *)
  0.0%                49:    i := 0 ;
  0.0%
  0.0%                50:    repeat
  0.0%
  0.0%                51:       i := i + 1 ;
  0.0%
  2.4%                52:       safe := a[i] and b[i + j] and c[i - j] ;
  0.0%
  1.2%                53:       if safe then
  0.0%
                      54:          begin
  1.2%                55:          setqueen ;
  0.0%
  0.0%                56:          x[j] := i ;
  0.0%
  0.0%                57:          if j < 8 then
  0.0%
  0.0%                58:             trycol( j + 1 )
  0.0%
                      59:          else
 95.2%  ********      60:             print ;
 99.0%  OOOOOOOO
  0.0%                61:          removequeen ;
  0.0%
                      62:          end ;
                      63:    until i = 8 ;
  0.0%                64: end ; (* trycol *)
  0.0%
```

Now you can see that most of the consumed time is a result of the call to the PRINT routine (line 60). Comparatively little time was spent as a result of the calls to the routines SETQUEEN and REMOVEQUEEN. Now look at the entire call chain to analyze each level of recursion. The following example tabulates the IO_SERVICES data kind against the domain of call chains. See *Section 3.3.7, "Using CALL_TREE Node Specifications"* for complete information about call tree node specifications.

```
PCAA> TABULATE/IO_SERVICES CALL_TREE BY CHAIN_ROUTINE

                 Performance and Coverage Analyzer           Page 1
        I/O System Service Calls (97 data points total) - "*"
Percent   Count            Call Chain Name
  1.0%        1   Chain : EIGHTQUEENS
  0.0%        0   Chain : . TRYCOL
  0.0%        0   Chain : . . TRYCOL
  0.0%        0   Chain : . . . TRYCOL
  0.0%        0   Chain : . . . . TRYCOL
  0.0%        0   Chain : . . . . . TRYCOL
  0.0%        0   Chain : . . . . . . TRYCOL
  0.0%        0   Chain : . . . . . . . TRYCOL
 99.0%       96   Chain : . . . . . . . . TRYCOL
```

You can see that one I/O service call was made within the main routine of PCA$8QUEENS and 96 I/O service calls were made at the eighth level of the TRYCOL recursion.

Sorting Call Chains

To see which level of recursion took the most time, sort the call chains in descending order, specifying the /CHAIN_NAME qualifier on the PLOT command. The /WRAP qualifier wraps the chain name identifier onto the next line instead of being truncated. For example:

```
PCAA> PLOT/DESCENDING/WRAP/CHAIN_NAME/PC_SAMPLING CALL_TREE
BY CHAIN_ROUTINE

                    Performance and Coverage Analyzer                Page 1
          Program Counter Sampling Data (35 data points total) - "*"
Percent   Count       Call Chain Name
 60.0% ******** Chain : PCA$8QUEENS, TRYCOL, TRYCOL, TRYCOL, TRYCOL,
 TRYCOL,
                    -:  TRYCOL, TRYCOL, TRYCOL
 11.4%       ** Chain : PCA$8QUEENS, TRYCOL, TRYCOL, TRYCOL, TRYCOL, TRYCOL
  8.6%        * Chain : PCA$8QUEENS, TRYCOL, TRYCOL, TRYCOL, TRYCOL,
 TRYCOL,
                    -:  TRYCOL
  5.7%        * Chain : PCA$8QUEENS, TRYCOL, TRYCOL, TRYCOL, TRYCOL,
 TRYCOL,
                    -:  TRYCOL, TRYCOL
  5.7%        * Chain : PCA$8QUEENS, TRYCOL, TRYCOL, TRYCOL, TRYCOL
  2.9%          Chain : PCA$8QUEENS, TRYCOL, TRYCOL, TRYCOL, TRYCOL,
 TRYCOL,
                    -:  SETQUEEN
  2.9%          Chain : PCA$8QUEENS, TRYCOL, TRYCOL, TRYCOL
  2.9%          Chain : PCA$8QUEENS, TRYCOL, TRYCOL, TRYCOL, TRYCOL,
 SETQUEEN
```

The resulting plot shows that most of the time is spent at the eighth level of recursion, although the fourth, fifth, and seventh levels do not appear significantly different.

Filtering by Call Chain

You can now filter by call chain. Although you can combine the /CUMULATIVE[=n], /MAIN_IMAGE[=program_address], and /STACK_DEPTH=n qualifiers to perform call chain analysis, most queries can be more simply expressed with the CHAIN_NAME filter specification. See *Section 3.3.2.1, "Filtering Performance Data"* for complete information about the CHAIN_NAME filter specification. For example:

```
PCAA> SET FILTER F1 CHAIN_NAME=(PCA$8QUEENS,*,SETQUEEN)
PCAA> PLOT/PC_SAMPLING ROUTINE SETQUEEN BY LINE


                    Performance and Coverage Analyzer                Page 1
           Program Counter Sampling Data (2 data points total) - "*"
Percent   Count     Line
PCA$8QUEENS\PCA$8QUEENS\TRYCOL\SETQUEEN\
  0.0%                30: procedure setqueen ;
                      31:
                      32: begin (* setqueen *)
  0.0%                33:    a[i] := false ;
100.0% ********       34:    b[i + j] := false ;
  0.0%                35:    c[i - j] := false ;
  0.0%                36: end ; (* setqueen *)
```

This example plots only those points where routine EIGHTQUEENS is on the bottom of the stack and routine SETQUEEN is on the top of the stack, with any set of routines in between these two.

4.3. Example 3: Using Multiple Data Kinds

This example demonstrates a method of isolating the most time-consuming statement of a program. First, find out which lines of a program take the most time to complete,then compare multiple data kinds in one plot to find out exactly what is causing the time to be spent.

This example uses an expansion of the program used in *Section 4.1, "Example 1: Reducing Execution Time"*. It has more extensive I/O. It inputs the numbers to be used instead of using a loop, sorts the primes it finds, and outputs the primes to a text file.

You can begin by compiling, linking, and running the program PCA$PRIMES_1.FOR, and by gathering PC sampling data. The /EXECUTABLE qualifier on the SET DATAFILE command causes the Collector to use the default data file specification, as in the following example:

```
$ FOR/NOOPT/DEBUG PCA$PRIMES_1.FOR
$ LINK/DEBUG PCA$PRIMES_1
$ DEFINE LIB$DEBUG PCA$COLLECTOR.EXE
$ RUN PCA$PRIMES_1

        PCA Collector Version V5.0

PCAC> SET DATAFILE/EXECUTABLE
PCAC> SET PC_SAMPLING
PCAC> GO
%PCA-I-BEGINCOL, data collection begins
%PCA-I-ENDCOL, data collection ends
$
$ PCA PCA$PRIMES_1
```

```
         Performance and Coverage Analyzer Version V5.0
```

Finding the Routine that Takes the Most Time

Enter the following command to find out which routine is taking the most time. The /MAIN_IMAGE qualifier charges any time spent in RTL routines back to the main image. The resulting plot shows that most of the time is spent in the sorting routine:

```
PCAA> PLOT/PC_SAMPLING/MAIN_IMAGE PROGRAM BY ROUTINE


                  Performance and Coverage Analyzer               Page 1
        Program Counter Sampling Data (1019612 data points total) - "*"
Bucket Name           +----+----+----+----+----+----+----+----+----+
SORT_PRIMES\          |
 SORT_PRIMES  . . .   |*******************************************  83.7%
INPUT_DATA\           |
 INPUT_DATA . . . .   |*******                                      11.9%
OUTPUT_PRIMES\        |
 OUTPUT_PRIMES  . .   |**                                            3.1%
PRIME\                |
 PRIME  . . . . . .   |*                                             1.0%
PCA$PRIMES_1\         |
 PCA$PRIMES_1 . . .   |                                              0.2%
SYSTEM$SERVICE\       |
 SYSTEM$SERVICE . .   |                                              0.0%
SYSTEM$SPACE\         |
 SYSTEM$SPACE . . .   |                                              0.0%
                      |
                      +----+----+----+----+----+----+----+----+----+
```

Examine the plot to see how the time is divided among the lines of the sorting routine. Entering the NEXT command is equivalent to entering the following:

```
PCAA> PLOT/SOURCE/MAIN_IMAGE ROUTINE SORT_PRIMES BY LINE

                  Performance and Coverage Analyzer               Page 1
        Program Counter Sampling Data (1019612 data points total) - "*"
Percent   Count  Line
SORT_PRIMES\SORT_PRIMES\
  0.0%            11:   SUBROUTINE SORT_PRIMES( IARRAY, M, N, IPARRAY, O)
                  .
                  .
                  .
                  34: C Loop writing the elements to the indexed file
                  35: C
  0.0%            36:   WRITE( UNIT = 10 ) 0, 0
  0.0%            37:   DO I = 1, M
  0.0%            38:       DO J = 1, N
                  39: C
  0.0%            40:           IF (IARRAY (I,J) .NE. 0) THEN
 56.7% ********   41:               WRITE (UNIT = 10) 250000-IARRAY(I, J)
                  42:           ENDIF
                  43: C
  0.0%            44:       END DO
  0.0%            45:   END DO
                  46: C
                  47: C Read the elements back
```

```
                   48: C
  0.0%             49:   READ( UNIT = 10, KEY = 0, KEYID = 1 ) I, J
  0.0%             50:   DO I = 1, O
                   51: C
 27.0%     ****    52:           READ( UNIT = 10, END = 3000 ) T, IPAR>
                   53: C
  0.0%             54:   END DO
                   55: C
  0.0%             56: 3000 CLOSE(UNIT=10)
  0.0%             57:   L = I
                   58: C
  0.0%             59:   RETURN
```

You can see that all of the time is spent at the two I/O statements in the sorting routine. The next step is to gather I/O data and create a table to see the raw data counts, as follows:

```
$ RUN PCA$PRIMES_1

        PCA Collector Version V5.0
PCAC> SET DATAFILE/EXECUTABLE/APPEND
PCAC> SET IO_SERVICES
PCAC> GO
%PCA-I-BEGINCOL, data collection begins
%PCA-I-ENDCOL, data collection ends
$ PCA PCA$PRIMES_1

         Performance and Coverage Analyzer Version V5.0

PCAA> TABULATE/IO_SERVICES ROUTINE SORT_PRIMES BY LINE

                  Performance and Coverage Analyzer                Page 1
        Program Counter Sampling Data (1019612 data points total) - "*"
           I/O System Service Calls (316152 data points total) - "O"
Percent   Count  Line
SORT_PRIMES\SORT_PRIMES\
                   33: C
                   34: C Loop writing the elements to the indexed file
                   35: C
  0.0%      115    36:   WRITE( UNIT = 10 ) 0, 0
  0.0%        0    37:   DO I = 1, M
  0.0%        0    38:        DO J = 1, N
                   39: C
  0.0%      483    40:           IF (IARRAY (I,J) .NE. 0) THEN
  7.0%    22045    41:               WRITE (UNIT = 10) 250000-IARRAY(I, J)
                   42:           ENDIF
                   43: C
  0.0%       83    44:       END DO
  0.0%        0    45:   END DO
                   46: C
                   47: C Read the elements back
                   48: C
  0.0%        7    49:   READ( UNIT = 10, KEY = 0, KEYID = 1 ) I, J
  0.0%        0    50:   DO I = 1, O
                   51: C
  7.0%    22046    52:           READ( UNIT = 10, END = 3000 ) T, IPA>
                   53: C
  0.0%        8    54:   END DO
                   55: C
  0.0%       25    56: 3000 CLOSE(UNIT=10)
  0.0%        0    57:   L = I
                   58: C
  0.0%        0    59:   RETURN
```

These are surprising results because one might expect to see a lot of time spent in the I/O statements shown here. However, most of the I/O is done elsewhere in the program. The following command plots the I/O services data in all the routines:

```
PCAA> PLOT/MAIN_IMAGE/IO_SERVICES/FILL="io" PROGRAM BY ROUTINE

                  Performance and Coverage Analyzer                Page 1
           I/O System Service Calls (316152 data points total) - "io"
Bucket Name                +----+----+----+----+----+----+----+----+----+
  INPUT_DATA\              |
   INPUT_DATA . . . .      |ioioioioioioioioioioioioioioioioioiioio   79.1%
  SORT_PRIMES\             |
   SORT_PRIMES  . . .      |ioioioioi                                 13.9%
  OUTPUT_PRIMES\           |
   OUTPUT_PRIMES  . .      |ioio                                       7.0%
  PCA$PRIMES_1\            |
   PCA$PRIMES_1 . . .      |                                           0.0%
  PRIME\                   |
   PRIME  . . . . . .      |                                           0.0%
  SYSTEM$SERVICE\          |
   SYSTEM$SERVICE . .      |                                           0.0%
  SYSTEM$SPACE\            |
   SYSTEM$SPACE . . .      |                                           0.0%
                           |
                           +----+----+----+----+----+----+----+----+----+
```

The resulting plot shows that most of the I/O service calls are in the input module.

Correlating I/O Service Calls with PC Sampling

At this point, examine the correlation between I/O service calls and PC sampling data. The INCLUDE command allows you to build a multiple data-kind plot, bringing in one new data kind at a time. The default qualifiers are taken from the currently active plot. For example:

```
PCAA> INCLUDE/PC_SAMPLING/FILL="pc"


                  Performance and Coverage Analyzer                Page 1
           I/O System Service Calls (316152 data points total) - "io"
        Program Counter Sampling Data (1019612 data points total) - "pc"
Bucket Name                +----+----+----+----+----+----+----+----+
  INPUT_DATA\              |
   INPUT_DATA . . . .      |ioioioioioioioioioioioioioioioioioioio   79.1%
                           |pcpcpcp                                 11.9%
  SORT_PRIMES\             |
   SORT_PRIMES  . . .      |ioioioioi                               13.9%
                           |pcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpc   83.7%
  OUTPUT_PRIMES\           |
   OUTPUT_PRIMES  . .      |ioio                                     7.0%
                           |pc                                       3.1%
  PCA$PRIMES_1\            |
   PCA$PRIMES_1 . . .      |                                         0.0%
                           |                                         0.2%
  PRIME\               |
   PRIME  . . . . . .  |                                         0.0%
                       |p                                        1.0%
  SYSTEM$SERVICE\      |
   SYSTEM$SERVICE . .  |                                         0.0%
                       |                                         0.0%
  SYSTEM$SPACE\        |
   SYSTEM$SPACE . . .  |                                         0.0%
                       |                                         0.0%
                       +----+----+----+----+----+----+----+----+
```

The resulting plot shows no significant relationship between I/O service calls and PC sampling.

Correlating I/O Service Calls with Physical I/O

Try the physical I/O counts next, and see the comparison:

```
PCAA> INCLUDE/PHYSICAL_IO/FILL="phys_io"
```

```
                  Performance and Coverage Analyzer                Page 1
           I/O System Service Calls (316152 data points total) - "io"
        Program Counter Sampling Data (1019612 data points total) - "pc"
           Total Physical I/O Counts (206391 data points total) - "phys_io"
Bucket Name              +----+----+----+----+----+----+----+----+----+
  INPUT_DATA\            |
   INPUT_DATA . . . .    |ioioioioioioioioioioioioioioioooioioioio   79.1%
                         |pcpcpcp                                    11.9%
                         |p                                           0.1%
  SORT_PRIMES\           |
   SORT_PRIMES  . . .    |ioioioioi                                  13.9%
                         |pcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcp 83.7%
                         |phys_iophys_iophys_iophys_iophys_iophys_iop 99.8%
  OUTPUT_PRIMES\         |
   OUTPUT_PRIMES  . .    |ioio                                        7.0%
                         |pc                                          3.1%
                         |                                            0.0%
  PCA$PRIMES_1\          |
   PCA$PRIMES_1 . . .    |                                            0.0%
                         |                                            0.2%
                         |                                            0.0%
  PRIME\                 |
   PRIME  . . . . . .    |                                            0.0%
                         |p                                           1.0%
                         |                                            0.0%
  SYSTEM$SERVICE\        |
   SYSTEM$SERVICE . .    |                                            0.0%
                         |                                            0.0%
                         |                                            0.0%
  SYSTEM$SPACE\          |
   SYSTEM$SPACE . . .    |                                            0.0%
                         |                                            0.0%
                         |                                            0.0%
                         |
                         +----+----+----+----+----+----+----+----+----+
```

This is a good correlation. Most of the time is being spent doing physical I/O in the sorting routine. Check now to see if most of the time being spent in the sorting routine is in the READ or the WRITE statement.

```
PCAA> INCLUDE/READ_COUNT/FILL=("rd","wrt")

                  Performance and Coverage Analyzer                Page 1
           I/O System Service Calls (316152 data points total) - "io"
        Program Counter Sampling Data (1019612 data points total) - "pc"
           Total Physical I/O Counts (206391 data points total) - "phys_io"
          Total Physical Read Counts (155125 data points total) - "rd"
Bucket Name              +----+----+----+----+----+----+----+----+----+
  INPUT_DATA\            |
   INPUT_DATA . . . .    |ioioioioioioioioioioioioioioioioioioioio   79.1%
                         |pcpcpcp                                   11.9%
                         |p                                          0.1%
                         |                                           0.2%
  SORT_PRIMES\           |
   SORT_PRIMES  . . .    |ioioioioi                                 13.9%
                         |pcpcpcpcpcpcpcpcpcpcpcpcpcpcpcppcpcpcpcpc  83.7%
                         |phys_iophys_iophys_iophys_iophys_iop      99.8%
                         |rdrdrdrdrdrdrdrdrdrdrdrdrdrdrdrdrdrdrdrd   99.8%
  OUTPUT_PRIMES\         |
   OUTPUT_PRIMES  . .    |ioio                                       7.0%
                         |pc                                         3.1%
                         |                                           0.0%
                         |                                           0.0%
  PCA$PRIMES_1\          |
   PCA$PRIMES_1 . . .    |                                           0.0%
                         |                                           0.2%
                         |                                           0.0%
                         |                                           0.0%
  PRIME\                 |
   PRIME  . . . . . .    |                                           0.0%
                         |p                                          1.0%
                         +----+----+----+----+----+----+----+----+----+

PCAA> INCLUDE/WRITE_COUNT

                  Performance and Coverage Analyzer                Page 1
           I/O System Service Calls (316152 data points total) - "io"
        Program Counter Sampling Data (1019612 data points total) - "pc"
           Total Physical I/O Counts (206391 data points total) - "phys_io"
          Total Physical Read Counts (155125 data points total) - "rd"
          Total Physical Write Counts (51266 data points total) - "wrt"
  Bucket Name            +----+----+----+----+----+----+----+----+----+
  INPUT_DATA\            |
   INPUT_DATA . . . .    |ioioioioioioioioioioioioioioioioioioioio   79.1%
                         |pcpcpcp                                   11.9%
                         |p                                          0.1%
                         |                                           0.2%
                         |                                           0.0%
  SORT_PRIMES\           |
   SORT_PRIMES  . . .    |ioioioioi                                 13.9%
                         |pcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpcpc   83.7%
                         |phys_iophys_iophys_iophys_iophys_iop      99.8%
                         |rdrdrdrdrdrdrdrdrdrdrdrdrdrdrdrdrdrdrdrd   99.8%
                         |wrtwrtwrtwrtwrtwrtwrtwrtwrtwrtwrtwrtwr     99.9%
  OUTPUT_PRIMES\         |
   OUTPUT_PRIMES  . .    |ioio                                       7.0%
                         |pc                                         3.1%
                         |                                           0.0%
                         +----+----+----+----+----+----+----+----+----+
```

The multiple data-kind plot shows that the time is being spent doing physical reads and writes. Examine the relationship of these data kinds in the source display. This example uses a TABULATE command, so you can see the raw data counts.

The following series of commands builds a multiple data-kind table that allows you to examine the relationship of the data kinds by their data counts:

```
PCAA> TABULATE/MAIN_IMAGE ROUTINE SORT_PRIMES BY LINE
PCAA> INCLUDE/IO_SERVICES
PCAA> INCLUDE/PHYSICAL_IO
PCAA> INCLUDE/READ_COUNT
PCAA> INCLUDE/WRITE_COUNT
```

```
                  Performance and Coverage Analyzer                Page 1
        Program Counter Sampling Data (1019612 data points total) - "*"
           I/O System Service Calls (316152 data points total) - "O"
            Total Physical I/O Counts (206391 data points total) - "x"
          Total Physical Read Counts (155125 data points total) - "@"
          Total Physical Write Counts (51266 data points total) - ":"
Percent    Count  Line
                   35: C
                   .
                   .
                   .
 56.7%   577999    41: WRITE (UNIT = 10) 250000-IARRAY(I, J), IARRAY (I, J)
  7.0%    22045
 78.3%   161681
 71.2%   110476
 99.9%    51205
                   .
                   .
                   .
 27.0%   274885    52: READ( UNIT = 10, END = 3000 ) T, IPARRAY( I )
  7.0%    22046
 21.5%    44326
 28.6%    44326
  0.0%        0
                   53: C
```

4.4. Example 4: Using Event Markers for Selective Analysis

This example demonstrates the use of event markers. The Analyzer filters the data so that only the dataset off with the event markers is used. This example uses the same program as the one used in *Section 4.3, "Example 3: Using Multiple Data Kinds"*.

If you want to see the program's performance independent of the I/O wait time, place the data gathered during the I/O statements in the event marker IO, and the rest of the program in the event marker NO_IO. Data gathered between two event markers is associated with the event name given to the first of the two markers.

The I/O statements you want to eliminate from analysis are as follows:

- Line 34 in module INPUT_DATA (a READ statement)
- Lines 41 and 52 in module SORT_PRIMES (the WRITE and the READ statements)

- Line 28 in module OUTPUT_PRIMES (an IF THEN statement)

The event markers are not placed on the lines themselves or on the lines immediately after the I/O statement. This prevents PCA from gathering two event markers for every iteration of the loop (a relatively “expensive” operation).

If there were significant calculations in the loop, you would set the event marker on the line itself and on the one immediately after. Use the TYPE command to find the exact line numbers. For example:

```
$ FOR/NOOPTIMIZE/DEBUG PCA$PRIMES_1.FOR
$ LINK/DEBUG PCA$PRIMES_1
$ DEFINE LIB$DEBUG PCA$COLLECTOR.EXE
$ RUN PCA$PRIMES_1

        PCA Collector Version V5.0

PCAC> SET DATAFILE/EXECUTABLE/APPEND
PCAC> TYPE INPUT_DATA 30:47

module INPUT_DATA\
    30: C
    31:         DO I = 1, M
    32:             DO J = 1, N
    33: C
    34:                 READ( UNIT = 10,
    35:         1             FMT = *,
    36:         1             IOSTAT = IOS,
    37:         1             END = 1000
    38:         1            )
    39:         1            IARRAY(I, J)
    40: C
    41:             END DO
    42:         END DO
    43: C
    44: 1000    CLOSE( UNIT = 10 )
    45: C
    46:         RETURN
    47:         END

PCAC> SET EVENT IO LINE INPUT_DATA\INPUT_DATA\%LINE 31
PCAC> SET EVENT NO_IO LINE INPUT_DATA\INPUT_DATA\%LINE 44
PCAC> TYPE SORT_PRIMES\35:60

module SORT_PRIMES\
    35: C
    36:   WRITE( UNIT = 10 ) 0, 0
    37:   DO I = 1, M
    38:       DO J = 1, N
    39: C
    40:           IF (IARRAY (I,J) .NE. 0) THEN
    41:               WRITE (UNIT = 10) 250000-IARRAY(I, J), IARRAY (I, J)
    42:           ENDIF
    43: C
    44:       END DO
    45:   END DO
    46: C
    47: C Read the elements back
    48: C
    49:   READ( UNIT = 10, KEY = 0, KEYID = 1 ) I, J
    50:   DO I = 1, O
    51: C
    52:           READ( UNIT = 10, END = 3000 ) T, IPARRAY( I )
    53: C
    54:   END DO
    55: C
    56: 3000 CLOSE(UNIT=10)
    57:   L = I
    58: C
    59:   RETURN
    60:   END

PCAC> SET EVENT IO LINE SORT_PRIMES\SORT_PRIMES\%LINE 36
PCAC> SET EVENT NO_IO LINE SORT_PRIMES\SORT_PRIMES\%LINE 56
PCAC> TYPE OUTPUT_PRIMES\20:39

module OUTPUT_PRIMES\
    20: C
    21:     IF (IOS .NE. 0) THEN
    22:         WRITE (6,*) ' Error opening listing file, Status = ',IOS
    23:         STOP
    24:     ENDIF
    25: C
    26:     DO I = 1, O
    27: C
    28:         IF (IPARRAY(I) .NE. 0) THEN
    29:             WRITE( 10, 2000 ) IPARRAY(I)
    30:         END IF
    31: C
    32:     END DO
    33: C
    34: 2000 FORMAT(I6)
    35: C
    36: 3000 CLOSE(UNIT=1)
    37: C
    38:     RETURN
    39:     END

PCAC> SET EVENT IO LINE OUTPUT_PRIMES\OUTPUT_PRIMES\%LINE 26
PCAC> SET EVENT NO_IO LINE OUTPUT_PRIMES\OUTPUT_PRIMES\%LINE 36
PCAC> SET PC
PCAC> GO
%PCA-I-BEGINCOL, data collection begins
%PCA-I-ENDCOL, data collection ends
```

Use the SET FILTER command to include only the data in the NO_IO event:

```
$ PCA PCA$PRIMES_1

         Performance and Coverage Analyzer Version V5.0

PCAA> SET FILTER FOO TIME=NO_IO
PCAA> PLOT/MAIN_IMAGE
```

```
                  Performance and Coverage Analyzer                Page 1
         Program Counter Sampling Data (16995 data points total) - "*"
  Bucket Name              +----+----+----+----+----+----+----+----+----+
  PCA$PRIMES_1\            |
   PCA$PRIMES_1 . . .      |****************************************  68.8%
  PRIME\                   |
   PRIME  . . . . . .      |**********************                    30.5%
  SORT_PRIMES\             |
   SORT_PRIMES  . . .      |                                           0.5%
  OUTPUT_PRIMES\           |
   OUTPUT_PRIMES  . .      |                                           0.2%
  INPUT_DATA\              |
   INPUT_DATA . . . .      |                                           0.1%
  SYSTEM$SERVICE\          |
   SYSTEM$SERVICE . .      |                                           0.0%
  SYSTEM$SPACE\            |
   SYSTEM$SPACE . . .      |                                            0.0%
                           +----+----+----+----+----+----+----+----+----+

PCAA> NEXT

                  Performance and Coverage Analyzer                Page 1
         Program Counter Sampling Data (16995 data points total) - "*"
                         Routine PCA$PRIMES_1\PCA$PRIMES_1
Percent   Count   Line
PCA$PRIMES_1\PCA$PRIMES_1\
                       23: C
                       24: C   Input the data
                       25: C
  0.0%                 26:     CALL INPUT_DATA( ARRAY, ARRAY_LENGTH,
                                                  ARRAY_WIDTH)
                       27: C
                       28: C
                       29: C   Loop to calculate the primes
                       30: C
  0.0%                 31:     DO I = 1, ARRAY_LENGTH
  0.0%                 32:         DO J = 1, ARRAY_WIDTH
 63.8%  ******* ->     33:             R = ARRAY(I,J)
  3.6%                 34:             IF (PRIME(R) .NE. .TRUE.) THEN
  0.1%                 35:                 ARRAY(I,J) = 0
                       36:             END IF
                       37:
  0.3%                 38:         END DO
  0.0%                 39:     END DO
```

The results show that this program spends a lot of time at an assignment statement. A simple assignment like the one in this example does not take significantly longer than the immediately following test. At this point, gather page fault data. The event setting commands are the same as before, but are shown without their output:

```
$ FOR/NOOPTIMIZE/DEBUG PCA$PRIMES_1.FOR
$ LINK/DEBUG PCA$PRIMES_1
$ DEFINE LIB$DEBUG PCA$COLLECTOR.EXE
$ RUN PCA$PRIMES_1

        PCA Collector Version V5.0

PCAC> SET DATAFILE/EXECUTABLE/APPEND
PCAC> TYPE INPUT_DATA 20:40
PCAC> SET EVENT IO INPUT_DATA\INPUT_DATA\%LINE 31
PCAC> SET EVENT NO_IO INPUT_DATA\INPUT_DATA\%LINE 44
PCAC> TYPE SORT_PRIMES 35:55
PCAC> SET EVENT IO SORT_PRIMES\SORT_PRIMES\%LINE 36
PCAC> SET EVENT NO_IO SORT_PRIMES\SORT_PRIMES\%LINE 56
PCAC> TYPE OUTPUT_PRIMES 20:40
PCAC> SET EVENT IO OUTPUT_PRIMES\OUTPUT_PRIMES\%LINE 26
PCAC> SET EVENT NO_IO OUTPUT_PRIMES\OUTPUT_PRIMES\%LINE 36
PCAC> SET PAGE_FAULTS
PCAC> GO
%PCA-I-BEGINCOL, data collection begins
%PCA-I-ENDCOL, data collection ends
```

Now, plot the page fault data:

```
$ PCA PCA$PRIMES_1

         Performance and Coverage Analyzer Version V5.0

PCAA> SET FILTER FOO TIME=NO_IO
PCAA> PLOT/PAGE_FAULT

                  Performance and Coverage Analyzer                Page 1
        Page Fault Program-Counter Data (266378 data points total) - "*"
  Bucket Name            +----+----+----+----+----+----+----+----+----+
  PCA$PRIMES_1\          |
   PCA$PRIMES_1 . . .    |***************************************  94.4%
  SYSTEM$SPACE\          |
   SYSTEM$SPACE . . .    |*                                         1.6%
  SYSTEM$SERVICE\        |
   SYSTEM$SERVICE . .    |                                          0.1%
  PRIME\                 |
   PRIME  . . . . . .    |                                          0.0%
  SORT_PRIMES\           |
   SORT_PRIMES  . . .    |                                          0.0%
  OUTPUT_PRIMES\         |
   OUTPUT_PRIMES  . .    |                                          0.0%
  INPUT_DATA\            |
   INPUT_DATA . . . .    |                                          0.0%
                         +----+----+----+----+----+----+----+----+----+

PCAA> NEXT


                  Performance and Coverage Analyzer                Page 1
        Page Fault Program-Counter Data (266378 data points total) - "*"
                         Routine PCA$PRIMES_1\PCA$PRIMES_1
Percent   Count   Line
PCA$PRIMES_1\PCA$PRIMES_1\
                       23: C
                       24: C   Input the data
                       25: C
  0.0%                 26:     CALL INPUT_DATA( ARRAY, ARRAY_LENGTH,
                                                     ARRAY_WIDTH)
                       27: C
                       28: C
                       29: C   Loop to calculate the primes
                       30: C
  0.0%                31:     DO I = 1, ARRAY_LENGTH
  0.0%                32:         DO J = 1, ARRAY_WIDTH
 94.3%  ******* ->    33:             R = ARRAY(I,J)
  0.0%                34:             IF (PRIME(R) .NE. .TRUE.) THEN
  0.0%                35:                 ARRAY(I,J) = 0
                      36:             END IF
                      37:
  0.0%                38:         END DO
  0.0%                39:     END DO
```

Because FORTRAN walks arrays in column-major order and because there is a large number of page faults in processing this array, you might try changing the order of the array walking to reduce the page faults.

4.5. Determining Acceptable Noncoverage (ANC)

Coverage data is collected and analyzed to determine whether tests should be written to cover certain parts of the code, or whether they are acceptably noncovered. For complete information on the collection of coverage data, see *Section 2.4.3, "Test Coverage Data"*. For information on the analysis of that data, see *Section 3.6, "Using Acceptable Noncoverage (ANC)"*.

This example uses the PRIMES_1.FOR program used in *Section 4.4, "Example 4: Using Event Markers for Selective Analysis"*.

Enter the following commands to collect coverage data at the starting address of each codepath in the program PRIMES_1.FOR. The collection points comprise the *coverage-set*. Specify the /ANC qualifier to store codepath information for each module containing coverage points in the performance data file. This does not declare coverage-set points as acceptably noncovered. For example:

```
$ RUN PRIMES_1

        PCA Collector Version V5.0

PCAC> SET COVERAGE/ANC PROGRAM_ADDRESS BY CODEPATH
%PCA-I-DEFDATFIL, set datafile required in this context, creating
'[]PCA$PRIMES_1.PCA'
PCAC> GO
%PCA-I-BEGINCOL, data collection begins
FORTRAN STOP
%PCA-I-ENDCOL, data collection ends
$
```

Enter the following commands to begin the analysis of the coverage data collected. To examine the lines of code that are not covered, the example traverses a /NONCOVERAGE plot. Buckets that do not contain coverage-set points have a hyphen (-) in the percentage column of the plot.

```
$ PCA PRIMES_1

         Performance and Coverage Analyzer Version 5.0

PCAA> PLOT/NONCOVERAGE
```

```
                 Performance and Coverage Analyzer                Page 1
             Test Noncoverage Data (71 data points total) - "*"
  Bucket Name            +----+----+----+----+----+----+----+----+----+
  SORT_PRIMES\           |
   SORT_PRIMES  . . .    |****************************************   40.8%
  INPUT_DATA\            |
   INPUT_DATA . . . .    |************************                   18.3%
  OUTPUT_PRIMES\         |
   OUTPUT_PRIMES  . .    |**********************                     16.9%
  PCA$PRIMES\            |
   PCA$PRIMES . . . .    |********************                       15.5%
  PRIME\                 |
   PRIME  . . . . . .    |*********                                   8.5%
  SYSTEM$SERVICE\        |
   SYSTEM$SERVICE . .    |                                               -
  SYSTEM$SPACE\          |
   SYSTEM$SPACE . . .    |                                               -
                         |
                         |
                         |
                         +----+----+----+----+----+----+----+----+----+
```

The resulting plot shows that all the buckets (except those for the pseudo-routines SYSTEM$SERVICE and SYSTEM$SPACE) are covered. The following example is a series of traversals of the individual buckets of the previous plot. The routines are traversed in their natural order.

```
PCAA> NEXT

                              Routine PRIME\PRIME
                       cannot be expanded into a subtree
                          No noncovered points found
```

The first plot showed that routine PRIME had some data hits and therefore was covered as a whole. This plot shows that all of its codepaths are covered. Continue to traverse:

```
PCAA> NEXT
      .
      .
      .
PCAA> NEXT

                 Performance and Coverage Analyzer                Page 1
             Test Noncoverage Data (71 data points total) - "*"
                     Routine OUTPUT_PRIMES\OUTPUT_PRIMES
Percent   Count   Line
OUTPUT_PRIMES\OUTPUT_PRIMES\
  1.4%                  8:     SUBROUTINE OUTPUT_PRIMES( IPARRAY, O )
                        9: C
                       10:     INTEGER*4   IOS, O, I
   -                   11:     DIMENSION IPARRAY( O )
                       12: C
  1.4%                 13:     OPEN( UNIT=10,
                       14:     1     FILE='PCA$PRIMES.LIS',
                       15:     1     STATUS='NEW',
                       16:     1     IOSTAT = IOS
                       17:     1    )
                       18: C
                       19: C   Error if it cannot be found
                     20: C
  1.4%               21:     IF (IOS .NE. 0) THEN
  0.0% ******** ->   22:         WRITE (6,*) ' Error opening listing
                                                           file,>
```

The traverse arrow points to a line of code that executes only when an unexpected error condition occurs. Therefore, it is reasonable to declare this line as acceptably noncovered (ANC) with the SET ANC command:

```
PCAA> SET ANC
PCAA> NEXT
      .
      .
      .
```

Assume that while traversing further, you have also entered the SET ANC command when the traverse arrow was pointing to line 23 in the OUTPUT_PRIMES routine, and to lines 25 and 26 in the INPUT_DATA routine.

The SHOW ANC command can be used at any time to list all the currently set acceptably noncovered points:

```
PCAA> SHOW ANC

Number of ANC points = 10
  000014E6 ------- INPUT_DATA\INPUT_DATA\%LINE 25
  000014EF ------- INPUT_DATA\INPUT_DATA\%LINE 25 + 9
  000014FA ------- INPUT_DATA\INPUT_DATA\%LINE 25 + 14
  00001503 ------- INPUT_DATA\INPUT_DATA\%LINE 25 + 1D
  0000150A ------- INPUT_DATA\INPUT_DATA\%LINE 26
  0000172D ------- OUTPUT_PRIMES\OUTPUT_PRIMES\%LINE 22
  00001736 ------- OUTPUT_PRIMES\OUTPUT_PRIMES\%LINE 22 + 9
  00001740 ------- OUTPUT_PRIMES\OUTPUT_PRIMES\%LINE 22 + 13
  00001749 ------- OUTPUT_PRIMES\OUTPUT_PRIMES\%LINE 22 + 1C
  00001750 ------- OUTPUT_PRIMES\OUTPUT_PRIMES\%LINE 23
```

As a result of the four SET ANC commands entered, all the noncovered coverage set points within the four lines of code have been set as acceptably noncovered. Several codepaths can correspond to a single line of source code.

For more information on the SET ANC and SHOW ANC commands, as well as on other related commands such as CANCEL ANC and LIST/COVERAGE_SET, refer to *Section 3.6, "Using Acceptable Noncoverage (ANC)"*.

Now assume that you have decided to modify program PRIMES_1.FOR by changing lines 29 and 34 in routine OUTPUT_PRIMES from the following:

```
        .
        .
        .
      WRITE( 10, 2000 ) I, IPARRAY(I)
        .
        .
        .
2000  FORMAT(I,I6)
        .
        .
```

```
         .
```

To the following:

```
         .
         .
         .
      WRITE( 10, 2000 ) IPARRAY(I)
         .
         .
         .
2000  FORMAT(I6)
         .
         .
         .
```

You performed coverage analysis of the original version of the program,and set certain points as ANC. You now want to reuse this information, where applicable, for the new version of the program. This way, you do not have to repeat the analysis of those parts of the program that are unchanged.

Rename the previously used performance data file from PRIMES_1.PCA to PRIMES_1.OLD. This file contains the ANC information you set for the original version of the program. Now assume you have collected coverage data for the new version of the program, and have stored that data in a new PRIMES_1.PCA performance data file. You are now ready to analyze the new data:

```
$ PCA PRIMES_1

         Performance and Coverage Analyzer Version 5.0

PCAA> SHOW ANC
No ANC points set
```

The new file does not yet contain any ANC information. Use the MERGE/ANC command to bring any previously set ANC information that is still valid into the new file:

```
PCAA> MERGE/ANC PRIMES_1.OLD
 Merging file DISK$:[USER.EXAMPLES]PCA$PRIMES_1.OLD;1

PCAA> SHOW ANC

Number of ANC points = 5
  000014E6 ------- INPUT_DATA\INPUT_DATA\%LINE 25
  000014EF ------- INPUT_DATA\INPUT_DATA\%LINE 25 + 9
  000014FA ------- INPUT_DATA\INPUT_DATA\%LINE 25 + 14
  00001503 ------- INPUT_DATA\INPUT_DATA\%LINE 25 + 1D
  0000150A ------- INPUT_DATA\INPUT_DATA\%LINE 26
```

As a result of the modification to routine OUTPUT_PRIMES, all the ANC information pertaining to that routine has been invalidated. However, the remaining ANC information has been merged from PRIMES_1.OLD into PRIMES_1.PCA. Analyze the OUTPUT_PRIMES routine again:

```
PCAA> PLOT/ANC ROUTINE OUTPUT_PRIMES BY LINE

                 Performance and Coverage Analyzer                Page 1
           Test Noncoverage/ANC Data (70 data points total) - "*"
Percent   Count   Line
OUTPUT_PRIMES\OUTPUT_PRIMES\
  1.4%              8:     SUBROUTINE OUTPUT_PRIMES( IPARRAY, O )
```

```
                         9: C
                        10:     INTEGER*4   IOS, O, I
   -                    11:     DIMENSION IPARRAY( O )
                        12: C
  1.4%                  13:     OPEN( UNIT=10,
                        14:     1     FILE='PCA$PRIMES.LIS',
                        15:     1     STATUS='NEW',
                        16:     1     IOSTAT = IOS
                        17:     1    )
                        18: C
                        19: C   Error if it cannot be found
                        20: C
  1.4%                  21:     IF (IOS .NE. 0) THEN
  0.0% ********         22:         WRITE (6,*) ' Error opening listing file,
                                    status= ', IOS
  0.0% ********         23:         STOP
                        24:     ENDIF
```

You still want the two noncovered lines to be declared as acceptably noncovered:

```
PCAA> SET ANC ROUTINE OUTPUT_PRIMES BY LINE

PCAA> PLOT/ANC ROUTINE OUTPUT_PRIMES BY LINE

                  Performance and Coverage Analyzer                Page 1
            Test Noncoverage/ANC Data (70 data points total) - "*"
Percent   Count   Line
OUTPUT_PRIMES\OUTPUT_PRIMES\
  1.4%                   8:     SUBROUTINE OUTPUT_PRIMES( IPARRAY, O )
                         9: C
                        10:     INTEGER*4   IOS, O, I
   -                    11:     DIMENSION IPARRAY( O )
                        12: C
  1.4%                  13:     OPEN( UNIT=10,
                        14:     1     FILE='PCA$PRIMES.LIS',
                        15:     1     STATUS='NEW',
                        16:     1     IOSTAT = IOS
                        17:     1    )
                        18: C
                        19: C   Error if it cannot be found
                        20: C
  1.4%                  21:     IF (IOS .NE. 0) THEN
  ANC  ********         22:         WRITE (6,*) ' Error opening listing file,
                                    status= ', IOS
  ANC  ********         23:         STOP
                        24:     ENDIF
```

The resulting plot shows that both lines are again set as ANC.

The above example shows two sequences of operations:

1. An initial analysis performed for a new program. Because no ANC information exists initially, you analyze the whole program and use the SET ANC command to set any acceptably noncovered points.
2. A cycle performed after each modification of an existing program. The MERGE/ANC command is used to validate any previously set ANC points. You then repeat analysis only for routines that have been modified.

Interpreting the Test Noncoverage Data Summary Page

This section explains some of the test noncoverage data appearing in the summary page.

```
                      Performance and Coverage Analyzer
              Test Non-Coverage Data (44 data points total) - "*"
                 PCA Version 5.0       29-APR-2006 09:43:51
PLOT Command Summary Information:Number of buckets tallied:
               59

Test Non-Coverage Data - "*"
Number of covered buckets:                                 44    74.6%
Number of acceptably not covered buckets:                   0     0.0% ❶
Number of remaining not covered buckets:                   15    25.4% ❷
Number of buckets with no coverage data:                    0     0.0% ❸
Data count in largest defined bucket:                       1     2.3%
Data count in all defined buckets:                         44   100.0%
Data count not in defined buckets:                          0     0.0%
Portion of above count in P0 space:                         0     0.0%
Number of PC values in P1 space:                            0     0.0%
Number of PC values in system space:                        0     0.0%

Total number of data values collected:                     44   100.0%

Command qualifiers and parameters used:
  Qualifiers:
    /NONCOVERAGE /NOSORT /NOMINIMUM /NOMAXIMUM
    /NOCUMULATIVE /SOURCE /ZEROS /NOSCALE /NOCREATOR_PC
    /NOPATHNAME /NOCHAIN_NAME /WRAP /NOPARENT_TASK /NOKEEP /NOTREE
    /FILL=("*","O","x","@",":","#","/","+")
    /NOSTACK_DEPTH /NOMAIN_IMAGE
  Node specifications:
    PROGRAM_ADDRESS BY 1 CODEPATHS

No filters are defined
```

❶ **Number of acceptably not covered buckets.** This line tells you the number of places in your application you have specified as acceptably noncovered (ANC). See *Section 3.6, "Using Acceptable Noncoverage (ANC)"* for more information on ANC.

❷ **Number of remaining not covered buckets.** This line tells you the number of places in your application that were not covered by tests.

❸ **Number of buckets with no coverage data.** This line tells you the number of places in your application on which PCA could not collect coverage data; for example, a protected section in your application where PCA could not insert a breakpoint.

4.6. Example 6: Measuring Ada Tasking Data

This example demonstrates the measurement of Ada tasks. Data is reduced interactively to determine the performance of the Ada tasking program. See *Section 2.4.8, "Tasking Data"* for complete information about the collection of tasking data.

The following commands compile, link, and run the Ada program DISCCHAR:

```
$ ACS SET LIB DISK$:[USER.ADA]
$ ADA/DEBUG DISCCHAR.ADA
$ ACS LINK/DEBUG DISCCHAR
$ DEFINE LIB$DEBUG PCA$COLLECTOR.EXE
$ RUN DISCCHAR.EXE

        PCA Collector Version V5.0

PCAC>
```

For this example, you need to collect tasking information and PC sampling data. Enter the following commands:

```
PCAC> SET PC_SAMPLING
PCAC> SET TASKING
PCAC> GO
%PCA-I-DEFDATFIL, set datafile required in this context, creating
'[]DISCCHAR.PCA'
%PCA-I-BEGINCOL, data collection begins
%PCA-I-ENDCOL, data collection ends

$
```

At this point, the following tasking data has been collected and can be analyzed:

- Task identifiers for all tasks
- Task types for all tasks
- The parent task for all tasks
- The program counter for the location of the creation of the task
- All context switches
- The priority of the task upon the context switch
- The relative time of the context switch

Invoke the Analyzer and specify the DISCCHAR data file:

```
$ PCA DISCCHAR

         Performance and Coverage Analyzer Version V5.0

PCAA>
```

You may want to see when the program is doing the most context switching. If this program represents a paging system, this would be the point where “thrashing” occurs. For example:

```
PCAA> PLOT/TASK_SWITCH/NOSORT TIME BY 30 MSECS

                Performance and Coverage Analyzer           Page 1
      Total Task Context Switches (72 data points total) - "*"
  Bucket Name            +----+----+----+----+----+----+----+
  TIME\                  |
    0 -     29  . . .    |**                                  1.4%
   30 -     59  . . .    |*************************          15.3%
   60 -     89  . . .    |****************************         16.7%
   90 -    119  . . .    |***********************************  20.8%
  120 -    149  . . .    |*********************************    19.4%
  150 -    179  . . .    |*********************************    19.4%
  180 -    200  . . .    |************                          6.9%
                         |
                         +----+----+----+----+----+----+----+
```

The resulting plot shows a peak between 90 and 179 milliseconds. To see which tasks are doing the context switching during that period of time, create a filter for a new plot:

```
PCAA> SET FILTER F1 TIME=90:179
PCAA> PLOT/TASK_SWITCH  TASK_TYPE BY TASK_TYPE_NAME

                 Performance and Coverage Analyzer           Page 1
       Total Task Context Switches (43 data points total) - "*"
Bucket Name             +----+----+----+----+----+----+----+
TASK_TYPE\              |
 MAIN$TASK  . . . .     |***********************************  34.9%
 DISPOSABLESEMAPHORE    |***************************          27.9%
 DH . . . . . . . .     |******************                   16.3%
 SCHEDULER  . . . .     |***************                      14.0%
 SPACEMANAGER . . .     |********                              7.0%
 ADA$START_UP . . .     |                                      0.0%
                        |
                        |
                        +----+----+----+----+----+----+----+
```

The resulting plot shows that the tasks DISPOSABLESEMAPHORE and MAIN$TASK are doing the most context switching. There are several instances of the task type DISPOSABLESEMAPHORE. Therefore, you may want to look at only those task switches caused by DISPOSABLESEMAPHORE. To do this, you have to AND two filters together. Enter the following set of commands to create this plot. FILTER F1 specifies a period of time; FILTER F2 specifies a task type.

```
PCAA> SET FILTER F1 TIME=90:179
PCAA> SET FILTER F2 TASK_TYPE=DISPOSABLESEMAPHORE
PCAA> TABULATE/NOZERO/TASK_SWITCH TASK by TASK_IDENTIFIER

                 Performance and Coverage Analyzer           Page 1
       Total Task Context Switches (12 data points total) - "*"
                                 Data
  Bucket Name                    Count  Percent
  TASK\
   Run   1\%Task   6  . . . . . .    4   33.3%
   Run   1\%Task   7  . . . . . .    4   33.3%
   Run   1\%Task   8  . . . . . .    4   33.3%
```

The resulting table shows that each instance of the task has four context switches. Analyzing the code, you can see that the context switches occurred at creation, rendezvous point P, rendezvous point V, and once more before exiting.

At this point, you want to analyze which task used the most time. Before you do this, cancel the filters:

```
PCAA> CANCEL FILTER/ALL
PCAA> PLOT/PC_SAMPLING TASK_TYPE BY TASK_TYPE_NAME

                 Performance and Coverage Analyzer           Page 1
      Program Counter Sampling Data (36 data points total) - "*"
```

```
Bucket Name            +----+----+----+----+----+----+----+
TASK_TYPE\             |
 ADA$START_UP . . .    |**********************************  58.3%
 DH . . . . . . . .    |*****************                   25.0%
 SCHEDULER  . . . .    |******                               8.3%
 MAIN$TASK  . . . .    |****                                 5.6%
 SPACEMANAGER . . .    |**                                   2.8%
 DISPOSABLESEMAPHORE   |                                     0.0%
                       |
                       |
                       +----+----+----+----+----+----+----+
```

This plot shows that most of the time is spent in the startup phase of the program.

The following commands filter out the startup data and create anew plot:

```
PCAA> SET FILTER F1 TASK_TYPE<>ADA$START_UP
PCAA> PLOT/PC_SAMPLING TASK_TYPE BY TASK_TYPE_NAME

                 Performance and Coverage Analyzer           Page 1
      Program Counter Sampling Data (15 data points total) - "*"
Bucket Name            +----+----+----+----+----+----+----+
TASK_TYPE\             |
 DH . . . . . . . .    |**********************************  60.0%
 SCHEDULER  . . . .    |*************                       20.0%
 MAIN$TASK  . . . .    |*********                           13.3%
 SPACEMANAGER . . .    |****                                 6.7%
 ADA$START_UP . . .    |                                     0.0%
 DISPOSABLESEMAPHORE   |                                     0.0%
                       |
                       +----+----+----+----+----+----+----+
```

You can see now that ADA$START_UP has 0%, and the other task types have increased their share of the time.

Because priorities may change during the execution of a program, you may want to check the range and frequency of the values associated with one task by entering the following commands. Note that FILTER F1 specifies only those data points that are associated with %TASK 2:

```
PCAA> SET  FILTER  F1  TASK_IDENTIFIER = %TASK 2
PCAA> TABULATE/TASK_SWITCH/NOSORT TASK_PRIORITY BY PRIORITY_UNIT

                 Performance and Coverage Analyzer           Page 1
       Total Task Context Switches (8 data points total) - "*"
                                 Data
  Bucket Name                    Count  Percent
  TASK_PRIORITY\
                  0  . . . . . .     0    0.0%
                  1  . . . . . .     0    0.0%
                  2  . . . . . .     0    0.0%
                  3  . . . . . .     0    0.0%
                  4  . . . . . .     0    0.0%
                  5  . . . . . .     6   75.0%
                  6  . . . . . .     0    0.0%
                  7  . . . . . .     2   25.0%
                  8  . . . . . .     0    0.0%
                  9  . . . . . .     0    0.0%
                 10  . . . . . .     0    0.0%
```

```
                    11  . . . . . .    0    0.0%
                    12  . . . . . .    0    0.0%
                    13  . . . . . .    0    0.0%
                    14  . . . . . .    0    0.0%
                    15  . . . . . .    0    0.0%
```

In the previous example, you may first want to know what type of task %TASK 2 is, then which task created %TASK 2 and what other tasks were created by %TASK2. The following command requests the Analyzer to look only at the data for %TASK 2:

```
PCAA> SET FILTER F1 TASK_IDENTIFIER = %TASK 2
```

The following command plots this data against the TASK_TYPE domain:

```
PCAA> PLOT/TASK_SWITCH/NOSORT TASK_TYPE BY TASK_TYPE_NAME
```

The following command includes more data within the plot; however, all of the data is charged to the parent task instead of the task itself.

```
PCAA> INCLUDE/PARENT
```

```
                 Performance and Coverage Analyzer Page 1
       Total Task Context Switches (8 data points total) - "*"
       Total Task Context Switches (8 data points total) - "O"
  Bucket Name        +----+----+----+----+----+----+----+----+
  TASK_TYPE\         |
   SPACEMANAGER . . . |**************************************** 100.0%
                      |                                          0.0%
                      |                                          0.0%
   ADA$START_UP . . . |                                          0.0%
                      |                                          0.0%
                      |                                          0.0%
   DH . . . . . . . . |                                          0.0%
                      |                                          0.0%
                      |                                          0.0%
   DISPOSABLESEMAPHORE|                                          0.0%
                      |                                          0.0%
                      |                                          0.0%
    MAIN$TASK . . . . |                                          0.0%
                      |OOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOO  87.5%
                      |                                          0.0%
    SCHEDULER . . . . |                                          0.0%
                      |                                          0.0%
                      |                                          0.0%
                      +----+----+----+----+----+----+----+----+
```

The resulting plot shows that %TASK 2 was type SPACEMANAGER. Its parent was MAIN$TASK and it had no children.

4.7. Using PCA in Screen Mode

You can display Analyzer output in either *nonscreen mode* (the default) or *screen mode*. Screen mode output is best displayed on any terminal that supports DECterms. VT52 class terminals are not well suited for screen mode because they do not support scrolling regions.

With screen mode, you can divide the terminal screen into sections or windows and display different kinds of data in each window. For example, you can display PLOT or TABULATE output at the top of the screen, LIST, SHOW, or SEARCH command output in the middle, and TYPE command output at the bottom. You can scroll through the output in each window with the SCROLL command.

To run PCA in screen mode, enter the SET MODE SCREEN command. If you plan to use screen mode frequently, you may want to add the SET MODE SCREEN command to your Analyzer initialization file. To return to line-by-line output, enter the command SET MODE NOSCREEN.

To see the names, windows, and types of all current displays, use the SHOW DISPLAY command. To cancel a display that you have previously defined with the SET DISPLAY command, use the CANCEL DISPLAY command.

You cannot make a display reappear once you have canceled it. Any displays that may have been hidden under the canceled display then become visible.

4.7.1. Concepts and Terms

The terms **display**, **window**, **screen**, and **pasteboard**, used throughout this chapter, have the following meanings:

Display	A collection of text lines, consisting of the output from Analyzer commands, such as PLOT, TABULATE, SHOW, or LIST. Each display is associated with a screen window through which you view the display's text.
Window	A rectangular region on the terminal screen through which you view a display. Its size is defined by a starting line number and by the number of text lines that you want to view through that window. You can use the SCROLL command to move a window over display text. You can view a whole display by using this command with its various qualifiers.
Screen	The terminal screen. On a terminal of VT100-class or higher, the screen consists of 24 lines by 80 or 132 columns of text. The screen can also consist of up to 100 lines by 255 columns, depending on the terminal model and the terminal height and width settings.
Pasteboard	Similar to a drawing board on the terminal screen to which windows are attached. Each window is pasted onto the pasteboard in the order that it is referenced, and each display is placed in the window with which it is associated. The most recently referenced display is pasted last onto the pasteboard. Also, as you create more displays, the later displays that you have created may overlay part or all of your earlier displays. What you see on the screen is the final appearance of the pasteboard.

4.7.2. Defining Windows

When you want to specify a window for a command (such as the DISPLAY command), you can use either a predefined PCA window name or the name of a window you have defined yourself. PCA provides a large number of predefined window names. To show the current PCA-defined windows and any windows you have defined, enter the SHOW WINDOW command.

Although these predefined windows should be adequate for almost any situation, you can create your own window definitions with the SET WINDOW command, described in the online PCA Command Dictionary

To delete a window definition, use the CANCEL WINDOW command. This command can be used to permanently remove any PCA-defined window definitions, as well as any of your own window definitions.

4.7.3. Screen Displays

PCA automatically defines the OUT, PLOT, SRC, and PROMPT screen displays. Note that the PLOT display is not defined in the Collector. You can create your own screen displays by referring to either their regular names or special pseudo-display names described in *Section 4.7.3.3, "Pseudo-Display Names"*.

4.7.3.1. Default Displays

PCA defines the following displays for output by default:

OUT	Shows output generated by the PCA commands you enter. By default, this display holds the most current 100 lines of output, but you can change this number. You can scroll through this output text using either the SCROLL command or the scrolling keys on the keypad.
PLOT	Shows output generated by the Analyzer from the most recent PLOT or TABULATE command. You can scroll through this output text using either the SCROLL command or the scrolling keys on the keypad.
SRC	Shows output generated by the most recent TYPE command. You can scroll through this output text using either the SCROLL command or the scrolling keys on the keypad.
PROMPT	Shows PCA's input. By default, it also displays PCA's error messages. This display cannot be scrolled.

4.7.3.2. User-Defined Displays

You can define your own screen displays with the SET DISPLAY command. The SET DISPLAY command defines the name, window location, and contents of a display. The name appears in the top left corner of the screen window and serves as a tag on the window itself and as a name for future reference in other commands.

If you want to use the name of an existing display, you must cancel the existing display before you can define the new display.

The following command generates a PLOT display, names it PLOT2, and places it in the lower half of the screen:

```
PCAA> SET DISPLAY PLOT2 AT H2 PLOT
```

If you omit the display-kind parameter on the SET DISPLAY command, an output screen display is created.

Other PCA output can be directed to any of these displays with the SELECT command.

4.7.3.3. Pseudo-Display Names

Each screen display has a unique name, such as OUT, to which you can refer. However, commands that accept display names also accept the names of five **pseudo-displays** that refer to displays relative to their positions in the PCA display list.

Each time you refer to a specific display with a DISPLAY or SET DISPLAY command, PCA updates its screen display list and reorders the list, if necessary. PCA always puts the display you referenced most recently at the end of the display list because that display should be pasted last on the pasteboard. The display you referenced first is at the beginning of the list and is likely to be covered by other displays. Pseudo-display names never refer to displays that were created with the /REMOVE qualifier on the DISPLAY and SET DISPLAY commands.

Pseudo-display names are used mainly in keypad and command definitions. For instance, KP9 is bound to the command DISPLAY %NEXTDISP. Repeated use of this key causes each successive display on the display list to be shown until you reach the display you want. See *Table B.11, "Analyzer Screen Mode Pseudo Display Names"* for the descriptions of the pseudo-display names.

4.7.4. Selecting Displays for Output or Scrolling

The SELECT command determines which screen display receives PCA output, and lets you choose the current scrolling display. You can specify any one of the following, with the restrictions noted in the SELECT qualifier descriptions in the online PCA Command Dictionary:

- A predefined display (SRC, OUT, PLOT, and PROMPT)
- A display previously created with the SET DISPLAY command
- A pseudo-display name: %CURDISP, %CURSCROLL, %NEXTDISP, %NEXTOUTPUT, %NEXTPLOT, %NEXTSCROLL, and %NEXTSOURCE

If you omit this parameter and do not specify a qualifier, you cancel the current scrolling display (no display then has the scrolling attribute). If you omit this parameter but specify a qualifier, you cancel the current display with that attribute.

Attributes are used to select the current scrolling display and to direct various types of PCA output to particular displays. This gives you the option of mixing or isolating different types of information, such as PCA input, output, diagnostic messages, and so on, in scrollable displays. You can use the SELECT command with one or more qualifiers to assign one or more corresponding attributes to a display.

Note that if you do not specify a qualifier, the /SCROLL qualifier is assumed by default.

If you use the SELECT command without specifying a display name, in general the attribute assignment indicated by the command qualifier is canceled. To reassign display attributes you must use another SELECT command. See the individual SELECT command qualifier descriptions in the online PCA Command Dictionary for details.

The following command selects display SRC2 as the current source and scrolling display:

```
PCAC> SELECT/SOURCE/SCROLL SRC2
```

The following command selects display OUT as the current input and error display. This causes PCA input, output (assuming OUT is the current output display), and diagnostic messages to be logged in the OUT display in the correct sequence:

```
PCAC> SELECT/INPUT/ERROR OUT
```

4.7.4.1. Viewing Displays with TYPE and SEARCH Commands

You can use the SEARCH command to find locations of text strings in your source, and you can use the TYPE command to view a section of source. The sections of source that will be displayed are found in the files that were used in compiling the current image. If your sources have moved to a different directory, then you must use the SET SOURCE command to inform PCA of the locations of the source. See *Section 4.7.4.2, "Setting the Directory Search List"* for information on using SET SOURCE.

Use the TYPE command to specify which lines of source code to place in the current display.

You can specify a list of line numbers, separated with commas, to display source code corresponding to each of the line numbers.

You can specify a range of line numbers, separating the starting and ending numbers in the range with a colon, to display the source code corresponding to that range of line numbers.

You can specify a module name with the line numbers to indicate that the lines are located in that module. The module name must be followed by a backslash (\) and the line numbers, without intervening spaces. It is not necessary to enter a module name if there are no other modules with those line numbers.

In nonscreen mode, the following TYPE command displays line 160 and lines 22 through 24 in the module COBOLTEST:

```
PCAA> TYPE COBOLTEST\160,22:24
module COBOLTEST
   160: START-IT-PARA.
module COBOLTEST
   22: 02      SC2V2      PC S99V99 COMP VALUE 22.33.
   23: 02      SC2V2N     PC S99V99 COMP VALUE -22.33.
   24: 02      CPP2 PC    PP99 COMP      VALUE 0.0012.
```

In screen mode, line 22 will be placed in the middle of the current source display.

The SEARCH command searches your source code for a specified string. The source line or lines containing an occurrence of that string are then displayed in the output window.

The following example searches for all occurrences of the letter D in lines 40 through 50 of the module COBOLTEST. In screen mode, the result is displayed in the output window.

```
PCAA> SEARCH/STRING/ALL COBOLTEST\40:50 D
40: 02    D2N    COMP-2 VALUE  -234560000000
41: 02    D      COMP-2 VALUE  222222.33
47: 02    DRO    COMP-2 VALUE  0.1
50: 02    DR5    COMP-2 VALUE  0.000001
```

You can reset the SEARCH command’s default qualifiers with the SET SEARCH command. The SET SEARCH command establishes current qualifiers and parameters to be used in the absence of SEARCH command qualifiers.

You can display the current SEARCH parameters with the SHOW SEARCH command, as follows:

```
PCAA> SET SEARCH ALL, STRING
PCAA> SHOW SEARCH
 Default search qualifiers: /ALL /STRING
```

4.7.4.2. Setting the Directory Search List

The SET SOURCE command directs PCA to search a specified list of directories for source files when source text must be displayed. By default, PCA expects a source file to be located in the same directory and in the same file as it was when it was compiled. If that file has been moved to another location, you must use the SET SOURCE command to specify that location. This search list is used by the EDIT, PLOT, SEARCH, and TYPE commands.

If you specify more than one directory on a single SET SOURCE command, PCA searches each directory in the list in the specified order whenever it needs to access a source file. PCA also checks the creation date and time recorded in the Debug Symbol Table to determine which version of a file was compiled by the compiler. If PCA finds a file in the directory list that matches the compiled file, it displays that file. If PCA does not find the compiled file, it displays the first file in the list with the correct name, along with an informational message.

If you frequently use the same SET SOURCE command, you may want to include it in your initialization file (see *Section 3.8, "Using Initialization Files and Command Procedures"*).

You can use the CANCEL SOURCE command to cancel the current source file directory search list established with a previous SET SOURCE command. After the directory search list is canceled, PCA is unable to find any source file that has been moved since being compiled.

You can use the SHOW SOURCE command to display the current source directory search lists established with the SET SOURCE command. You can use the /EDIT qualifier with this command to show the directory search list established with the last SET SOURCE/EDIT command.

The following SET SOURCE command tells PCA to look for source files in directories [MYDIR], [YOURDIR], and [MOREDIR] in that order. The SHOW SOURCE command tells PCA to display the directory settings.

```
PCAA> SET SOURCE [MYDIR],[YOURDIR],[MOREDIR]
PCAA> SHOW SOURCE
     source directory search list for all modules:
            [MYDIR]
            [YOURDIR]
            [MOREDIR]
```

4.7.5. Manipulating Displays

You can manipulate screen displays in a variety of ways. You can scroll a window over a display, move the display across the screen, or you can expand or contract a window associated with a display. For all operations, the default display is the one currently marked with the scroll attribute.

Scrolling Displays

The SCROLL command moves the screen window over the text of a screen display. With this command you can look at all sections of a display, even though the display text is much larger than the screen window.

You must use one of the following qualifiers with the SCROLL command: /UP[:*n*], /DOWN[:*n*], /LEFT[:*n*], /RIGHT[:*n*], /TOP, or /BOTTOM. If you use one of the four qualifiers that has the optional :*n* parameter, you can specify the number of lines or spaces by which you want to scroll the window over the display. If you do not use this optional parameter, the display is scrolled by approximately three quarters of the height of the window for the /UP and /DOWN qualifiers, or eight spaces left or right for the /LEFT and /RIGHT qualifiers.

To see the ends of very long display lines, shift the window to the right using the SCROLL/RIGHT command. To shift the window back to the left, use the SCROLL/LEFT command.

To scroll the window up or down over a display, use the SCROLL/UP or SCROLL/DOWN command. The SCROLL/TOP command moves the window to the top of the specified display. The SCROLL/BOTTOM command moves the window to the bottom of the display.

The following command scrolls the window up through the OUT display by four lines:

```
PCAA> SCROLL/UP:4 OUT
```

Moving Displays

The MOVE command allows you to move a screen display vertically and horizontally across the screen. For each display specified, the MOVE command creates a window of the same dimensions elsewhere on the screen and maps the display to it, while maintaining the relative position of the text within the existing window.

You must use one of the following qualifiers with the MOVE command: /UP[:*n*],

/DOWN[:*n*], /LEFT[:*n*], or /RIGHT[:*n*]. By using the optional :*n* parameter, you can specify the number of lines or spaces by which you want to move the display (the default is 1). You can change the direction indicated by the qualifier by specifying a negative number.

The MOVE command does not change the order of a display on the display pasteboard. Depending on the relative order of displays, the MOVE command may cause the display to hide or uncover another display or be hidden by another display, partially or totally. A display can only be moved up to the edge of the screen.

The following command moves display NEW_OUT up by 3 lines and to the right by 5 columns:

```
PCAA> MOVE/UP:3/RIGHT:5 NEW_OUT
```

Expanding or Contracting Displays

The EXPAND command expands or contracts a window associated with a screen display by moving one or more display-window borders according to the qualifiers specified (/UP[:*n*], /DOWN[:*n*], RIGHT[:*n*], /LEFT[:*n*], where the optional *n* parameters default to 1). You can contract a display by specifying a negative value.

The EXPAND command does not affect the order of a display on the display pasteboard. Depending on the relative order of displays, the EXPAND command may cause the specified display to hide, uncover another display, or be hidden by another display, partially or totally.

Except for the PROMPT display, any display can be contracted to the point where it disappears (at which point it is marked as removed). It can then be expanded from that point. Contracting a display to the point where it disappears will cause it to lose any attributes that were selected for it. The PROMPT display cannot be contracted or expanded horizontally but can be contracted vertically to a height of two lines.

The following command moves the top border of display OUT2 up by one line, and the right border to the left by 12 columns:

```
PCAA> EXPAND/UP/RIGHT:-12 OUT2
```

Figure B.3, "PCA-Defined Keypad Key Functions for Screen Manipulation" shows the PCA-defined keypad functions for manipulating screen displays. Depending on the type of keyboard you have, you can either press a key or type a command to put the keypad in a DEFAULT, MOVE, EXPAND, or CONTRACT state.

4.7.6. Saving and Extracting Displays

When you want to keep the current contents of a display for later reference, you can save a copy of an existing screen by using the SAVE command.

When you want to view the contents you have saved, use the new display name with a DISPLAY command.

Just as you can save a plot or table in a file with the FILE command, you can save the contents of a screen display in a file with the EXTRACT command. You can also use EXTRACT to create a file containing all of the information necessary to create the current screen at a later time.

When you use the EXTRACT command to save the contents of a display into a file, only those lines that are currently stored in the display's memory buffer (as determined by the /SIZE qualifier on the DISPLAY or SET DISPLAY command) are written to the file. Note that you cannot extract the contents of the PROMPT display into a file, and you cannot save those contents into another display.

The following command writes all the lines in display SRC into the file PCA.TXT:

```
PCAA> EXTRACT SRC
```

The following command appends all the lines in display OUT to the end of file [STEVE.WORK]MYFILE.TXT:

```
PCAA> EXTRACT/APPEND OUT [STEVE.WORK]MYFILE
```

4.7.7. Keypad Key Functions

Instead of using the terminal keyboard keys to type in PCA commands, you can press keys on your terminal's numeric keypad to enter various commands bound to those keys. Using the keypad speeds input entry because one or two keystrokes will enter an entire command for you. You can also use the *color keys* (PF1=GOLD, PF4=BLUE) to associate each keypad key with one or more command sequences or functions. A keypad key may have a default function that is automatically performed when you press it.

PCA provides a set of standard keypad definitions that perform most of the commonly used PCA commands. These include commands such as PAGE NEXT, SET MODE SCREEN, the scrolling commands, and traverse commands. Many of the standard keypad definitions manipulate screen displays when PCA is in screen mode. *Figure B.2, "Analyzer-Defined Keypad Key Functions"* shows the Analyzer-defined keypad functions.

4.7.8. Defining Keys

You can define your own keypad definitions or change the PCA-defined standard keypad definitions with the DEFINE/KEY command. The DEFINE/KEY command associates a command string and a set of attributes with a key on the terminal keyboard or keypad.

Note that one key can have several different functions, and that the function used depends on the state you choose. The PCA-defined state names are DEFAULT, GOLD, and BLUE. States are established with the /SET_STATE qualifier or with the SET KEY command. See the online PCA Command Dictionary for complete information on the SET KEY command. The state-name parameter that is used with the /IF_STATE, /LOCK_STATE, and /SET_ STATE qualifiers can be any alphanumeric string you choose.

The following command associates KP7 with the SHOW PLOT command. Because the /TERMINATE qualifier is used, you do not need to press the Return key after pressing KP7 to execute the command.

```
PCAA> DEFINE/KEY/TERMINATE KP7 "SHOW PLOT"
```

Use the SHOW KEY command to see what keys are currently defined:

```
PCAA> SHOW KEY KP2
DEFAULT keypad definitions:
  KP2 = "Scroll/Down"
```

The DELETE/KEY command cancels the key definitions established with the DEFINE/KEY command. The UNDEFINE/KEY command performs the same function.

See the online PCA Command Dictionary for complete information on SET KEY, SHOW KEY, and DELETE/KEY, for all states.

Chapter 5. Using VAX Vectors with PCA

This chapter explains how to analyze your application if you are using a vector processor or the VAX Vector Instruction Emulator Facility (VVIEF). The following topics are discussed:

- Analyzing programs containing vector instructions
- Performing vector instruction sampling
- Performing vector instruction counting
- Analyzing vector processor data
- Analyzing vector instructions using vector-specific domains and data kinds

All the features described in this chapter work for both real vector processors and VVIEF.

5.1. Analyzing the Vector Instructions in Your Program – an Overview

PCA lets you:

- Examine how you have split the processing of the application between scalar and vector processors.
- Analyze how well your application's algorithms use the vector processor.

Certain programs run significantly faster on computers containing scalar and vector processors than on computers containing scalar processors alone. Programs that use repetitive array and matrix operations can run faster on a vector processor because those programs are constrained by scalar performance bottlenecks. Programs that spend most of their time performing I/O operations,executing system services, or using data types not supported by vector hardware (for example, BYTE and LOGICAL) do not benefit as much by being executed on a computer with both scalar and vector processors. See the *FORTRAN Performance Guide* for information on improving the run-time performance of FORTRAN programs executed on a vector processor.

5.2. Finding Where Your Application Uses Vector Processing

The Collector provides two data kinds for sampling vector-processing information: vector PC sampling and vector CPU sampling. You use the SET command, as shown in the following example, to enable sampling of PC values for random vector instructions:

```
PCAC> SET VPC_SAMPLING
```

The last command enables the sampling of vector PC values and shows you where the wall-clock time is being spent in the application performing vector instructions. The sampling rate defaults to an interval of 10 milliseconds and includes all the idle process time associated with running the program. Call stack information is collected by default. The following command enables the sampling of vector PC values and lets you examine the particular areas of your application where process time is spent performing vector instructions.

```
PCAC> SET VCPU_SAMPLING
```

The sampling rate defaults to an interval of 10 milliseconds and includes only the time that the application is running on the processor. Call stack information is collected by default.

You can disable the collection of call stack information with the /NOSTACK_PCS qualifier. You can set the timer interval length with the /INTERVAL qualifier.

When you sample the vector PC values, you can determine the scalar/vector parallelism throughout your entire program. The collection of vector PC or CPU sampling data provides you with the following information on each vector instruction:

- Program counter of the vector instruction
- Program relative time stamp
- Vector instruction opcode
- Vector stride
- Vector control word (instruction dependent)
- Vector length register
- Vector mask register
- Call stack information (optionally)

5.2.1. Collecting Concurrent Scalar and Vector Sampling

You can collect both scalar and vector samples during a collection run. The timer intervals must be the same for both types of sampling. If you have set different intervals for each, the Collector uses the timer interval of the last sampling command entered. The following example sets the timer interval to 20 milliseconds for CPU sampling, and 100 milliseconds for vector CPU sampling:

```
PCAC> SET CPU_SAMPLING/INTERVAL:20
PCAC> SET VCPU_SAMPLING/INTERVAL:100
```

In the example above, the interval for CPU and vector CPU sampling is reset to 100.

Note

You should not try to collect scalar PC samples and vector CPU samples in the same collection, as this will cause a distortion in the data collected. Likewise, you should not try to collect scalar CPU samples and vector PC samples in the same collection.

5.2.2. Gathering Scalar PC Sampling Within the Vector Instruction Emulator Only

VVIEF PC sampling in Scalar PC sampling data When you gather scalar PC sampling data in the collection run, there is a probability that the sampled PC values are within the emulator image itself.

Because you are only seeking information on PCs in the application and not in the vector emulator, the Collector can determine what the PC value was within the address range of the application when the emulator was invoked. In this way the PC value is traced back to the location that was being executed in your application when the PC was sampled.

5.3. Counting Vector Processor Instructions

Use the SET VCOUNTERS command to instruct the Collector to count all vector processor instructions in all or part of an application. From this information, you can determine to what extent the vector processor is used. You must specify at least one nodespec to indicate the domain of the data collected.

The following example collects vector instruction counts using the nodespec for an entire program:

```
PCAC> SET VCOUNTERS PROGRAM_ADDRESS BY VINSTRUCTION
```

The following example collects vector instruction counts using the nodespec for routine XYZ.

```
PCAC> SET VCOUNTERS ROUTINE XYZ BY VINSTRUCTION
```

See the online PCA Command Dictionary for a complete list of available nodespecs with the SET VCOUNTERS command.

To collect call stack information, use the /STACK_PCS qualifier on the command line.
(The /NOSTACK_PCS qualifier is the default.)

The same information is collected for vector counting as for vector sampling.

5.4. Analyzing Vector Processor Data

The Analyzer plots and displays the results of the vector instructions data gathered in the Collector. You can use three views to aid in the analysis of the scalar/vector processor parallelism: Table, Histogram, and Annotated Source.

Depending on what was gathered by the collection run, you can set the data kind to the any of the following:

- Vector instructions counted
- Vector PC sampling
- Vector CPU sampling

The following domains are available with vector instruction analysis:

- VINSTRUCTIONS – Sets the domain to the vector instruction found at the sampled or counted PC.
- VLENGTH – Sets the domain to the Vector Length Register (VLR) values.
- VMASK – Sets the domain to the Vector Mask Register (VMR) values.
- VOPCODE – Sets the domain to specific vector instructions.
- VOPERATIONS – Sets the domain to the number of operations per Vector instruction.
- VREGISTERS – Sets the domain to the Vector Register usage.

- VSTRIDE – Sets the domain to the Vector Stride values.

5.4.1. Finding the Most-Used Vector Instructions

To determine which vector instructions are used most by your program in the INSTRUCTION domain, enter the following command line:

```
PCAA> PLOT/VCOUNTERS INSTRUCTION BY VOPCODE
```

This command bases the report view on the disassembled opcode for each vector instruction in the entire application. The number of times a vector instruction is used lets you see if your application is spending a lot of time performing certain operations. For example, if you see that the SYNC vector instruction is executed more than any other vector instruction, you can infer that the scalar processor is spending too much idle time waiting for the vector processor to finish an operation.

You can specify the vector instructions you want to display, as in the following example, which displays only the SYNC and MSYNC vector instructions on the report.

```
PCAA> PLOT/VCOUNTERS VOPCODE SYNC, VOPCODE MSYNC
```

5.4.2. Finding the Locations of Vector Instructions

To find where in your program you are using vector instructions,use the following command:

```
PCAA> PLOT/VCOUNTERS PROGRAM_ADDRESS BY VINSTRUCTION
```

This command displays the address of each vector instruction in your program. In the display, the Analyzer also shows the ratio, as a percentage, of the execution count of each vector instruction to the execution count of all the vector instructions.

Example 5.1, "Sample Output of PLOT/VCOUNTERS Command" shows the output produced by the PROGRAM_ADDRESS BY VINSTRUCTION nodespec.

Example 5.1. Sample Output of PLOT/VCOUNTERS Command

```
                      Performance and Coverage Analyzer        Page 1
     Vector Instruction Execution Counts (3469 data points total) - "*"
Bucket Name          +----+----+----+----+----+----+----+----+----+----+
FFT\FFT\             |
  %LINE 46 + 18 MSYNC|**********************************************1.8%
  %LINE 46 + 2F MTVLR|**********************************************1.8%
  %LINE 46 + 33 VLDL |**********************************************1.8%
  %LINE 47 + 14 VSTL |**********************************************1.8%
  %LINE 47 + 28 MSYNC|**********************************************1.8%
  %LINE 47 + 2D SYNC |**********************************************1.8%
  %LINE 47 + 6 VSADDL|**********************************************1.8
  %LINE 47 VSADDL  . |**********************************************1.8%
  %LINE 72 + 32      |
    MTVMRLO  . . . . |**********************************************1.8%
  %LINE 74 VSADDL  . |**********************************************1.8%
  %LINE 75 + 3 MSYNC |**********************************************1.8%
  %LINE 75 + 8 SYNC  |**********************************************1.8%
FT$MAIN\FFT$MAIN\    |
  %LINE 24 VVMERGE . |*************************                     0.9%
                     |
                       +----+----+----+----+----+----+----+----+----+----+
```

5.4.3. Finding if the Vector Processor is Optimally Used

The VLENGTH domain lets you determine the number of elements in the vectors that are acted on by a vector instruction. Generally, the larger the vector length, the more optimally the vector processor is being used. The following example bases the report view on the value of the Vector Length Register (VLR) for each vector instruction sampled.

```
PCAC> PLOT/VPC_SAMPLING VLENGTH BY ELEMENT
```

The VLR contains the number of elements in the vector that is being acted upon.

The VMASK domain lets you determine how many elements in the vector register are being operated on. For example:

```
PCAC> PLOT/VCOUNTERS VMASK BY CELL
```

In the previous examples, if the VLR is 20 and the VMASK has 10 cells enabled, only 10 of the first 20 elements in the register are acted on.

Finding if Faster Instruction Execution is Needed

Use the VSTRIDE domain to determine how far apart consecutive vector elements are in memory. **Stride** is the distance between the starting addresses of consecutive elements of a vector. Instructions execute faster if the stride is smaller. For example, a vector of bytes would have a stride of 1; a vector of longwords would have a stride of 4. The following example causes the report view to be based on the length of the stride per vector instruction:

```
PCAA> PLOT/VCOUNTERS VSTRIDE BY BYTE
```

Showing the Vector Processor Usage

Use the VOPERATIONS domain to determine the number of operations performed by the various vector instructions. The number of operations is represented by the number of enabled elements in he VMR up to the length in the VLR.

If the number of operations per instruction is high, the vector processor is being used optimally. (See the example of the PLOT/VCOUNTERS VMASK BY CELL command earlier in this section, which shows that the number of operations is 10.) To plot the number of operations per vector instruction, enter the following command:

```
PCAA> PLOT/VCPU_SAMPLING VOPERATIONS BY OPERATION
```

5.4.4. Finding How Well the Use of Vector Registers Is Distributed

During the collection phase, the names of the registers used in the vector instruction is derived from the vector control word. There are 16 vector registers numbered V0 through V15.

If the data shows that only a few vector registers are being used, you can probably optimize the application by using more registers or by allowing for more vector instruction chaining or pipelining. However, the extent to which you can optimize your application is dependent on the language you are using.

The more vector registers your application uses during vector processing, the better the performance. Vector registers should be large. Memory referencing patterns must support a continuous supply of data to the vector registers for optimal vector performance.

Example 5.2, "Displaying Vector Register Usage" displays all vector registers.

Example 5.2. Displaying Vector Register Usage

```
PCAA> PLOT/VCOUNTERS VREGISTER BY REGISTER

                      Performance and Coverage Analyzer        Page 1
      Vector Instruction Execution Counts (5263 data points total) - "*"
  Bucket Name        ----+----+----+----+----+----+----+----+----+----+
  VREGISTER\         |
   V00  . . . . . . .|**************************************************
                     |                                            11.0%
   V02  . . . . . . .|*****************************************    9.1%
   V10  . . . . . . .|************************************         7.9%
   V03  . . . . . . .|******************************               6.7%
   V09  . . . . . . .|******************************               6.7%
   V04  . . . . . . .|****************************                 6.1%
   V05  . . . . . . .|*************************                    5.5%
   V07  . . . . . . .|**********************                       4.9%
   VLR  . . . . . . .|**********************                       4.9%
   V06  . . . . . . .|**********************                       4.9%
   V08  . . . . . . .|**********************                       4.9%
   V11  . . . . . . .|*******************                          4.3%
   V01  . . . . . . .|*****************                            3.8%
   V12  . . . . . . .|*****************                            3.6%
   V13  . . . . . . .|*****************                            3.6%
   V14  . . . . . . .|*****************                            3.6%
   V15  . . . . . . .|*****************                            3.6%
   VMRHI  . . . . . .|***********                                  2.4%
   VMRLO  . . . . . .|***********                                  2.4%
   VCR  . . . . . . .|                                             0.0%
                     |
                     +----+----+----+----+----+----+----+----+----+----+
```

Example 5.3, "Displaying Register Usage for Individual Vector Instructions" plots the use of registers V00 and V02.

Example 5.3. Displaying Register Usage for Individual Vector Instructions

```
PCAA> PLOT VCOUNTER REGISTER V00, REGISTER V02

                      Performance and Coverage Analyzer        Page 1
     Vector Instruction Execution Counts (5263 data points total) - "*"
Bucket Name     +----+----+----+----+----+----+----+----+----+----+
 VREGISTER\     |
 V00  . . . . . |**************************************************11.0%
 V02  . . . . . |****************************************           9.1%
                |
                +----+----+----+----+----+----+----+----+----+----+
```

5.4.5. Vectors Special Considerations

Because vector instructions are likely to be grouped together, sampling hits of vector initialization instructions like VLD occur more frequently. Sampling hits of SYNC and MSYNC vector instructions are also frequent because they tend to be time-consuming; the probability of hitting them, or the instructions immediately following, are higher.

Note also that there may be a skewing of vectors data collection because of the algorithm PCA uses: when PCA encounters a time-consuming vector instruction, it is likely that PCA will not sample that instruction. Instead, PCA will sample the vectors instruction that immediately follows.

Appendix A. Sample Programs

This appendix contains a FORTRAN program called PRIMES that is used in many of the examples throughout this file, and the programs (or relevant fragments) used for the examples in *Chapter 4, "Productivity Enhancements with PCA"*. The program is found in the PCA$EXAMPLES area.

Program PCA$PRIMES

```
 PROGRAM PCA$PRIMES

C This program generates all the prime numbers in a given integer
C range.  Prime numbers are placed in PRIMES_TABLE as they are
C generated.  After being verified, these prime numbers are written
C out to a text file PRIMES.DAT.
C
 INTEGER LOW,HIGH,COUNT,ERROR_COUNT,PRIMES_TABLE
 LOGICAL PRIME
 DIMENSION PRIMES_TABLE(10000)

C Read in the desired integer range from a file and range-check it.
C
 CALL READ_RANGE(LOW, HIGH)
 LOW = MAX (1, LOW)
 HIGH = MIN (HIGH, 10000)
 HIGH = MAX (LOW, HIGH)

C Generate all prime numbers in the given range.
C
 COUNT = 0
 DO 10 I = LOW, HIGH
 IF (PRIME(I)) THEN
 COUNT = COUNT + 1
 PRIMES_TABLE (COUNT) = I
 END IF
10 CONTINUE

C Verify that the numbers in PRIMES_TABLE really are prime.
C
 ERROR_COUNT = 0
 DO 20 I = 1, COUNT
 IF (.NOT. PRIME(PRIMES_TABLE(I))) THEN
 ERROR_COUNT = ERROR_COUNT + 1
 END IF
20 CONTINUE
 IF (ERROR_COUNT .NE. 0) THEN
 TYPE 30, ERROR_COUNT
30   FORMAT (I5, ' wrong prime numbers generated')
 END IF

C Write the prime numbers out to PRIMES.DAT and type summary data
C on the terminal.
C
 CALL OUTPUT_TO_DATAFILE(PRIMES_TABLE, COUNT)
 TYPE 40,COUNT,LOW,HIGH
40   FORMAT(I5, ' prime numbers generated between', I5, ' and', I5)
 STOP
 END

C Function to identify whether a given number is prime or not.
C If it is prime, the returned function value is TRUE.
C
 LOGICAL FUNCTION PRIME(NUMBER)
 PRIME = .TRUE.
 DO 10 I = 2, NUMBER/2
 IF ((NUMBER - ((NUMBER / I) * I)) .EQ. 0) THEN
 PRIME = .FALSE.
 RETURN
 ENDIF
10 CONTINUE
 RETURN
 END

C Subroutine to read in the integer range in which primes are to
C be found.
C
 SUBROUTINE READ_RANGE(LOW, HIGH)
 INTEGER LOW, HIGH

 OPEN(UNIT=1, FILE='PRIMESIN.DAT', STATUS='OLD')
 READ(1,100,END=110,ERR=120) LOW, HIGH
100 FORMAT(2I5)
 CLOSE(UNIT=1)
 RETURN
110 CALL READ_END_OF_FILE
 RETURN
120 CALL READ_ERROR
 RETURN
 END

C Subroutine to print an error message for a read end-of-file.
C
 SUBROUTINE READ_END_OF_FILE

 TYPE 150
150   FORMAT(' Unexpected end-of-file reading input file')
 RETURN
 END

C Subroutine to print an error message for an input read-error.
C
 SUBROUTINE READ_ERROR

 TYPE 160
160   FORMAT(' Read error reading input file')
 RETURN
 END

C Subroutine to output the prime numbers to a data file.
C
 SUBROUTINE OUTPUT_TO_DATAFILE(IPRIMES_TABLE, ICOUNT)
 DIMENSION IPRIMES_TABLE(ICOUNT)

 OPEN(UNIT=2, FILE='PRIMESOUT.DAT', STATUS='NEW')
 WRITE (2, 200) (IPRIMES_TABLE(I), I=1,ICOUNT)
200 FORMAT(I5)
 CLOSE(UNIT=2)
 RETURN
 END
```

The following programs are used for the examples in *Chapter 4, "Productivity Enhancements with PCA"*.

Program for *Section 4.1, "Example 1: Reducing Execution Time"*

```
C
C PCA$PRIMES
C
PROGRAM PCA$PRIMES
C
C This program counts the prime numbers in the range 1 to 10000.
C
INTEGER*4 I,COUNT
C
LOGICAL PRIME
C
C
C Loop to calculate the primes
C
DO I = 1, 10000
IF (PRIME(I) .EQ. .TRUE.) THEN
COUNT = COUNT + 1
END IF

END DO
C
WRITE(6,*) 'Total number of primes = ', COUNT
STOP
END

C

C Function to identify whether the number in the given range is prime

Cnumber or not.  If so, returned function value is TRUE.
C
LOGICAL FUNCTION PRIME(NUMBER)
C
PRIME = .TRUE.
DO 10 I = 2, (NUMBER/2)
C
IF ((NUMBER - ((NUMBER / I) * I)) .EQ. 0) THEN
PRIME = .FALSE.
RETURN
ENDIF
C
10 END DO
C
RETURN END
```

Program for *Section 4.2, "Example 2: Analyzing Call Stack Data"*

```
program eightqueens( output ) ;

(****************************************************************)
(* The purpose of this program is to determine where eight       *)
(* queens are safe on a chess board without any of them          *)
(* able to capture another.                                      *)
(****************************************************************)

var
i : integer ;
a : array[1..8] of boolean ;
b : array[2..16] of boolean ;

c : array[-7..7] of boolean ; x : array[1..8] of integer ; safe : boolean ;
 k: integer;

procedure print ;

(****************************************************************)
(* This routine will print the contents of the board.            *)
(****************************************************************)


begin (* print *)
for k := 1 to 8 do
write( x[k]: 2 ) ;
writeln ;
end ; (* print *)

procedure trycol( j : integer ) ;

(****************************************************************)
(* This routine will try the Jth column on the board.            *)
(****************************************************************)

var
i : integer ;

procedure setqueen ;

(****************************************************************)
(* This routine will set the value of the queen on the board     *)
(****************************************************************)

begin (* setqueen *)
a[i] := false ;
b[i + j] := false ;
c[i - j] := false ;
end ; (* setqueen *)

procedure removequeen ;

(****************************************************************)
(* This routine will remove the queen from the board.            *)
```

```
(*****************************************************************)

begin (* removequeen *)
a[i] := true ;
b[i + j] := true ;
c[i - j] := true ;
end ; (* removequeen *)

begin (* trycol *)
i := 0 ;
repeat
i := i + 1 ;
safe := a[i] and b[i + j] and c[i - j] ;
if safe then
begin
setqueen ;
x[j] := i ;
if j < 8 then
trycol( j + 1 )
else
print ;
removequeen ;
end ;
until i = 8 ;
end ; (* trycol *)


begin (* eightqueens *)

(*****************************************************************)
(* This is the main program. It will first initialize the arrays  *)
(* that represent the board. Next, it will try the first column   *)
(* for safeness.                                                  *)
(*****************************************************************)

for i := 1 to 8 do
a[i] := true ;
for i := 2 to 16 do
b[i] := true ;
for i := -7 to 7 do
c[i] := true ;

trycol( 1 ) ;

writeln ;

end. (* eightqueens *)
```

Program for *Section 4.3, "Example 3: Using Multiple Data Kinds"*, *Section 4.4, "Example 4: Using Event Markers for Selective Analysis"*, and *Section 4.5, "Determining Acceptable Noncoverage (ANC)"*

```
C PCA$PRIMES_1
```

```
C This program generates all the prime numbers in a given integer

Crange.  Prime numbers are placed in PRIMES_TABLE as they are
Cgenerated.  After being verified, these prime numbers are written
C out to a text file PRIMES.DAT. C
INTEGER LOW,HIGH,COUNT,ERROR_COUNT,PRIMES_TABLE LOGICAL PRIME
DIMENSION PRIMES_TABLE(10000)

C Read in the desired integer range from a file and range-check it.

C
CALL READ_RANGE(LOW, HIGH) LOW = MAX (1, LOW)
HIGH = MIN (HIGH, 10000) HIGH = MAX (LOW, HIGH)

C Generate all prime numbers in the given range.

C
COUNT = 0
DO 10 I = LOW, HIGH IF (PRIME(I)) THEN COUNT = COUNT + 1
PRIMES_TABLE (COUNT) = I END IF

C Verify that the numbers in PRIMES_TABLE really are prime.

C
ERROR_COUNT = 0 DO 20 I = 1, COUNT
IF (.NOT. PRIME(PRIMES_TABLE(I))) THEN
ERROR_COUNT = ERROR_COUNT + 1
END IF
20 CONTINUE
IF (ERROR_COUNT .NE. 0) THEN
TYPE 30, ERROR_COUNT
30 FORMAT (I5, ’ wrong prime numbers generated’)
END IF

C Write the prime numbers out to PRIMES.DAT and type summary data

Con the terminal.
C
CALL OUTPUT_TO_DATAFILE(PRIMES_TABLE, COUNT) TYPE 40,COUNT,LOW,HIGH
40   FORMAT(I5, ’ prime numbers generated between’, I5, ’ and’, I5)
STOP END

C Function to identify whether a given number is prime or not.

CIf it is prime, the returned function value is TRUE.
C
LOGICAL FUNCTION PRIME(NUMBER) PRIME = .TRUE.
DO 10 I = 2, NUMBER/2
IF ((NUMBER - ((NUMBER / I) * I)) .EQ. 0) THEN PRIME = .FALSE.
RETURN ENDIF
10CONTINUE RETURN
END

C Subroutine to read in the integer range in which primes are to

Cbe found.
C
SUBROUTINE READ_RANGE(LOW, HIGH) INTEGER LOW, HIGH
```

```
OPEN(UNIT=1, FILE='PRIMESIN.DAT', STATUS='OLD')
READ(1,100,END=110,ERR=120) LOW, HIGH
100 FORMAT(2I5)
CLOSE(UNIT=1)
RETURN
110 CALL READ_END_OF_FILE RETURN

120 CALL READ_ERROR RETURN
END

C Subroutine to print an error message for a read end-of-file.

C
SUBROUTINE READ_END_OF_FILE

TYPE 150
150 FORMAT(' Unexpected end-of-file reading input file')
RETURN END

C Subroutine to print an error message for an input read-error.

C
SUBROUTINE READ_ERROR

TYPE 160
160 FORMAT(' Read error reading input file')
RETURN
END

C Subroutine to output the prime numbers to a data file.

C
SUBROUTINE OUTPUT_TO_DATAFILE(IPRIMES_TABLE, ICOUNT) DIMENSION
 IPRIMES_TABLE(ICOUNT)

OPEN(UNIT=2, FILE='PRIMESOUT.DAT', STATUS='NEW')
WRITE (2, 200) (IPRIMES_TABLE(I), I=1,ICOUNT)
200 FORMAT(I5)
CLOSE(UNIT=2)
RETURN END

C
C
C Loop to calculate the primes
C
DO I=1, 10000
IF (PRIME(I) .EQ. .TRUE.) THEN COUNT = COUNT + 1
END IF END DO

WRITE(6,*) 'Total number of primes = ', COUNT
STOP
END

C

C Function to identify whether the number in the given range C is prime
 number or not. If so, returned function value is
```

```
C TRUE.
C
LOGICAL FUNCTION PRIME(NUMBER)
C
PRIME = .TRUE.
DO 10 I = 2, (NUMBER/2)
IF ((NUMBER - ((NUMBER / I) * I)) .EQ. 0) THEN PRIME = .FALSE.
RETURN ENDIF

10 CONTINUE

RETURN
END
```

Program for *Section 4.6, "Example 6: Measuring Ada Tasking Data"*

```
-- ++

-- ABSTRACT:
-- The following is a test program that simulates disc IO.
--
-- --
package DiscCharacteristics is

-- ++

-- The purpose of this package is to make known all of the global
-- characteristics that describe the disc.
-- --

tracks : constant INTEGER := 200;
sectors : constant INTEGER := 12;
surfaces : constant INTEGER := 2;
platters : constant INTEGER := 2;
type discaddress is record
pl : INTEGER range 0..platters-1;
tr : INTEGER range 0..tracks-1;
su : INTEGER range 0..surfaces-1;
se : INTEGER range 0..sectors-1;
end record;
type discrequest is (seek,read,write);
type discstatus is (busy,done,seekerror,readerror,writerror);

sectorlength : constant INTEGER := 512; -- this in bytes type discbuffer
 is array(1..sectorlength) of character; type discbufferptr is access
 discbuffer;

type disccommand is record
dreq : discrequest;
addr : discaddress;
bptr : discbufferptr;
end record;

pragma PACK(discbuffer);

end DiscCharacteristics;
```

```
.
.
.
package Semaphores is

-- ++

-- The purpose of the semaphore package is to create a semaphore on the

-- fly. Each semaphore is a dynamically created task.
-- --

task type disposablesemaphore is
entry P;
entry V;
end disposablesemaphore;

procedure P (s : in disposablesemaphore);
procedure V (s : in disposablesemaphore);

end Semaphores;

package body Semaphores is

-- ++

-- The P routine is used to signal that the user has entered a critical

-- region.
-- --

procedure P(s : in disposablesemaphore) is begin
s.P;
end P;

-- ++

-- The V routine is used to signal that the user has left the critical

-- region.
-- --

procedure V(s : in disposablesemaphore) is begin
s.V;
end V;

task body disposablesemaphore is
begin
accept V;
accept P;
end disposablesemaphore;

end Semaphores;
.
.
.

end Discchar;
```

Appendix B. PCA Reference Tables

This appendix contains reference tables for both the Collector and the Analyzer, as well as screen display information.

B.1. Collector Reference Tables

Table B.1, "RMS Services Measured by the Collector" lists the Record Management Services (RMS) measured by the Collector SET IO_SERVICES command.

Table B.1. RMS Services Measured by the Collector

$CLOSE	$ERASE	$OPEN	$REWIND
$CONNECT	$EXTEND	$PARSE	$SEARCH
$CREATE	$FIND	$PUT	$SPACE
$DELETE	$FLUSH	$READ	$TRUNCATE
$DISCONNECT	$FREE	$RELEASE	$UPDATE
$DISPLAY	$GET	$REMOVE	$WAIT
$ENTER	$NXTVOL	$RENAME	$WRITE

For more information on these RMS services, see the *VSI OpenVMS Record Management Services Reference Manual*.

Table B.2, "Non-RMS Services Measured by the Collector" lists the non-RMS system services measured by the Collector SET IO_SERVICES command.

Table B.2. Non-RMS Services Measured by the Collector

$ASSIGN	$DASSGN	$QIO	$QIOW
$CANCEL	$CREMBX	$DELMBX	

Table B.3, "Node Specification Parameter Syntax" describes the node specification parameter syntax.

Table B.3. Node Specification Parameter Syntax

Node Specification	Parameters
node specification	LINE [path-name \] %LINE n ROUTINE path-name ROUTINE path-name BY nodekind MODULE path-name BY nodekind LINE path-name BY nodekind PROGRAM_ADDRESS BY nodekind
path-name	identifier [\identifier …]
nodekind	ROUTINE LINE CODEPATH VINSTRUCTION (not valid for LINE)

Node Specification	Parameters
n	Any integer line number
identifier	Any routine or module name

Table B.4, "Collector Logical Names" lists and describes the logical names recognized by the Collector.

Table B.4. Collector Logical Names

Logical Name	Description
PCA$DATAFILE	Defines the name of the performance data file the Collector uses. Defining this logical name is equivalent to using the SET DATAFILE/APPEND command. To specify the performance data file, use the following command at DCL level: `$ DEFINE PCA$DATAFILE [LEE]MYDATA.PCA`

PCAC$DECW$DISPLAY	Establishes the workstation display screen for the PCA Collector DECwindows interface. If you are using a workstation, the DECwindows interface is the default. If you do not want to use the DECwindows interface while on a workstation, type the following DCL command before you invoke the Collector:
	
	`$ DEFINE PCAC$DECW$DISPLAY " "`
	
	To return to the default DECwindows display, deassign the logical name, as follows:
	
	`$ DEASSIGN PCAC$DECW$DISPLAY`

PCA$RUN_NAME	Defines the name of the current collection run. Defining this logical name is equivalent to using the SET RUN_NAME command. To define a collection run name, use the following command at DCL level: `$ DEFINE PCA$RUN_NAME "name-of-run"`
PCA$INHIBIT_MSG	Specifies that PCA's informational messages should not be output. The value you assign to this logical name is not significant,but you must assign some value to it. For example, use the following command at the DCL level: `$ DEFINE PCA$INHIBIT_MSG "INFO"`
PCAC$INIT	Defines the initialization file the Collector looks for at the beginning of the Collector session. If you do not specify a file type for the initialization file, the default is .PCAC. To define the Collector initialization file, use the following command at DCL level: `$ DEFINE PCAC$INIT [LEE]PCAC_STARTUP.PCAC`
PCAC$INPUT	Defines the input stream for the Collector. If this logical name is not defined, the default input stream is SYS$INPUT. To define the Collector input stream, use the following command at DCL level: `$ DEFINE PCAC$INPUT [LEE]MYINPUT.PCAC`
PCAC$OUTPUT	Defines the output stream for the Collector. If this logical name is not defined, the default output stream is SYS$OUTPUT. To define the Collector output stream, use the following command at DCL level:

Logical Name	Description
	`$ DEFINE PCAC$OUTPUT [LEE]MYOUTPUT.DAT`

B.2. Analyzer Reference Tables

Table B.5, "Analyzer Logical Names" list and describes the logical names recognized by the Analyzer.

Table B.5. Analyzer Logical Names

Logical Name	Description

PCAA$DECW$DISPLAY	Establishes the workstation display screen for the PCA Analyzer DECwindows interface. If you are using a workstation, the DECwindows interface is the default. If you do not want to use the DECwindows interface while on a workstation, type the following DCL command before you invoke the Analyzer:
	
	`$ DEFINE PCAA$DECW$DISPLAY " "`
	
	To return to the default DECwindows display, deassign the logical name, as follows:
	
	`$ DEASSIGN PCAA$DECW$DISPLAY`

PCAA$INIT	Defines the initialization file the Analyzer looks for at the beginning of the Analyzer session. If you do not specify a file type for the initialization file, a default file type of .PCAA is assumed. Define the Analyzer initialization file at DCL level using the following command: `$ DEFINE PCAA$INIT [LEE]PCAA_STARTUP.PCAA`
PCAA$INPUT	Defines the input stream for the Analyzer. If this logical name is not defined, the default input stream is SYS$INPUT. Define the Analyzer input stream at DCL level using the following command: `$ DEFINE PCAA$INPUT [LEE]MYINPUT.PCAA`
PCAA$OUTPUT	Defines the output stream for the Analyzer. If this logical name is not defined, the default output stream is SYS$OUTPUT. Define the Analyzer output stream at DCL level using the following command: `$ DEFINE PCAA$OUTPUT [LEE]MYOUTPUT.DAT`
SYS$LP_LINES	Defines the number of lines per page to be used by the PRINT and FILE commands when formatting PLOT or TABULATE output. If this logical name is not defined, 66 lines per page is assumed. Define a page size of 40 lines at DCL level using the following command: `$ DEFINE SYS$LP_LINES 40`
SYS$PRINT	Defines the printer queue. For example: `$ DEFINE SYS$PRINT CLUSTER_PRINTER`

Table B.6, "Data-Kind Qualifiers and Supported Domains" lists the data-kind qualifiers and their respective domains.

Table B.6. Data-Kind Qualifiers and Supported Domains

Data-Kind Qualifier	Appropriate Domains
/PC_SAMPLING	PROGRAM_ADDRESS CALL_TREE TASK TASK_PRIORITY TASK_TYPE TIME[1]
/CPU_SAMPLING	PROGRAM_ADDRESS CALL_TREE TASK TASK_PRIORITY TASK_TYPE TIME[1]
/COUNTERS	PROGRAM_ADDRESS CALL_TREE TASK TASK_PRIORITY TASK_TYPE TIME[1]
/COVERAGE	PROGRAM_ADDRESS CALL_TREE TASK TASK_PRIORITY TASK_TYPE TIME[1]
/NONCOVERAGE /ANC	PROGRAM_ADDRESS TIME[1]
/PAGE_FAULTS /FAULT_ADDRESS	PROGRAM_ADDRESS TIME[2] TASK TASK_PRIORITY TASK_TYPE
/SERVICES	PROGRAM_ADDRESS CALL_TREE TIME[2] SYSTEM_SERVICES TASK TASK_PRIORITY TASK_TYPE
/IO_SERVICES /READ_COUNT /WRITE_COUNT /PHYSICAL_IO	PROGRAM_ADDRESS CALL_TREE TIME[2] IO_SYSTEM_SERVICES FILE_NAME RECORD_SIZE FILE_VBN FILE_KEY READ_COUNT

Data-Kind Qualifier	Appropriate Domains
	WRITE_COUNT PHYSICAL_IO_COUNT
/TASK_SWITCH	TASK TASK_TYPE TASK_PRIORITY TIME[2]
/EVENT	PROGRAM ADDRESS TASK TASK[2]
/VCOUNTERS /VCPU_SAMPLING /VPC_SAMPLING	VLENGTH VMASK VOPCODE VOPERATIONS VSTRIDE

[1]These data-kind qualifiers work with TIME BY EVENT only.

[2]These data-kind qualifiers work with TIME BY EVENT and with TIME BY [n] MSECS.

Table B.7, "The SET Command with Corresponding Data-Kind Qualifiers" shows the correspondence of the Collector SET commands to the Analyzer data-kind qualifiers.

Table B.7. The SET Command with Corresponding Data-Kind Qualifiers

Collector SET Command	Corresponding Analyzer Data-Kind Qualifier
SET PC_SAMPLING	/PC_SAMPLING
SET CPU_SAMPLING	/CPU_SAMPLING
SET COUNTERS	/COUNTERS /COVERAGE /NONCOVERAGE /ANC
SET COVERAGE	/COVERAGE /NONCOVERAGE /ANC
SET PAGE_FAULTS	/PAGE_FAULTS /FAULTING_ADDRESS
SET SERVICES	/SERVICES
SET IO_SERVICES	/IO_SERVICES /READ_COUNT[1] /WRITE_COUNT [1] /PHYSICAL_IO_COUNT[1]
SET TASKING	/TASK_SWITCH
SET EVENT	/EVENT
SET VCOUNTERS	/VCOUNTERS /COVERAGE
SET VCPU_SAMPLING	/VCPU_SAMPLING
SET VPC_SAMPLING	/VPC_SAMPLING

[1]This is collected for disk I/O only, not terminal I/O.

B.2.1. Analyzer Node Specification Summary

Valid node specifications that the Analyzer accepts on the PLOT and TABULATE commands are shown in *Table B.8, "Analyzer Node Specifications"*. They are grouped by data domain.

Table B.8. Analyzer Node Specifications

Data Domain	**Valid Node Specifications**
Program Address	PROGRAM_ADDRESS BY MODULE PROGRAM_ADDRESS BY ROUTINE PROGRAM_ADDRESS BY [n] LINES PROGRAM_ADDRESS BY CODEPATH PROGRAM_ADDRESS BY [n] BYTES PROGRAM_ADDRESS BY VINSTRUCTION
	MODULE pathname MODULE pathname BY ROUTINE MODULE pathname BY [n] LINES MODULE pathname BY CODEPATH MODULE pathname BY [n] BYTES MODULE pathname BY VINSTRUCTION
	ROUTINE pathname BY [n] LINES ROUTINE pathname BY CODEPATH ROUTINE pathname BY [n] BYTES ROUTINE pathname BY VINSTRUCTION
	LINE [pathname \] %LINE n LINE [pathname \] %LINE n BY CODEPATH LINE [pathname \] %LINE n BY [n] BYTES
Call Tree	CALL_TREE BY CHAIN_MODULE CALL_TREE BY CHAIN_ROUTINE CALL_TREE BY CHAIN_LINE CHAIN_MODULE chain_name CHAIN_ROUTINE chain_name CHAIN_LINE chain_name
Vector length	VLENGTH BY [n] ELEMENTS
Vector masks	VMASK BY [n] CELLS
Vector opcodes	INSTRUCTION BY VOPCODES VOPCODE vector-opcode
Vector operations	VOPERATIONS BY [n] OPERATIONS
Vector registers	VREGISTER BY REGISTER REGISTERvector-reg
Vector strides	VSTRIDES BY [n] BYTES
Time	TIME BY EVENT TIME BY [n] MSECS EVENT event-name EVENT event-name BY [n] MSECS
Task	TASK_TYPE BY TASK_TYPE_NAME TASK_PRIORITY BY n PRIORITY_UNITS TASK BY TASK_IDENTIFIER

Data Domain	**Valid Node Specifications**
	TASK_IDENTIFIER task_id TASK_TYPE_NAME task_type
System Services	SYSTEM_SERVICES BY SERVICE SERVICE service-name
I/O System Services	IO_SYSTEM_SERVICES BY IO_SERVICE IO_SERVICE io_service-name
File Name	FILE_NAME BY FILE
File Virtual Block Number	FILE_VBN BY [n] BLOCKS
Indexed File Keys	FILE_KEY BY KEYS
File Record Size	RECORD_SIZE BY [n] BYTES
Physical Read Count	READ_COUNT BY [n] COUNTS
Physical Write Count	WRITE_COUNT BY [n] COUNTS
Total Physical I/O Count	PHYSICAL_IO_COUNT BY [n] COUNTS
n	Any integer or integer line number
path name	identifier [\identifier …]
identifier	Any routine or module name
vector-opcode	A vector instruction opcode
vector-reg	A vector register name
event-name	Any event marker name
service-name	Any system service name
io_service-name	Any I/O system service name
task_id	An instance of a task
task_type	A declared task type

You can abbreviate all keywords to their shortest unique forms. However, you must always spell out module names, routine names, event names,and system service names.

Table B.9, "Filter Specification by Data Kind" lists the filter restrictions by data-kind qualifier.

Table B.9. Filter Specification by Data Kind

Filter Restriction	**A**	**B**	**C**	**D**	**E**	**F**	**G**
CHAIN_NAME	Yes[1]	Yes	Yes	Yes	Yes		Yes
FAULT_ADDRESS					Yes		
FILE_KEY			Yes				
Data Kind Table Key **A—/COUNTERS, /COVERAGE, /CPU_SAMPLING, /PC_SAMPLING** **B—/ANC, /NONCOV** **C—/IO_SERVICES, /READ_COUNT, /PHYS_IO_COUNT, /WRITE_COUNT** **D—/SERVICES** **E—/PAGE_FAULTS, /FAULT_ADDR** **F—/TASK_SWITCH, /EVENT** **G—/VCOUNTERS, /VCPU_SAMPLING, /VPC_SAMPLING**							

Filter Restriction	**A**	**B**	**C**	**D**	**E**	**F**	**G**
FILE_NAME			Yes				
FILE_VBN			Yes				
IO_SERVICE			Yes				
PROGRAM_ADDRESS	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PHYSICAL_IO_COUNT			Yes				
READ_COUNT			Yes				
RECORD_SIZE			Yes				
RUN_NAME	Yes		Yes	Yes	Yes	Yes	Yes
SERVICE				Yes			
TASK_IDENTIFIER	Yes		Yes	Yes	Yes	Yes	
TASK_PRIORITY	Yes		Yes	Yes	Yes	Yes	
TASK_TYPE	Yes		Yes	Yes	Yes	Yes	
TIME=x[:y]	Yes[2]		Yes	Yes	Yes	Yes	Yes
TIME=event	Yes		Yes	Yes	Yes	Yes	Yes
VLENGTH=n							Yes
VMASK=n							Yes
VOPCODE=vector-opcode							Yes
VOPERATIONS=n							Yes
VREGISTER=vector-reg							Yes
VSTRIDE=n							Yes
WRITE_COUNT			Yes				
Data Kind Table Key **A—/COUNTERS, /COVERAGE, /CPU_SAMPLING, /PC_SAMPLING** **B—/ANC, /NONCOV** **C—/IO_SERVICES, /READ_COUNT, /PHYS_IO_COUNT, /WRITE_COUNT** **D—/SERVICES** **E—/PAGE_FAULTS, /FAULT_ADDR** **F—/TASK_SWITCH, /EVENT** **G—/VCOUNTERS, /VCPU_SAMPLING, /VPC_SAMPLING**							

[1]Note that yes means the filter is applied to the given data kind. A blank means that it is not.

[2]For /CPU_SAMPLING only

B.3. Screen Displays

Table B.10, "Default Key Bindings for Traverse Commands" lists the default key bindings for the traverse commands.

Table B.10. Default Key Bindings for Traverse Commands

Function	**Key**
FIRST	KP5
FIRST SUBTREE	GOLD KP5

Function	Key
NEXT	Ctrl/N
NEXT SUBTREE	GOLD Ctrl/N
BACK	Ctrl/P
BACK SUBTREE	GOLD Ctrl/P

Table B.11, "Analyzer Screen Mode Pseudo Display Names" describes the pseudo-display names.

Table B.11. Analyzer Screen Mode Pseudo Display Names

Name	Description
%CURDISP	Refers to the current display (the display you have most recently viewed using a DISPLAY or SET DISPLAY command).
%NEXTDISP	Refers to the next display in the list after the current display (the least recently viewed display).
%NEXTOUTPUT	Refers to the next output display in the display list after the current output display. An output display receives regular PCA output.
%NEXTPLOT	Refers to the next plot display in the display list after the current plot display. The current plot display receives output from PLOT, TABULATE, and related commands.
%NEXTSOURCE	Refers to the next source display in the display list after the current source display. The current source display receives output from the TYPE command.
%NEXTSCROLL	Refers to the next scroll display in the display list after the current scrolling display. The current scrolling display is the default display for the SCROLL command and for the keypad scrolling keys.

Figure B.1, "Collector-Defined Keypad Key Functions" shows the Collector-defined keypad functions. *Figure B.2, "Analyzer-Defined Keypad Key Functions"* shows the Analyzer-defined keypad functions. Both figures show default functions at the top of each key, GOLD functions in the middle, and the BLUE functions at the bottom.

Note

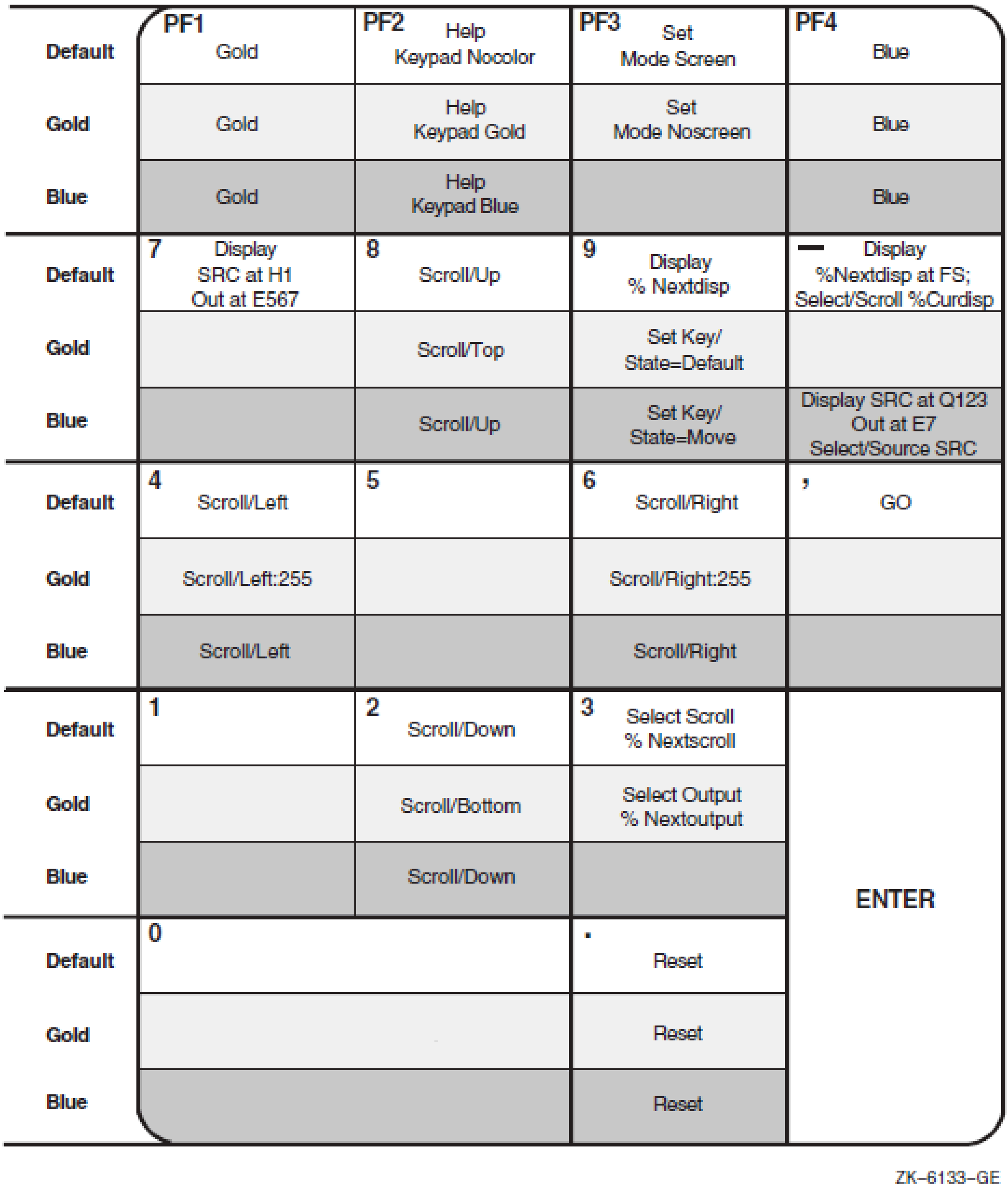
Most keypad keys are *terminated*, which means that you do not have to press the Return or the Enter key before the command executes. Some of the BLUE keys are not terminated, to allow you to enter additional parameters to the command before pressing the Return or the Enter key. Those commands are echoed on the terminal screen.

The Enter key has the same effect as the Return key. To cancel the GOLD or the BLUE function, press the Reset (Period) key immediately after pressing either of those keys.

Pressing Ctrl/W refreshes the screen. It has the same effect as the DISPLAY/REFRESH command.

Figure B.3, "PCA-Defined Keypad Key Functions for Screen Manipulation" shows the PCA-defined keypad functions for screen manipulation.

Figure B.1. Collector-Defined Keypad Key Functions



Default	**PF1** Gold	**PF2** Help Keypad Nocolor	**PF3** Set Mode Screen	**PF4** Blue
Gold	Gold	Help Keypad Gold	Set Mode Noscreen	Blue
Blue	Gold	Help Keypad Blue		Blue
Default	**7** Display SRC at H1 Out at E567	**8** Scroll/Up	**9** Display % Nextdisp	**—** Display %Nextdisp at FS; Select/Scroll %Curdisp
Gold		Scroll/Top	Set Key/ State=Default	
Blue		Scroll/Up	Set Key/ State=Move	Display SRC at Q123 Out at E7 Select/Source SRC
Default	**4** Scroll/Left	**5**	**6** Scroll/Right	**,** GO
Gold	Scroll/Left:255		Scroll/Right:255	
Blue	Scroll/Left		Scroll/Right	
Default	**1**	**2** Scroll/Down	**3** Select Scroll % Nextscroll	**ENTER**
Gold		Scroll/Bottom	Select Output % Nextoutput	
Blue		Scroll/Down		
Default	**0**		**.** Reset	
Gold			Reset	
Blue			Reset	

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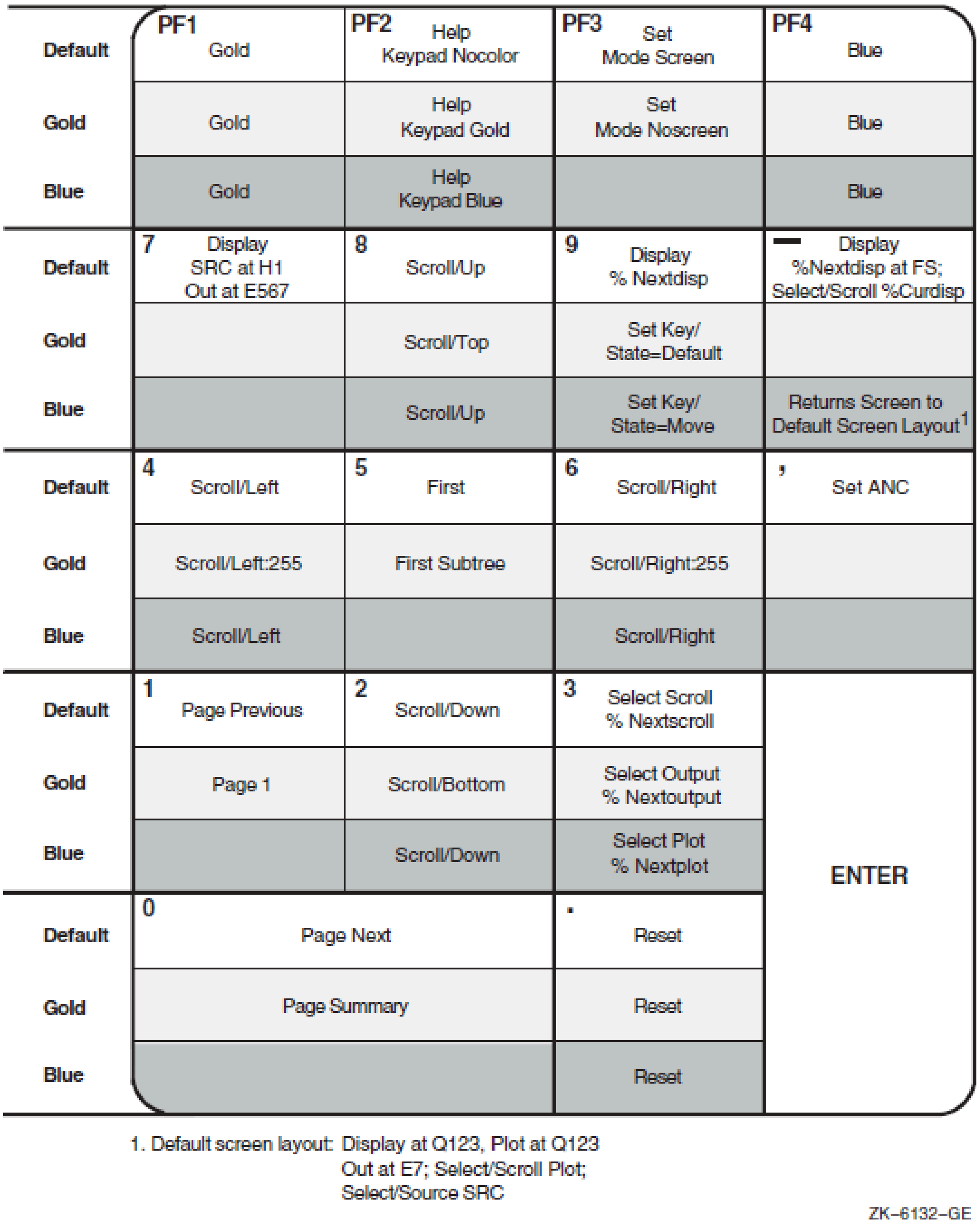
Figure B.2. Analyzer-Defined Keypad Key Functions



	PF1	PF2	PF3	PF4
Default	Gold	Help Keypad Nocolor	Set Mode Screen	Blue
Gold	Gold	Help Keypad Gold	Set Mode Noscreen	Blue
Blue	Gold	Help Keypad Blue		Blue
	7	8	9	-
Default	Display SRC at H1 Out at E567	Scroll/Up	Display % Nextdisp	Display %Nextdisp at FS; Select/Scroll %Curdisp
Gold		Scroll/Top	Set Key/ State=Default	
Blue		Scroll/Up	Set Key/ State=Move	Returns Screen to Default Screen Layout[1]
	4	5	6	,
Default	Scroll/Left	First	Scroll/Right	Set ANC
Gold	Scroll/Left:255	First Subtree	Scroll/Right:255	
Blue	Scroll/Left		Scroll/Right	
	1	2	3	ENTER
Default	Page Previous	Scroll/Down	Select Scroll % Nextscroll	
Gold	Page 1	Scroll/Bottom	Select Output % Nextoutput	
Blue		Scroll/Down	Select Plot % Nextplot	
	0		.	
Default	Page Next		Reset	
Gold	Page Summary		Reset	
Blue			Reset	

1. Default screen layout: Display at Q123, Plot at Q123 Out at E7; Select/Scroll Plot; Select/Source SRC

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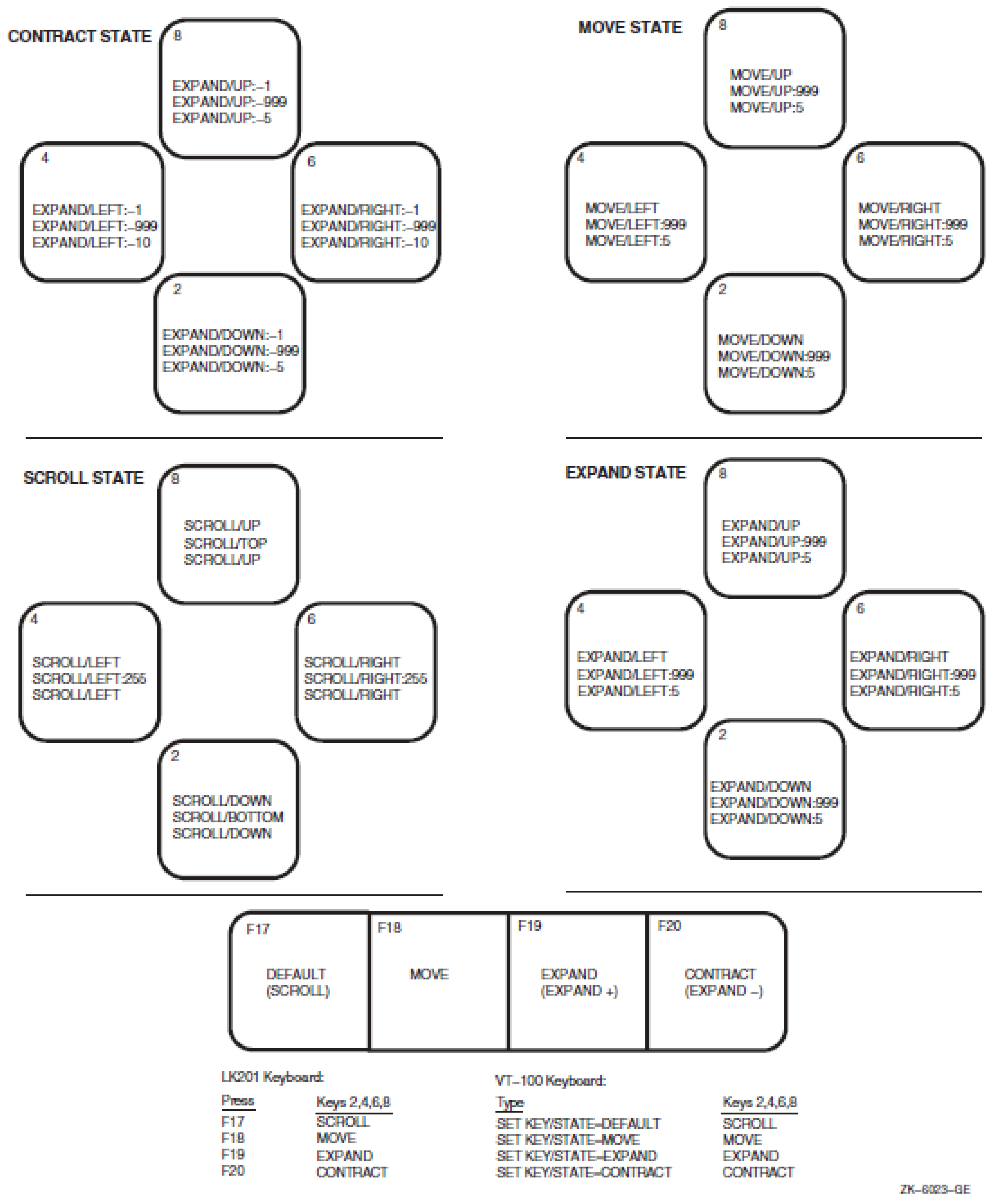
Figure B.3. PCA-Defined Keypad Key Functions for Screen Manipulation



LK201 Keyboard:

Press	Keys 2,4,6,8
F17	SCROLL
F18	MOVE
F19	EXPAND
F20	CONTRACT

VT–100 Keyboard:

Type	Keys 2,4,6,8
SET KEY/STATE=DEFAULT	SCROLL
SET KEY/STATE=MOVE	MOVE
SET KEY/STATE=EXPAND	EXPAND
SET KEY/STATE=CONTRACT	CONTRACT

Appendix C. Questions and Answers

This appendix contains commonly asked questions about PCA and their answers.

1. **Why is 80% of my program in P1 space? How do I get the wait time reflected in code I can change?**

   When your program is waiting for a system service to complete, the program counter points to a location in the system service vector in P1 space. Because waiting for an I/O operation to complete is the most common form of system service wait, your program can appear to be spending most of its time in P1 space.

   If your program does a lot of terminal I/O, you should expect the program to be I/O-bound and to appear to spend a lot of time in P1 space; the terminal is a slow device. If your program primarily does disk or tape I/O and appears to spend a lot of time in P1 space, investigate why the program is I/O-bound. By reprogramming your program's I/O to reduce the I/O wait time, you may be able to speed up your program considerably.

   To get the system service wait time reflected in the code of your own program, gather stack PC values using the STACK_PC command in the Collector,then issue the PLOT or TABULATE command with the /MAIN_IMAGE qualifier to plot your data. This will charge the time outside your image (including that spent in P1 space) to the actual location within your image that caused the time to be spent.

2. **How do I get the time spent in shareable images to be charged to the parts of my program that used it?**

   Gather stack PC data in the Collector and use the /MAIN_IMAGE qualifier with your PLOT command. This charges the time outside your image to the PC within the image that caused it.

3. **How do I get the time spent in a specific RTL routine to be charged to the parts of my program that used it?**

   Gather stack PC data in the Collector, then issue the PLOT command with /MAIN_IMAGE=SHARE$RTL and /STACK =n qualifiers.

4. **How can I find the specific instructions within a line that are taking the most time?**

   Use PLOT LINE module_name\%LINE nnn BY BYTE. Then, look at a machine listing to correlate byte offsets from the beginning of the line to the specific instructions.

5. **How do I discard the time spent in terminal I/O?**

   Place an event marker before each terminal I/O statement and a different event marker after the terminal I/O statement. Then use SET FILTER foo TIME <> the_first_event_marker_name in the Analyzer. This discards all the time spent waiting for terminal I/O. See *Chapter 4, "Productivity Enhancements with PCA"* for an example of this.

6. **When linked with PCA,why does my program ACCVIO before entering the Collector?**

If the PCAC> prompt never appears, the Collector has probably not been installed as a privileged image. Possibly,the system manager forgot to edit the system startup file to include @SYS$STARTUP:PCA$STARTUP.COM. If the PCAC> prompt does appear, see question 7.

7. **Why does my program behave differently when running with PCA?**

   One of the following conditions probably exists:

   a. Uninitialized stack variables

   b. Dependence on memory above SP

   c. Assumptions about memory allocation
   Conditions 1 and 2 occur because PCA comes in as a handler and uses the stack above the user program's stack. Consequently, the stack is manipulated in ways that are different than when run without PCA. Although this is unlikely to happen, compiler code generation bugs have caused this sort of behavior.

   Condition 3 occurs because PCA now lives in the process memory space and requests memory by means of SYS$EXPREG. PCA requests a large amount of memory at initialization to minimize the altering of memory allocation, but this still may happen.

   PCA may have a bug where it is smashing the stack or the random user memory. VSI appreciates your input on this because these bugs are hard to track down, and because they have been known to come and go based on the order of modules in a linker options file.

   VSI recommends that you do the following:

   - Issue the GO/NOCOLLECT command. If the program does not behave as expected, the problem is your link with PCA.

   - Try a run with simple PC sampling only. PC sampling is the least likely mode for bugs. If your program does not behave as expected, the problem probably lies with your program. If your program behaves as expected, the problem probably lies with PCA.

   If you still believe that PCA is changing the behavior of your program, please submit an SPR with the following:

   - A copy of the .EXE linked with PCA.

   - A command procedure which reproduces the problem using the above program.

   - Anything else you think VSI might find useful.

8. **Why does it take so long to create a performance data file?**

   The Collector copies the portions of the DST it needs to the performance data file. This can take some time for large programs. The DST is placed in the performance datafile to avoid confusion over which image contains the DST for the data gathered. Also, PCA does not need all the information in the DST and condenses it. This avoids the overhead of reading useless information every time the file is used.

9. **My application takes 10 days to compile. Is there a way I can avoid compiling my whole application with /DEBUG?**

Yes. PCA provides all functionality except annotated source listings and codepath analysis, because all objects contain traceback information and most of the DST information that PCA needs is there. Once you find which modules are of interest, you can compile those with /DEBUG, then relink the application and gather the data again.

10. **PCA tells me a large amount of time is being spent at a call instruction. Why? The call instruction should be a small part of the time spent executing the routine.**

    First, check page faulting. Sometimes the faulting behavior of a program causes a moderately called routine to get paged out just before it is called, and the page fault is a disk access. If that is not the case, check for JSB linkages to an RTL routine.

    For performance reasons, some RTL routines use JSB linkages. This can cause confusion for the user when the /MAIN_IMAGE qualifier is used. This is especially true with PC sampling data, but can occur with any kind of data for which you can gather stack PC data.

    Because a JSB linkage does not place a call frame on the stack, the return address to the site of the call is lost to PCA. Consequently, the first return address found by /MAIN_IMAGE is the site of the call to the routine that called the RTL by means of a JSB linkage. As an example, suppose routine MAIN called routine FOO, which in turn called the RTL by means of a JSB linkage. Then, suppose that a PC sampling hit occurred in the RTL. The PCs recorded are the actual PC when the hit occurred, the PC of the call to FOO, and the PC of the call to MAIN. Thus, in the presence of the / MAIN_IMAGE qualifier, the first PC within the image is the PC of the call to FOO. Consequently, FOO's call site is inflated by the number of data points in the RTL that are in routines that have JSB linkages.

    This method can yield useful information. If you compare the time with /MAIN_IMAGE to the time without /MAIN_IMAGE, you can tell how much time was spent in JSB linkage routines. You cannot, however, separate the various JSB linkage routines. Note further that if the JSB routine is called from the main program, the data points will be lost because there is no caller of the main program.

11. **Why does the Analyzer report 0.0% for a line and then output a full line of stars, indicating that the line was covered?**

    Probably, the total number of data points is over 2000,and the percentage is less than 0.05%. Therefore, rounding makes it 0.0%.

12. **I have a utility routine that I have optimized as much as I can. I need to know who is calling it and how often, so I can reduce the number of calls to it. How do I get this information?**

    Use the PLOT command with the /MAIN_IMAGE = utility_routine qualifier to obtain the following options:

    - PLOT CALL_TREE BY CHAIN_ROUTINE lists all the call chains that pass through utility_routine with the number of data points for each call chain. See *Section 3.3.7, "Using CALL_TREE Node Specifications"*.

    - PLOT/STACK = 1 PROGRAM BY ROUTINE lists all the callers of utility_routine.

    - If one particular caller of utility_routine is of interest, try the following: SET FILTER filter_name CHAIN=(*,caller,utility_routine,*). This assures that the data being viewed is only that whose chains have a subchain caller, utility_routine.

- Many other combinations of /CUMULATIVE, /MAIN_IMAGE, /STACK with various filters and nodespecs may be useful.

13. **Why am I getting several coverage data points associated with my routine declaration when I do COVERAGE BY CODEPATH?**

    Several languages generate prologue code at each routine entry to initialize the language specific semantics. As far as PCA is concerned, code is code and deserves code path analysis. This environment is usually set up by a CALLS or JSB to an RTL routine. PCA considers CALLS, CALLG, and JSB to be transfers of control, because control does not in principle have to come back, and places a BPT in the instruction following.

14. **Why are hexadecimal numbers showing up in the CALL_TREE plot?**

    The Analyzer was not able to symbolize the return address it found in the call stack. If I/O services or services data is being gathered, these may be addresses in the relocated system service vector.

15. **How can I avoid all the source header information and get right to the most interesting line?**

    Use the traverse commands, NEXT, FIRST, PREVIOUS, CURRENT.

16. **How can I easily compare different kinds of data?**

    Use the INCLUDE command, which uses a subset of PLOT qualifiers and parameters.

17. **The Analyzer is running out of virtual memory. What do I do?**

    Raise the appropriate quotas, limit the number of displays, and limit the memory used by displays (use /SIZE=n).

    Limit the size of your plots with the following methods:

    - Use limiting nodespecs. For example, if PROGRAM_ADDRESS BY LINE does notwork, try MODULE foo BY LINE, or ROUTINE fee BY LINE.
    - Use the traverse commands after issuing PLOT/your_qualifiers PROGRAM_ADDRESS BY MODULE.
    - Use the /NOZEROS, /MINIMUM, /MAXIMUM qualifiers.
    - Use filters with CALL_TREE nodespecs to reduce the number of call chains.
    - Do not use the DECwindows interface.

18. **The Collector is running out of virtual memory. What do I do?**

    If you are doing coverage or counter analysis, limit the number of breakpoint settings by using either MODULE BY LINE or CODEPATH node specifications instead of using PROGRAM BY LINE or do not use the DECwindows interface. Then do several collection runs to gather the data.

19. **Why do some plots execute more quickly than others?**

    Some PLOT commands execute more quickly than others because PCA uses all available information from the previous plot to produce the requested one. For example, if you enter PLOT PROGRAM BY LINE and then enter PLOT/DESCENDING, PCA only sorts the previous plot.

However, if you use a different nodespec, such as PLOT ROUTINE foo$bar BY CODEPATH, then PCA must rebuild its internal tables and read the data again, which takes more time. In addition, the number of filters and buckets you use affects the time it takes to build a plot. This is because filters affect the amount of data the Analyzer looks at, and because all buckets must be searched for each data point.

20. **Why don't I see all my subroutine calls in a CALL_TREE plot?**

    It may be that you have a JSB linkage. See question 7.

21. **Why do I get bad offsets when plotting MACRO modules by byte?**

    When plotting MACRO modules by byte, the offset is actually from the beginning of the module, including the data psects. You get bad offsets because the linker moves the psects around based on the psect attributes. Thus, the offsets you get may have no relationship to any listing you may have. However, if you use PLOT ROUTINE foo BY BYTE, then the offsets are from the beginning of the routine. (This only works if you have an .ENTRY foo … directive in your program.)

22. **Can PCA measure shareable images activated "on the fly" with LIB$FIND_IMAGE_SYMBOL?**

    Yes, if you relink against the image you want to activate. PCA uses a structure built by the image activator to find all the shareable image information it needs. By relinking the image, the image activator knows about the image and LIB$FIND_IMAGE_SYMBOL will work.

23. **Why do I get an undefined symbol error message when I use the hexadecimal number FF0?**

    PCA considers FF0 an identifier unless you precede it with a zero. Any hexadecimal number with the digits A through F must be preceded by a zero to be correctly interpreted by PCA.

24. **Why do most of my PC samples land on instructions immediately after a time-consuming hardware instruction rather than the hardware instruction itself?**

    ASTs cannot be delivered during a hardware instruction. Therefore, when the AST fires to collect the PC sample, it is most likely to fire right after the time-consuming instruction. This behavior is apparent in MACRO.