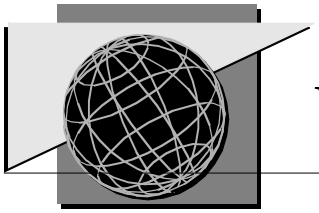

VisualWorks Advanced Tools

User's Guide

Part Number: DS10003002

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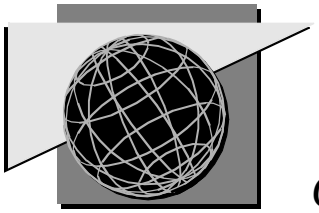
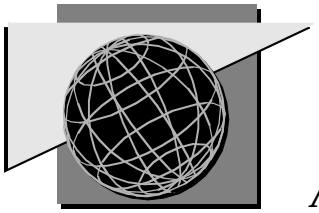
Revision 1.2, October 1995 (Software Release 2.5)

This document is subject to change without notice.

ParcPlace-Digitalk, Inc., 999 East Arques Avenue, Sunnyvale, CA 94086-4593



Contents



About This Book

This user guide describes the tools and reusable code provided in the VisualWorks Advanced Tools™. Each of the remaining chapters deals with one of the code modules in the kit. The code modules are independent of one another, so the order in which they are discussed is arbitrary.

For information about installing this product, features specific to this release, and limitations, see the *VisualWorks Advanced Tools Installation Guide and Release Notes*.

Audience

This manual is intended for users of VisualWorks Advanced Tools. As the product name suggests, it is assumed that you are familiar with object-oriented programming concepts in general and VisualWorks in particular.

Organization

This user guide describes the tools and reusable code provided in the VisualWorks Advanced Tools. Each of the remaining chapters deals with one of the code modules in the kit. The code modules are independent of one another, so the order in which they are discussed is arbitrary.

Appendix A lists the disk files containing the code modules. It also describes the contents of the disk files in terms of classes and class categories and provides a cross-reference to the appropriate chapters in this guide.

For information about installing this product, features specific to this release, and limitations, see the *VisualWorks Advanced Tools Installation Guide and Release Notes*.

Conventions

This section describes the notational conventions used to identify technical terms, computer-language constructs, mouse buttons, and mouse and keyboard operations.

Typographic Conventions

This book uses the following fonts to designate special terms:

Example	Description
template	Indicates new terms where they are defined, emphasized words, book titles, and words as words.
`cover.doc`	Indicates filenames, pathnames, commands, and other C++, UNIX, or DOS constructs to be entered outside VisualWorks Advanced Tools (for example, at a command line).
***`filename`*`.xwd`**	Indicates a variable element for which you must substitute a value.
windowSpec	Indicates Smalltalk constructs; it also indicates any other information that you enter through the VisualWorks Advanced Tools graphical user interface.
Edit menu	Indicates VisualWorks Advanced Tools user-interface labels for menu names, dialog-box fields, and buttons; it also indicates emphasis in Smalltalk code samples.

Special Symbols

This book uses the following symbols to designate certain items or relationships:

Examples	Description
File?**New** command	Indicates the name of an item on a menu.
<Return> key <Select> button <Operate> menu	Indicates the name of a keyboard key or mouse button; it also indicates the pop-up menu that is displayed by pressing the mouse button of the same name.
<Control>-<g>	Indicates two keys that must be pressed simultaneously.
<Escape> <c>	Indicates two keys that must be pressed sequentially.

Examples	Description
Integer>>asCharacter	Indicates an instance method defined in a class.
Float class>>pi	Indicates a class method defined in a class.
Caution:	Indicates information that, if ignored, could cause loss of data.
Warning:	Indicates information that, if ignored, could damage the system.

Screen Conventions

This tutorial contains a number of sample screens that illustrate the results of various tasks. The windows in these sample screens are shown in the default Smalltalk look, rather than the look of any particular platform. Consequently, the windows on your screen will differ slightly from those in the sample screens.

Mouse Buttons

Many hardware configurations supported by VisualWorks have a three-button mouse, but a one-button mouse is the standard for Macintosh users, and a two-button mouse is common for OS/2 and Windows users. To avoid the confusion that would result from referring to <Left>, <Middle>, and <Right> mouse buttons, this book instead employs the logical names <Select>, <Operate>, and <Window>.

The mouse buttons perform the following interactions:

<Select> button	*Select* (or choose) a window location or a menu item, position the text cursor, or highlight text.
<Operate> button	Bring up a menu of *operations* that are appropriate for the current view or selection. The menu that is displayed is referred to as the *<Operate> menu*.
<Window> button	Bring up the menu of actions that can be performed on any VisualWorks Advanced Tools *window* (except dialogs), such as **move** and **close**. The menu that is displayed is referred to as the *<Window> menu.*

Three-Button Mouse

VisualWorks uses the three-button mouse as the default:

- The left button is the <Select> button.
- The middle button is the <Operate> button.
- The right button is the <Window> button.

Two-Button Mouse

On a two-button mouse:

- The left button is the <Select> button.
- The right button is the <Operate> button.
- To access the <Window> menu, you press the <Control> key and the <Operate> button together.

One-Button Mouse

On a one-button mouse:

- The unmodified button is the <Select> button.
- To access the <Operate> menu, you press the <Option> key and the <Select> button together.
- To access the <Window> menu, you press the <Command> key and the <Select> button together.

Mouse Operations

The following table explains the terminology used to describe actions that you perform with mouse buttons.

When you see:	Do this:
click	Press and release the <Select> mouse button.
double-click	Press and release the <Select> mouse button twice without moving the pointer.

When you see:	Do this:
<Shift>-click	While holding down the <Shift> key, press and release the <Select> mouse button.
<Control>-click	While holding down the <Control> key, press and release the <Select> mouse button.
<Meta>-click	While holding down the <Meta> or <Alt> key, press and release the <Select> mouse button.

Additional Sources of Information

Printed Documentation

In addition to this tutorial, the core VisualWorks documentation includes the following documents:

- *Installation Guide:* Provides instructions for the installation and testing of VisualWorks on your combination of hardware and operating system.
- *Release Notes:* Describes the new features of the current release of Visual-Works.
- *Tutorial:* Introduces the VisualWorks tools, class library, and approach to application design. It also introduces basic object-oriented concepts and the Smalltalk language.
- *Cookbook:* Provides step-by-step instructions for performing hundreds of common VisualWorks tasks.
- *User's Guide:* Provides an overview of object-oriented programming, a description of the Smalltalk programming language, a VisualWorks tools reference, and a description of various reusable software modules that are available in VisualWorks.
- *International User's Guide:* Describes the VisualWorks facilities that support the creation of nonEnglish and cross-cultural applications.
- *Object Reference:* Provides detailed information about the VisualWorks class library.

The documentation for the VisualWorks database tools consists of the following documents:

- *VisualWorks' Database Tools Tutorial and Cookbook*: Introduces the process and tools for creating applications that access relational databases. The

"Cookbook" chapter describes how to programmatically customize various aspects of a database application.

- *Database Connect User's Guide*: Provides information about the external database interface. Versions of it exist for Oracle7, SYBASE, and DB2 databases.

Online Documentation

To display the online documentation browser, open the **Help** pull-down menu from the VisualWorks main menu bar and select **Open Online Documentation**. Your choice of online books includes:

- *Database Cookbook:* Online version of the "Cookbook" part of the *VisualWorks' Database Tools Tutorial and Cookbook* described above.
- *Database Quick Start Guides:* Describes how to build database applications. It covers such topics as data models, single- and multiwindow applications, and reusable data forms.
- *International User's Guide:* Online version of the *International User's Guide* described above.
- *VisualWorks Cookbook:* Online version of the *Cookbook* described above.
- *VisualWorks DLL and C Connect Reference:* Describes C data classes, object engine access functions, and user-primitive functions.

Obtaining Technical Support

If, after reading the documentation, you find that you need additional help, you can contact ParcPlace-Digitalk Technical Support. ParcPlace-Digitalk provides all customers with help on product installation. ParcPlace-Digitalk provides additional technical support to customers who have purchased the ObjectSupport package. VisualWorks distributors often provide similar services.

Before Contacting Technical Support

When you need to contact a technical support representative, please be prepared to provide the following information:

- The *version id*, which indicates the version of the product you are using. Choose **Help**?**About VisualWorks** in the VisualWorks main window. The version number can be found in the resulting dialog under **Version Id:**.
- Any modifications (*patch files*) distributed by ParcPlace-Digitalk that you have imported into the standard image. Choose **Help**?**About VisualWorks**

in the VisualWorks main window. All installed patches can be found in the resulting dialog under **Patches:**.

- The complete error message and stack trace, if an error notifier is the symptom of the problem. To do so, select **copy stack** in the error notifier window (or in the stack view of the spawned Debugger). Then paste the text into a file that you can send to technical support.

How to Contact Technical Support

ParcPlace-Digitalk Technical Support provides assistance by:

- Electronic mail
- Electronic bulletin boards
- World Wide Web
- Telephone and fax

Electronic Mail

To get technical assistance on the VisualWorks line of products, send electronic mail to **`support-vw@parcplace.com`**.

Electronic Bulletin Boards

Information is available at any time through the electronic bulletin board CompuServe. If you have a CompuServe account, enter the ParcPlace-Digitalk forum by typing
`go ppdforum` at the prompt.

World Wide Web

In addition to product and company information, technical support information is available via the World Wide Web:

1. In your Web browser, open this location (URL):

   http://www.parcplace.com
2. Click the link labeled “Tech Support.”

Telephone and Fax

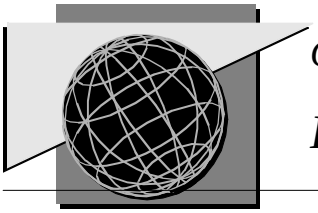
Within North America, you can:

- Call ParcPlace-Digitalk Technical Support at 408-773-7474 or 800-727-2555.

- Send questions and information via fax at 408-481-9096.

  Operating hours are Monday through Thursday from 6:00 a.m. to 5:00 p.m., and Friday from 6:00 a.m. to 2:00 p.m., Pacific time.

Outside North America, you must contact the local authorized reseller of Parc-Place-Digitalk products to find out the telephone numbers and hours for technical support.



Chapter 1

Profiling Time and Memory Usage

The Time Profiler helps you locate portions of your code that consume undue amounts of processing time. The Allocation Profiler performs a similar service for memory usage.

The user interface is very similar for both profilers, so they are often discussed generically in this chapter—"profiler" refers to both equally.

Creating an Object Allocation Profiler

To open a Time Profiler, select **Profiles** in the Advanced Programming Launcher, then select **time** in the submenu. To open an Allocation Profiler, select **allocations** in the submenu. A profiler window contains the following components: a code view for entering the code to be analyzed, a slider control for adjusting the sample size and, in the Allocation Profiler only, a **space statistics** button to extend the coverage of the analysis. Each of these components is discussed further below.

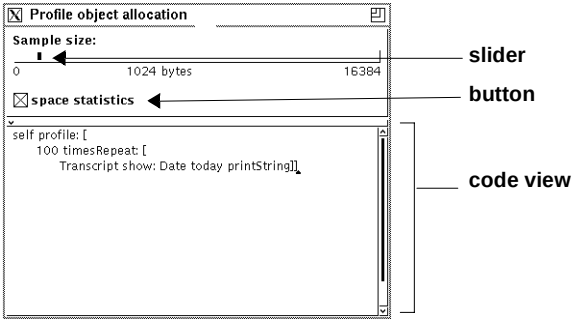


Figure 1-1 The parts of a profiler

Profiling a Block of Code

To create a profile of time or memory usage, enter the Smalltalk expressions in the code view of the profiler encased in a self profile: [ ] expression (an example is provided as a template when you open a new profiler). For example, suppose you wanted to find out what proportion of the memory allocated by the following expression was allocated by the Date method:

```
self profile: [Transcript show: Date today printString]
```

Enter the expression in the code view of an Allocation Profiler, then highlight it and select **do it** in the <Operate> menu. After the expression is executed (today's date is printed in the System Transcript), the results of the analysis are displayed in a new window. For an explanation of the report, see "Analyzing the Object Allocation Profile" on page 15.

In the Allocation Profiler, click on the **space statistics** check box to include a summary of object/byte allocations by class. This summary is described on page 21.

Optimizing the Sample Size

A profiler typically provides only an approximation of the time or memory being used by each method that is called. It does so, in effect, by monitoring the process at a regular interval, called the *sampling interval*. For example, if a babysitter checks in on children playing in their room every half hour, the sampling interval is 30 minutes.

At each 30 minute check point, the babysitter has to assume that the behavior of the moment has been going on for the past half hour. By reducing the sample size to 15 minutes, the babysitter will get a more accurate picture of the children's activities, though it will cost more time and effort.

The sample size can affect the accuracy of the results dramatically. Reducing the sample size improves the accuracy, but may slow down the profiling run disproportionately. Setting the sample size to zero, for example, causes the profile to be updated after each indivisible chunk of time or memory is used, which can be very time-consuming. In most situations, the default sample size provides adequate accuracy without slowing things down unnecessarily.

To reduce the sample size (for brief processes), move the slider to the left until the desired numerical size is shown below the slider. To increase the sample size (for time- or memory-intensive processes), move the slider to the right. (To move the

slider, place the cursor on the dark bar, press and hold the <Select> button on the mouse, then move the mouse to position the slider.)

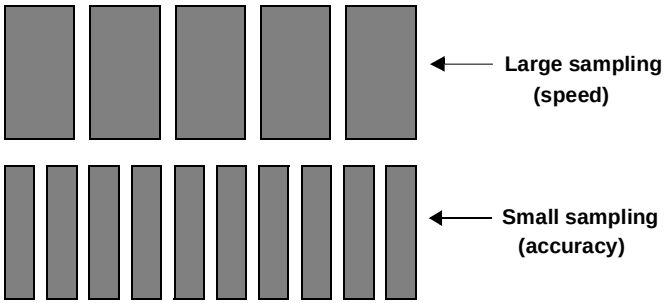


Figure 1-2 Speed versus accuracy trade-off when adjusting the sample size

In the example used above, printing today's date in the transcript, the process is so light in its memory usage that the default sampling interval of 1024 bytes is inappropriate. The process is only monitored a few times, resulting in misleading allocation statistics. The obvious solution is to reduce the sample size so the process is checked more frequently.

An alternative technique is to leave the sample size at the default, but repeat the process many times. We can accomplish this by entering the following expression in the code view of the profiler:

```
self profile: [100 timesRepeat: [Transcript show: Date today printString]]
```

This approach often gives superior accuracy because the odds of one or more checkpoints occurring in a low-consumption part of the process are improved. In our example, it turns out that the Date today part of the process only allocates about 3 percent of the bytes, so in a single pass it would be overlooked unless the sample size was very small.

Analyzing the Object Allocation Profile

After the process that you are profiling has finished executing, the profile is displayed in a profile window having the following components:

- A record of the sampling parameters.
- A slider for changing the cutoff percentage and a button for applying a new percentage.

- A text view for displaying the statistics.
- A **totals** switch and a **tree** switch for selecting the type of statistics to be displayed in the text view; and, in an allocation profile for which the **space statistics** check box was turned on, a third switch labeled **space usage** for displaying those statistics.

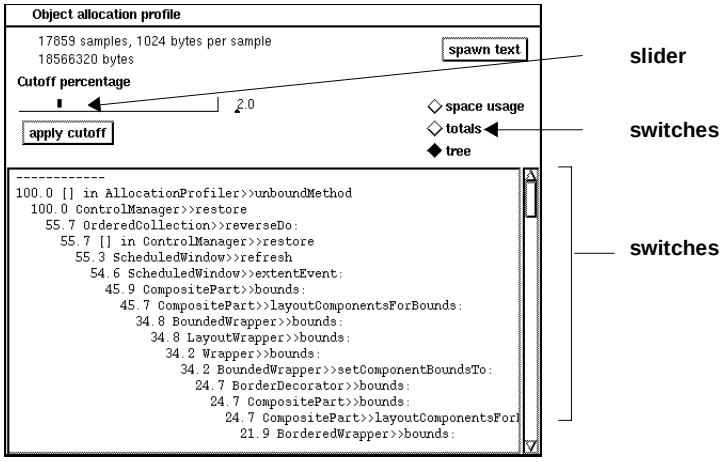


Figure 1-3 The structure of a profile window

Each of these components is discussed further below.

At the top of the profile window, a set of statistics display useful information about the profiling run, which include:

- Number of samples
- Sample size
- Total bytes consumed (allocation profile)
- Total milliseconds consumed, in both elapsed and processor time (time profile).

This information is useful in judging whether a change in the sampling interval will prove fruitful—because relatively few samples were taken, for example. This information also serves to label the profile, distinguishing it from profiles generated by other sampling runs on the same code.

Tree Report

When the **tree** switch is selected, the text view displays a listing of consuming methods that were called during the process. This listing is useful for locating the

places in your code that consume the most time or memory, and therefore merit your optimizing attention.

Each method selector is preceded by a number representing the percentage of system resource (bytes or milliseconds) consumed by that method. The tree is displayed in the form of an indented list—each method is indented under its calling method.

Adjusting the Cutoff Percentage

Only those methods that consumed more than a threshold percentage of time or memory are shown. The default is 2 percent, meaning any method that consumed less than 2 percent of the time or memory is excluded from the listing. In effect: "If it's smaller than this, don't bother me with it."

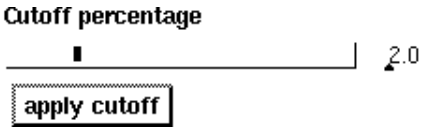


Figure 1-4 The slider and button used to change cutoff percentage

To get finer detail in the profile, reduce the cutoff percentage by moving the slider to the left. To restrict the profile to the methods that consumed larger chunks of time or memory, move the slider to the right. After you have changed the position of the slider, apply the new cutoff by clicking on the **apply cutoff** button.

Contracting and Expanding the List

Another means of making the list more manageable in size is to temporarily remove selected subhierarchies from the display. To do so, select the method above an unwanted subhierarchy and then use the **contract fully** command. The selected method redisplays in boldface, indicating that it can be expanded to show more detail; its called methods will be eliminated from the display.

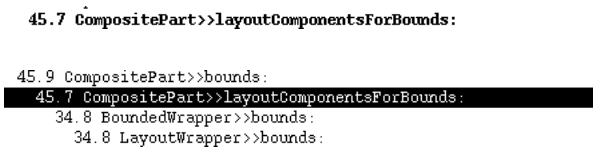


Figure 1-5 A profile entry contracted and expanded

To restore detail under a contracted method, use either **expand** (for a single level of called methods) or **expand fully** (for the entire subhierarchy) in the <Operate> menu.

Spawning a Method Browser

To examine the body of a method in the tree, select the desired method and then use **spawn** in the <Operate> menu. A method browser will be opened in a separate window. Besides the selected method, which is listed in boldface in the new window, the browser will list parent and child methods when appropriate.

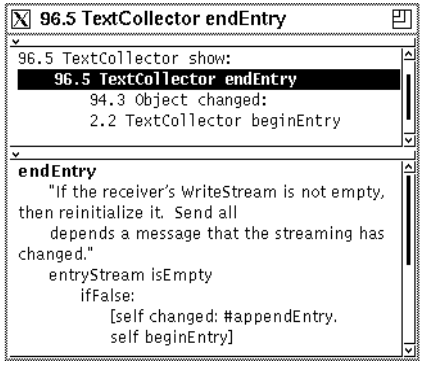


Figure 1-6 A Method Browser on the selected method and its neighbors

While the browser offers most of the features of a code view, including text editing, you cannot recompile an edited method (via **accept**) in this window because that could cause confusion about the state of the code at the time of the profile.

You can also browse **senders** of the selected message, **implementors** of the method, and implementors of **messages** contained in the selected method. These operations are the same as in the System Browser.

Totals Report

When the **totals** switch is selected, the text view displays a list of the fundamental object-creating methods that were called, with the percentage of system resource consumed by each.

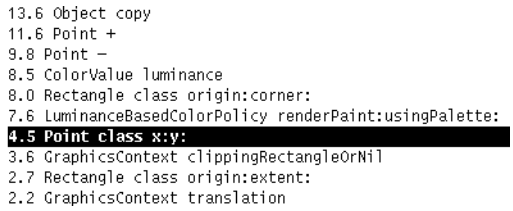


Figure 1-7 A sample "totals" report

For example, a process that deals with graphics might make many calls to the x:y: method in the Point class. That activity would be summarized here. If you felt Point was taking an inordinate amount of time or memory to get the job done, you might investigate alternative coding paths that would generate fewer messages to Point.

To open a code browser on a selected method and its surrounding contexts, use the **spawn** command as described above.

Space Usage Report

When the **space usage** switch (only available in an allocation profile) is selected, the text view displays a list of object types that were created—technically, a list of classes that were instantiated. For each, the number of instances is indicated along with the cumulative memory usage (in bytes). The cutoff percentage has no effect on this report—all classes that allocated objects are listed.

This report differs from the **totals** report in two important ways. First, it summarizes the activity by class rather than by object-allocating methods within classes. For example, Point>>asPoint and Point>>+ might be listed separately in the **totals** report but they are subsumed under a single entry for Point in the **space usage** report.

Second, **space usage** shows the number of instances and the *amount* of memory used, while **total** shows a *percentage* of allocated memory.

```
    Class                      Instances       Bytes
Point                            6563         131260
Rectangle                        2083         41660
Float                            1694         27104
Interval                         181          4344
GraphicsContext                  156          13104
Fraction                         92           1840
DisplayScanner                   57           5472
ByteString                       50           1183
Array                            36           584
FontDescription                  30           1200
CharacterBlock                   28           784
CharacterBlockScanner            27           3132
RunArray                         18           504
ColorValue                       8            192
Text                             6            120

  Allocation summary:
11029 total objects, average size 21.1 bytes.
1744 byte objects, average size 16.2 bytes.
9285 pointer objects, average size 22.0 bytes.
```

Figure 1-8 A sample "space usage" report

An allocation summary is provided at the bottom of the **space usage** report, which shows a count of total objects and the average size of each object. This information is broken down by byte-type and pointer-type objects.

Overview of the Code

The following classes provide the kernel of profiler functionality:

- Profiler and its subclasses, TimeProfiler and AllocationProfiler
- MessageTally, a subclass of Magnitude
- ProfilerListHolder, a subclass of ValueHolder
- ProfileOutlineBrowser, a subclass of OutlineBrowser

In early releases of VisualWorks, the MessageTally class provided time-profiling behavior in addition to its current reduced role. The profiling part of its functionality has been factored into Profiler, which provides more general support for assessing usage of an arbitrary system resource. The two subclasses, TimeProfiler and AllocationProfiler, specialize that spying ability for specific resources.

This architecture aligns with the fundamental notion that any system resource can be metered with the sampling apparatus provided by Profiler and the storage mechanism provided by MessageTally. For example, you could construct new subclasses of Profiler to measure disk seeks.

The newly trimmed-down version of MessageTally represents a single node in the tree-like hierarchy of message-sends that occur during the process being

profiled. When the profiler stops the running process to take a sample, a MessageTally is created for the method that is currently executing (unless that method was already tallied in the previous sample, in which case its tally is simply updated). Then instances of MessageTally are created and/or updated for the calling methods.

Each MessageTally remembers its place in the calling tree by holding onto its caller and its callees. This permits the report generator to construct the indented list known as the **tree** report.

Allocation Profiler's Wrapped Methods

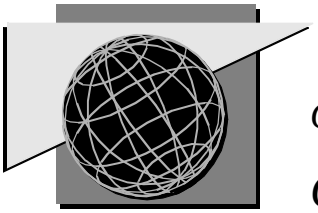
While TimeProfiler enforces its sampling interval straightforwardly, by monitoring the system clock, AllocationProfiler requires a more complicated mechanism. It maintains a list of primitive methods that allocate space for objects. Each time one of these methods is called, the original method is renamed. In its place, a "wrapped" version is substituted. This new version meters the memory usage in addition to performing its original function. At the end of the profiling run, AllocationProfiler restores all such wrapped methods to their original state.

AllocationProfiler assembles its list of allocating primitives during initialization of the class. The list and the resulting cache can become out of date when you add, delete or change a primitive method. Before using AllocationProfiler after you have filed in or otherwise recompiled code containing primitive calls, execute AllocationProfiler initialize.

Time and Space Overhead

The profilers impose relatively minor time and space overhead on the running process. Time overhead depends on the sampling frequency you choose—with the default of 16 milliseconds, the process will take roughly 50-70 percent more time than in its unmonitored condition. Memory overhead varies depending on the nature of the code.

The classes described in this chapter are useful in applications requiring advanced mathematical constructs such as complex numbers and infinity.



Chapter 2

Class Reports

Overview

The Class Reports tool performs a variety of automated checks on specified classes and helps you:

- Repair common coding errors.
- Estimate memory requirements of your application.
- Document your code.

Class Reports is a specific tool that is built on top of a set of general system-analysis capabilities. Those system-analysis facilities could well be put to use in other ways as well.

Creating Class Reports

To open a Class Reports window, select **Class Reports** in the Advanced Programming Launcher.

The Class Reports window contains the following components for defining the contents of the report:

- A Class Patterns view for roughly defining the classes to be checked.
- A Class List view for selecting individual target classes.
- Three switches for choosing a type of report.
- Depending on the type of report selected, two extra switches may be provided for choosing the output destination.
- Depending on the type of report and the output destination, additional options may be provided.
- A button labeled **run** for launching a scan-and-report sequence.

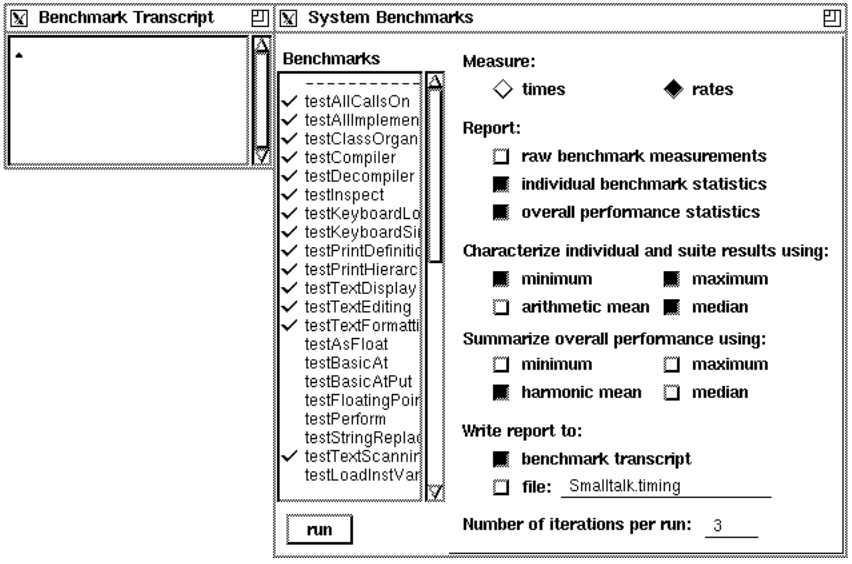


Figure 2-1 Initial display of a Class Report window

Selecting the Target Classes

You can generate a report for a single class, all classes or any list of classes. Keep in mind as you assemble your list that the amount of time required to produce a report increases with each added class.

Use the Class Patterns view to make a rough cut at the list. Enter one or more wildcard patterns, one per line. Each such entry can contain a class category component and/or a class component. If both components are present, separate them with a greater-than symbol (>). Then choose **accept** in the <operate> menu to display all classes matching those criteria in the Class List view. Wildcard patterns are not case sensitive; an asterisk (*) stands for any string, and a number sign (#) stands for any single character. You can also use the **paste** command to insert a list of patterns that you use frequently.

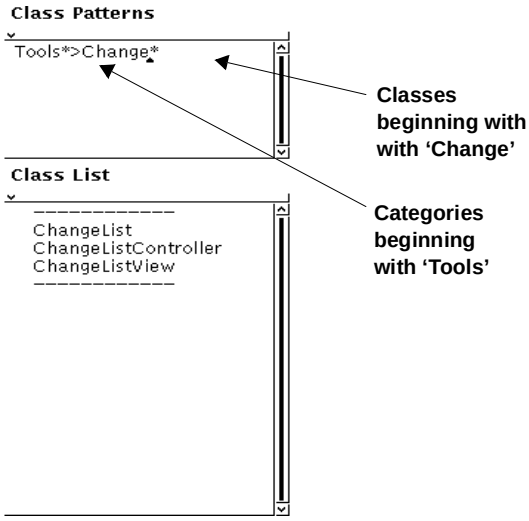


Figure 2-2 Using a wildcard pattern to define a work list of classes

The following examples are all valid class patterns:

Table 2-1 Valid class patterns

Tools*	Classes in categories beginning with 'Tools'
tools*	Same as above
Tools-Misc>*	Classes in the Tools-Misc category
Tools*>Changes*	Classes beginning with 'Changes' in categories beginning with 'Tools'
Changes*	Classes beginning with 'Changes'
ChangesList	The class name ChangeList

Then, in the Class List view, click on the desired class or classes to highlight them for inclusion in the report. Use the **add all** command in the <operate> menu to select all of the classes in the list at once; use **clear all** to deselect all of them. To select a range of classes, hold down the <Shift> key while dragging through the

desired class names; to deselect a range of classes, hold down the <Control> key while dragging.

Locating Coding Errors

To scan the selected classes for coding errors, select the **Correctness** switch in the upper left corner of the Class Reports window. Two new switches will appear, labeled **Report** and **Browse**. When the **Report** switch is selected, ten report options are displayed. Each option has a check box, and you can check any number of them to build up the desired report. When the **Browse** switch is selected, eight of the options are offered—the other two are only appropriate for report output.

Class Report Options

Messages Sent but Not Implemented

Each method in the class is checked to make sure that every message sent is implemented somewhere in the system. No attempt is made to assure the appropriateness of the implementor. For example, a `self grok` message is acceptable even if `grok`'s implementor is not in the target class or its superclass hierarchy.

Methods that send an unimplemented message are reported or, in **Browse** mode, listed in a browser for examination and possible correction.

Messages Implemented but Not Sent

Each method in the class is checked to make sure that its selector is sent by at least one calling method.

Defining what it means for a message to be "sent" is problematic. As an extreme example, one could have code that says `self perform: (a,b) asSymbol`, where `a` and `b` are variables that hold `'foo'` and `'bar'`, respectively. This code, then, sends the message `foobar`, but no practical analyzer can figure this out. So system tools have to take a particular stand as to what it means for a message to be sent.

In the case of this facility, the stance taken is exactly the same as that taken by the **senders** and **messages** facilities in the System Browser: a message is sent if some compiled code has the message selector as a literal. It will be a literal if the selector is used in code (e.g., `self foobar`), or if the symbol exists in literal form (e.g., `self perform: #foobar`). It will not be a literal if the symbol is part of an array literal (e.g., `self perform: #(#foobar) first`). (The exception to this rule is a

set of special selectors known by the compiler classes. These selectors are always considered to be sent, even if they do not appear as literals anywhere.)

As a result, the facility may falsely report that some implemented messages are not sent, so the report should be used as a guide. The above example is, of course, poor programming style.

However, there is at least one widely-used idiom that is considered good style but still fails the current test, and that is the use of arrays to hold menu values. The message for creating a menu is:

```
PopUpMenu
    label: ...
    values: #(#msg1 #msg2 ...)
```

These messages are performed by the code, so they are sent. However, because the selectors are stored in literal arrays, they will not be perceived by Class Reports as having been sent. Often, such messages are not sent from any other code, so the facility will incorrectly report them as "implemented but not sent."

This test could, of course, be extended to include literal arrays. However, that would be inconsistent with System Browser behavior, which reports "Nobody" for senders of such menu messages.

Methods that are not sent are reported or, in **Browse** mode, listed in a browser for examination.

Method Consistency

When two messages sent to the same instance or class variable assume different object types, a conflict is reported.

Similarly, when a temporary variable is used to hold two very different kinds of objects (considered bad form) and thus is sent incompatible messages, a conflict is reported.

The current value of each class variable, pool variable and global variable is also tested to be sure its class implements the messages that are sent to it.

Finally, an inconsistency is reported when a message is sent to self that is not understood by the self object.

When inconsistent methods are found, they are reported or, in **Browse** mode, listed in a browser.

Subclass Responsibilities Not Implemented

Each method that consists of a self subclassResponsibility message motivates a check of each leaf subclass to make sure it owns or inherits a reimplementation of that message.

Note that abstract subclasses need not implement these messages—in such cases, the report will falsely report errors, so use the report as a guide.

Offending methods are reported or, in **Browse** mode, listed in a browser.

Undeclared References

Each method in the class is checked to verify that no undeclared literals are used. Offending methods are reported or, in **Browse** mode, listed in a browser.

Instance Variables Not Referenced

Each instance variable is checked to make sure it is referenced by at least one method. Unreferenced variables are reported; this option is not available in **Browse** mode.

Check Comment

The class comment is checked to make sure it mentions all instance variables, class variables and class instance variables that are in the class definition.

The comment is expected to follow a particular syntax:

- Any amount of plain text followed by a line that says “Instance Variables:”.
- After that line, there should be a line for each instance variable, containing the variable’s name followed by one or more spaces and tabs, followed by a “type” specification in angle brackets, followed by one or more tabs and spaces, followed by text describing the variable.
- If the class has indexed instance variables, include another line as described above, substituting “(indexed instance variables)” for the variable name.

The type specification is typically one or more class names, or nil, separated by vertical bars. In place of class name, you can also use "ClassName of: OtherClassName", for example "Array of: Boolean". The syntax allows more complicated descriptions; for more information, see the method comments in Parser>>typeExpression and Parser>>simpleType.

If the class defines any class variables, the comment should have a section similar to the instance variable section. The heading line is expected to say "Class Variables:".

Finally, if the class has messages defined as self subclassResponsibility, these messages should be listed in a section with "Subclasses must implement the following messages:" as its heading.

The parsing of class comments is somewhat rigid and sometimes what appears to be a valid comment will generate errors in this report, so use the report as a guide. For example, if a type description does not fit on one line, or if the variable description does not start on the same line, the facility will report these as errors.

For instance variables, the facility performs a protocol test:

- All messages sent to each instance variable are verified as being implemented for the named class (or, if more than one class is named, for at least one of them).
- If the class has existing instances, each variable is expected to hold an object of the named type.
- For each class variable, the current value is expected to be an object of the named type.

This option is not available in **Browse** mode. If a comment contains the words UNDER DEVELOPMENT (in capital letters), that fact is reported and no checking takes place for that class.

Backward Compatibility Message Sends

The methods are checked to see whether they send messages that exist (only) in a backward compatibility protocol.

Indefinite Backward Compatibility Message Sends

Similar to the preceding option, but the checker only pays attention to the ambiguous case, when a message send exists in both a backward compatibility category and another category. In this situation, static analysis cannot determine whether the message send is inappropriate, so it is reported as a candidate for your further investigation.

Backward Compatibility Class References

The methods are checked to see whether they refer to a class that is in a class category that contains the string ‘backward compat’ (without case sensitivity).

Estimating Memory Requirements

To receive an estimate of the memory requirements of the target classes, select the **Space** switch in the upper-right portion of the Class Reports window. Three new switches will appear. Each button provides a different perspective on the estimated memory requirements, as follows:

- **Class Size**—For each target class, the report shows the estimated number of bytes required for the class definition, variables, methods and class organization.
- **Method Size**—For each method in a target class, the following measurements are reported:
  - **Code Bytes**—the memory occupied by the method's byte code, the portable compiled form of the method that is used to create native machine code.
  - **Literals**—the number of literal pointers created by the compiler to refer to such things as message selectors, arrays, strings and floats. Each such literal pointer contributes 4 bytes to the total.
  - **Literal Bytes**—the number of bytes required by literal objects other than Symbols.
  - **Full Blocks**—the number of full blocks in each method. Full blocks are blocks that contain out-of-scope references to temps, or nonlocal (^) returns. Full blocks are nonoptimal because they are slower and use more dynamic memory. This is only of concern in methods that are used frequently. For further information about full blocks, see the *VisualWorks User's Guide*.
  - **Total**—the estimated total number of bytes needed by each method, including overhead (20 bytes) not reported in the other columns. A total byte count for all methods is also displayed.
- **Instance Size**—For each target class, the following measurements are reported:
  - **Count**—the number of instances that exist.
  - **TotBytes**—the memory, in bytes, occupied by all instances.
  - **AveByte**—the average number of bytes for each instance.

  A summary line reports the same measurements for all target classes.

These reports are intended to help you optimize memory usage by identifying places in your code where memory usage is disproportionate to the functional contribution of the code.

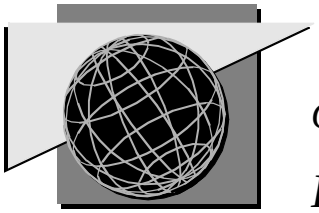
Documenting Your Code

To create a listing of some or all of the elements that make up the code in the target classes, select the **Manual** switch in the upper left portion of the Class Reports window. Two new switches will appear, labeled **Report** and **Print**. When the **Report** switch is selected, the documentation is displayed in a separate window. When **Print** is selected, the output is sent to a printer instead.

The following check-box options are provided for defining the code components to be included in the listing. The options are hierarchic and interconnected, as follows:

- **class definition**
  - **class comment**
- **include metaclass**—include the metaclass definition.
- **protocol names**—instance protocol names are reported; class protocol names are included when the **include metaclass** check-box is selected.
- **include private protocols**—include any protocol beginning with the string “private.” Private protocols are made separable in this way because only public protocol is relevant for certain types of manuals.
- **methods**—list method selectors, including metaclass and private methods if those check-boxes are selected.
  - **method comments**
  - **method bodies**—including method comments.

Various text emphases are used for the different components of documentation. For example, #italic is used for the class comment.To change one of these emphases, modify and recompile the appropriate method in the emphases protocol on the instance side of the ManualWriter class.



Chapter 3

Full Protocol Browser

The Full Protocol Browser is an expanded version of the System Browser. It has all of the capabilities of a standard System Browser. In addition, it enables you to include superclass and subclass protocol in the message category and message views. You can also filter the methods by class.

This hierarchic view of a class's functionality can be especially helpful under the following circumstances:

- When you are exploring unfamiliar code, because the Full Browser presents the full behavior set of each class.
- When you are modifying a polymorphic method, because the Full Browser makes it easy to trace inherited behavior.

Creating a Full Browser

To create a Full Protocol Browser, select **Full Browser** in the Advanced Programming Launcher.

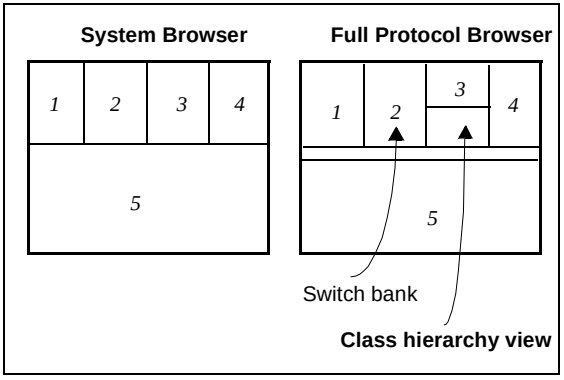


Figure 3-1 System Browser compared to Full Protocol Browser

A Full Browser appears much like a standard System Browser, with the addition of a class hierarchy view, as shown in Figure 3-2. In addition, three switches are provided for filtering the browser's display.

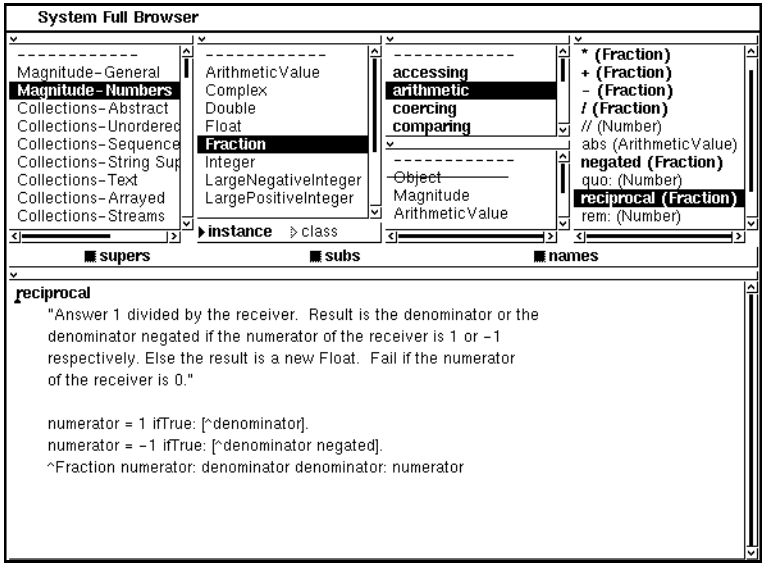


Figure 3-2 A Full Browser, with the ArithmeticValue class selected

The class hierarchy view enables you to filter out parts of the hierarchy and to perform cross-reference searches that are limited to the hierarchy, as described in later sections.

Displaying the Full Protocol of a Class

As shown in Figure 3-2, selecting a class such as Fraction in the class view causes the class's hierarchy to be displayed in the hierarchy view. The current class displays in boldface type as a visual cue.

All messages and message categories in this hierarchy display in the appropriate views. The message category view, also known as the protocol view, differs from a view in the System Browser in that the entries list alphabetically. In the message view, polymorphic messages are repeated unless you filter them out, so each method selector can be identified by the class in which it is implemented. In Figure 3-2, for example, the reciprocal method is listed twice, once for ArithmeticValue and again for Fraction. Messages in the current class are displayed in boldface for visibility.

By default, the Object class is excluded from the active list so it is displayed with a line through it. The following section tells how to include and exclude classes from the list.

Filtering Messages by Class

The hierarchy view enables you to filter unwanted classes from the protocol views. To exclude a class, click on it in the hierarchy view. It will be redisplayed with a line through it. To exclude multiple classes that are listed in sequence, hold down a <Shift> key while dragging through the classes to be excluded.

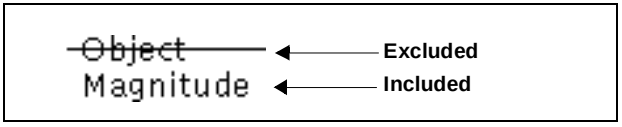


Figure 3-3 The appearance of included and excluded classes in the hierarchy view

To include a class that was previously excluded, click on it. It will be redisplayed without the line through it.

To include multiple classes that are listed in sequence, hold down the <Control> key while dragging through the classes to be included.

Use the switches in the switch bank to set up default filtering that suits your purposes. Two of the switches provide a convenient means of including or excluding protocol for all superclasses except Object (supers), or all subclasses (subs). By default, duplicate inherited methods are not shown (because they are overridden by the local method)—to show them, select **show inherited duplicates** in the hierarchy view's menu.

The third switch, **names**, toggles whether the implementing class is identified after each method selector.

Searching within the Hierarchy

The **senders** command in the message view's menu operates as it does in a System Browser, searching all classes in the system for methods that se

To limit the search to methods implemented by a class in the current hierarchy, select **senders in hierarchy** in the <Operate> menu of the hierarchy view. Note that all classes in the hierarchy are included in the search, regardless of whether they are filtered out of the protocol and message listings. This is typically much

faster than a search of the entire library, and tends to exclude uninteresting implementations. Similar hierarchic counterparts for the **implementors** and **messages** commands are also available in the hierarchy view's menu.

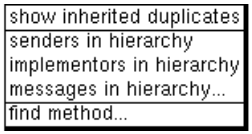


Figure 3-4 The <Operate> menu of the hierarchy view, used to limit scope of search

Scoping Rules

The hierarchy view's menu also offers a **find method** command, which differs from the protocol view's command of the same name in two ways. First, because the list of selectors may be very large, you get an opportunity to filter it by specifying a wildcard pattern. Second, the implementing class is shown for each selector, and duplicates are listed in inheritance order.

The scope of the commands in the class view's menu and the protocol view's menu are limited to a single class, as in a standard System Browser. However, when a method selector is highlighted, the commands relate to that class. Otherwise, they relate to the class that is highlighted in the class view. (In **FullBrowser**'s code, **selectedClass** and **nonMetaClass** refer to the method view's class, while **currentClass** and **currentNonMetaClass** refer to the class view's class.)

For example, suppose you have selected ArithmeticValue in the class view and then you highlight the denominator (Fraction) entry in the message list view. When you select the **comment** command to display the class comment, Fraction's comment is displayed. To see the comment for ArithmeticValue, select a message for that class (or no message at all).

To restate this scoping mechanism, the selected message's class overrides the class view's class.

There are two exceptions to this rule: the **remove** and **rename as** commands in the message category view. Removing or renaming a message category affects the class that is highlighted in the class view, in all circumstances.

The scope of a message category is extended in a perhaps unexpected but useful way in a Full Browser. As you would expect, when you select a message category such as comparing, all comparing methods in the filtered hierarchy are listed. In addition, methods in superclasses and subclasses that have the same selectors as comparing methods in the current class are included, even if they are located in

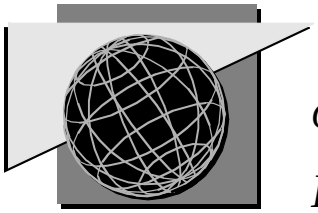
protocols other than comparing. In other words, when the same selector appears in two different protocols in the hierarchy, Full Browser lists those that could conceivably be grouped in the current protocol because they match qualifying selectors in the current class.

For example, suppose you select the accessing protocol for the Integer class. Both Integer and its subclass LargePositiveInteger implement a method called digitLength. The LargePositiveInteger version of digitLength would be included even if it were housed in a protocol named other than accessing. This behavior obeys the convention that polymorphic messages are placed in protocols of the same name, while allowing for human error and personal choice in the enforcement of that convention.

In summary, the changes in the scoping rules compared with a standard System Browser are as follows:

- Class and protocol view commands apply to the class of the selected message, if any; otherwise, they apply to the current class. Exceptions are the **remove** and **rename as** commands, which always apply to the current class.
- In the hierarchy view, the **find method** command applies to the filtered hierarchy while the other commands ignore the filters.

Conflicts in protocol names for polymorphic messages are ignored.The Time Profiler helps you locate portions of your code that consume undue amounts of processing time. The Allocation Profiler performs a similar service for memory usage.



Chapter 4

Parser Compiler

Overview

The parser compiler classes make it easier to write compilers in Smalltalk. The SQL classes provide an example of an SQL compiler written using the parser compiler facilities.

A typical compiler handles four functions:

- **Scanning**—breaking the source code into tokens (words, numbers, operators, etc.).
- **Parsing**—combining tokens into larger structured units.
- **Semantic analysis**—verifying that variables have been declared, performing type checking, etc.
- **Code generation**—producing a program in machine code or other final form. This may occur in several phases if optimization or more than one representation of the output code is involved.

The parser compiler classes provide the following support for these activities:

- **Scanning**—the Smalltalk Scanner, slightly modified.
- **Parsing**—This phase is the primary focus of the Parser Compiler, providing an efficient language for writing your parser.
- **Semantic analysis**—the Parser Compiler makes it fairly easy to mix in semantics during parsing. This helps to generate an error message that points at the right place in the source code.
- **Code generation**—you're on your own. The Parser Compiler itself demonstrates one style of code generation: It generates Smalltalk source code during parsing. The complexity of most languages prevents being able to combine code generation with parsing.

Scanning Source Code

The scanner defines seven standard types of token:

- word—a variable or unary message selector
- number—integer or floating point
- character
- string
- binary—infix operators such as + and >=
- keyword—a word followed by a colon (see below)
- signedNumber—a number optionally preceded by a minus sign, with no intervening delimiters

There is an eighth standard token type, keywords, for one or more keywords in succession with no intervening delimiters. This produces a single token. Keywords are only recognized specially if your grammar uses the word keyword or keywords, or if your grammar includes any literal keywords. (This is for the benefit of grammars that don't use keywords, but use the colon for other purposes.)

In addition, the scanner makes assumptions about delimiters (blank, tab, end-of-line and new-page), which separate tokens but aren't tokens themselves. It also assumes that the following characters are tokens on their own: # ( ) | [ ] . : = ^ and ;. To change any of these assumptions requires an understanding of the Scanner's mechanics—you have to write your own initScanner method that calls super initScanner and then substitutes the appropriate entries in the typeTable.

Parsing

For the parsing phase, begin by making your parser a subclass of ExternalLanguageParser—SQLCompiler has been provided as an example. If your source language is method-oriented and you want the output of the parser to be executable CompiledMethods, make your parser a subclass of General-Parser instead.

This gives your class basic parsing functionality. The parser scans source code one character at a time and one token at a time. You must then write production rules describing the various parts of your language. These rules define parsing algorithms, which your parser will use to recognize constructs such as functions and clauses in the source code. The syntax of production rules will be described in a moment.

Each clause or other construct found in the source code must be instantiated as a node in a parse tree. For example, when an SQL clause is recognized in the source code by SQLCompiler, an instance of SQLClause is created. Classes such as SQLClause typically are subclassed from a more general class such as SQLNode.

As an example of this node-creation mechanism, the production rule implemented by SQLCompiler for recognizing an SQL commit statement creates an instance of SQLStatement as follows:

```
EmulationBorderDecorationPolicy unInstallcommitStatement =
    #COMMIT #WORK
            [statement: 'COMMIT WORK']
```

In this example, the word COMMIT followed by WORK in the source causes execution of the block. A statement: message is sent to SQLCompiler, and that method sends an instance creation message to SQLStatement with the 'COMMIT WORK' string as the statement name.

The ultimate output of the parser is an array containing objects such as SQLFunction, which themselves are often composites of smaller language constructs such as SQLClause. This array represents a parse tree that you can use to generate code.

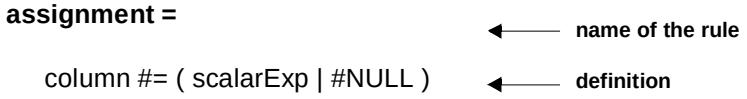
As the parse tree is being assembled, it is stored in an OrderedCollection called stack, held by GeneralParser. This stack responds to collection protocol such as removeLast, and stack operations are frequently embedded in blocks within the production rules. For example, the SQLCompiler>>queryTerm rule contains the following assignment into a temporary variable:

```
tableExp := stack removeLast.
```

A Rule has a Name and a Definition

A production rule describes a semantic unit of the language in terms of other semantic units combined with literal tokens. It introduces the name of the semantic unit, followed by =, followed by the definition, which may include references to other production rules or to literal keywords that are expected at various points in the source-code.

As an example, the following production rule is taken from SQLCompiler:



When a production rule is invoked, its definition is used as a template for the current source code. If the template fits, the rule returns true, triggering creation of the appropriate node in the parse tree. If the definition doesn't match, either the rule returns false, or an error notification occurs.

Rules are Similar to Methods

It is no accident that a production rule looks like a Smalltalk method. It is created just as a Smalltalk method is, by adding it to the instance protocol for your compiler class (SQLCompiler, in this case). You can use the System Browser to do so, or you can file it in. This is possible because the ParserCompiler's responsibility is to take production rules and translate them into equivalent Smalltalk code, which is then translated into an executable method. Each production rule is translated into a method whose selector is the name of the production rule. As a result:

- You can browse production rules in the same way you browse Smalltalk methods.
- Production rules can call Smalltalk code, and vice versa.

Temporary Variables Can be Used

A production rule can have temporary variables. These are defined the same way as in Smalltalk, by enclosing the list of names between two vertical bars.

A production rule begins with a method pattern consisting of the name of the rule, plus names for any arguments. Except for the terminating equal sign (=), the syntax is identical to that of a Smalltalk method, allowing for unary, binary and keyword patterns.

A Rule Definition is a Series of Alternatives

The body of a production rule, called its definition, is a series of *alternatives*, separated by vertical bars (|). The parser tries to match the current source code to each alternative in turn. If a given alternative succeeds, the definition succeeds and returns true. If an alternative fails, the next alternative is tried.

The final alternative in a series can be left empty to return true immediately. If the series is enclosed in parentheses, the empty alternative is indicated by a vertical bar preceding the closing parenthesis. If the series is the body of the definition, the

empty alternative is indicated by making a vertical bar the last element of the definition.

For example:

```
( a | b ) c  The next tokens must match either 'a' or 'b', followed by 'c'

( a | ) c The next token or tokens must match either 'a' followed by 'c', or
'c' alone
```

An Alternative is a Series of Terms

An alternative is a series of *terms*, each alternative optionally preceded by an at sign (@). Each term is evaluated sequentially against the source code. If a term succeeds, the parser proceeds to the next term; otherwise it fails. If the last term in the alternative succeeds, the alternative returns true. If the alternative fails, behavior depends on several factors:

- If the at sign is present, the source code stream is rolled back to the state it was in when the alternative was started, and false is returned.
- If the term that failed was the first in the alternative, false is returned.
- Otherwise, an error notification is returned.

Figure 4-1 summarizes these outcomes in a decision tree showing that action that results when a term is evaluated under various conditions.

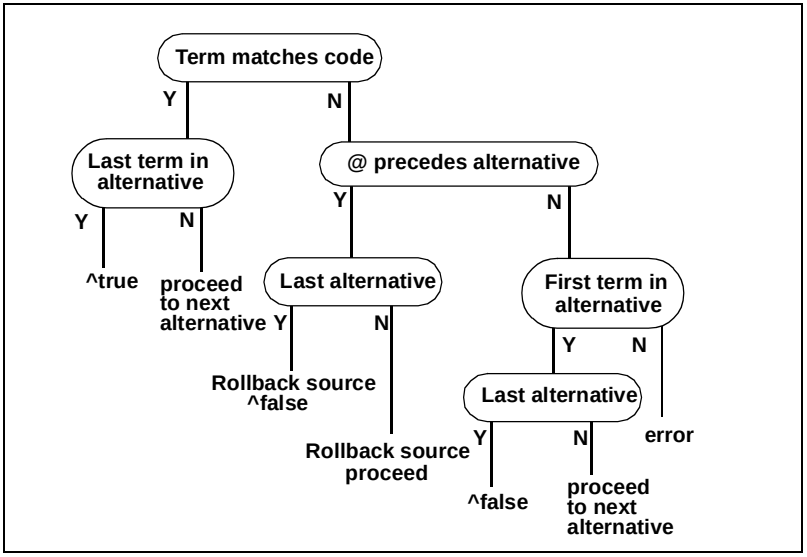


Figure 4-1 Summary of the outcomes in a decision tree

Two examples follow:

```
a b c
```

Expect to find an a, followed by b and c. If a is not found, proceed to the next alternative or return false. If b or c is not found, print an error message.

```
@ a b c
```

Expect to find an a, followed by b and c. If a, b, and c are not found when expected, proceed to the next alternative or return false.

Suppose the parser matches a, but fails to match b. For accurate error detection, the ParserCompiler will not automatically back up on failure, so in this case a message would appear saying b expected. However, it is possible that if the source stream were backed up, we might be able to match c d rather than a b. Therefore, in this case, it is appropriate to write the rule as:

```
@ a b | c d
```

Then, if a succeeds but b fails, the parser will back up and try to match c followed by d.

Another way to think about it is: When the first term in an alternative is matched, the parser assumes it has found the correct alternative. If a later term fails to match, the parser reports an error based on its assumption that the correct template was applied unsuccessfully. The at sign removes that assumption so that, instead of generating an error in this situation, the compiler proceeds to the next alternative.

A Term is an Action or a Unit-Plus-Qualifier

A term can be an *action*, or it can be a *unit* followed by one of the following symbols:

```
*    *! +  +!  \    \!                                    !*
```

We will discuss the more common type of term first: units and their quantifying modifiers.

A Unit is a Word, Terminal or Parenthesized Definition

A unit can be a word, a *terminal*, or a definition wrapped in parentheses. If it is a word, that word is assumed to be the name of another production rule. Some examples:

Table 4-1 Word and associated production rule

foo	Evaluate the production rule foo on the current source code. If it returns false, fail the current alternative, else continue.
word=#ABC	If the next token in the source is ABC, push it on the stack and scan another token, else fail the alternative.
keyword=#ABC:	If the next token in the source is ABC:, push it on the stack and scan another token, else fail the alternative.
$(	If the next token is the open parenthesis character, scan another token, else fail the alternative. The stack is unaffected.
#ABC	If the next token in the source is ABC, scan another token, else fail the alternative. The stack is unaffected.
#ABC: [keyword type]	If the next token in the source is ABC:, scan another token, else fail the alternative. The stack is unaffected.

Table 4-1 Word and associated production rule

#~=	If the next token in the source is ~=, scan another token, else fail the alternative. The stack is unaffected.
#'<<='	If the next token in the source is <<=, scan another token, else fail the alternative. The stack is unaffected.
(...)	When parentheses are encountered, the enclosed part of the rule is parsed according to the rules for definition on page 42.

The following examples illustrate the use of the seven quantifying symbols with units. In these examples, foo pushes a FooNode onto the stack, while foo2 does not affect the stack.

Table 4-2 Quantifying symbols

foo *	Expect zero or more repetitions of foo. The top value on the stack will be an Array of FooNodes.
foo *!	Expect zero or more repetitions of foo. The top N values on the stack will be FooNodes, where N is the number of repetitions.
foo +	Expect one or more repetitions of foo. The top value on the stack will be an Array of FooNodes.
foo +!	Expect one or more repetitions of foo. The top N values on the stack will be FooNodes.
foo \ foo2	Expect one or more repetitions of foo, separated by foo2. The top value on the stack will be an Array of FooNodes.
foo \! foo2	Expect one or more repetitions of foo, separated by foo2. The top N values on the stack will be FooNodes.
foo !*	Expect one occurrence of foo. Assume that foo leaves an Array on the stack. Pop the Array off the stack and push each of its elements onto the stack.

A Terminal is a Single Token

A terminal is a single token in the language, such as a number, a string, a variable name or a keyword. In the ParserCompiler, the following terminals are recognized:

- A dollar sign ($) followed by a single character, representing a literal character in the source.

- A number sign (#) followed by:
  - A string (any sequence of characters enclosed in single quotes)
  - A word (an alphabetic character followed by alphabetic characters or digits)
  - A keyword (a word followed by a colon)
  - A binary symbol (anything that represents a legal binary operator in Smalltalk, such as //, \\, *, ~~ and ~=)
- The sequence word=#someWord, where someWord is a word as defined above
- The sequence keyword=#someKeyword, where someKeyword is a keyword as defined above

The difference between #someWord and word=#someWord, is that in the former case someWord becomes a reserved word in the language and is always treated specially. In the latter case, someWord does not become a reserved word and is treated specially only when it is preceded by word=.

An Action is a Block or a Special Symbol

An action can be either a Smalltalk block or one of the following special symbols:

Table 4-3 Action symbols

Symbol	Description
<	Saves the source position in a local variable (specifically, the temps instance variable in ParserCompiler). Note that only one source position per production rule is saved, so if you overwrite it, the old value is lost.
>	Assumes that the source position was previously saved via <, and that the top value on the stack is a parse node. The parse node is sent a sourcePosition:to: message, with the saved position as the first argument and the current position as the second argument. This implies that your node classes must implement a sourcePosition:to: message when you use this symbol in a production rule.
<<	Pushes the source position onto the stack.

Table 4-3 Action symbols

Symbol	Description
>>	Assumes that the top value on the stack is a parse node, and that the next value is a source position saved by <<. The parse node is sent a sourcePosition: message, with an interval from the saved position to the current position as the argument. The source position is removed from the stack, and the parse node remains the top element.
?	Pops the top value off the stack. If it is true, proceed, otherwise fail the current alternative.
.	Pops the top value off the stack and proceed.

The first four operations are for matching source code positions to parse nodes. The last two are for use with Smalltalk blocks. When a Smalltalk block appears in a production rule, the block is evaluated and the result is pushed onto the stack. If you are interested in the effect of the block but not the returned value, follow the block with a period to get rid of the unwanted value. To decide whether to continue parsing after a block has been evaluated, follow the block with a question mark to cause the current alternative to proceed or abort depending on the returned value.

Two Types of Block Syntax are Allowed

Two distinct syntaxes are accepted for Smalltalk blocks. One form of syntax is identical to that of normal Smalltalk blocks having zero arguments. The second form is nonstandard and requires further explanation—it has the advantage of very concise coding, with the disadvantage of very restricted syntax.

Like a normal block, this special block is enclosed in square brackets. It consists of exactly one message—the message can be either a binary or keyword message, but not a unary message. The receiver is specially coded:

- If there is no receiver, the message is sent to the parser itself.
- If the message selector is preceded by a colon (:), the top value is popped off the stack and used as the receiver.

Each of the arguments is likewise specially coded:

- If there is no argument, or if the argument is a colon (:), the top value is popped off the stack and used as the argument.
- If the argument is a normal Smalltalk literal (Symbol, String, Number, Array, ByteArray, Character, or nil, true or false), it is used in the ordinary way.

- If the argument is a temporary variable, instance variable, class variable or global variable, it is used in the ordinary way.

For example, the following block sends a copyWith: message to the top value on the stack, with the second value on the stack as argument:

```
[ :copyWith: ]
```

Note that no argument can be the result of a message send.

Summary of Grammar for Parsing Methods

Here is a simplified version of the grammar for parsing methods, written in itself:

```
method = pattern #= temporaries definition

pattern = word | (keyword word)+

temporaries = $| word* $| |d

definition = alternative ($| alternative)*

alternative = ($@ | ) term*

term = unit
      ( (#* | #*!)
      | (#+ | #+!)
      | (#\ | #\!) unit | )

unit = word | character
     | $# (word | keyword | binary | string)
     | $( definition $)
```

Creating your Own Compiler

In preparation for writing programs in your new language, first define a compiler class MyLanguageCompiler, then define a dummy class MyLanguage. Define the following class method for MyLanguage:

```
compilerClass

    ^MyLanguageCompiler
```

Then any methods defined in class MyLanguage or any of its subclasses will compile with MyLanguageCompiler rather than the standard Smalltalk compiler. The example methods in the SQL class are compiled by SQLCompiler in just this way.

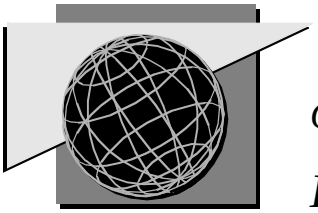
The typical instance creation protocol for a parser takes either a Stream or a String as input, as well as the name of the top-level production rule to be applied. For example:

```
CParser parse: aStream as: #cFile
```

The final step in code generation is done by the message generate:. This message is defined in GeneralParser on the assumption that the output of your compiler (i.e., the single element left on the stack at the end of recognizing a method) is a string that is actually a Smalltalk source method, which then gets handed to the Smalltalk compiler.

However, you can override this method in your own compiler to do something different. It should return a selector if the code generation succeeds, or nil if it fails. In the case of the SQL example, the final object is an Array containing a parse tree in the form of a hierarchy of nodes. Try the examples on the instance side of the SQL class, inspecting the results recursively to see the structure of the parse tree.

This object responds to Smalltalk messages and can thus be manipulated to suit the next phase of compilation.



Chapter 5

Enhanced Numbers

The classes described in this chapter are useful in applications requiring advanced mathematical constructs such as complex numbers and infinity.

Complex Numbers

An instance of class Complex has two components, a real number such as a Float, and an imaginary number (a multiple of *i*, which represents the square root of -1). A Complex number is represented in the following format: (5.5 + 3 i)—white space inside the parentheses is ignored.

Creating an Instance

An instance can be created by using the literal form shown above, or via the real:imaginary: method, as in Complex real: 5.5 imaginary: 3. When the real component is zero, sending the message i to an integer is sufficient, as in 3 i. When the imaginary component is zero, the shorter fromReal: method can be used. In summary, the expressions in the left column generate the Complex numbers in the right column below:

3 i	(0 + 3 i)
5.5 + 3 i	(5.5 + 3 i)
Complex fromReal: 5.5	(5.5 + 0 i)
Complex real: 5.5 imaginary: 3	(5.5 + 3 i)

Protocol Summary

Complex numbers support the usual numeric operations, including accessing, arithmetic, mathematical functions, coercion, comparison, conversion, testing and

generality. Nonequal comparison, truncation and rounding are not valid with complex numbers. Additional methods include:

Table 5-1 Accessing

r	Same as abs, which returns an absolute magnitude. For example, (5.5 + 3 i) r returns 6.26498.
theta	Return the angle between the receiver and the positive real axis, in radians

Table 5-2 Arithmetic

conjugated	Reverse the sign of the imaginary component.

Table 5-3 Converting

asPoint	Return a Point with the real component as the x value and the imaginary component as the y value.
i	Multiply the receiver by (-1 sqrt). This message is also understood by Number after **`MetaNum.st`** is filed in.

Metanumbers

MetaNumeric **Class**

Infinity and Infinitesimal are the best examples of metanumbers, which are impossible but mathematically useful constructs. The MetaNumeric class is an abstract superclass with four subclasses, as follows:

```
MetaNumeric
    Infinity
    Infinitesimal
    NotANumber
    SomeNumber
```

The MetaNumeric class provides coercion and conversion support for its subclasses. Must of this support comes in the form of double dispatching methods, which bring coercion into play when two unlike numbers fail in some arithmetic or comparison operation.

For example, suppose you execute the following expression:

```
2.3 + (Infinity positive)
```

The Float method for addition doesn't know how to add infinity to a floating point number directly, so it asks the Infinity object to perform the addition. It does so by evaluating:

```
(Infinity positive) sumFromFloat: self
```

The sumFromFloat: method is implemented by MetaNumeric, the abstract superclass of Infinity. After coercing the floating point number into meta form (making it an instance of SomeNumber), the superclass hands off to Infinity to perform the specific addition. All metanumbers need to have non-metanumbers coerced to meta form, so this behavior is performed by their common superclass, MetaNumeric.

Infinity **Class**

Infinity represents a number too large to be represented in any other form. We will use the terms *+infinity* and *-infinity* to denote the positive and negative forms of this number.

It is defined to mean that for any real number *x*, the following is true:

```
-infinity < x < +infinity
```

Creating an Instance of Infinity

The expression Infinity positive creates a positive instance of Infinity, and Infinity negative creates a negative instance.

Protocol Summary

The usual numeric operations are supported by Infinity, according to the following rules (where *x* is any real number):

```
x + +infinity = +infinity
x - +infinity = -infinity
x * +infinity = +infinity when x > 0
x * -infinity = -infinity when x > 0
```

```
0 * +infinity = 0
+infinity + +infinity = +infinity
-infinity - +infinity = -infinity
+infinity * (+/-)infinity = (+/-)infinity
-infinity * (+/-)infinity = (-/+)infinity
+infinity - +infinity = undefined value, and an error occurs
```

Because +infinity is not a single value, but a set of all real numbers that are unrepresentably large, it makes no sense to ask whether +infinity = +infinity. Doing this will cause an error.

Infinitesimal **Class**

infinitesimal is a number so close to zero it cannot be represented as a conventional number—it can be thought of as the reciprocal of Infinity.

Creating an Instance of Infinitesimal

Creating an instance of Infinitesimal is done exactly as with Infinity, by executing an expression such as:

```
Infinitesimal positive
Infinitesimal negative
Infinitesimal negative: aBoolean
```

Protocol Summary

We will use the terms *+tiny* and *-tiny* to denote the positive and negative forms of this number.

The usual numeric operations are supported, according to the following rules (where *x* is any real number unless otherwise specified):

```
x + +tiny = x when x ~= 0.
0 + +tiny = +tiny
x * +tiny = +tiny when x > 0
x * -tiny = -tiny when x > 0
0 * +tiny = 0
+tiny + +tiny = +tiny
-tiny - +tiny = -tiny
+tiny * (+/-)tiny = (+/-)tiny
-tiny * (+/-)tiny = (-/+)tiny
```

```
+tiny - +tiny = undefined value, and an error occurs
x / +infinity = +tiny  when x > 0
x / +tiny = +infinity when x > 0
+tiny * +infinity = undefined value, and an error occurs
```

Loosely speaking, +tiny is not a single value, but a set of all real numbers that are unrepresentably small. As with infinity, it makes no sense to ask whether +tiny = +tiny.

NotANumber **Class**

An instance of NotANumber can be used as a placeholder for the result of an illegal mathematical expression, such as 8 arcSin. Since the behavior of NotANumber consists of various kinds of error signals of the form "You can't do such-and-such with a NaN," the result is substituting one kind of error for another. In theory, NotANumber error signals could be trapped by a signal handler at a high level in your application, which could then decide, for example, to continue with some time-consuming computation, noting the error in a log, rather than abort because of the error. NotANumber was created for the sake of completeness—along with Infinity and Infinitesimal, it is defined by IEEE in the set of floating point numbers.

Creating an Instance of NotANumber

To create an instance, execute NotANumber new.

Protocol Summary

NotANumber implements the common arithmetic and comparison methods, raising an error signal for each.

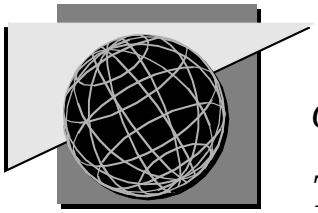
The printable form of an instance is "NaN" so error strings use that term, as in:

```
'Can''t perform arithmetic functions on NaN'
```

SomeNumber **Class**

SomeNumber represents a conventional scalar number coerced into metanumeric form so it can be used in both conventional and metanumeric computations. Such a number responds to numeric operations as usual, but has the same generality as other metanumbers and can be used in metanumeric computations. It is

essentially a support class for the other metanumeric classes so it has little potential for reusability.



Chapter 6

Terminal Emulator

The Terminal Emulator provides a smart terminal for access to shell facilities, external editors, etc., as well as serial-port connections to modems and other devices. It can also be integrated into your Smalltalk application to provide users access to those external facilities.

Creating a Free-Standing Emulator

To create an emulator, first file in the following auxiliary code files supplied with VisualWorks in the **`utils`** directory or folder (in addition to the **`Terminal.st`** file supplied with this product):

- **`Serial.st`** (all platforms)
- **`ExtIPC.st`** (UNIX platforms only)
- **`UnixIPC.st`** (UNIX platforms only)

Then select **Terminal** in the Advanced Programming Launcher. A window will be opened on a VT100 terminal by default. To change the default, execute the expression:

```
CTermConnection defaultTerminalEmulation: SunTerminal.
```

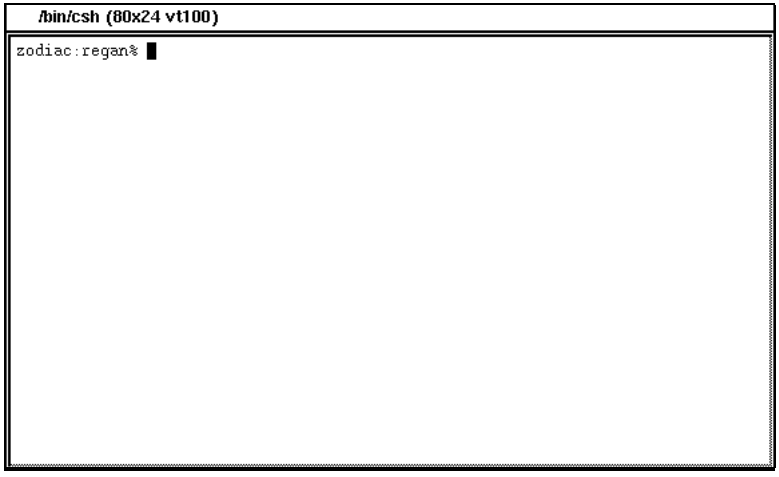


Figure 6-1 Terminal Emulator window

The VT100 and Sun console are the two available terminal types.

In a UNIX environment, the terminal is connected to a UNIX shell whose type is determined from the value of what's set in the **`SHELL`** environment variable.

If that variable is not set, a C shell is used, by default. To change the default shell type, execute an expression such as:

```
CTermConnection defaultUnixShellName: 'sh'
```

On Microsoft Windows machines and the Macintosh, the terminal is opened on the default serial port.

The terminal supports cursor positioning, highlighting and other characteristics required by full-screen editors such as **`vi`** and **`emacs`**. The <F1>, <F2>, <F3> and <F4> function keys are mapped to the VT100's <PF1> through <PF4> keys. The user-interrupt key sequence is <F10> rather than <Control>-<c> within the Terminal window, by default.

The <Operate> menu provides the following commands:

Table 6-1 <Operate> menu commands

Command	Description
copy	Copy the highlighted text in the terminal view.
paste	Insert text that has been copied from another window.
do it	Execute the highlighted expression (presumed to be Smalltalk) in the terminal view.
inspect it	Execute the highlighted expression and open an inspector on the result.
reset	Perform a software reset of the terminal window.

Perform a software reset of the terminal window.

Most of the features of a VT100 terminal are supported, with the following notable exceptions:

- Double-width and/or double-height characters
- Graphics character set and international replacement character set
- Software control over numeric keypad mode
- Software control over cursor-key mode (no switching from cursor mode to application mode)
- Keyboard locking during escape sequences
- Device attribute reports
- Software switching from 80-column mode to 132-column mode

Resizing a Terminal Emulator window can cause undesired results because the external process (such as an **emacs** editor) is not notified of the change automatically. Depending on the program, you may be able to manually inform it of the new rows-and-columns count (which is displayed in the window label). For example, the command to reset the window size (in some varieties of UNIX) is of the form:

```
% stty rows 24 columns 80
```

Putting an Emulator in Your Application

The free-standing terminal emulator consists of a VisualComponent inside a ScheduledWindow. To invoke the complete package programmatically rather

than from the Advanced Programming Launcher, execute the following expression:

```
CTermConnection open
```

This expression opens the same default apparatus as you get when you select **Terminal** in the Launcher. For specific alternatives such as a TTY connection, see the class protocol called view creation in CTermConnection.

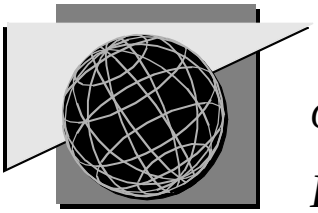
To create the VisualComponent separately, for inclusion in a composite view, use an expression of the following form:

```
CTermView new model: (CTermConnection connectToTty: 'tty2')
```

In this example, a connection is established to the device named tty2. To get the default serial port, use the unary message connectToTty instead. Variants of the connect message can be found in the instance creation protocol for CTermConnection. Note that connectToPty: does not take a String argument, but rather an instance of UnixPseudoTtyAccessor. To create a VisualComponent with a connection to the default pseudoterminal, then you would execute the following expression:

```
CTermView new model: (
    CTermConnection connectToPty: (
        UnixPseudoTtyAccessor openMaster))
```

The resulting VisualComponent can then be installed in your composite view in the usual way.



Chapter 7

Project Browser

If you use multiple projects to group your VisualWorks windows, the Project Browser is convenient for navigating among the projects. The Project Browser also enables you to access the Change Set of any project without having to exit the current project. Finally, the Project Browser provides a convenient window browser for inspecting any window in any project, including an outline of its component hierarchy, which can be useful when debugging your application. You can also invoke such a browser by sending inspect to a ScheduledWindow.

For more information about projects, see the *VisualWorks User's Guide*.

Opening a Project Browser

To open a Project Browser, select **Project Browser** in the Advanced Programming Launcher.

A Project Browser lists all of your projects in the upper left view. When you select one project from the list, the upper-right view lists the windows in that project while the bottom view displays the desktop layout of Smalltalk windows in that project, as shown in Figure 7-1. Selecting a window name in the upper-right view causes the corresponding image in the bottom view to redisplay in front of any obscuring window images. In the window-image view, all windows are shown as if they were open, including iconified windows.

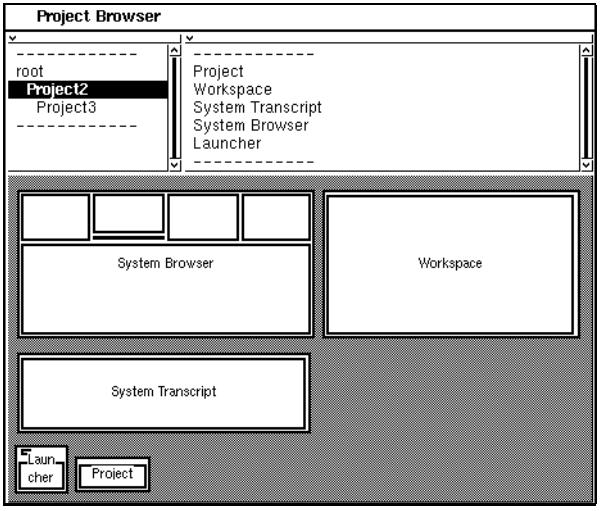


Figure 7-1 The three parts of the Project Browser

Relabeling a Window

The entries in the window list view are taken from the window labels. To change a window label, even in another project, select the desired project and window in the Project Browser. Then use the **relabel as** command in the <Operate> menu to bring up a prompter for the new label.

Renaming a Project

The entries in the project list view are taken from the text views of the various Project windows. To change an entry, edit the text in the pertinent Project window, then select **accept** in the text view's <Operate> menu. You can also use the **rename as** command in the Project Browser's <Operate> menu to rename the highlighted project.

Updating Project Information

If you open a new project or change the text in a Project window as described above, each existing Project Browser will reflect an inaccurate list of projects until you update it. To do so, make sure no project is selected—if one is selected, click on it to deselect it. Then select **update** in the <Operate> menu. Similarly, you must **update** the list after deleting a project.

Updating Window Information

When the current project is selected, changes in the window configuration are not always reflected in the window list view or the window image view. To update those views, select **update** in the <Operate> menu of the project list view.

Entering a Project

The Project Browser can be used to enter any project from any other project. This permits you to roam freely in the hierarchy of projects, without having to enter from and exit to a parent project. For example, suppose the project hierarchy is as pictured below, with Project P-1 at the root of the hierarchy.

Normally (using the Project windows rather than the Project Browser), you would have to enter Project P-2 to get to Project P-3.

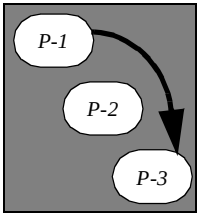


Figure 7-2 Using a Project Browser to leapfrog intervening projects

The Project Browser lets you skip P-2 and jump right to P-3. Similarly, you can exit direct to P-1 from P-3. The deeper your hierarchy of projects, the more helpful you will find this feature.

To enter a project from the Project Browser, select the desired project in the upper left view. Then select **enter** in the <Operate> menu. This technique applies whether you are traveling up or down in the hierarchy—instead of using **exit project** in the Launcher to return to a parent project, just use **enter**.

Inspecting a Change Set

Each project maintains its own summary of code changes, called a *change set*.

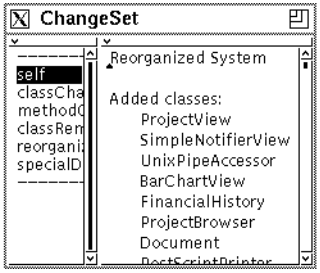


Figure 7-3 A Change Set Inspector

The Project Browser enables you to inspect the change set for any project without leaving your current project. To do so, select the desired project in the upper left view of the Project Browser, then select **inspect changes** in the <Operate> menu. For more information about change sets, see the *VisualWorks User's Guide*.

Exploring a Window's Structure

When a window name is selected, you can use the **inspect** command to open a Window Browser on the selected window. In the Window Browser you can **expand** and **contract** portions of the window's component hierarchy to reveal the parts that interest you most. You can also **raise** or **lower** the actual window, which is useful when a window has become buried.

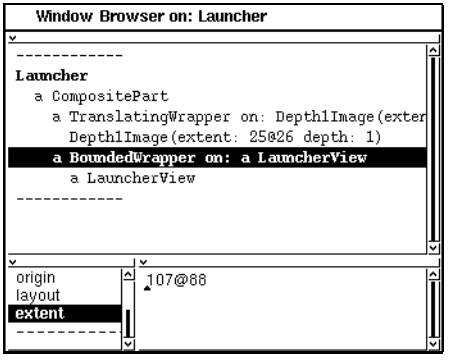


Figure 7-4 Using a Window Browser to examine window structure

Within the component hierarchy, you can select a particular component and inspect its instance variables in the inspector views, spawn an Inspector with the

inspect command, or **browse** the code for its class. Use the **flash** command to briefly highlight the component in the actual window.

Overview of the Code

The Project Browser is implemented via three new classes:

- ProjectBrowser, a subclass of Model
- ProjectView, a subclass of View
- WindowBrowser, a subclass of OutlineBrowser

In addition, SelectionInListView is used twice, once for each of the list views in the Project Browser.

ProjectBrowser **class**

ProjectBrowser holds a collection of all instances of Project in the window hierarchy. In addition, it keeps a list of the windows in the selected project, and remembers both the selected project and the selected window. Because of its specialized functionality, ProjectBrowser is not a likely candidate for reuse unless you are employing instances of Project in your application.

ProjectView **class**

ProjectView might be adapted to a model other than a ProjectBrowser.

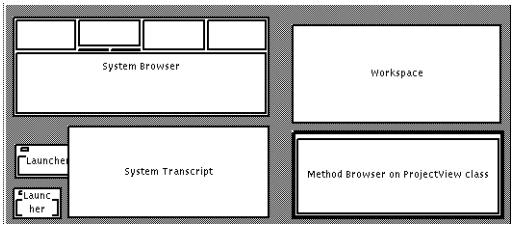


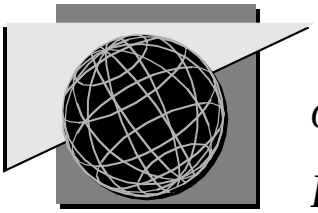
Figure 7-5 A project view

ProjectView adds a small amount of *displaying* and *updating* protocol to the behavior it inherits from View. Some of the messages it sends to its model, such as projectWindows, assume a ProjectBrowser as model so you would need to subclass it and change such assumptions. The update: method may also need revision, as it expects a parameter indicating whether a project has changed, a window has been selected, or a window has been deselected.

The heart of ProjectView is in its method for drawing a useful caricature of an application window. To modify the caricaturing style (with wider outside borders, for example), you would examine and modify the displayWindow:on:highlighted: method.

WindowBrowser **class**

A WindowBrowser holds information about window components as well as bookkeeping information for managing selective displays of the list. Its parent, OutlineBrowser, is more general and therefore a more likely candidate for reuse. OutlineBrowser is a support class provided with VisualWorks Advanced Tools.



Chapter 8

Benchmarks

The Benchmark class provides a framework and a convenient interface for running benchmarks to compare your application's performance across versions and in various operating environments. A simple subclass of Benchmark can be built to run the benchmarking tests. As an example, we have provided a subclass called SystemBenchmark, which contains updated versions of the historic test suite we at ParcPlace use to compare system performance on different platforms.

This chapter describes the reusable interface and related mechanisms provided by the Benchmark class, using the SystemBenchmark subclass as an example. The final section then explains how to implement your own benchmarks.

Using the Benchmark Interface

To open the example System Benchmarks window, select **Benchmarks** in the VisualWorks Advanced Tools Launcher.

In addition to the System Benchmarks window, a Benchmark Transcript window will open to display the test results.

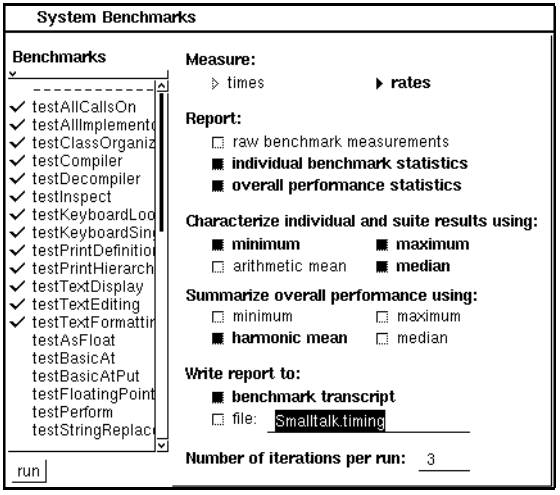


Figure 8-1 The System Benchmarks window with default settings

The System Benchmarks window has two views, arranged side by side. The benchmarks view, on the left side, lists the available benchmark tests. The parameters view, on the right, contains a variety of buttons and fill-ins for controlling report attributes. A button marked **run** is located below the list view—use the button to begin execution of a test suite.

Assembling the Test Suite

Although a benchmarking run can be limited to a single type of test, such as adding 3 + 4 thousands of times, a run frequently involves a suite of several related tests. You can use the benchmarks view to select the tests you want to include in a run. To select an individual test, just click on it with the <Select> button; click again to deselect it. A check mark appears in the margin next to each selected test.

Selection Techniques

To select multiple adjacent tests, hold down the <Shift> key while dragging the cursor through the desired tests (the check marks will appear after you release both the mouse button and the <Shift> key). To deselect multiple adjacent tests, hold down the <Control> key while dragging through the test names.

To cancel all selections, use **clear selections** in the <Operate> menu; use **select all** to include all of the tests. The subclass can define a default suite of tests—in our example, SystemBenchmark uses as defaults the tests used by

ParcPlace for standard comparisons of platform performance. You can reset the test suite to the defaults at any time by selecting **reset to default** in the <Operate> menu. To summarize these operations:

Table 8-1 Selection techniques for system benchmarks

Operation	Description
click <select> button	Select and deselect a single test
<Shift> + drag <select>	Select multiple tests
<Control> + drag <select>	Deselect multiple tests
select all	Select all tests
clear selections	Des
reset to default	Sel

First iteration

Setting the Report's Granularity

At the end of each benchmarking run, a re g statistics accumulated during the tests. Three butto ers view control the level of detail in the report, as

Raw Benchmark Measureme

Second iteration

Details about each iteration of each test m n be used to discover significant variations among iter an opera-tion, for example, might consume a dispr because it might not take advantage of compiled-co

n The following times, for example, we ns of two tests in the SystemBenchmark suite placement.

[display text]
10 repetition(s) in
0.921 seconds
92100.0 microseconds per repetiti

Third iteration

[text replacement and redisplay]
20 repetition(s) in
5.1 seconds
255000.0 microseconds per repeti

```
[display text]
    10 repetition(s) in
    0.88 seconds
    88000.0 microseconds per repetition

[text replacement and redisplay]
    20 repetition(s) in
    4.98 seconds
    249000.0 microseconds per repetition

[display text]
    10 repetition(s) in
    0.94 seconds
    94000.0 microseconds per repetition

[text replacement and redisplay]
    20 repetition(s) in
    4.98 seconds
    249000.0 microseconds per repetition
```

Individual Benchmark Statistics

A summary of statistics for each test. In effect, this section of the report summarizes the details described above, whether or not the details themselves are included in the report. This information is useful for identifying the slow performers in a suite of tests, marking them as candidates for optimization.

Results are converted to rates (by the convert:toRateFor: method in the subclass) when the rates switch is selected. When the **times** switch is selected, no such conversion takes place. (The class comment for Benchmark discusses this mechanism and its implications further.) Types of statistics are described in “Choosing Types of Statistics” on page 73.

The following example reports the minimum, maximum and median for the raw times reported in the example above:

Table 8-2 Individual benchmark results (three iterations)

Benchmark	Minimum	Maximum	Median
TextDisplay	136.170	145.455	138.979
TextEditing	82.7451	84.7389	84.7389

Benchmark Suite Statistics

A summary for the entire suite, the purpose of creating a suite in the first place is to measure the performance of some subsystem. Benchmarking provides a weighted average for the performance of that subsystem, which you can then use to compare with an identical benchmarking run under different operating circumstances.

For the weighted average, the report displays the same columns as for the individual statistics. For example, if you elect to display only the median value for individual benchmarks, only the median value for the suite-wide statistic will be shown.

Table 8-3 Benchmark suite results (three iterations)

Rating Type	Minimum	Maximum	Median
Minimum	118.539	126.309	125.558
Maximum	139.13	142.222	142.222
H-Mean	116.364	119.425	118.321
Median	118.539	126.309	125.558

Let's use the minimum H-Mean (harmonic mean) to illustrate the derivation of these statistics further. Each time the test suite is performed, the individual test results are converted to rates and then combined mathematically to arrive at the harmonic mean score for that iteration.

The suite was performed three times, in our example, so three such harmonic means are derived. The minimum H-Mean represents the lowest of the three scores. Similarly, the maximum H-Mean is the highest of the three, and the median H-Mean is the median (or middle value) of the three.

Choosing Types of Statistics

The two summary sections of the report can include different types of statistics. You control which types are included in the report by selecting buttons in the parameters view. The types of statistics are as follows (*i* represents the number of iterations):

- Minimum—the result from the best-performing iteration.
- Maximum—the result from the worst-performing iteration.
- Arithmetic mean—the average of all iterations; sum/*i*.

- Harmonic mean—The number of iterations, divided by the sum of the inverses of the weighted results for the separate iterations.

  $i / [(1/result_1) + (1/result_2) + ...]$

  Note: *The median harmonic mean of the* SystemBenchmark *default test suite is the standard benchmark score used by ParcPlace when comparing system performance in different operating configurations. This test suite differs from the suite used in prior releases of VisualWorks, so the scores cannot be compared across versions meaningfully.*

- Median—the value that is midway through a ranked list of the scores. For example, if you specify five iterations, the median is the third element in the sorted collection of scores.

The harmonic mean is only useful when summarizing overall performance, so it is not available under the heading **Characterize individual and suite results using:**. Under the heading **Summarize overall performance using:**, the arithmetic mean is only offered when you select the **times** switch; when the **rates** switch is selected, the harmonic mean is offered.

Setting the Report Destination

The report can be displayed in the Benchmark Transcript window, stored in a disk file, or both. Use the buttons under the heading **Write report to:** in the parameters view to select one or both destinations. You can provide the name of a file in the fill-in blank. The file will be created in the start-up directory unless you specify an absolute or relative pathname.

Setting the Number of Iterations

The test suite can be repeated as a means of improving the accuracy of the results. By default, the iteration count is set to three. To change the number of iterations, type the desired number in the fill-in blank labeled **Number of iterations per run**.

The number of iterations represents the number of times the test suite will be repeated—this is not to be confused with repetitions that are hard-coded into a given method. For example, the test3plus4 method repeats the 3 + 4 operation 100,000 times for each iteration, so three iterations would cause the operation to be repeated 300,000 times.

In some situations, a single iteration may produce more interesting results. For example, a method might take a relatively long time to execute on its first pass,

but run much faster subsequently. However, if your application calls the method only infrequently, the first-iteration results might prove more illuminating.

To begin execution of the testing run, click on the **run** button. If your window manager is configured to prompt you for placement of windows, you might consider turning off that feature before running the default test suite or other suites involving window-displaying operations. However, prompt-for-placement can be left on without affecting the results.

Creating a Benchmark Subclass

The benchmarks are implemented via the following four classes, all of which are subclasses of Object:

- Benchmark, and its subclass SystemBenchmark
- BenchmarkTable
- BenchDecompilerTestClass

Benchmark Superclass

Benchmark is an abstract superclass whose protocol provides the interface we have been describing, as well as the timing and statistical analysis facilities for a benchmarking run. It has instance variables for remembering the report parameters as selected in the interface, and the test results as they are accumulated. Benchmark also provides the reporting protocol, making use of BenchmarkTable (described further below).

SystemBenchmark Subclass

Subclasses of Benchmark, such as SystemBenchmark, are responsible for providing the specific tests to be run. See the methods that begin with the word "test" in SystemBenchmark for examples.

In addition, subclasses must implement the following accessing messages:

```
benchmarkLabelForSelector:

benchmarkSelectors
initiallySelectedBenchmarks
```

Subclasses may also need to override Benchmark's weighting protocol, to establish relative weights for test methods and to convert the results to an appropriate

rate; and the defaults protocol, which determines the default selections in the user interface.

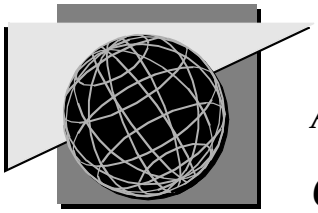
BenchmakTable **Class**

BenchmarkTable provides two-dimensional reporting capabilities that might well be useful to other applications, though the code requires extensions to make it more generally useful. It holds onto a report name, a collection of column labels and a collection of rows. Each row is assumed to be a collection itself.

The protocol is tailored to the needs of the benchmark reports, though it provides a subset of a more generally useful set of behaviors.

BenchDecompilerTestClass **Class**

BenchDecompilerTestClass is a holder for methods that are decompiled during the SystemBenchmark>>testDecompiler benchmark. The code in the methods has no functional value—in fact, it is obsolete.



Appendix A

Code Files

Introduction

The following table summarizes important characteristics of the code library containing the VisualWorks Advanced Tools. For each code module, the disk filename, class category and class names are reported. The modules are listed in the same order in which they are describedin this guide.

Table 1 Code files listing

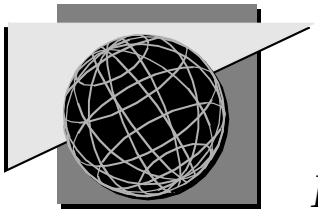
Chapter	Filename	Category	New Classes
(Support files)	**`Install.st`**		(installation tool)
	`OKLaunch.st`		(adds methods to the existing Launcher-View class)
	`OKSupprt.st`	AT-Support	EvaluationHolder LabeledObjectHolder OutlineBrowser
	`OpenLook.st`	Interface-Openlook	OpenLookBorderDecoration-Policy, OpenLookHorizontalScroll-bar, OpenLookLabeledButton-View, OpenLookPushButtonView, OpenLookScrollar, OpenLookScrollBarController, OpenLookVerticalScrollbar, OpenLookWidgetPolicy
	`Windows.st`	Interface-Windows3	Win3Border, Win3BorderDecoration-Policy, Win3LabeledButtonView, Win3PushButtonView, Win3ScrollBar, Win3WidgetPolicy

Table 1 Code files listing

Chapter	Filename	Category	New Classes
	Support.st	Support	BasicButtonController, BasicButtonView, BasicLabeledButtonView, BeveledBorder, EmulationBorderDecoration-Policy, EmulationFixedThumb-ScrollBar, EmulationScrollBar, EmulationScrollBarControl-ler, Label, PushButtonView, SelectController, SimpleBorder, ToggleButtonController, TriggerButtonController, VisualBlock, VisualPairButton
Parser compiler	**Parser.st**	AT-ParserCompiler	ExternalLanguageParser GeneralParser ParserCompiler PushFragment RecognizerFragment
	SQL.st	AT-Parsing Example	SQL SQLClause SQLCompiler SQLFunction SQLIdentifier SQLInfixOperation SQLLiteral SQLModifier SQLNode SQLPostModifier SQLStatement
Enhanced numbers	**Complex.st**	Magnitude-Numbers	Complex
	MetaNum.st	Magnitude-Numbers-MetaNumeric	Infinitesimal Infinity MetaNumeric NotANumber SomeNumber

Table 1 Code files listing

Chapter	Filename	Category	New Classes
Terminal emulator	**`Terminal.st`**	AT-Terminals	CharacterTerminal CTermConnection CTermController CTermView SunTerminal VT100Terminal
Class reports	**`SysAnal.st`**	AT-SystemAnalysis	ClassDeclarations ClassNameChooser ClassReporter InstanceTally ManualWriter MessageAnalyzer MessageCollector ReferencePathCollector SystemAnalyzer
Profiling time and memory usage	**`Profiler.st`**	AT-Profiling	AllocationProfiler MessageTally ProfileOutlineBrowser Profiler ProfilerListHolder TimeProfiler
Benchmarks	Bench.st	AT-Benchmarks	BenchDecompilerTestClass Benchmark BenchmarkTable SystemBenchmark
Full protocol browser	FullBrow.st	AT-Tools	FullBrowser
Project browser	ProjBrow.st	AT-Tools	ProjectBrowser ProjectView WindowBrowser ScheduledWindow>>inspect



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