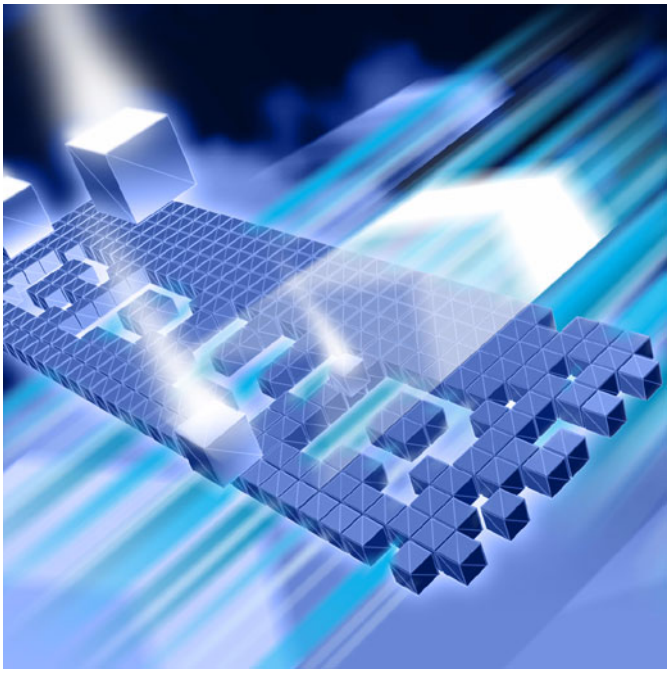


Understanding DevPartner®

DevPartner Studio Professional Edition
DevPartner Studio Enterprise Edition
DevPartner for Visual C++ BoundsChecker Suite

Release 9.0.1

Compuware

Customer support is available from our Customer Support Hotline or via our FrontLine Support Web site.

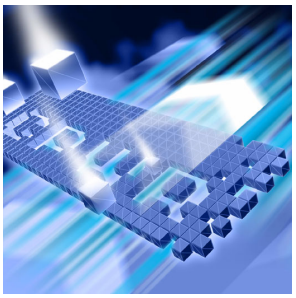
Customer Support Hotline:
1-800-538-7822

FrontLine Support Web Site:
http://frontline.compuware.com

US Patent Nos.: 5,987,249, 6,332,213, 6,186,677, 6,314,558, 6,760,903 B1,and 6,016,466

January 2, 2009

Table of Contents



Preface

Who Should Read This Manual xiii
What This Manual Covers xiv
Conventions Used In This Manual xv
For More Information xv

Chapter 1

Introducing DevPartner

What is DevPartner Studio? 1
- Error Detection 2
- Static Code Analysis 2
- Coverage Analysis 3
- Memory Analysis 3
- Performance Analysis 4
- In-Depth Performance Analysis 4
- System Comparison 5

DevPartner and Visual Studio 5
- Menus and Toolbars in Visual Studio 6
- Using DevPartner in Visual Studio 8
- Integrated Online Help 8

Visual Studio Team System Support 8
Using Terminal Services and Remote Desktop 9
- Licensing 10
- Running Multiple Sessions Under Terminal Services 10

DevPartner in the Software Development Cycle 10

Chapter 2

Error Detection

What is Error Detection? 14
Using Error Detection Out of the Box 14
Ready: Deciding the Scope of Error Detection Analysis 15
Set: Configuring Options and Settings 16
Go: Running Your Solution with Error Detection 17
Analyzing the Data in the Results Pane 19
Saving Session Files 23
Deciding When to Use ActiveCheck vs. FinalCheck 24
Understanding ActiveCheck 24
Understanding FinalCheck 25
Comparing ActiveCheck and FinalCheck — An Example 26
Using the Program Error Detected Dialog Box 27
Understanding the Actions You Can Take 27
Understanding the Memory and Resource Viewer Dialog Box 29
Exploring the Memory and Resource Viewer User Interface 30
Understanding the Suppression and Filtering Dialog Boxes 30
Suppressing Errors 31
Filtering Errors 34
Understanding Call Validation 36
Enabling Memory Block Checking 37
Using the Settings Dialog Box 37
Setting General Properties 38
Setting Data Collection Properties 39
Setting API Call Reporting Properties 40
Setting Call Validation Options 41
Setting COM Call Reporting Properties 42
Setting COM Object Tracking Options 43
Setting Deadlock Analysis Options 43
Setting Memory Tracking Options 45
Setting .NET Framework Analysis Options 48
Setting .NET Framework Call Reporting Properties 49
Setting Resource Tracking Options 49
Setting Modules and Files Options 50
Setting Fonts and Colors Options 52
Setting Configuration File Management Options 53
Tracking Windows Messages and Event Logging 54
Exporting Data to XML 54
Exporting Data from within Visual Studio 54
Exporting Data from the Error Detection Standalone Application 55

Exporting Data from the Command Line 55
Running Error Detection from the Command Line 56
Command Line Options and Syntax 56
Running FinalCheck from the Command Line 57
Submitting Data to Visual Studio Team System 58
Visual Studio Team System Support in DevPartner Error Detection 58

Chapter 3

Static Code Analysis

What is Code Review? 60
Using Code Review Out of the Box 60
Ready: Deciding How You Want to Run the Review 61
Set: Selecting Options and Settings 62
Go: Starting Your Code Review Session 64
Analyzing the Results and Repairing Violations 64
Saving Session Files 68
Setting Options 69
Configuring General Options 70
Setting Naming Guidelines Options 74
Managing Suppressed Rules 76
Suppressing Rules 77
Viewing Summary Data 78
Viewing Code Violations 80
Viewing Naming Violations 82
Analyzing Hungarian Results 82
Analyzing Naming Guidelines Results 83
Viewing Collected Metrics 85
Understanding McCabe Metrics 86
Viewing Call Graph Data 88
Understanding Call Graph References 89
Setting Call Graph Configuration Options 91
Using the Command Line Interface 93
Understanding the Error File 95
Exporting Data to XML 96
Exporting Session Data from within DevPartner 96
Exporting Session Data from the Command Line 96
Exporting Session Data from a Batch Process 97
Understanding Naming Analysis 98
Understanding the Naming Guidelines Naming Analyzer 98
Understanding the Hungarian Naming Analyzer 101
Using the Code Review Rule Manager 103

Configuring Rules 103
Configuring Triggers 106
Configuring Rule Sets 108
Configure Hungarian Name Sets 111
Manipulating the Rule List 114
Creating New Rules Using Regular Expressions 116
Matching Lines Exceeding 90 Characters 117
Matching Tabs Used Instead Of Spaces 118
Matching Instances Where Code Catches System.Exception 118
Matching Methods Having More Than One Return Point 119
Enforcing Initialization Of Variables When They Are Defined 120
Matching Instances Of More Than One Statement Per Line 121
Ensuring Open Braces Are Placed On A Separate Line 122
Ensuring Loop Counters Are Not Modified Inside the Loop Bodies 122
Submitting Data to Visual Studio Team System 124
Visual Studio Team System Support in DevPartner Code Review 124

Chapter 4

Automatic Code Coverage Analysis

What is Coverage Analysis? 126
Using Coverage Analysis Out of the Box 126
Ready: Consider What You Want to Analyze 126
Set: Properties and Options 127
Go: Collect Coverage Data 128
Analyze the Data 129
Saving Session Files 133
Setting Properties and Options 134
Solution Properties 134
Project Properties 135
Options 135
Excluding Images 136
About Instrumentation 137
Collecting Data from Various Types of Applications 138
Collecting Data From Managed Code 138
Collecting Data for Unmanaged Code 139
Collecting Data from Multiple Processes 141
Collecting Data from Remote Systems 141
Collecting Data From .NET Web Applications 142
Collecting Data from Classic Web Script Applications 145
Web Service Requirements 145
Deleting Temporary Files from NMSource 146
Configuring IIS for Data Collection 146

Configuring Internet Explorer for Coverage Analysis 147
Collecting Data from a Service 147
Collecting Data from COM and COM+ Applications 147
Merging Session Data 148
Reviewing Merge Data 149
Merge States 150
ASP.NET Modules in Merge Files 151
Merge Settings 152
Exporting Coverage Data 152
Controlling Data Collection 153
Analyzing from the Command Line 153
Using the Coverage Analysis Viewer 153
What You Can Do in the Coverage Analysis Viewer 154
What you Cannot Do in the Coverage Analysis Viewer 154
Integration with DevPartner Error Detection 154
Submitting Data to Visual Studio Team System 155

Chapter 5

Finding Memory Problems

What is Memory Analysis? 158
Using Memory Analysis Out of the Box 159
Ready: Consider What You Want to Analyze 159
Set: Properties and Options 160
Go: Collect Memory Analysis Data 160
Analyze the Memory Analysis Data 164
Saving Session Files 169
Memory Problems in Managed Visual Studio Applications 170
How Memory Analysis Helps You 171
Setting Properties and Options 171
Solution Properties 172
Project Properties 172
Options 174
Starting a Memory Analysis Session 174
Using the Session Control Window in Memory Analysis 175
Using the Object Reference Graph 179
Using the Call Graph to Identify Execution Paths 181
Using the Allocation Trace Graph 182
Viewing and Editing Source Code 184
Identifying Memory Problems 186
Running a Memory Analysis Session 187
Locating Memory Leaks 188

Running a Memory Leaks Analysis Session 189
Understanding Memory Leaks Analysis Results 190
Alternate Methods of Solving the Problem 195
Solving Scalability Problems with Temporary Objects 197
Examples of Scalability Problems 197
A Possible Cause: Temporary Objects 197
Running a Temporary Objects Analysis Session 198
Identifying Scalability Problems 199
Analyzing Temporary Object Data 201
Interpreting Results to Fix Scalability Problems 203
Using RAM Footprint to Improve Performance 203
Measuring RAM Footprint 204
Optimizing Memory Use 210
Analyzing Web Applications with Memory Analysis 211
Collecting Server-side Memory Data 211
Collecting Data from Multiple Processes 212
Prerequisites for Analyzing Web Applications 212
Running a Memory Analysis Session on a Web Application 213
If You Get Unexpected File Save Dialogs or Saved Session Files 214
If You Get a Security Exception 215
Using Memory Analysis In Your Development Cycle 215
Submitting Data to Visual Studio Team System 216

Chapter 6

Automatic Performance Analysis

What is Performance Analysis? 218
Using Performance Analysis Out of the Box 218
Ready: Consider What You Want to Analyze 219
Set: Properties and Options 219
Go: Collect Performance Data 220
Analyze the Data 221
Saving Session Files 226
Setting Properties and Options 227
Solution Properties 227
Project Properties 227
Options 229
Excluding Images 230
About Instrumentation 231
Collecting Data from Various Types of Applications 231
Collecting Data From Managed Code 232
Collecting Data from Unmanaged Code 233
Collecting Data from Multiple Processes 234

Collecting Data from Remote Systems . . . 235
Collecting Data From .NET Web Applications . . . 236
Collecting Data from Classic Web Script Applications . . . 238
Web Application Data Collection Tips . . . 239
Web Service Requirements . . . 240
Deleting Temporary Files from NMSource . . . 240
Configuring IIS for Data Collection . . . 241
Configuring Internet Explorer for Data Collection . . . 242
Collecting Data from a Service . . . 242
Collecting Data from COM and COM+ Applications . . . 242
Collecting Data for Recursive Functions . . . 242
Analyzing a Call Graph . . . 243
Child-side Analysis . . . 245
Parent-side Analysis . . . 245
Comparing Sessions . . . 246
Interpreting Session Comparison Results . . . 248
Exporting Performance Data . . . 248
Controlling Data Collection . . . 249
Analyzing from the Command Line . . . 249
Using the Performance Analysis Viewer . . . 250
What You Can Do in the Performance Analysis Viewer . . . 250
What you Cannot Do in the Performance Analysis Viewer . . . 250
Performance Analysis Tips for .NET Applications . . . 250
Submitting Data to Visual Studio Team System . . . 252

Chapter 7

In-Depth Performance Analysis

What is Performance Expert? . . . 254
Performance Expert and Performance Analysis . . . 254
Using Performance Expert Out of the Box . . . 255
Ready: Consider What You Want to Analyze . . . 255
Set: Properties and Options . . . 256
Go: Collect Performance Expert Data . . . 257
Analyze the Data . . . 259
Saving Session Files . . . 270
Setting Properties and Options . . . 271
Solution Properties . . . 271
Project Properties . . . 272
Options . . . 273
Finding Application Problems with Performance Expert . . . 274
Accounting for Child Methods . . . 275

Usage Scenarios 276
Identifiable Performance Problem 277
Scaling Problem in an Application 279
Performance Slow but No Specific Issue 282
Collecting Data from Web Applications 282
Managed Code Only 282
web.config Requirements 283
Multiple Process Profiling 283
Single Process Profiling on IIS 6.0 283
No Remote Session File for Components Running Under DLLHOST 284
Source Code on Remote Machines 284
Session Files Saved to Open Solution 284
Automating Data Collection 284
Using Command-line Switches 285
Using an XML Configuration File 285
Collecting Data from Distributed Applications 287
Enabling Remote Data Collection with DPAnalysis.exe 287
Saving Session Files on Remote Machines 288
Collecting Data with Terminal Services or Remote Desktop 288
Remote Profiling and Windows XP Service Pack 2 288
Firewalls and Remote Data Collection 290
Exporting DevPartner Data to XML Format 290
Using Performance Expert with Performance Analysis 291
Performance Expert in the Development Cycle 292
Submitting Data to Visual Studio Team System 294

Chapter 8

System Comparison

What is System Comparison? 296
Using System Comparison Out of the Box 297
Ready: Consider What You Want to Compare 298
Set: Prepare for System Comparison 299
Go: Make a Change and Create a Snapshot 300
Analyze Results 301
The System Comparison Service 303
Changing Automatic Snapshot Settings 303
Categories of Differences 304
Comparing Registry Keys 308
Comparing Specific Files 309
Installing Without DevPartner 312
Running the Comparison Utility from the Command Line 313

Software Development Kit 314
System Comparison Snapshot API 314
Taking a Snapshot 315
Logging Messages 316
Reporting Progress 317
Writing a Plug-in 317
What is a Plug-in? 317
Plug-in Sample Step By Step Instructions 318
Creating and Testing Your Plug-in 321
Modifying a Deployed Plug-in 322
Highlights of the Plug-in Schema 323
About the Redistributable Assemblies 324

Appendix A

About DevPartner Studio Enterprise Edition and TrackRecord

What Is DevPartner Studio Enterprise Edition? 325
The Development Process 326
The DevPartner Studio EE Solution 327
Improved Project Control 327
Higher Software Quality 327
Improved Productivity 328
Feature Overview 329
Requirements Management 329
Merging Coverage Data 329
Project Activity Tracking 330
Automatic Notification of Changes 330
Customizable Workflow 331
Remote Access via the Web 331
Central Store of Shared Information 331
About TrackRecord and DevPartner Studio 331
DevPartner Studio Interaction with TrackRecord 332
Defect Submissions 332
TrackRecord and DevPartner Studio Coverage Analysis 332

Appendix B

DevPartner Studio Supported Project Types

Supported Project Types 335
Error Detection Supported Project Types 337
Code Review Supported Project Types 340
Coverage Analysis, Performance Analysis, Memory Analysis, and Performance Expert Supported Project Types 342

Appendix C

Starting Analysis from the Command Line

Introducing DPAnalysis.exe 345
Running DPAnalysis.exe from the Command Line 346
Using DPAnalysis.exe with an XML Configuration File 349
XML Configuration File Element Reference 350
Profiling Web Applications with the XML Config File 361
Collecting Analysis Data from a Remote Machine 363

Appendix D

Analysis Session Controls

Introducing Session Control Files 365
Creating a Session Control File Within Visual Studio 366
Using the Session Control API 367
Using the Session Control APIs with Managed Applications 369
Using the Session Control APIs with Unmanaged Applications 370
Saving Files through the Session Control API 371
Interactions and Precedence 372

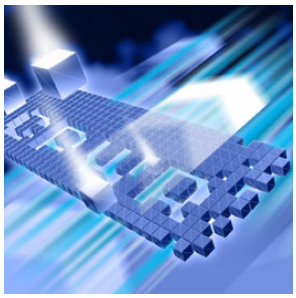
Appendix E

Exporting Analysis Data to XML

Introducing DevPartner Data Export 375
Exporting Analysis Data to XML 376
Exporting Analysis Data to XML from the Command Line 376
Devpartner.Analysis.Export.exe Usage Examples 377

Index

Preface



- Who Should Read This Manual
- What This Manual Covers
- Conventions Used In This Manual
- For More Information

This manual describes how to get started using your Compuware® DevPartner® Studio software.

Who Should Read This Manual

This manual is intended for new DevPartner Studio users. Chapter 1 presents an overview of DevPartner Studio concepts; subsequent chapters describe individual DevPartner components. Each component chapter begins with a brief Ready, Set, Go procedure to get new users up and running with DevPartner Studio.

Users of previous versions of DevPartner should read the Preface to the *Installing DevPartner* manual to see how this version of DevPartner differs from previous versions.

This manual contains information relevant to all DevPartner Studio products, including the Professional and Enterprise Editions, and the DevPartner for Visual C++ BoundsChecker Suite.

Note: The DevPartner for Visual C++ BoundsChecker Suite analyzes unmanaged code only. The DevPartner memory analysis, static code analysis, and Performance Expert features analyze managed code only, and are therefore not supported in the DevPartner for Visual C++ Bounds-Checker Suite.

This manual assumes that you are familiar with the Windows interface, with Microsoft Visual Studio, and with software development concepts.

What This Manual Covers

This manual contains the following chapters and appendixes:

- **Chapter 1**, ***Introducing DevPartner*** describes the concepts and components of DevPartner.
- **Chapter 2**, ***Error Detection***, explains how to use DevPartner to uncover errors in your C and managed and unmanaged C++ code.
- **Chapter 3**, ***Static Code Analysis,*** explains how DevPartner helps you locate a variety of errors in Visual Basic and Visual C# code.
- **Chapter 4**, ***Automatic Code Coverage Analysis***, describes how to use DevPartner to track how much of your code is covered by your tests.
- **Chapter 5**, ***Finding Memory Problems***, describes how to use DevPartner to diagnose application anomalies that can be caused by misuse of memory and objects.
- **Chapter 6**, ***Automatic Performance Analysis***, explains how DevPartner helps you locate bottlenecks and code in need of optimization.
- **Chapter 7**, ***In-Depth Performance Analysis***, explains how DevPartner helps you analyze a variety of full system performance issues.
- **Chapter 8**, ***System Comparison,*** describes how DevPartner helps you identify differences between computer systems to assist with troubleshooting application development problems.
- **Appendix A**, ***About DevPartner Studio Enterprise Edition and TrackRecord***, explains how to use DevPartner Studio with Compuware enterprise tools.
- **Appendix B**, ***DevPartner Studio Supported Project Types***, contains tables listing project types supported by each DevPartner Studio feature.
- **Appendix C**, ***Starting Analysis from the Command Line***, describes the `DPAnalysis.exe` command line interface.
- **Appendix D**, ***Analysis Session Controls***, describes creating a session control file for coverage, memory, performance, and Performance Expert sessions.
- **Appendix E**, ***Exporting Analysis Data to XML***, describes exporting coverage, performance, and Performance Expert data to an XML file.

Conventions Used In This Manual

This book uses the following conventions to present information.

- Screen commands and menu names appear in **bold typeface**. For example:

  Choose **Item Browser** from the **Tools** menu.

- File names appear in `monospace typeface`. For example:

  The *Understanding DevPartner* manual (`Understanding DevPartner.pdf`) describes...

- Variables within computer commands and file names (for which you must supply values appropriate for your installation) appear in *`italic monospace type.`* For example:

  Enter `http://`*`servername`*`/cgi-win/itemview.dll` in the `Destination` field...

For More Information

Refer to the feature-level online help for step-by-step instructions for specific DevPartner Studio tasks.

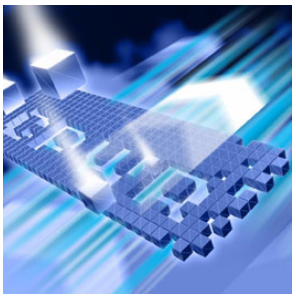
View the DevPartner InfoCenter page from the **Start > DevPartner** menu to learn more about DevPartner Studio components.

In addition to this manual, the following information is also included in the DevPartner Studio documentation set:

- The *Installing DevPartner* manual provides What's New information, a detailed list of system requirements, and installation instructions.
- The *DevPartner Studio Quick Reference* provides an at-a-glance summary of DevPartner features accompanied by quick-start advice.
- The *DevPartner Advanced Error Detection Techniques* manual provides concepts and procedures to help you understand the use of your Compuware® DevPartner Error Detection software.
- The *Known Issues* file contains a list of known issues and technical notes for DevPartner Studio. The file is available in your installation directory, or you can refer to the `ReadMe.htm` file for a link to the Known Issues file on the Web.

Chapter 1

Introducing DevPartner



- What is DevPartner Studio?
- DevPartner and Visual Studio
- Visual Studio Team System Support
- Using Terminal Services and Remote Desktop
- DevPartner in the Software Development Cycle

This chapter provides an introduction to DevPartner Studio Professional Edition and DevPartner for Visual C++ BoundsChecker Suite. Use this manual to understand the concepts underlying both DevPartner products.

Note: The DevPartner for Visual C++ BoundsChecker Suite analyzes unmanaged code only. The DevPartner memory analysis, static code analysis, and Performance Expert features analyze managed code only, and are therefore not supported in the DevPartner for Visual C++ BoundsChecker Suite.

What is DevPartner Studio?

DevPartner Studio is a software tool that provides a variety of programmer productivity features, such as automated error detection, source code analysis, coverage analysis, memory analysis, performance profiling, system performance analysis, and system comparison.

DevPartner can analyze a broad range of both managed and unmanaged applications written in a variety of languages. Refer to Appendix B, "DevPartner Studio Supported Project Types" for a complete list of supported project types and languages.

The following sections summarize the features of DevPartner Studio.

Error Detection

DevPartner Studio provides automated error detection for managed and unmanaged programs. DevPartner error detection is built on BoundsChecker™ technology, and is designed to locate the following hard-to-find errors in your Windows-based applications:

- Memory, resource, and COM interface leaks
- Invalid use of Windows API calls
- Invalid use of memory or pointers
- Memory overrun errors
- Un-initialized memory usage
- Use of dangling pointers
- Errors in .NET finalizers

DevPartner error detection monitors your application from the moment of creation until the final moments before the process is unloaded from memory. You can monitor all DLL loads and unloads, static constructors and destructors as well as the normal flow of your application. You can also tune DevPartner error detection to collect only information necessary to solve a particular problem by filtering out specific files or portions of your application.

See "Error Detection" on page 13 for more information about DevPartner error detection.

Static Code Analysis

DevPartner helps developers write compliant Visual Basic and C# code within Visual Studio. DevPartner identifies programming and naming violations in the .NET Framework, analyzes method call structures, and tracks overall code complexity.

The DevPartner software detects a variety of coding errors:

- Variable naming inconsistencies
- Violations of coding covenants
- Win32 API validation errors
- Common logic errors
- .NET portability issues
- Structured exception handling errors

Using an extensive and extensible rule set, DevPartner also assists in the porting of legacy Visual Basic code by identifying constructs that will not work in the .NET environment.

See "Static Code Analysis" on page 59 for more information about DevPartner static code reviews.

Coverage Analysis

The DevPartner coverage analysis feature allows developers and test engineers to be sure they are testing all of an application's code. When you run your tests with coverage analysis, DevPartner tracks all applications, components, images, methods, functions, modules, and individual lines of code covered by your tests. When your tests end, DevPartner displays information about what code was exercised and what code was not exercised.

DevPartner collects coverage data for managed code applications, including Web and ASP.NET applications, as well as unmanaged C++ applications. (See Appendix B, "DevPartner Studio Supported Project Types" for a complete list of supported technologies).

You can run the coverage analysis and error detection features simultaneously. Knowing the percentage of code covered in your tests will help you to have an appropriate level of confidence in your error detection results.

See "Automatic Code Coverage Analysis" on page 125 for more information about code coverage analysis.

Memory Analysis

DevPartner analyzes how memory is allocated by your managed Visual Studio application. When you run your application under memory analysis, DevPartner shows you the amount of memory consumed by an object or class, tracks the references that are holding an object in memory, and identifies the lines of source code within a method that are responsible for allocating the memory.

More importantly, DevPartner presents memory data in context. This enables you to navigate chains of object references and calling sequences of the methods in your code. Presenting memory data in context provides both an in-depth understanding of how your program uses memory and the critical information you need to optimize memory use.

See "Finding Memory Problems" on page 157 for more information about memory analysis.

Performance Analysis

The DevPartner performance analysis feature analyzes your code for performance bottlenecks. It pinpoints these bottlenecks to individual lines of source code, and provides method-level insight into the way your application uses third-party components, the operating system, and, most importantly, the .NET Framework.

DevPartner supports performance profiling in Microsoft Visual Studio 2005 and Visual Studio 2008. (See Appendix B, "DevPartner Studio Supported Project Types" for a complete list of supported technologies).

To improve performance of critical parts of your code, use DevPartner performance analysis to locate performance bottlenecks and to verify that the improvements you make really do impact performance.

See "Automatic Performance Analysis" on page 217 for more information about analyzing an application's performance.

In-Depth Performance Analysis

The DevPartner Studio Performance Expert feature takes performance profiling a step further than DevPartner's performance analysis feature. For managed code Visual Studio applications, Performance Expert provides a deeper analysis of the following hard-to-solve problems:

- CPU/thread usage
- File/disk I/O
- Network I/O
- Synchronization wait time

Performance Expert analyzes your application at run time and locates the problematic methods in your code. It then allows you to view details about individual lines in the method, or to examine parent-child calling relationships to help you determine the best way to fix the problem. When you decide on an approach, Performance Expert enables you to jump directly to the problem lines in your source code, so you can quickly fix problems.

See "In-Depth Performance Analysis" on page 253 for more information.

System Comparison

The DevPartner System Comparison utility compares two computer systems, or compares the current state of a computer with a previous state, allowing you to determine why your application:

- Works on one computer but not on another
- Works differently on different computers
- No longer works on a computer on which it previously worked

To compare systems, System Comparison creates XML files, called snapshot files, that contain information about a computer system, such as its installed products, system files, drivers, and many other system characteristics. It then compares snapshot files and reports the differences between them.

Unlike the other DevPartner features, System Comparison is not integrated into the Visual Studio environment. It runs as a standalone utility to minimize its impact on target systems.

System Comparison consists of a service that takes nightly snapshots of a system, and the user interface that enables you to take snapshots manually and to compare snapshots to find differences. System Comparison also includes a command line interface and a Software Development Kit (SDK). The SDK allows software developers to gather additional information for comparison and to embed snapshot functionality in deployed applications.

See "System Comparison" on page 295 for more information about the System Comparison utility.

DevPartner and Visual Studio

DevPartner integrates seamlessly into the Visual Studio environment. This integration makes it easy for you to use the capabilities of the product as you write and debug your applications. You can perform code analysis frequently as you develop an application without leaving the development environment.

The DevPartner Studio software simultaneously supports application development within the Visual Studio 2008 and Visual Studio 2005 environments. This support assists developers as they migrate code from the older Microsoft environments to the latest .NET Frameworks.

The following tables identify the DevPartner features available in various Visual Studio environments.

Table 1-1. Installed Features for DevPartner Studio Professional Edition

Microsoft Visual Studio 2008	Microsoft Visual Studio 2005
Performance Analysis	Performance Analysis
Coverage Analysis	Coverage Analysis
Error Detection	Error Detection
Static Code Analysis	Static Code Analysis
Memory Analysis	Memory Analysis
Performance Expert	Performance Expert

Table 1-2. Installed Features for DevPartner for Visual C++ BoundsChecker Suite

Microsoft Visual Studio 2008	Microsoft Visual Studio 2005
Performance Analysis	Performance Analysis
Coverage Analysis	Coverage Analysis
Error Detection	Error Detection

Menus and Toolbars in Visual Studio

DevPartner adds a menu and several toolbars to Visual Studio, and it adds menu commands to several Visual Studio menus, including context (right-click) menus. Menu commands and toolbars provide access to session controls, the rules for static code reviews, options dialogs, and instrumentation controls.

DevPartner adds a toolbar to Visual Studio to provide quick access to DevPartner features. Figure 1-1 on page 7 illustrates the DevPartner toolbar in Visual Studio 2008.

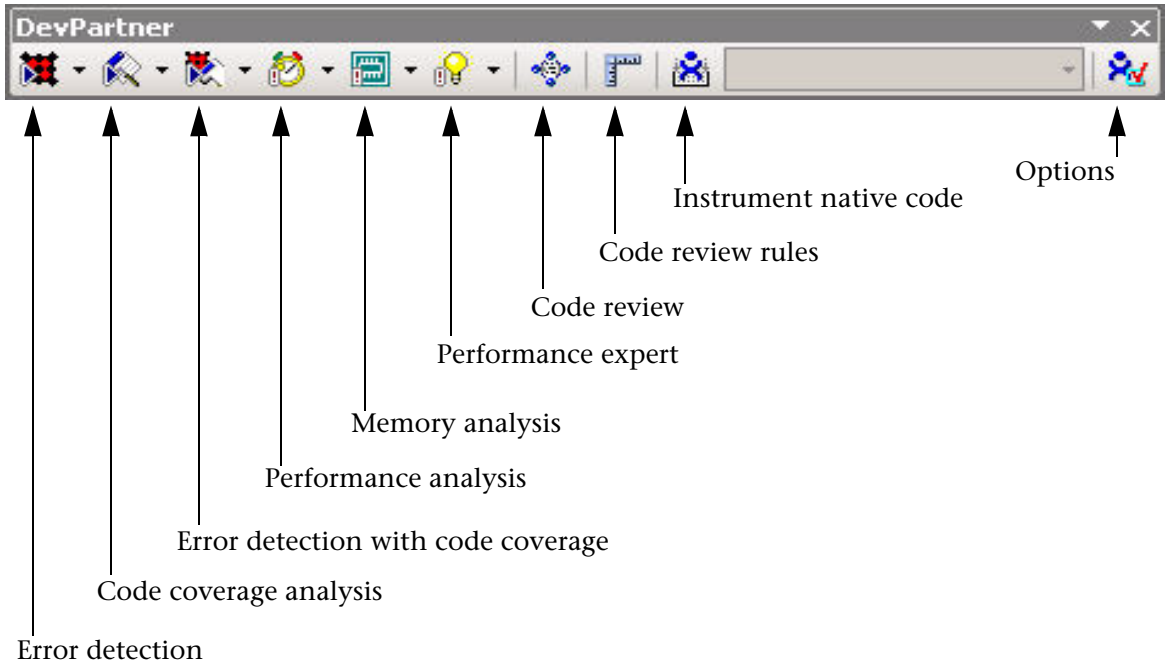


Figure 1-1. DevPartner Toolbar

DevPartner also places a session control toolbar in the IDE. When the coverage analysis, memory analysis, performance analysis, and Performance Expert features are active, the session control toolbar is active.

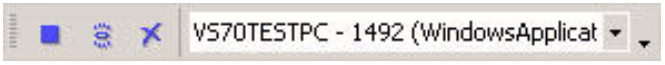


Figure 1-2. The DevPartner Session Control toolbar

The DevPartner Session Control toolbar consists of three icons and a process list.

- **Stops** data collection and takes a final data snapshot
- Takes a data **Snapshot**
- **Clears** data collected to the point at which the Clear action executes

The process list focuses data collection on a single process for applications that use multiple processes.

In addition to the menu and toolbars, DevPartner uses the Visual Studio dockable windows and panes to display the results of analysis sessions. It also uses the Solution Explorer to display the names of session files. DevPartner also adds pages to Visual Studio Options, Solution Properties, and Project Properties for configuring DevPartner code analysis operations.

Using DevPartner in Visual Studio

The general work flow for using DevPartner within Visual Studio consists of one or more of these general-purpose tasks:

- Open or create a Solution in Visual Studio
- Set options for code analysis operations
- Enable the analysis you want to perform from the DevPartner menu or toolbar
- Run your application
- View the session results returned by DevPartner

DevPartner gives you wide flexibility in choosing the parts of your application to monitor, selecting what data to view, and creating filters to eliminate unwanted information.

DevPartner also gives you the option to perform many functions from the command line. This capability provides a way to use DevPartner functionality in automated batch processing operations, such as nightly-build smoke tests.

Integrated Online Help

DevPartner provides extensive online help about each of its features. This help should be the first place you turn for how-to and reference information.

Provided in the same format as the rest of Visual Studio help, the DevPartner online help appears in the Visual Studio help collection as a separate book. The DevPartner Studio book contains a volume for each DevPartner feature.

Visual Studio Team System Support

Visual Studio 2005 Team System is Microsoft's version control, defect tracking, and process management software for Visual Studio 2005 software development projects. DevPartner Studio supports Microsoft Visual Studio Team System if the Team System client software is installed and a Team Foundation Server connection is available.

DevPartner Studio supports submission of a **Work Item** of the type **Bug** to Visual Studio Team System. When you submit a **Bug**, DevPartner automatically populates the **Work Item** form with selected session data. To submit a **Bug** from DevPartner Studio, the active Team System project must support a **Work Item** of the type **Bug**. DevPartner Studio automatically adds data only to this type of **Work Item**.

You can submit a **Work Item** that includes DevPartner data from any of the following views in a DevPartner session file:

- A method list or method table in a Coverage, Memory, or Performance Analysis session file, or in a Performance Expert session file
- The code review **Problems** or **Naming** tabs
- A list of errors or leaks in any Error Detection tab, or list of instances in the Error Detection Modules or .NET Performance tabs

To submit a Team System **Work Item** from DevPartner Studio, in a DevPartner session file right-click on a method or other eligible item and choose **Submit Work Item**. DevPartner populates the Title and Description or Symptom field. Fill in any other required data and save the **Work Item**.

Note: If you use the Team Explorer context menus in Visual Studio, DevPartner does not automatically populate the **Work Item** with session data.

For more information about submitting data from DevPartner Studio to Team System, see the Visual Studio Team System sections in the chapters of this manual. Consult the Microsoft Visual Studio 2005 Team System documentation for complete information on how to use Team System to support your development and project management activities.

Using Terminal Services and Remote Desktop

DevPartner Studio supports Windows Terminal Services. You can use Terminal Services to do anything you would be able to do using the machine directly, such as:

- Configure DevPartner options on remote systems.
- Enable or disable analysis on remote systems.
- Profile an application that runs on a remote system.

Licensing

A Terminal Services connection requires one DevPartner concurrent license per user display. A server connected through a Terminal Services connection does not require the DevPartner Studio Remote Server license.

Running Multiple Sessions Under Terminal Services

Multiple DevPartner sessions can run simultaneously on the Terminal Server. Multiple sessions can be launched by a single user or multiple users. If a single user launches two instances of the console, both instances will share the same workspace settings because DevPartner stores workspace settings on a per-user basis. If different users launch instances of coverage analysis, workspace settings can be configured separately for each instance.

Collected data will include activity in the server process from all users on the Terminal Server. To better focus data collection during a session, eliminate or limit extraneous application activity that uses the monitored processes or invokes the monitored targets.

DevPartner in the Software Development Cycle

Software development projects consist of several phases, often referred to as the software development life cycle. Software development life cycles differ among development organizations, and DevPartner adapts to virtually any development life cycle model.

Tip: Organizations may define the actions between phases as project milestones.

The following figure depicts the phases in a typical development life cycle.

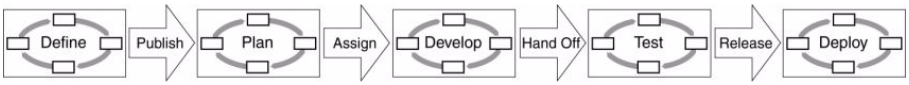


Figure 1-3. Typical Software Development Life Cycle Phases

Within each of these phases, DevPartner assists project managers, development leads, developers, and testers to produce code as free from errors, coding irregularities, performance bottlenecks, and memory problems as possible.

During the Define and Plan phases, DevPartner Enterprise Edition's requirement definition and project-tracking capabilities help ensure clear communication with the entire project team.

During the Develop and Test phases, which are often the most time-consuming and precarious phases, DevPartner helps developers find and resolve software defects, as well as fine-tune and test the application under development. Information generated by DevPartner features can be shared among development team members to foster communication.

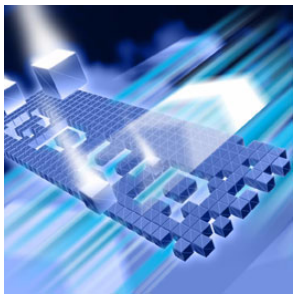
During the Test phase, development organizations use internal load testing and scenario-based testing to verify the operation of features in an application under development. This internal testing continues until the end of the development life cycle. DevPartner provides many advantages during this phase of the development cycle. Using an active analysis technology, DevPartner error detection and performance analysis features can align with Compuware *QA*Center test tools, such as *QA*Run and *QA*Load, to provide supplemental advantages to streamline the application testing process.

Finally, during the Deploy phase, a development team using DevPartner can successfully build and release its application with a high degree of confidence in the final product release. Inevitably, however, internal or external customers may find problems that even the most sophisticated technologies fail to uncover. Since such problems can adversely affect the end-user experience, your development team needs to address them when they arise. DevPartner Enterprise Edition helps you manage this process with its defect detection, verification, and resolution capabilities.

As a team grows in size or an application grows in complexity, the additional defect tracking and integration technologies of the DevPartner Enterprise Edition can further enhance an organization's productivity during and after deployment. The DevPartner Enterprise Edition provides integration between DevPartner and the Compuware TrackRecord and Reconcile applications. See "About DevPartner Studio Enterprise Edition and TrackRecord" on page 325 for more information about using DevPartner in an enterprise environment.

Chapter 2

Error Detection



- What is Error Detection?
- Using Error Detection Out of the Box
- Deciding When to Use ActiveCheck vs. FinalCheck
- Using the Program Error Detected Dialog Box
- Understanding the Memory and Resource Viewer Dialog Box
- Understanding the Suppression and Filtering Dialog Boxes
- Understanding Call Validation
- Using the Settings Dialog Box
- Tracking Windows Messages and Event Logging
- Exporting Data to XML
- Running Error Detection from the Command Line
- Submitting Data to Visual Studio Team System

This chapter contains two sections. The first section provides a quick-start procedure to get first-time users up and running with error detection. The second section provides reference information for an in-depth understanding of DevPartner error detection features.

Refer to the DevPartner online help for additional task-oriented information about error detection. For information that goes beyond the basics, refer to *Advanced Error Detection Techniques*, provided in PDF format with the DevPartner software installation.

What is Error Detection?

DevPartner Studio is a comprehensive debugging solution for C and C++ development. Incorporating frequent checks with DevPartner error detection into your application development cycle allows you to produce stable, error-free code. DevPartner Studio automates error-detection and analysis without adding time to the development process. The following features help you identify elusive bugs that are beyond the reach of traditional debugging and testing techniques:

- Comprehensive error detection
- Flexible debugging environment
- Integration with the Visual Studio debugger
- Integration with Microsoft Visual Studio
- Advanced error analysis
- Open error-detection architecture

Using Error Detection Out of the Box

The following Ready, Set, Go procedure introduces you to using DevPartner error detection.

To get up and running quickly, follow the steps presented in shaded boxes. If you would like more information about the subject being described in the shaded box, read the additional text following the box.

Note: Analyzing an application with DevPartner Studio does not require elevated system privileges. The system privileges you use to create and debug your application are sufficient for DevPartner to analyze the application.

Ready: Deciding the Scope of Error Detection Analysis

Consider how you want to run DevPartner error detection on your code, as well as the types of errors and memory leaks you need to locate.

Note: DevPartner error detection creates data files for each target application. You must ensure that you have write access to the directory containing the target executable before starting error detection.

The following procedure assumes:

- Your solution contains unmanaged source code.
- You are running error detection in Visual Studio 2008 or Visual Studio 2005.

Note: Refer to "Error Detection Supported Project Types" on page 337 for a comprehensive list of supported project types for DevPartner error detection.

Deciding How to Run the Session

You can run DevPartner error detection in several ways, depending on the needs of your situation:

- Run error detection interactively as part of your routine code validation process (daily or weekly) from inside Microsoft Visual Studio, or using the standalone application.
  - All of the error detection features can be accessed in the Visual Studio environment. You can configure DevPartner Studio settings, check your program, and review detected errors.
  - You can run DevPartner Studio as an independent application, completely outside of Visual Studio, but will not have access to the Visual Studio editor to edit your code.
- Automate error detection to run from a batch file or the command line using `bc.exe`.
  - When you use DevPartner Studio from a DOS command line, you can set up automated testing scripts. See "Running Error Detection from the Command Line" on page 56 for more information.
- Instrument your code with FinalCheck for a thorough validation at major development milestones (in Visual Studio only).

Deciding the Types of Errors to Locate

You can use error detection to locate a wide variety of errors and leaks that may arise in your code, as well as to track down any problems you suspect you already have:

- Enable COM object tracking when you think you are using COM objects properly, but want to be sure you have not introduced any errors.
- Enable Deadlock Analysis when you want to ensure that you are using synchronization objects properly, or if you have an application that deadlocks occasionally and you are not sure why.
- Extend the memory tracking system to include your custom allocators to ensure they are implemented without leaks or errors. To describe your custom allocators, add descriptive information about your allocators to the `UserAllocators.dat` file. Refer to "Working with User-Written Allocators" in *Advanced Error Detection Techniques*.

Set: Configuring Options and Settings

You can customize DevPartner error detection to report specific types of errors, while ignoring or filtering out any "noise" that you do not care about.

For this procedure, you can use the default DevPartner properties and options. No changes to the settings are required.

Note: Depending on how you are running DevPartner error detection, there are several menu options to access the Settings dialog box (see "Using the Settings Dialog Box" on page 37).

By default, error detection finds simple memory leaks, some memory errors, and resource leaks. DevPartner error detection can also find every instance the following types of errors, leaks, and events if you edit the default configuration.

- API calls and validation errors
- Potential deadlock situations
- COM interface leaks
- Memory allocations and deallocations
- Windows messages and other significant events (see "Tracking Windows Messages and Event Logging" on page 54)

Additionally, you can configure DevPartner Studio to use FinalCheck. With FinalCheck, error detection instruments your C or C++ application, allowing it to pinpoint errors to the exact statement where they occurred. FinalCheck takes longer to run and uses more resources, but locates and pinpoints difficult-to-find memory, pointer, and leak errors.

In addition to configuring error detection for specific errors and leaks, the error detection settings allow you to:

- Define error detection parameters
- Change the fonts and colors used in the display
- Save parameters as a configuration file to use again
- Load different configuration files into your current session

Go: Running Your Solution with Error Detection

You are now ready to run your solution under DevPartner error detection.

1. Open your solution inside Visual Studio.
2. Select **DevPartner** > **Start with Error Detection**.
3. Exercise the parts of your program that you want to check for errors. DevPartner error detection pops-up the **Program Error Detected** dialog box each time it encounters a severe error (see Figure 2-1). Other errors are not severe enough, or are common enough, and are recorded and displayed in the **Results** pane (located in the upper left of the error detection main window) so you can address them later.

The Program Error Detected dialog box (see "Using the Program Error Detected Dialog Box" on page 27) displays a description of the error, followed by call stack information, and finally the code segment where the error was detected (when available). For further explanation about the error that was detected, click the **Explain** button.

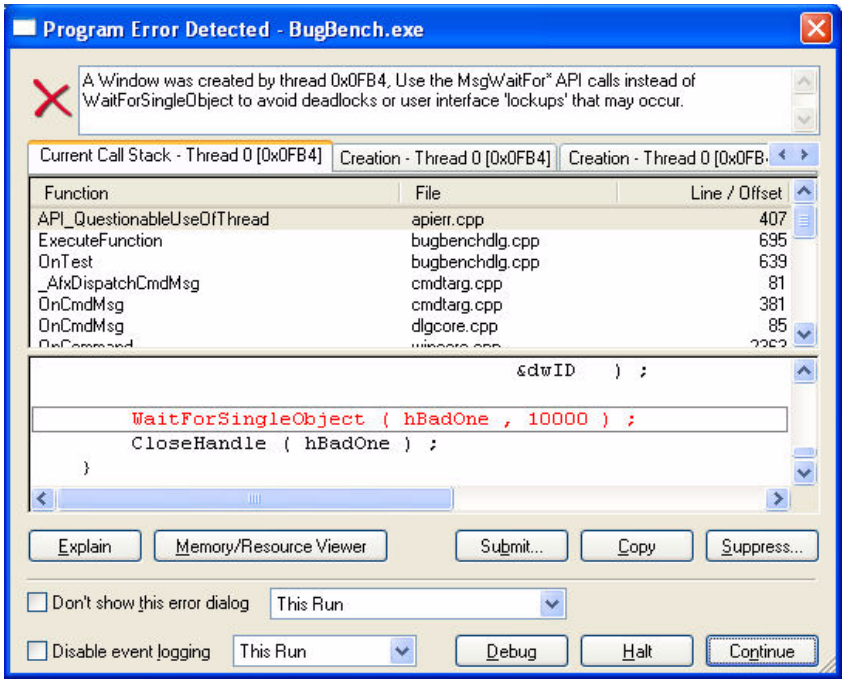


Figure 2-1. The **Program Error Detected** Dialog Box

4 If the Program Error Detected dialog box appears, respond in one of the following ways, and then continue exercising your program:

Note: If the Program Error Detected dialog box does not appear, you can skip this step.

- **Explain** - Give a more verbose explanation of the error.
- **Suppress** - Open the Suppression dialog box and pre-populate it with this error. Suppressing an error will prevent future occurrences from being acted upon by error detection. See "Understanding the Suppression and Filtering Dialog Boxes" on page 30.
- **Debug** - Open your code in the Visual Studio debugger at the line that generated the error.
- **Halt** - Terminate your program and place focus in the **Results** pane.
- **Continue** - Acknowledge the error and move on. The error is placed in the **Results** pane for further review after the session is complete.

5 Terminate your program when you are done checking it.
You will often find that your program has no natural end, and you will need to terminate it when you have collected enough data. Use one of the following three methods to terminate your program:

- ◇ Click **Halt** on the **Program Error Detected** dialog box.
- ◇ Select **Stop Debugging** from the **Debug** menu.
- ◇ Exit your program.

You have completed running a basic error detection session. Look in the **Results** pane to analyze the data from the errors and leaks you detected.

Analyzing the Data in the Results Pane

The **Results** pane, located in the upper left of the main error detection window (see Figure 2-2), uses a series of tabs for navigating through the various types of information.

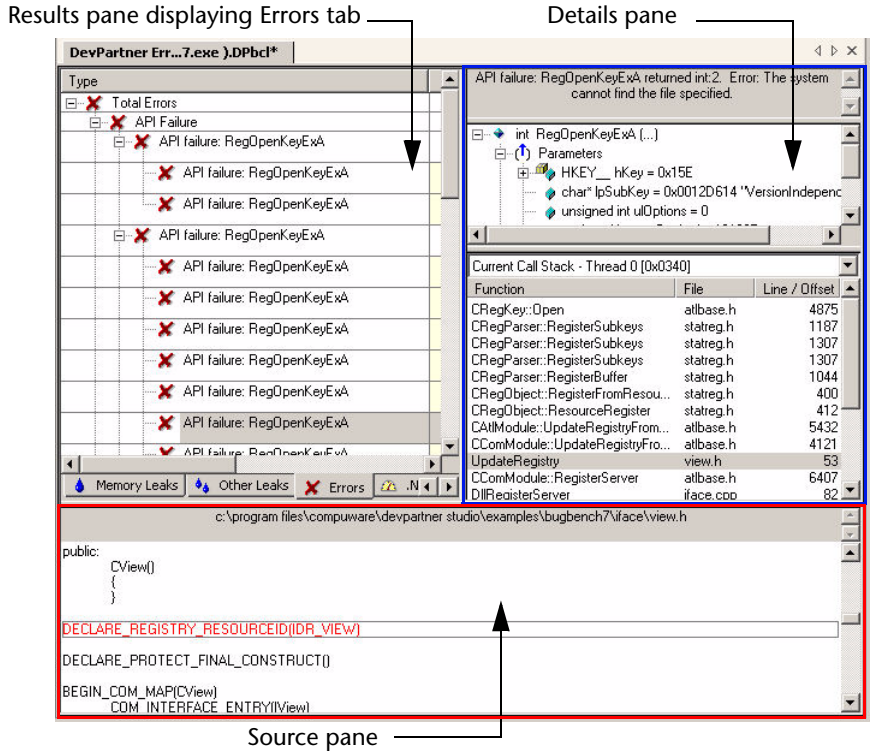


Figure 2-2. The DevPartner Error Detection Main Window

After you complete a session, focus is directed to the **Summary** tab of the **Results** pane to begin reviewing the data (see Figure 2-3).

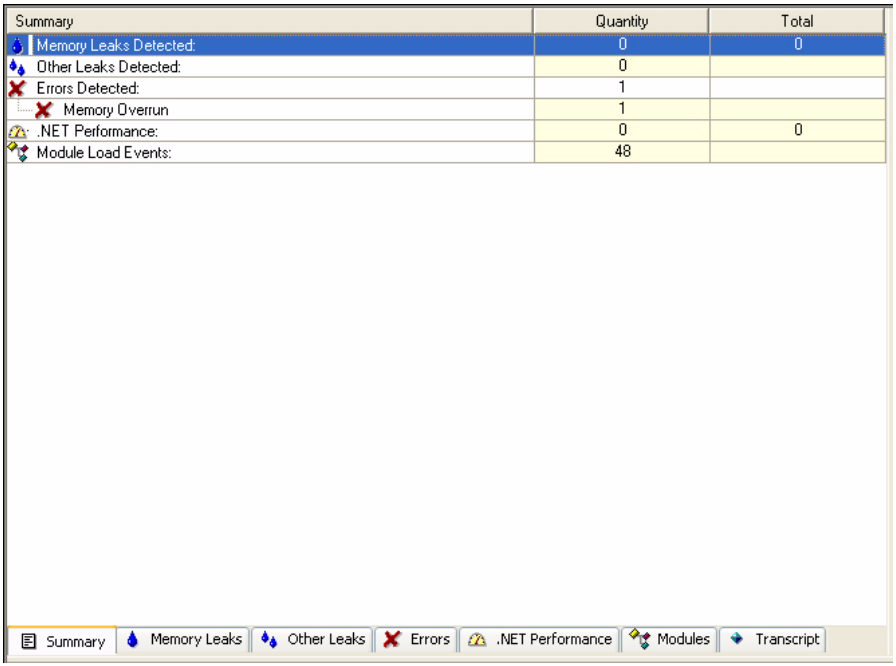


Figure 2-3. Results Pane Displaying Summary Tab

The **Summary** tab provides an overview of all errors and leaks detected in your session. Double-click on a specific event to navigate to a tab containing more detail about the selected event.

1. Examine the **Summary** tab of the **Results** pane for an overview of the errors and leaks detected.
2. Double-click on an error listed on the **Summary** pane.
   Focus is switched to the tab pertaining to the type of error or leak. This tab categorizes the errors and makes it easier to focus on recurring errors, so you can diagnose and fix them.
3. Fully-expand a category and select a specific leak, error, or event.
   The highest level of the list presents the categories of leaks, errors, and events. Fully-expanding the category displays the individual errors, leaks, and events detected (see Figure 2-4 on page 21).

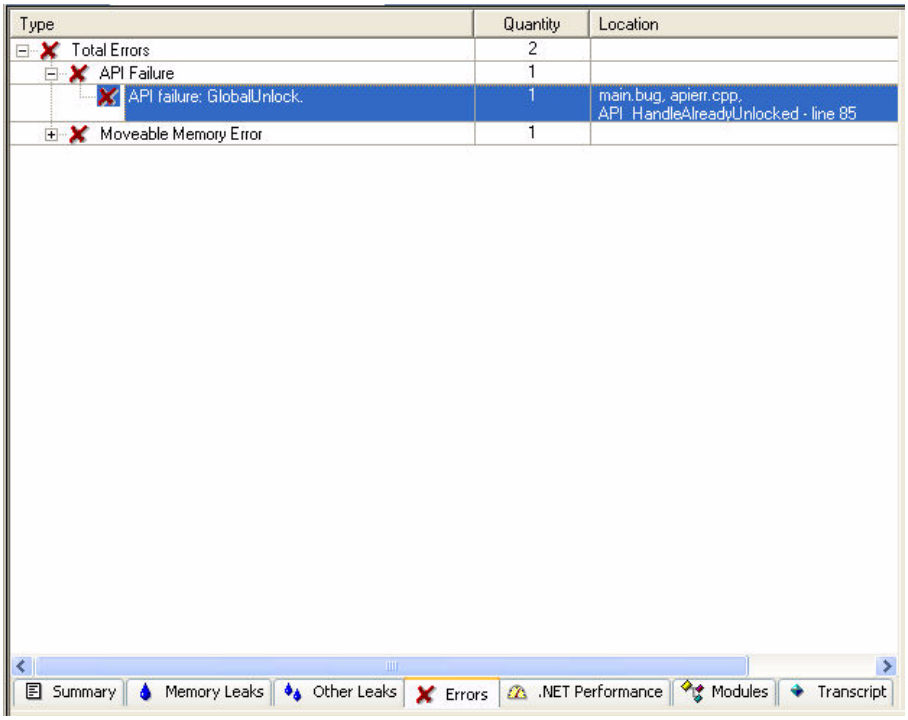


Figure 2-4. Errors Tab Displaying Selected Error

The **Results** pane includes the following tabs: **Memory Leaks**, **Other Leaks**, **Errors**, **.NET Performance**, **Modules**, and **Transcript** (see Figure 2-4 on page 21). From these tabs, you may want to perform other actions to categorize or evaluate the data presented:

- To sort the data on these tabs, click a column header (such as **Type**, **Quantity**, or **Deallocator** in the **Other Leaks** tab).
- For additional information about an event on a tab, right-click on the event and choose **Explain.**
- To view an event in the context of other events in your application, right-click on the event and choose **Locate in Transcript**. The **Transcript** tab provides a chronological list of all events that occurred within your application

*Tip: You can also access source code for a specific error by right-clicking on the specific error in one of the **Results** pane tabs, and selecting **Edit Source**. This opens the source file in the **Source** pane, and places focus at the line of code that generated the error.*

4 Examine the **Details** pane (see Figure 2-2 on page 19).

The top of the **Details** pane describes the selected error in detail. Below the description is the current call stack.

The upper right section of the main error detection window is the **Details** pane (see Figure 2-2 on page 19). The type of information displayed in the **Details** pane depends on the currently selected event. The error or event is always described in more detail, but the **Details** pane can also display call stacks, P/Invoke use-count graphs, COM use-counts, and more.

5 Examine the call stack.

Depending on the type of error, the call stack can show where the error or leak was detected, or where it was allocated. If more than one call stack is available, you can switch between them using the drop-down list.

The bottom section of the main error detection window is called the **Source** pane (see Figure 2-2 on page 19). The **Source** pane displays the source file associated with the currently selected call stack. The source code changes when you select a different call stack in the **Details** pane.

6 Examine the **Source** pane.

The **Source** pane is displaying the code associated with the currently selected call stack, and highlighting the location where the error or leak was detected or allocated.

7 Review the source code to determine why an error or leak was detected.

8 Right-click in the **Source** pane and select **Edit Source**.

The source file is opened in the Visual Studio editor, at the same location displayed in the **Source** pane.

9 Edit your source code to repair the error, and save your solution.

You have now identified and been placed inside the editor to resolve an error or leak in your code using DevPartner error detection.

Saving Session Files

*Tip: You can configure error detection to prompt you to save session files when you select **File** > **Close** using the **General** settings.*

Saving your session file allows you to refer back to these results. You might want to open a saved session file for several reasons:

- To look back at the kinds of leaks and errors you have previously encountered
- To export the session data to XML at a later date (see "Exporting Data to XML" on page 54):
  - To disseminate the data to other parties
  - To compare the data between various sessions
  - To build a database of trends
- To continue fixing the errors discovered in this session later

Note: Session files are saved with a `.dpbcl` extension. The default location for session files is in the same directory as your executable.

10 Select **File** > **Save Selected Items As** to save your session file.

11 Use the **Save File As** dialog to select a location and name for the session file.

If you are running error detection in Visual Studio, or running the standalone application, the steps to save the session file vary.

Saving the Session File from Visual Studio

1 Select **File** > **Save Selected Items As**.

2 Use the **File Save As** dialog to select a location and name for the session file.

Saving the Session File from the Standalone Application

1 Choose **File** > **Save Session Log As**.

2 Use the **Save As** dialog to select a location and name for the session file.

This concludes the Ready, Set, Go section of this chapter. Now that you have a basic understanding of the mechanics of running an error detection session, continue reading the rest of this chapter for additional information. Refer to the Advanced Error Detection Techniques guide for more in-depth discussion of advanced topics, or refer to the DevPartner online help for task-based information.

Deciding When to Use ActiveCheck vs. FinalCheck

DevPartner Studio can analyze Windows applications with both ActiveCheck™ and FinalCheck™ technologies.

Understanding ActiveCheck

ActiveCheck technology refers to the standard operation of checking for errors, leaks, and events without instrumentation of the source code. Because it does not require instrumentation of your code, ActiveCheck detects errors in your program without requiring you to recompile or relink. ActiveCheck is enabled in every error detection session.

ActiveCheck can do the following:

- Report API validation errors at run-time
- Report memory and resource leaks when your program terminates
- Isolate errors to the line where the memory or resource was allocated or the error was generated
- Identify potential deadlocks

When you run your program under DevPartner Studio with ActiveCheck, it automatically analyzes your program as it runs. DevPartner Studio monitors your program's API calls, memory allocations and deallocations, windows messages, and other significant events, then uses this data to detect errors and to provide a complete trace of your program's execution. You can even check programs that do not have source code available.

Because ActiveCheck requires no compilation or relinking overhead, you can use it daily. Use ActiveCheck throughout the software development cycle to find API validation errors, deadlocks, resource leaks, and COM interface leaks.

Table 2-1 and Table 2-2 list errors detected by ActiveCheck.

Table 2-1. API, COM, and Memory Errors Detected by ActiveCheck

API and COM Errors	Memory Errors
• COM interface method failure • Invalid argument • Invalid COM interface method argument • Parameter range error • Questionable use of thread • Windows function failed • Windows function not implemented	• Dynamic memory overrun • Freed handle is already unlocked • Handle is already unlocked • Memory allocation conflict • Pointer references unlocked memory block • Stack memory overrun • Static memory overrun

Table 2-2. Deadlock-related, .NET, and Pointer and Leak Errors Detected by ActiveCheck

Deadlock-related Errors	.NET Errors	Pointer and Leak Errors
• Deadlock • Potential deadlock • Thread deadlocked • Critical section errors • Semaphore errors • Mutex errors • Event errors • Handle errors • Resource usage and naming errors • Suspicious or questionable resource usage • Windows event errors	• Finalizer errors • `GC.Suppress` finalize not called • Dispose attributes errors • Unhandled native exception passed to managed code	• Interface leak • Memory leak • Resource leak

Understanding FinalCheck

FinalCheck is a patented technology that inserts diagnostic logic into your code when you compile it. With FinalCheck, DevPartner Studio can pinpoint errors to the exact statement where they occurred.

Use FinalCheck for key project milestones and for detecting errors that are difficult to find. FinalCheck is a superset of ActiveCheck that finds all the errors ActiveCheck finds, plus those listed in Table 2-3.

Table 2-3. Additional Errors Detected by FinalCheck

Memory Errors	Pointer and Leak Errors
• Reading overflows buffer • Reading uninitialized memory • Writing overflows buffer	• Array index out of range • Assigning pointer out of range • Expression uses dangling pointer • Expression uses unrelated pointers • Function pointer is not a function • Memory leaked due to free • Leak due to leak • Memory leaked due to reassignment • Memory leaked leaving scope • Returning pointer to local variable • Leak due to unwind • Leak due to module unload • Leak due to thread ending

Comparing ActiveCheck and FinalCheck — An Example

If you allocate a block of memory using `new` or `malloc` and store the pointer in a local variable, DevPartner Studio records that information. If you later re-assign another value into the local variable without first either deallocating the memory block or assigning the pointer to another variable, you have created a leak in your application.

- **Using ActiveCheck:** DevPartner Studio reports that the block allocated by `malloc` or `new` was leaked and points to the line where the memory was allocated. The error is reported when your application exits.
- **Using FinalCheck:** DevPartner Studio reports the location where the block was allocated and highlights the line where you assigned the new value into the last remaining variable referencing the block. The error is reported when it occurs.

Using the Program Error Detected Dialog Box

DevPartner Studio displays the **Program Error Detected** dialog box (see Figure 2-5 on page 27) when it detects a severe error in your application.

The top of the **Program Error Detected** dialog box describes the error detected. Below the error description is one or more tabs, each associated with a call stack corresponding to a location within your application. Review the reported error and the source information to help locate the source of the problem and correct it.

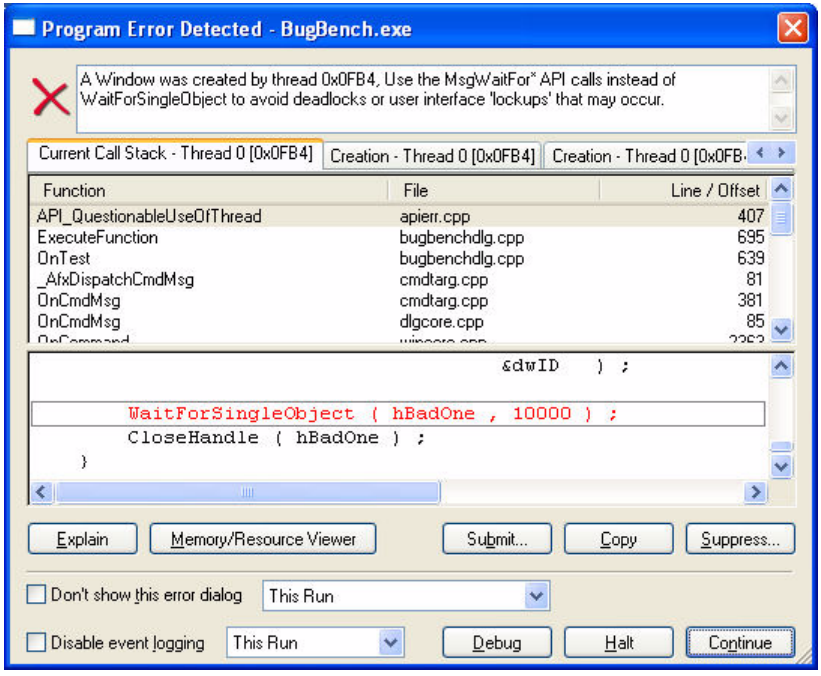


Figure 2-5. The **Program Error Detected** Dialog Box

Understanding the Actions You Can Take

Explain, **Memory and Resource Viewer**, **Debug**, **Copy** and **Suppress** buttons appear on the **Program Error Detected** dialog box. If you installed DevPartner Studio Enterprise Edition with TrackRecord integration, you also have a **Submit** button available.

Explain

Click **Explain** to obtain detailed explanations of each error, sample code, and a list of possible solutions to correct the problem.

Memory and Resource Viewer

Click **Memory/Resource Viewer** to view a detailed accounting of memory and resources that have not been freed. For more information, see "Understanding the Memory and Resource Viewer Dialog Box" on page 29, and the *Advanced Error Detection Techniques* guide.

Submit

Submit is only available if TrackRecord is part of your DevPartner installation. Click **Submit** to open a new defect or new task page in TrackRecord.

Copy

Click **Copy** to transfer the contents of all windows and tabs (except the **Source** pane) to the clipboard. You can then paste this information into other applications.

Suppress

Click **Suppress** to open a dialog box that enables you to suppress the current error. For more information on how and why to use suppressions, refer to "Understanding the Suppression and Filtering Dialog Boxes" on page 30, and the *Advanced Error Detection Techniques* guide.

Debug

Debug appears at the bottom of the dialog box when you are working in Visual Studio, but is not available in the standalone application. Click **Debug** to open your code in the Visual Studio debugger.

Halt

Click **Halt** to stop the application. This effectively kills the process, and there might be other means by which you would rather stop your application.

Continue

Click **Continue** to acknowledge the error, close the dialog box and continue executing the application. The error is saved to the session file for later reviewing in the **Results** pane.

Understanding the Memory and Resource Viewer Dialog Box

Access the **Memory and Resource Viewer** by clicking the **Memory/ Resource Viewer** button in the **Program Error Detected** dialog box. The **Memory and Resource Viewer** allows you to analyze memory and resource allocations that have not been freed.

For example, most memory analysis tools can not determine what happens with memory during the execution of an application. Leaked memory or resources are only reported after the application stops. The DevPartner Studio **Memory and Resource Viewer** provides a "snapshot" of the memory and resources, taken at any point in a program's execution. You can also "mark" the currently allocated memory blocks or resources, limiting the view of blocks allocated after a program's initialization or over the course of a transaction.

These capabilities can be especially useful in situations where:

- 24/7 server applications may never end during regular use
- An application may hang from resource exhaustion
- An application may consume large amounts of memory that is automatically cleaned up at program termination

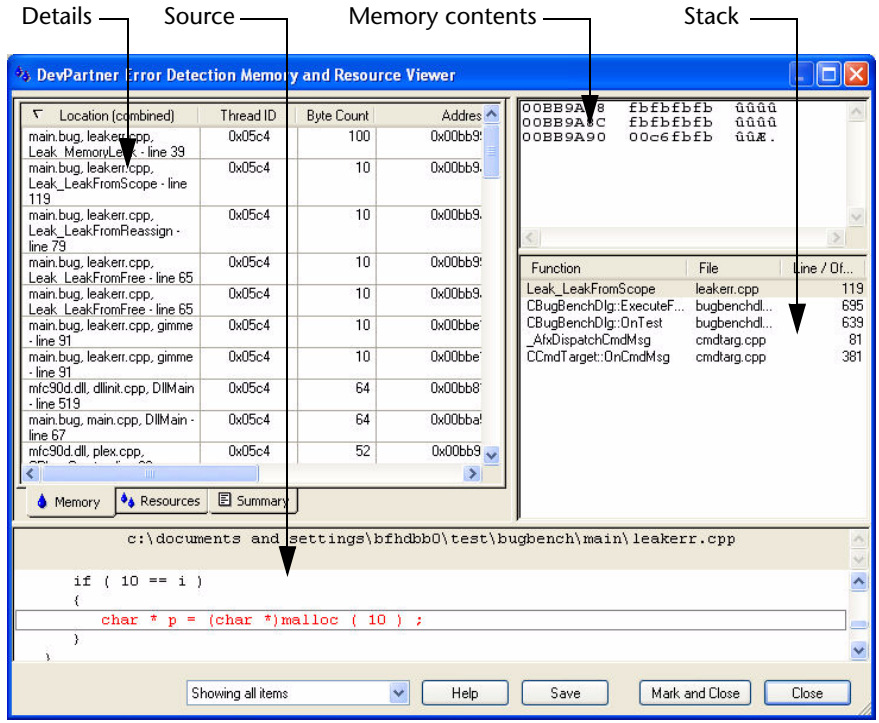


Figure 2-6. The **Memory and Resource Viewer** Dialog Box.

Exploring the Memory and Resource Viewer User Interface

To access the **Memory and Resource Viewer** dialog box, click **Memory/ Resource Viewer** in the **Program Error Detected** dialog box.

The **Memory and Resource Viewer** dialog box is made up of four panes:

- **Memory contents pane**

  Displays the content of memory blocks in a variety of formats. Not available for resources.

- **Details pane**

  Includes separate **Memory**, **Resources**, and **Summary** tabs. Displays details about each memory and resource allocation.

- **Stack pane**

  Displays a memory dump and callstack information for entries in the **Memory** tab; displays a description and callstack information for entries in the **Resources** tab.

- **Source pane**

  Displays the source code corresponding to a callstack entry (when it is available).

Saving Memory and Resource Viewer Contents

Click **Save** to record the current contents of the **Memory and Resource Viewer** dialog box as a text file that you can review later.

Setting a Reference Point

Click **Mark and Close** to set a reference point for recording memory and resource data. This lets you compare memory and resource allocations before and after the event where you marked the reference point.

Understanding the Suppression and Filtering Dialog Boxes

DevPartner Studio provides **Suppression** and **Filter** dialog boxes, which allow you to reduce the data collected or displayed. The intent of either method is to limit the data to a manageable subset for analysis.

For example, you can suppress call validation errors from `FindResourceA` in Kernel32 or for all calls in Kernel32. After you make this selection, you can apply it to a variety of different selection criteria within your application. DevPartner Studio defaults to the least restrictive option (see Figure 2-7).

When you apply a suppression or filter, you can also:

- Enter a comment to describe why a given suppression or filter was created.
- Choose to apply the suppression or filter to the current run or future runs.
- Create suppression or filter files as a way to store the suppression or filter instructions for reuse or to share.

Suppressing Errors

By suppressing errors, you instruct DevPartner Studio to skip over any future occurrences of those errors. Suppressed errors are not recorded in the log and they are not displayed in the **Program Error Detected** dialog box. To suppress an error:

- Click **Suppress** when the error appears in the **Program Error Detected** dialog box.
- Right-click on a specific error in one of the panes of the error detection main window, and select **Suppress.**

Creating and Saving Suppression Files

You can create multiple suppression files, and in so doing create additional suppression libraries for the various DLLs that make up a large application. You can easily reuse or share suppressions among members of a development team.

Note: When you first open an `.EXE` in DevPartner error detection, a default suppression file is created in the same directory as the `.EXE` you are checking.

The following sections describe the ways you can create a suppression file in DevPartner error detection.

From the *Suppression Files* Dialog Box

To create a suppression file from the **Suppression Files** dialog box, follow these steps:

1. Access the **Suppression Files** dialog box.
   - **Visual Studio:** Select **DevPartner > Error Detection Rules > Suppressions**.
   - **Standalone:** Select **Program > Rules > Suppressions**.
2. Click **Add**.
3. Type the name you want to assign to the suppression file in the **File Name** text box, then click **Open**.
4. Click **Yes** to confirm.

The suppression file you created is added to the **Available Suppression Files** list in the top pane of the **Suppression Files** dialog box.

5 Click **OK**.

At this point the suppression file has been created, but is empty until you add some suppressions (see "Adding Entries to a Suppression File" on page 33).

Note: The suppressions you add are not saved until you close the current error detection session.

From the *Suppression* Dialog Box

To create a suppression file from the **Suppression** dialog box, follow these steps:

1 After you complete a session, right-click on a specific error in the **Memory Leaks**, **Other Leaks**, **Errors**, **.NET Performance**, or **Modules** tab, and select **Suppress**.

2 In the **Suppression** dialog box, click the browse button (**...**) to the right of the **Location** field. The **Add Suppression File** dialog box opens.

3 Type the name you want to assign to the suppression file in the **File Name** text box, then click **Open**.

4 Click **Yes** to confirm.

5 Click **OK**.

At this point, the suppression file contains the instruction to suppress the error that you right-clicked in Step 1.

Note: The instruction you just added, and any subsequent suppressions you add, are not saved until you close the current error detection session.

Adding Entries to a Suppression File

To add an entry to a suppression file, follow these steps:

1. In the **Results** pane, select a tab: **Memory Leaks**; **Other Leaks**; **Errors**; **Modules**; or **Transcript**.
2. Right-click a specific error, leak, or module within that tab and select **Suppress**. The **Suppression** dialog box opens (see Figure 2-7 on page 34).
3. Select the type of suppression to add.

   The top pane displays various suppression options. The selections vary depending on the event you select (whether it is an error, a leak, or a module), and the context in which error detection encountered it.
4. If needed, type a comment to describe the suppression entry.

Note: Comments can be valuable when you update a suppression file, especially if the suppression is address-based and a third-party vendor ships a new or updated library.

5. To save this suppression to use again, select the **Save Suppression Information** check box.
6. To specify the location of the suppression file in which to add this entry, select a file from the **Location** drop down menu.
   - ◇ If you make no selection, the entry is added to the default program suppression file.
   - ◇ If you have not yet added suppression files to your program, the default program suppression file is the only choice.
   - ◇ To specify a suppression file in another location, click the browse button (**...**) (immediately to the right of the **Location** drop down menu) and select a different suppression file.
7. Click **OK** to continue.

Note: The entries you add are not saved until you close the current error detection session.

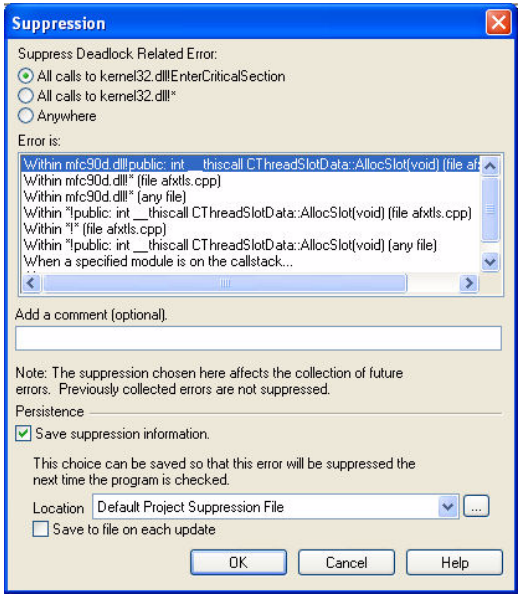


Figure 2-7. The Suppression Dialog Box (The Filtering Dialog Box Uses the Same Design).

Filtering Errors

Filtering hides events already recorded in a `.DPBCL` log file. DevPartner Studio finds these errors but either hides them from view in the **Results** pane or displays them with the appearance you specified under **Fonts and Colors**. To select errors that you want to filter:

- Right-click on a specific error in one of the panes of the error detection main window, and select **Filter.**
- Select a specific error in one of the panes of the error detection main window, and click the **Filter** button on the toolbar.

If you remove a filtering instruction, the associated errors are no longer filtered and appear in the **Results** pane.

Creating a Filter File

There are two ways to create a filter file.

From the *Filter Files* Dialog Box

To create a filter file from the **Filter Files** dialog box, follow these steps:

1. Open the **Filter Files** dialog box.
2. Click **Add**.

   The **Add Filter File** dialog box opens.

3 Type the name you want to assign to the filter file in the **File Name** text box, then click **Open**.

4 Click **Yes** to confirm.

The filter file you created is added to the **Available Filter Files** list in the top pane of the **Filter files** dialog box. At this point, the filter file is empty and has no effect on your view of program results.

Note: The filters you add are not saved until you close the current error detection session.

From the *Filter* Dialog Box

To create a filter file from the **Filter** dialog box, follow these steps:

1 After you complete a session, right-click a specific event or error in the **Memory Leaks**, **Other Leaks**, **Errors**, **Modules**, or **Transcript** tab, then select **Filter**. The **Filter** dialog box opens (see Figure 2-7 on page 34).

2 Click the browse button (**...**) to the right of the **Location** field.

The **Add Filter File** dialog box opens.

3 Type the name you want to assign to the filter file in the **File Name** text box, then click **Open**.

4 Click **Yes** to confirm.

At this point, the filter file contains the instruction to hide the error or event that you selected in Step 1.

Note: The filter you just added, and any subsequent filters you add, are not saved until you close the current error detection session.

Adding Entries to a Filter File

To add an entry to an existing filter file, follow these steps:

1 In the **Results** pane, select a tab: **Memory Leaks**; **Other Leaks**; **Errors**; **Modules**; or **Transcript**.

2 Right-click a specific error, leak, or module within that tab and select **Filter**. The **Filter** dialog box opens (see Figure 2-7 on page 34).

3 Select an option.

These options are listed in the top pane of the dialog box. The selections vary depending on the event you select (whether it is an error, a leak, or a module), and the context in which error detection encountered it.

4 If needed, type a comment to describe the entry.

Note: Comments can be valuable when you update a filter file, especially if the filter is address-based and a third-party vendor ships a new or updated library.

5 If you want to save this entry to use again, select the **Save Filter Information** check box.

6 To specify the location of the filter file in which to save this entry, select a file from the **Location** drop down menu.

- ◇ If you make no selection, the entry is added to the default program filter file.
- ◇ If you have not yet added filter files to your program, the default program filter file is the only choice.
- ◇ To specify a filter file in another location, click the browse button (**...**) (immediately to the right of the **Location** drop down menu) and select a different filter file.

7 Click **OK** to continue.

Note: The entries you add are not saved until you close the current error detection session.

Viewing and Hiding Filtered Errors

Use the **View Filtered Errors** toolbar icon to toggle between viewing and hiding filtered errors in the **Results** pane.

Removing Filter Entries

To remove a filter entry you no longer want, select **DevPartner > Error Detection Rules > Filters**. Select the filter file containing the entry, and clear its associated check box.

Understanding Call Validation

When you enable Call Validation, DevPartner Studio validates over 5,000 Windows API calls. DevPartner Studio checks for a large number of events, including (but not limited to) the following:

- ◆ Handle and pointer errors
- ◆ Flags
- ◆ Range checks
- ◆ API and method failures
- ◆ Invalid structure sizes
- ◆ Memory access failures

If you determine that flag checking or range checking generates unwanted errors that do not apply to the problem you are solving, clear the **Flag, range and enumeration arguments** check box. Call Validation continues checking return values and, more importantly, handles, and pointers passed to or from Windows calls.

Enabling Memory Block Checking

When you enable memory block checking, Call Validation performs a more detailed analysis of all calls to the C run-time library and a number of other calls. Memory block checking decreases overall performance, but may be useful when diagnosing hard-to-find errors. By default, this setting is disabled.

Using the Settings Dialog Box

*Tip: Use the configuration file management functions in the **Settings** dialog box to save sets of error-checking parameters as configuration files. When you are working with multiple projects, you can load, edit, and associate these configuration files with the different projects on which you are working.*

The DevPartner Studio settings enable you to:

- Select only the types of data collection needed for a particular problem
- Enable or disable portions of each major type of data collection
- Control what portions of your program are analyzed
- Use the default DevPartner Studio settings to find the most common errors with the minimum impact on performance

You can access the **Settings** dialog box in the following ways:

- **Standalone:** Select **Program** > **Settings**
- **Visual Studio:** Select **Tools** > **Options** and then select **DevPartner** > **Error Detection** from the tree view.

The **Settings** dialog box has a tree view that shows the major settings categories. When you select a category, the dialog box displays the detailed settings for the category.

The DevPartner Studio standalone application and the integrated Visual Studio version use the same tree view and settings dialog boxes.

All groups of settings follow the same basic structure. You can enable or disable major types of data collection by selecting the top-level check box in the dialog box.

There are other settings under each top-level check box that further define how DevPartner Studio analyzes your application. Change the settings to customize your error detection process.

For example, you can make trade-offs between detecting a broad or narrow range of errors:

- Broad range — Many data types, many related settings selected
  - Detects more errors
  - Has potential for more false positives
  - Reduces performance (due to larger number of errors detected)
  - Creates larger log files
- Limited range — Few data types, few related settings selected
  - Provides a narrow focus on a particular function
  - Detects fewer errors
  - Can miss relevant errors
  - Has a greater chance of seeing only those errors pertaining to the problem at hand
  - Provides faster performance
  - Creates smaller log files

Setting General Properties

General properties are the first to display when you access the **Program Settings** dialog box.

- **Log events:** Select to enable event logging. (You can also enable event logging from other parts of DevPartner error detection.)
- **Display error and pause:** Controls the display of the **Program Error Detected** dialog box, which pops up for certain errors, pausing execution of your program.
- **Prompt to save program results:** When selected, you are prompted to save program results before you exit the program or close the error detection session.
- **Show memory and resource viewer when application exits:** When selected, DevPartner error detection opens the **Memory/Resource Viewer** dialog box upon exiting the application you are testing.
- **Source file search path:** Specify full paths to the source file(s) you want to include in this configuration.

The following settings are only available in the error detection standalone application:

- **Override symbol path:** Specify the full path to the symbol file(s) you want to include in this configuration. Click the ellipsis button (...) to the right of this field to open the **Symbol Path** dialog box.
- **Working directory:** Specify the working directory for the target process.

Note: If an application will not start up, the problem might be caused by a working directory that is read-only. Some applications require write access to the working directory.

- **Command line arguments:** Specify any arguments to be passed through the command line to your application.

Note: If DevPartner error detection fails to correctly start your application, check the command line arguments. These arguments are especially important for COM server applications.

Setting Data Collection Properties

The Data Collection program settings control the following parameters for error detection:

- **Call parameter encoding depth:** Specify the amount of detail gathered on the parameters of a call. A low value speeds up processing, but does not report deeper levels of detail referenced by pointers. A higher value reports deeper call details, but slows down processing and increases the size of the log file.
- **Maximum call stack depth on allocation:** Specify the maximum depth of the call stack tracked for every allocation. Because allocations are made frequently and do not often result in errors, performance might suffer if you select a large value. Also, selecting a larger value can greatly increase error detection memory usage in the application under test.
- **Maximum call stack depth on error:** Specify the maximum depth of the call stack walked through for reported errors. You can set this value as high as you require without an adverse effect on performance, as long as you have enough log file space.
- **NLB file directory:** (This field is required) Select the location where generated NLB (optimized type library) files are saved. Typically this is the same location as your project, so that removal of the project and NLB files is simplified. If you specify a directory that does not exist, error detection prompts you to select a valid directory when you run your application. You can also use the **Browse** button (**...**) to browse your system and specify the directory where you want to save generated NLB files.

Note: NLB files contain all API description file information required for error detection.

Setting API Call Reporting Properties

Tip: Deselect an API function when you know that your program makes API calls that you do not need to check. Limiting the data collection helps improve performance.

Use API call reporting to record calls that your application makes to system functions, as well as the parameters and return values. DevPartner error detection records structure information for return values and parameters based on the **Encoding Depth** specified under **Data Collection** settings.

To enable API call reporting, and make the API check boxes and modules active, select the **Enable API call reporting** check box. The following settings control API logging for error detection:

*Tip: Selecting **Collect window messages** will dramatically increase log file size. For best results, select this feature only to debug window message problems.*

- **Collect window messages:** Select to collect windows control messages as part of API logging.
- **Collect API method calls and returns:** Select to collect the API method calls and returns for the modules selected in the API module tree view.
- **View only modules needed by this application:** Select this check box to display only the API modules needed by your program in the tree view. Clear the check box to expand this tree view and display all available API modules.
- **API Modules Tree View:** Displays the API modules associated with the project. Click the plus (+) symbol next to an item to see the functions it contains. Check boxes next to each item enable you to select specific modules or functions for API logging.

Enabling call reporting can significantly increase the size of the log file. To minimize log file size, consider collecting call reporting data only for a selected portion of your application. Here are some ways to limit the portion to be checked:

- Use the check boxes in the **Modules** tree view to deselect API modules that do not need to be checked.
- Use **Modules and Files** to limit the scope of logging.
- Add API calls that enable or disable event logging to your application. Refer to the comments included in `NmApiLib.h`. This file, part of the DevPartner software installation, defines the event reporting APIs exported by DevPartner error detection.
- Turn off event logging.

Setting Call Validation Options

When enabled, Call Validation monitors calls from your application to the operating system libraries and COM method calls. It attempts to validate the parameters passed, and check that the call returned a value indicating success. The following elements control aspects of Call Validation for error detection:

- **Enable call validation:** Select this check box to enable call validation components.
- **Enable memory block checking:** Select this check box to enable validation of more extensive memory checking of parameters referring to memory. This feature is inactive until you select **Enable memory tracking** under **Memory Tracking** in the **Program Settings** tree view.

Note: When you select **Enable memory block checking**, DevPartner error detection performs more extensive checking. The results might be more accurate and might catch more bugs. Sessions with this feature enabled will take longer to complete.

- **Fill output arguments before call:** Select this check box to fill output arguments with the pattern specified in the **Memory Tracking** settings under **Fill on allocation**.
- **COM failure codes:** Select this check box to enable checking of any COM method return values.

Tip: Many COM methods in normal use report a "Not Implemented" error. Disabling this check might significantly reduce the number of errors reported.

- **Check for COM "Not Implemented" return code:** Select this check box to enable checking for the `HRESULT E_NOTIMPL` ("Not Implemented") return code. DevPartner error detection checks only COM interfaces that are included in DLLs selected under **DLLs to check for API errors (failures or invalid arguments)** in this dialog box.
- **API failure codes:** Select this check box to enable the checking of return values from APIs residing in the selected DLLs.
- **Check invalid argument errors (COM or API):** Select one or both of these check boxes to enable the checking of the arguments (parameters) to APIs in the selected DLLs and/or COM interfaces that error detection supports.

*Tip: To improve performance and reduce the number of errors reported, select these features only as required. To reduce the number of false call validation errors, select **Handle and Pointer Arguments** and clear **Flag, Range and Enumeration Arguments**.*

Tip: Disabling DLLs from this list can reduce the number of unwanted errors. It can also improve performance.

- **Category:** (**Handle and pointer arguments** or **Flag, range and enumeration arguments**) Available when you select one or both **Check invalid argument errors selections (COM or API)**. Select one or both of these check boxes to enable argument checking based on the type of argument.
- **Check statically linked C run-time library APIs:** Available when you select **API failure codes** or **Invalid argument errors: API**. Select this check box to enable the checking of static C run-time calls. If you are not using the static C run-time library, clear this selection to avoid seeing errors in third-party libraries.
- **DLLs to check for API errors (failures or invalid arguments):** Available when you select **API failure codes** or **Invalid argument errors: API**. Select this check box to enable API argument and return value checking in the listed DLLs.

Note: You can use a tool (such as Depends, provided with Visual Studio) to find the DLLs and APIs within a DLL that your application uses.

Enabling Memory Overwrite Detection on API Calls

Checking for damage to memory blocks caused by API calls (such as `strcpy`) is not enabled by default. To enable memory overwrite detection on API calls, follow these steps:

1. Select the **Enable memory tracking** check box.
2. In the **Program Settings** tree view, select **Call Validation**.
3. Select the **Enable call validation** check box.
4. Select the **Enable memory block checking** check box.

Setting COM Call Reporting Properties

Use COM call reporting to record calls to COM interfaces as well as the returns for the interfaces selected in the **All Interfaces** tree. DevPartner error detection will record parameter values and the returned `HRESULT`.

Tip: Select only the interfaces you need to check. Decreasing the number of interfaces checked decreases the size of the log file and improves performance.

To enable COM call reporting, and activate the list of COM interfaces, select the **Enable COM method call reporting on objects that are implemented in the selected modules** check box. Use the following controls to configure COM call reporting:

- **Report COM method calls on objects implemented outside of the listed modules:** Select this check box to configure error detection to report the COM method calls and returns for the interfaces not listed in the **All Interfaces** tree.

- **All Components Tree View:** Displays the COM interfaces associated with the project. Click the plus (+) symbol next to the **All Components** entry to see a complete list of COM interfaces. Check boxes next to each item let you select specific interfaces for COM call reporting.

Setting COM Object Tracking Options

Use COM object tracking to monitor your program for leaked COM objects. Object leaks are displayed in the **Other Leaks** tab of the **Results** pane. When you select an object leak error in the **Other Leaks** tab, you can examine the calls to `AddRef()` and `Release()` on your object to try to locate the missing call to `Release()`.

Tip: To improve performance, select a subset of All COM Classes. Consider selecting all COM classes only when running an initial pass of your application, or when making a final QA pass.

To enable COM object tracking, and activate the **All COM Classes** tree view, select the **Enable COM object tracking** check box.

Using the **All COM Classes** tree view, select the COM classes that you want to monitor. If you do not see the COM class for your application, click **Refresh from Registry** to update the list.

Note: When selecting a subset of COM classes, note that most vendors name their objects with a common prefix.

Setting Deadlock Analysis Options

Use Deadlock Analysis to monitor multi-threaded applications for deadlocks. This includes the following types of analysis:

- Monitoring and reporting of deadlocks as they occur in the application
- Monitoring the usage patterns of the synchronization objects within your application for potential deadlocks

To enable Deadlock Analysis, and activate the other Deadlock Analysis controls, select the **Enable deadlock analysis** check box.

The following settings control the Deadlock Analysis behavior:

- **Assume single process:** When selected, error detection assumes that all named synchronization objects used within your application are used only within the process. Clear this check box to relax some of the deadlock detection rules associated with named synchronization objects.

- **Enable watcher thread:** Select this check box to create a watcher thread in your application to monitor for localized deadlocks. By default, this feature is disabled to prevent error detection from interfering with your application.

  If your application becomes unresponsive and appears to deadlock, enabling this feature allows error detection to perform more detailed analysis of your application.

Note: If you write complex `DLL_THREAD_ATTACH` logic that does not expect to encounter extra threads in the process, you should not enable this option.

- **Generate errors when:** Use the following selections to specify when error detection should report deadlock errors:

  - **A critical section is re-entered:** Select to generate a warning if you attempt to re-enter a critical section that your thread already owns. Although re-entering a critical section is not an error, your application must enter and leave the critical section the same number of times.

  - **A wait is requested on an owned mutex:** Select to generate a warning if you attempt to wait on a mutex that your thread already owns.

  - **Number of historical events per resource:** Enter the number of call stacks to record for each synchronization object reported in an error or warning.

    The stack information associated with each synchronization object enables you to determine why a synchronization object is in a given state. This can help you debug deadlock situations.

Note: Increasing the number of call stacks maintained for each synchronization object consumes additional memory in your application and has an effect on application performance.

  - **Report synchronization API timeouts:** Select to report an error when a wait on a synchronization object times out without the wait being successfully completed.

    Enable this option to monitor synchronization object API failures without having to enable API call reporting for all Windows calls.

__Tip:__ You can use the __Report wait limits or actual waits exceeding__ feature to enforce a maximum wait policy within your application.

  - **Report wait limits or actual waits exceeding (seconds):** Active after you select Report timeouts. Error Detection checks the time-out value passed to synchronization object wait calls. If the time-out values exceed the limit you specify here, the call is reported as an error.

Note: Any wait specified as `INFINITE` will not be flagged as an error.

- **Synchronization Naming Rules:** Select from these object standards:
  - **Don't warn about resource naming:** If selected, error detection does not warn you about named or unnamed resources encountered in your application.
  - **Warn about named resources:** Select to generate warnings for each named synchronization resource encountered within your application. You can use this check to locate named resources that can be manipulated outside of the application.
  - **Warn about unnamed resources:** Select to generate warnings for each unnamed synchronization resource encountered in your application. You can use this check to find unnamed resources that might need to be named to be used by other processes or to meet a corporate naming convention.

*Tip: If you are performing security audits, consider enabling the **Warn about named resources** feature to determine if unexpected named resources are visible outside the process. Named resources are visible outside the process and should have proper security applied to them to prevent unauthorized use.*

Note: By default, error detection does not produce warnings for either named or unnamed resources encountered during program execution.

Setting Memory Tracking Options

When you enable Memory Tracking, DevPartner error detection:

- Monitors all calls in your application that allocate and free memory
- Reports on memory not freed at the end of the application

Additionally, if you have built your application with FinalCheck instrumentation and you select **Enable FinalCheck**, error detection:

- Records instances where the last reference to an allocated block of memory goes out of scope
- Reports memory and pointer errors at the statement level throughout the run

To enable Memory Tracking, and activate all of the memory tracking options, select the **Enable memory tracking** check box.

Note: You must select the **Enable memory tracking** check box before you can enable **Memory block checking** under the Call Validation settings.

The following settings control the behavior of Memory Tracking:

- **Enable leak analysis only**: Select this check box to disable everything in Memory Tracking, with the exception of monitoring for leaks. Memory Tracking will not look for overruns, use of uninitialized memory, or dangling pointers. Call Validation memory block checking is also disabled because Memory Tracking is not evaluating any memory allocated by system modules.

Note: Some of the COM interface hooks will not get handled completely when this feature is enabled.

- **Enable FinalCheck:** Select this check box to enable FinalCheck. When selected, error detection performs additional checks on FinalCheck instrumented modules. When disabled, these checks are not performed.

- **Show leaked allocator blocks:** Select this check box to enable the reporting of leaks on blocks that are used for suballocations. Suballocated blocks are normally created by memory allocation functions such as `malloc` or `new`. If you are writing your own memory allocators, enable this feature to monitor all memory in your application, including buffers that are suballocated into blocks returned from functions such as `malloc` or `new`. DevPartner error detection monitors your custom memory allocators only after you list them in `UserAllocators.dat`. For more information about `UserAllocators.dat`, read the chapter "Working with User-Written Allocators" in the *Advanced Error Detection Techniques* guide.

- **Enforce strict reallocation semantics:** Select this check box to enable strict enforcement of semantics. When error detection enforces strict reallocation semantics, a pointer to memory that has been reallocated is treated as though it were a dangling pointer, and using that pointer generates an error. If strict reallocation semantics are not enabled, a reallocated pointer may be used as long as it points to the same memory location as the new pointer, and no errors are generated. For example:

```
char *ptrA = (char *) malloc(17);
// ptrA is now validly pointing to 17 bytes of memory.
char *ptrB = (char *) realloc(ptrA, 15);
// ptrB is now validly pointing to 15 bytes of memory.
// With strict semantics, ptrA is now an invalid pointer,
regardless of the value.
// Without strict semantics, ptrA is still valid as long as it
equals ptrB
```

- **Enable Guard Bytes:** When enabled, guard bytes are inserted at the end of allocated memory blocks to detect memory overrun errors. Overruns can cause heap corruption or stack corruption, that, in turn, can cause random crashes and unexpected data overwrites.
  - **Pattern:** Enter the hexadecimal guard byte pattern. This pattern is used to determine if allocated memory blocks are overrun.
  - **Count:** Select the number of guard bytes to be used. If you encounter random heap corruption errors but error detection is not reporting heap-overrun errors, consider increasing the number of guard bytes. Doing so will increase memory usage, but might detect a hard to find heap corruption error.
- **Check heap blocks at runtime:** Specify how often the entire heap will be checked to see if guard bytes have been overwritten. DevPartner error detection always checks each block for overrun when it is freed. There are three options for additional checks:
  - **On free**
  - **Use adaptive analysis**
  - **On all memory API calls**
- **Enable fill on allocation:** When enabled, the fill pattern specified is applied to memory as it is allocated.
  - **Pattern:** Specify the hexadecimal fill pattern to be used.
- **Check uninitialized memory:** When selected, newly allocated memory is initialized with a known pattern and then checked for that pattern when the memory is referenced.
  - **Size:** Select the minimum number of bytes to check for the fill pattern. To reduce the number of false error reports, increase this value.
- **Enable poison on free:** Select this check box to enable poisoning of memory upon freeing it.
  - **Pattern:** Enter the pattern to be written to the memory location that is being poisoned.

Setting .NET Framework Analysis Options

Use .NET Framework analysis when you develop applications that use a mixture of unmanaged and managed code and unmanaged resources. Applications that use both managed and unmanaged code might incur a performance penalty. The data you gather here can help you evaluate the extent and severity of any such penalty. If you discover problems and lack the time to fix all of them, this analysis can help you decide which are the most serious.

To enable the .NET Framework analysis controls in this panel, select the **Enable .NET analysis** check box. Use the following controls to configure .NET Framework analysis:

- **Exception monitoring:** Select this check box to monitor instances where unmanaged or legacy code throws exceptions that are not handled, and are passed back to the managed code.

Note: Exceptions passed from unmanaged to managed code are likely to generate errors because the necessary handles are no longer in unmanaged code. You should carefully review any exceptions noted. Possible errors include partially initialized data structures, memory leaks, resource leaks, and so on.

- **Finalizer monitoring:** Select this check box to monitor incorrect use of unmanaged resources, such as failing to call the appropriate dispose method (leaks) or incorrect implementation of classes that encapsulate unmanaged resources.
- **COM interop monitoring:** Select this check box to monitor which class IDs are causing transitions between managed and unmanaged or legacy code. This function also identifies which interface IDs are used.

Note: You can use COM interop monitoring to determine which methods are being called frequently. If you find methods called many times, consider porting the object to avoid transitions. If re-writing is not an option, consider adding a new method that transfers data in bulk to reduce the number of transitions.

- **PInvoke interop monitoring:** Select this check box to count the number of times unmanaged or legacy code is called (broken out by DLLs and, if possible, by APIs). This helps you determine why your application is going into unmanaged or legacy code.

Note: PInvoke interop monitoring provides a count of the PInvoke calls that your application makes. The PInvoke interop monitoring report can be used to monitor managed to unmanaged transitions. Review the list to determine if excess calls are being made.

- **Interop reporting threshold:** Assuming *x* is the value specified in this field: when the number of times the application makes *call_A* is greater than or equal to *x*, add *call_A* to the .NET Analysis results. This enables you to filter out calls that happen only a limited number of times. As you lower this threshold, more calls are included in your results.

Note: The interop reporting threshold allows you to exclude COM transitions from being reported in the COM interop and PInvoke interop monitoring reports. DevPartner error detection only reports transitions if the number of transitions is greater than or equal to the value specified.

Setting .NET Framework Call Reporting Properties

*Tip: .NET Framework Call Reporting can generate a large amount of data, and cause system slowdowns. Enable .NET Framework Call Reporting only when necessary to debug and understand the framework, and even then select only the assemblies you need to check. Limiting the number of assemblies selected in the **All types** tree view decreases the size of the log file and improves performance.*

Use .NET Framework Call Reporting to record calls to, and returns from, .NET interfaces. DevPartner error detection attempts to differentiate between "User Assemblies" and "System Assemblies" for .NET modules based on where the NLB file for an assembly is found.

To enable .NET Framework Call Reporting, and activate the list of .NET assemblies, select the **Enable .NET method call reporting** check box.

The **All Types Tree View** displays the .NET assemblies associated with the project. Click the plus (+) symbol next to the **All types** entry to expand the tree. The tree contains branches for both .NET User Assemblies and .NET System Assemblies. Check boxes next to each item enable you to select specific assemblies for .NET Framework call reporting.

Setting Resource Tracking Options

When you enable Resource Tracking, error detection:

- Monitors all calls in your application that allocate and free system resources other than memory
- Reports resources that have not been freed when your application ends

To enable Resource Tracking, and activate the list of resources, select the **Enable resource tracking** check box. When you select a check box in the associated list, error detection tracks the resources created by that DLL.

You can further refine resource tracking to a particular set of resources by selecting from one or more resource de-allocation APIs. For example, to exclude all registry related resources, clear the **RegCloseKey** check box under the **ADVAPI.DLL** resource.

Setting Modules and Files Options

Use the Modules and Files settings to specify the modules that make up the application.

Note: Excluding modules, or components of modules, does not affect instrumentation at all. You can only limit instrumentation by using the Instrumentation Manager.

*Tip: You may need to explicitly add a module to this list so that you can then exclude it from evaluation. DevPartner error detection automatically includes any modules that are not listed under **Modules and Files**. When you need to exclude a module that is not listed, you must first add the module, and then clear its check box to exclude it.*

DevPartner error detection automatically evaluates all modules in your program. Use the Modules and Files settings to:

- Exclude modules from evaluation
- Exclude components within a module from evaluation
- Add modules you want to evaluate

Modules and Files includes the following settings:

- **Modules and Files List:** Shows the modules being checked.
  - To exclude an entire module from checking, clear the check box next to that module.
  - To expand a module and view its contents, click the plus symbol to the left of the module path.
  - To exclude specific items within a module, expand the module then clear the check box next to the item(s) to be excluded.

Note: After you clear a check box next to a module or an item within a module, it appears on the list but is not analyzed when you run error detection on your application.

The check box next to a module name is colored yellow if one or more of its components has been cleared.

Disabling all the modules in the Modules and Files settings will not prevent reporting of some error types. DevPartner error detection always reports memory overruns within any module, and other types of events originating from the `MFCxxxx.dll` libraries.

- **Show leaks and errors only if source code is available:** Select this check box to limit reported leaks and errors to those having source code available. When enabled, this option might reduce the number of leaks and errors reported. When disabled (the default condition), all leaks and errors are reported.
- **Add module:** Click to open the **Choose Module to Add** dialog box; use this dialog box to select and add the module.

- **Remove module:** Click to remove a selected module from the Modules and Files list. Active only when a module is selected.

Note: You cannot remove the main executable.

- **System directories:** Click to open the **System Directories** dialog box.

Setting System Directories Options

Use the **System Directories** dialog box to exclude entire directories that you do not need to check. For example, a directory may contain modules that generate errors that you have already dealt with. Excluding directories that you do not need to check can speed up your error detection sessions.

Note: DevPartner error detection reports all errors of undetermined origin and all errors that will cause catastrophic failure of your application. Such errors are reported even though they might occur in modules within an excluded directory.

The following settings are available for the **System Directories** dialog box.

- **Add:** Opens the **System Directory to Add** dialog box. Use this dialog box to select a directory to add to the list of directories excluded from checking by error detection.
- **Remove:** Click to remove a selected system directory from the list.
- **OK:** Click to close the **System Directories** dialog box and save any changes you have made.
- **Cancel:** Click to close the **System Directories** dialog box and discard any changes you have made.

Directory Icon

The directory icon next to each path name in the **System Directories** list indicates two different possible conditions:

- **Single Directory:** Indicated by a single folder icon. Only the immediate contents of the selected directory are included.
- **Directory and All Sub-directories:** Indicated by a three-folder icon. The selected directory and all sub-directories are included.

To toggle between the two options, click the icon next to the directory name.

Note: In some instances you may find that you need to explicitly add critical third-party DLLs that are contained in an excluded directory. Explicitly adding these third-party DLLs might reveal problems you may not otherwise locate. To explicitly add a DLL, use the **Modules and Files** settings.

Setting Fonts and Colors Options

Fonts and Colors control the appearance of items that appear in the tabs of the error detection window. For example, you can increase the font size of the error data you view most frequently, or decrease font sizes to display more information in a tab.

Use the following controls to define the fonts and colors:

- **Show settings for:** Lists the different tabs that appear in the **Results** pane. Select the tab for which you are changing fonts and colors.
- **Use Defaults:** Click to discard all current settings and restore the original fonts and colors.
- **Displayable items:** Select an item from this list to change its font or color properties.
- **Font:** Select a font to use for the currently selected item under **Displayable items**.
- **Size:** Select a font size to use for the currently selected item under **Displayable items**.
- **Item foreground:** Shows the foreground color for the current selection in the **Displayable items** list. Select a foreground color from this drop-down menu or click **Custom** to the left of the menu to define a custom foreground color.
- **Item background:** Shows the background color for the current selection in the **Displayable items** list. Select a foreground color from this drop-down menu or click **Custom** to the left of the menu to define a custom background color.
- **Bold:** When selected, the text for the displayable item appears in a bold font.
- **Tab Size:** Use this control to specify the indent size for code displayed in the **Source Code** pane.

  Note: This control is available only when the **Show settings for** selection is **Source Pane** and the **Displayable items** selection is **Main**.
- **Sample Text Box:** A text box at the bottom of the Fonts and Colors window shows how the current displayable item appears with the combination of fonts and colors selected.

Setting Configuration File Management Options

Use the Configuration File Management settings to manage configuration files. The title bar of the **Program Settings** dialog box displays the configuration file currently in use.

Note: When you change a setting in the **Program Settings** dialog box, an asterisk appears after the configuration file name until you save the properties, reload the file, or load a different file. If you load a different file or reload the file without saving, any changes to the current file are lost.

Use the following controls to define the Configuration File functionality:

- **Configuration file name:** The full path and name of the configuration file.
- **Reload:** Loads the current configuration file again, discarding any changes. This returns you to the last saved version of the current configuration file.
- **Load:** Opens the **Load From** dialog box.
  - Select **Internal User Defaults** to load your user default settings.
  - If you select **Configuration File**, the **Load Configuration File** dialog opens. Use this to select a different configuration file to load.
- **Save:** Saves all active changes in the currently loaded configuration file.
- **Save As:** Opens the **Save Configuration File** dialog box. Use this to save the current configuration settings under a different file name.
- **Reset:** Resets all the program property settings to the default factory settings.
- **Save Defaults:** Save the current settings as your user defaults. All new projects will use these settings.
- **Delete Defaults:** Delete the user default configuration settings and revert to factory settings. All new projects will use the factory settings.

Tracking Windows Messages and Event Logging

Windows is an event-driven environment in which much of your program is executed in response to Windows messages and other events. DevPartner Studio intercepts events as they occur, and logs them. You can use these logs to see a complete history of events that led to a problem.

DevPartner Studio logs the following events:

- Windows messages.

  These events show how your program reacted to Windows messages.
- API calls and API returns along with argument information.
  These events define the order in which procedures are executed in your program.
- Output debug string messages from the program you are checking.
- Error messages.

Exporting Data to XML

DevPartner allows you to export comprehensive session results data to XML, providing you with a simple way to port your results data into various report formats, email, an internal Web page, etc.

Exporting Data from within Visual Studio

Follow these steps when you are using Error Detection from within Visual Studio to export all data from the currently displayed session file to an XML file:

1. Open an Error Detection session file.
2. Select **File > Export DevPartner Data**.

   A **Save As** dialog box appears.
3. Choose the location for the exported data file.
4. Click **OK**.

Exporting Data from the Error Detection Standalone Application

Follow these steps when you are using the Error Detection standalone application to export all data from the currently displayed session file to an XML file:

1. Open an Error Detection session file.
2. Select **File > Export Data**.

   A **Save As** dialog box appears.
3. Choose the location for the exported data file.
4. Click **OK**.

Exporting Data from the Command Line

You can elect to generate an XML file from the session file data when you run error detection from the command line by passing the proper flags to `BC.exe` at execution time, or by calling `BC.exe` and specifying a pre-existing session file.

DevPartner error detection uses the `DPSErrorDetection.xsd` schema file located in the error detection installation directory when generating the XML output. Do not edit this file.

If DevPartner cannot export your session data to XML, it generates an error message describing the problem it encountered.

Running a Session and Exporting Data

When you specify an executable, error detection runs a session on the executable and then generates XML output from the results:

`BC.exe [/B session.DPbcl] [/X[S|D] xmlfile.xml] target.exe [args]`

The `S` and `D` flags used with `/X` allow you to export either Summary or Detail information to XML.

Note: When you specify an executable, you must still specify an corresponding session file using the `/B` flag.

Converting an Existing File

When you specify a session file only (*session*`.DPbcl`), error detection converts the specified session file to XML and saves the output:

`BC.exe [/B session.DPbcl]  [/X[S|D] xmlfile.xml]`

Running Error Detection from the Command Line

You can run DevPartner Studio from a DOS command line, using `bc.exe` or `bc.com`.

Note: For legacy support of the 7.x versions, DevPartner error detection allows you to continue using `bc7.com` in your script files.

- `bc.exe` starts the UI for DevPartner Studio standalone.
- `bc.com` is a small console program that spawns `bc.exe` and waits for it to complete.

The difference between `bc.exe` and `bc.com` is important for batch scripts. Invoking `bc.exe` directly starts DevPartner Studio and continues on to the next command without waiting for `bc.exe` to complete. If the next step in the script is to check for a result, it will not be available.

Note: If you type only `bc`, the OS chooses `bc.com` instead of `bc.exe`.

For more information, refer to Using Error Detection from the Command Line in *DevPartner Advanced Error Detection Techniques*.

Command Line Options and Syntax

Brackets `[ ]` indicate that a command is optional.

```
BC.exe [/?]
BC.exe session.DPbcl
BC.exe [/B session.DPbcl] [/C configfile.DPbcc] [/M] [/NOLOGO]
[/X[S|D] xmlfile.xml] [/OUT errorfile.txt] [/S] [/W workingdir]
target.exe [args]
```

Table 2-4. Command Line Options

Option	Action
/?	Display usage information
session.DPbcl	Open an existing session file
/B *session*.DPbcl	Run in batch mode and save the session file to a log file *session*.DPbcl
/C *configfile*.DPbcc	Use the *configfile*.DPbcc options
/M	Start BC.exe and minimize when running
/NOLOGO	Do not show the splash screen when loading BC.exe

Table 2-4. Command Line Options

Option	Action
/X *xmlfile*.xml	Generate XML output and save to the specified file. When you specify an executable, error detection runs a session on the executable and then generates XML output from the results. When you specify a session file only (`session.DPbcl`), error detection converts the specified session file to XML and saves the output. **Note:** When you specify an executable, you must still specify an corresponding session file using the /B switch.
/XS *xmlfile*.xml	The /X flag used with the S modifier instructs error detection to only save Summary data to the xml file. Information about the running of the error detection session (Session data) is always exported.
/XD *xmlfile*.xml	The /X flag used with the D modifier instructs error detection to only save Details data to the xml file. Information about the running of the Error Detection session (Session data) is always exported.
/OUT *errorfile*.txt	Output any error messages to a text file
/S	Run in silent mode. Do not open the **Program Error Detected** dialog box on errors.
/W *workingdirectory*	Set the target's working directory
target.exe [*args*]	The executable to launch and its arguments

Note: You must specify the full directory path to your program executable if it is not located on the current path (the environment variable listing the directories that the system searches in order to find an executable).

Running FinalCheck from the Command Line

You can also run FinalCheck from the command line. For more information, refer to the following topics in the *Checking a Program with FinalCheck* section of the online help.

- Running FinalCheck from the Command Line
- NMCL Options
- NMLINK Options

Submitting Data to Visual Studio Team System

DevPartner Studio supports Microsoft Visual Studio Team System if the Team Explorer client is installed and a Team Foundation Server connection is available.

Visual Studio Team System Support in DevPartner Error Detection

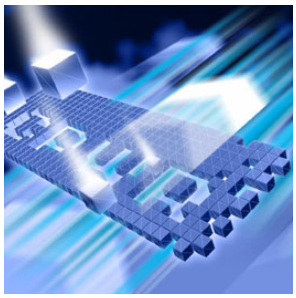
You can submit data as a **Work Item** of the type **Bug** for a selected item in the following Error Detection tabs:

- Errors tab — submit a selected error
- Memory leaks tab — submit a selected leak
- Modules tab — submit a selected instance
- Other leaks tab — submit a selected leak
- .NET Performance tab — submit a selected instance

When you submit a **Bug**, DevPartner populates the **Work Item** form with data from the tab. For more information about DevPartner Studio integration with Visual Studio Team System, see "Visual Studio Team System Support" on page 8.

Chapter 3

Static Code Analysis



- What is Code Review?
- Using Code Review Out of the Box
- Setting Options
- Suppressing Rules
- Viewing Summary Data
- Viewing Code Violations
- Viewing Naming Violations
- Viewing Collected Metrics
- Viewing Call Graph Data
- Using the Command Line Interface
- Exporting Data to XML
- Understanding Naming Analysis
- Using the Code Review Rule Manager
- Creating New Rules Using Regular Expressions
- Submitting Data to Visual Studio Team System

This chapter contains two sections. The first section provides a quick-start procedure to get first-time users up and running with code review. The second section provides reference information for an in-depth understanding of some DevPartner Studio code review functions.

Refer to the DevPartner Studio online help for additional task-oriented information about code review.

What is Code Review?

DevPartner code review helps developers write best-practices compliant Visual Basic and Visual C# code in Visual Studio. DevPartner code review identifies programming and naming violations, analyzes method call structures, and tracks overall code complexity.

Note: The code review feature analyzes managed code only, and is not supported in the DevPartner for Visual C++ BoundsChecker Suite.

The DevPartner code review feature delivers the following functionality:

- Static code analysis and review

  DevPartner code review performs a comprehensive static code analysis of your source code in Visual Studio, and displays results in the **DevPartner Code Review** window.

- Automated command-line batch processing

  You can execute a batch review of your solution from the command line. You can run these automated batch reviews in conjunction with a nightly build. You can also save time by using an automated batch review on large applications while you perform other tasks.

- Data export to XML

  DevPartner code review allows you to export session results in XML format, providing you with a simple way to transform your results data into report formats, e-mail, an internal Web page, etc. You can export your data to XML from code review after running a session, from the command line, or as part of an automated batch process.

- Rules management and customization

  The Rule Manager lets you configure rules used by code review to enforce code compliance with the standards you set. You can also group rules into sets for use in a review session, and create your own custom rules.

Using Code Review Out of the Box

The following Ready, Set, Go procedure introduces you to using DevPartner code review.

To get up and running quickly, follow the steps presented in shaded boxes. If you would like more information about the subject being described in the shaded box, read the additional text following the box.

Note: DevPartner code review creates data files for each target application. You must ensure that you have write access to the directory containing the target executable before starting code review.

Analyzing an application with DevPartner Studio does not require elevated system privileges. The system privileges you use to create and debug your application are sufficient for DevPartner to analyze the application.

Ready: Deciding How You Want to Run the Review

DevPartner code review is very flexible, with several different configurations you should consider for any session.

The following procedure assumes:

- You are running a review of a Visual Basic or Visual C# single-developer solution.
- You are running code review in Visual Studio 2008 or Visual Studio 2005.
- All of the projects in your solution compile without errors.
- All projects to be reviewed are set to output debug information.

Note: Refer to "Code Review Supported Project Types" on page 340 for a comprehensive list of supported project types for code review.

- Deciding What Rules to Enforce — You can use a wide variety of code review rules to enforce industry best practices in your code. You can also create custom rules and rule sets using the Rule Manager if you have additional standards to enforce.
- Selecting the Naming Guidelines to Enforce — DevPartner code review can use built-in naming analyzers to ensure your code follows industry-accepted naming standards.
- Collecting Metrics Data — You can collect metrics data during your review, which displays code complexity results (complexity, bad fix probability, and understanding level), based on McCabe Metrics.
- Collecting Call Graph Data — You can collect call graph data (representing all potential inbound and outbound calls) during your review.
- Excluding Projects in Your Solution — DevPartner code review includes all projects in your solution by default. If you know there are projects in your solution that you do not want code review to analyze, you can exclude them.

Note: You must have all selected projects set to output debug information. If a selected project is not set to output debug information for any available build configurations, when code review runs you will be warned about build errors, and that project will be excluded from future sessions.

Set: Selecting Options and Settings

DevPartner code review is flexible and customizable. Use the **General** options page (see Figure 3-1 on page 62) to customize code review. To access the **General** options page, select **DevPartner > Options** and then select **DevPartner > Code Review** from the **Options** tree view.

For this procedure, you can use the default DevPartner properties and options. No changes to the settings are required.

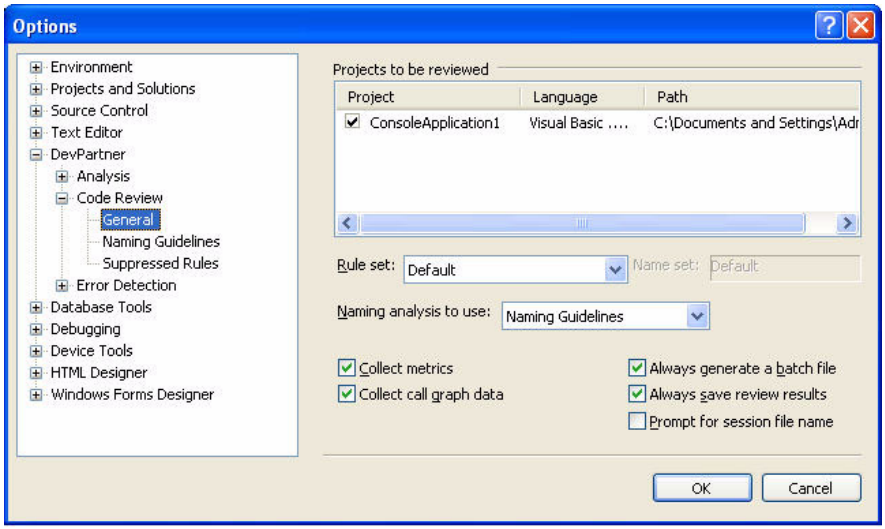


Figure 3-1. DevPartner Code Review General Options

- Selecting a Rule Set — You can choose a rule set from the **Rule Set** list prior to running your review. The **Default** rule set includes all Medium and High priority rules supplied by code review, which enables you to enforce common best practices in the industry. Table 3-2 on page 72 provides a list of the standard rule sets that come with code review.

Note: You can use the Rule Manager (see "Using the Code Review Rule Manager" on page 103) to create custom rules and rule sets.

- Selecting a Naming Guideline — You can choose a naming guideline from the **Naming Analysis To Use** list. The default behavior is for code review to enforce naming guidelines modeled after the Microsoft .NET naming conventions. However, you can enforce the Hungarian Notation naming convention instead, or enforce none at all.
- Enabling or Disabling Collection of Metrics Data — Select the **Collect Metrics** check box to enable collection of McCabe Metrics data (see "Collecting McCabe Metrics" on page 73). Clear the check box to disable this functionality.
- Enabling or Disabling Collection of Call Graph Data — Select the **Collect Call Graph Data** check box to enable collection of static method call data. Clear the check box to disable this functionality.

  If you run your review with this function enabled, the **Call Graph** tab in the Results window displays a static graphical representation of the inbound and outbound call path corresponding to the method or property selected from the **Solution Tree** in the far left pane.

Note: Call paths are statically generated. This means that the graph shows the potential method calls in the call path, rather than the dynamic method calls made during program execution.

- Excluding Unwanted Projects — A check box next to each project in the **Projects To Be Reviewed** text box controls whether that project will be analyzed by code review (see Figure 3-1 on page 62). Clear the check box associated with any projects you do not want code review to analyze.

Note: You must have all selected projects set to output debug information. If a selected project is not set to output debug information for any available build configurations, when code review runs you will be warned about build errors, and that project will be excluded from future sessions.

Go: Starting Your Code Review Session

The process of DevPartner analyzing your code is referred to as the session. When the review is completed, the session data is displayed in the Results window (see Figure 3-2 on page 65), and will be saved to a file when you exit code review.

1. Open your solution in Visual Studio.
2. Select **DevPartner > Perform Code Review**.

   DevPartner performs a code review on all projects in the solution. The Results window opens, and a status bar on the **Summary** pane tracks the progress of the session.

You have completed running a basic code review session, and the data has been compiled in the Results window for you to analyze.

Analyzing the Results and Repairing Violations

The Results window is your focus once you have completed running a review of your solution. The session data is displayed in the Results window, and you use it to begin identifying, locating, and repairing violations.

1. Examine the **Problems** tab of the Results window (see Figure 3-2) to see code violations found during the review.
2. Ensure the **Severity** column is sorting the violations from highest to lowest priority (default behavior). Toggle the column between ascending and descending order, if required, by clicking the column heading.

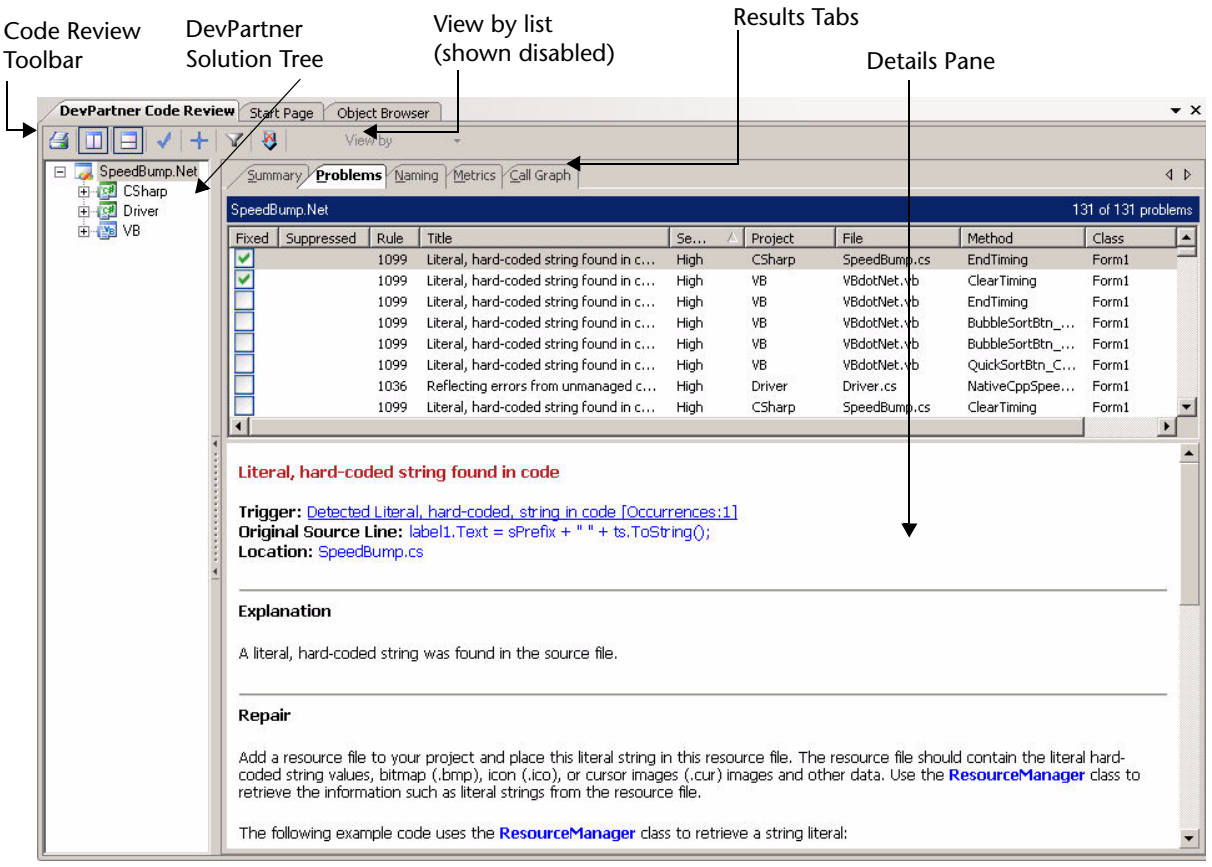


Figure 3-2. DevPartner Code Review Results Window

Tip: *Typically, you want to correct the most critical code violations first. The* ***Problems*** *tab is designed to sort the code violations in order of severity, allowing you to easily select the highest priority violations first.*

There are several tabs available in the Results window that separate the session data into distinct categories.

- Select the **Summary** tab to examine a report summarizing the violations of various types that were discovered during the review (see "Viewing Summary Data" on page 78).
- Select the **Problems** tab to view the code violations discovered during the review. The default behavior of the **Problems** tab is to sort the list of violations from highest severity to lowest (see "Viewing Code Violations" on page 80).
- Select the **Naming** tab to view the naming violations discovered during the review. This list also provides suggestions for repair, when applicable, and will be empty if the review was configured to ignore naming (see "Viewing Naming Violations" on page 82).

- Select the **Metrics** tab to view code complexity results (Complexity, Bad Fix Probability, and Understanding Level), based on McCabe Metrics (see "Viewing Collected Metrics" on page 85).
- Select the **Call Graph** tab for a graphical representation of the method calls (see "Viewing Call Graph Data" on page 88).

Filtering Results

After running a code review session, the results can include a lot of data, making it difficult to focus on one area to repair. Use the Code Review Solution Tree (see Figure 3-2 on page 65) to filter the results by selecting a project, file, or method. Filtering the data limits what is displayed, allowing you to focus on the results that are most important to you.

Analyzing Code Violations

By default, the **Problems** tab has focus in the Results window following a code review. The **Problems** tab displays the code violations found in the current solution. An associated Details pane (see Figure 3-2 on page 65) below the **Problems** tab provides more explanation, examples, references to MSDN and other sources explaining the problem, and suggested repairs (when available) for the selected code violation.

3. Select the first code violation listed on the **Problems** tab (highest priority). The Details pane is populated with information about the selected code violation. The **Trigger** and **Location** headings tell you why you had a code violation and where the violation was located.
4. Scroll down and examine the **Explanation**, code samples (if available), and suggested **Repair** for the code violation. Follow any external links to more explanations about the violation for additional information.
5. Double-click on the code violation listed on the **Problems** tab.

   DevPartner opens a new window containing the Visual Studio editor and your source code, with focus placed at the line of code where the problem exists.
6. Repair the code violation using the Visual Studio editor.
7. Return to the **Problems** tab in the code review Results window.
8. Select the **Fixed** check box to indicate that you corrected the violation.

9 Select the next code violation in the **Problems** tab, repeating steps 5 through 8 until you feel you addressed enough code violations for this session.

Note: DevPartner code review attempts to keep track of changes to line numbering, and maintain synchronization between the violations and the source code. After enough modifications, though, the results can lose synchronization with the source code, and line numbers might change. You may wish to re-run a code review session after modifying the source code to any great extent, and continue repairing violations with the new **Problems** tab list.

You have now resolved code violations in your solution using code review.

Analyzing Naming Violations

The **Naming** tab lists naming violations that code review finds during a review. The appearance of the **Naming** tab varies depending on the type of naming analysis you selected on the **General** options page (see Figure 3-4 on page 70) prior to the review. An associated Details pane (like the one associated with the **Problems** tab in Figure 3-2 on page 65) below the **Naming** tab provides more explanation, resources, and suggested repairs (when available) for the selected naming violation.

Note: The Details pane is not available when you are using Hungarian naming.

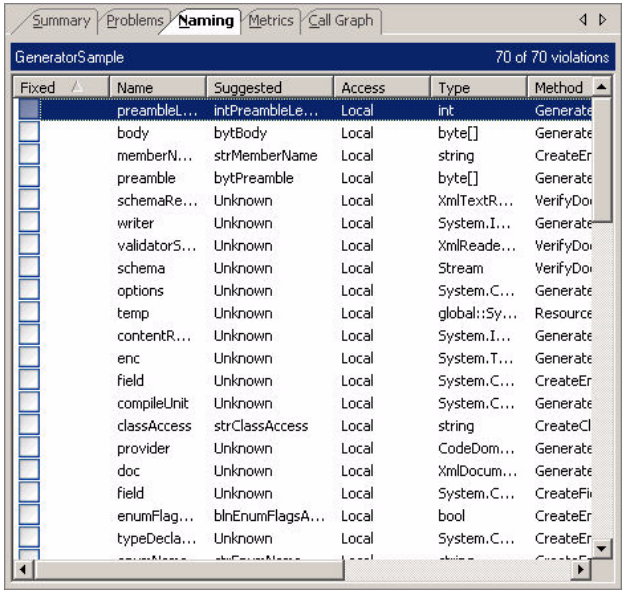


Figure 3-3. Naming Tab and Details Pane

10 Select the **Naming** tab to identify the naming violations discovered during the session (see Figure 3-3). All naming violations found during the review are listed in this tab. When available, a suggestion for proper naming appears beside the violation.

11 Select the first naming violation on the **Naming** tab.
The Details pane is populated with information about the selected naming violation (see Figure 3-3).

Note: If you selected Hungarian naming, no Details pane would be available.

12 Examine the detailed explanation and/or suggestion for proper naming (when available). Follow any external links if you want more information about the violation.

13 Double-click on the naming violation in the **Naming** tab list to go to the source.

14 Repair the naming violation.

15 Return to the **Naming** tab in the code review Results window.

16 Select the **Fixed** check box to indicate you corrected the violation.

17 Select the next naming violation in the **Naming** tab, repeating steps 11 through 16 until you feel you addressed enough naming violations for this session.

You have now resolved naming violations in your solution using code review.

Saving Session Files

Saving your session file allows you to refer back to these results. You might want to open a saved session file for several reasons:

- To export the session data to XML at a later date (see "Exporting Data to XML" on page 96).
- To continue fixing the violations discovered in this session later.

Note: The default behavior of code review is to save your session file for you when you exit, unless you clear the **Always save review results** setting under **General** options (see "Configuring General Options" on page 70).

1. With focus in the Results window, select **File > Save Code Review Session As**.
2. Enter a name for the session file and click **Save**.

   By default, code review will save the session file as *SolutionName*.dpmdb in the same location as your solution.

DevPartner saves session files as part of the active solution. They appear in the **DevPartner Studio** virtual folder in Solution Explorer. DevPartner code review session files take the .dpmdb extension.

By default, DevPartner physically saves the session files in your project's output folder. DevPartner automatically increments the file name based on the contents of the default directory (for example, MyApp.dpmdb, MyApp1.dpmdb, and so on). If you save session files to a location other than the default directory, you must manage the file naming.

For projects that do not have an output directory, such as a Visual Studio 2005 Web site project, DevPartner physically saves the files to the project directory.

Session files generated from the command line are not automatically added to the project's solution. You can manually add externally generated session files to an open solution in Visual Studio.

This concludes the Ready, Set, Go section of this chapter. Now that you have a basic understanding of the mechanics of running a code review session, continue reading the rest of this chapter for more information.

Setting Options

Use the many available options to customize code review behavior. Your specific settings are preserved in a preferences database on your system. DevPartner provides three option pages to modify code review options:

- General Options
- Naming Guidelines Options
- Suppressed Rules

Configuring General Options

The **General** options page contains code review settings that you can modify prior to a code review. To access the **General** options, from the **DevPartner** menu select **Options**, then select **DevPartner > Code Review > General** from the Tree View.

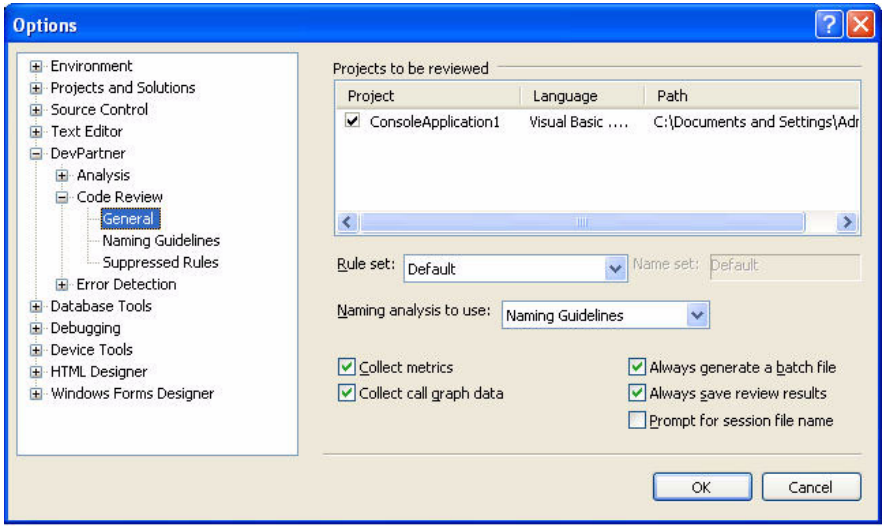


Figure 3-4. General Options Page

Selecting Projects To Be Reviewed

You can choose some or all of the projects in a solution from the **Projects to be reviewed** list. The contents will be empty if:

- You did not load a C# or Visual Basic solution in Visual Studio.
- You loaded a solution containing only C++ projects.

The **Projects to be reviewed** list contains the following information.

Table 3-1. Projects To Be Reviewed List

Item	Description
Check Box	The corresponding project will be reviewed when checked
Project	The name of the project

Table 3-1. Projects To Be Reviewed List (Continued)

Item	Description
Language	Visual Studio language associated with the project: • Visual Basic • C# • Web Site **Note:** The Web Site language type is only available in Visual Studio 2005 or later. It pertains to language-independent projects that use ASP.NET technologies.
Path	The path and name of the listed project

If you never made selections to the list of projects, DevPartner reviews all projects in the current solution by default. Once you edit the list of projects, DevPartner saves the state of included or excluded projects for the next time you work with this solution. The following caveats apply:

- You must select at least one project in order to review a solution. Otherwise, DevPartner will not let the code review proceed.
- You must have all selected projects set to output debug information. If a selected project is not set to output debug information for any available build configurations, you will be warned about build errors, and that project will be excluded from future sessions.
- If you select one or more projects that no longer exist in the solution, DevPartner will review the remaining projects.
- If you inadvertently delete all the projects in a solution that you later attempt to review, DevPartner will alert you that your selected projects no longer exist in the solution and will suggest that you make appropriate changes on the **General** options page.

Note: You cannot select individual files, classes, or methods within a given project.

Selecting Rule Sets

You can select a rule set from the **Rule set** list to apply to a code review. The **Rule set** list contains all DevPartner-supplied and user-configured rule sets. The selected rule set is preserved and used each time you run a session on the current solution.

Note: Make sure that you select a valid rule set that contains rules and already exists in the rules database. Attempting to use a rule set that has been removed via the Rule Manager, or is empty could invalidate the results.

You can create and customize rules (along with their associated triggers, which cause the rules to fire when they are violated), and create and manage rule sets, using the **Rule Manager** (see "Using the Code Review Rule Manager" on page 103).

Table 3-2. Standard Rule Sets

Rule Set Name	Description
All Rules	Provides a master rule set which, out of the box: • Contains all DevPartner rules in the rules database • Contains any user-configured rules in the rules database • Ensures a comprehensive code review
Date Formatting	Checks for proper formatting and use of date values, in particular 2-digit year formatted dates
Default	Contains high and medium priority rules
Design Time Properties	Checks for design time properties and property values of forms and controls to assist with good user interface design
Internationalization	Assists with localization, string handling, and comparison for the international market
Logic	Checks for proper program logic, good .NET Framework programming practices, error handling, type checking, and garbage collection
Performance	Checks for code that negatively impacts performance
Naming Guidelines	Searches for .NET Framework naming discrepancies that involve two or more identifiers in the source code
Web Applications	Checks for good ASP.NET development, HTML tag use, validation, performance, caching, and state

Selecting a Type of Naming Analysis

*Tip: You should choose a naming analysis type. Otherwise, DevPartner will bypass critical analysis functions. Only choose **None** to temporarily ignore naming anomalies while concentrating on other programming problems.*

Use the **Naming analysis to use** list to choose the type of naming analysis to apply to a review. Your choices include:

- **Naming Guidelines (default)**: Patterned after the Visual Studio .NET Framework naming guidelines.

Note: You must also set options on the **Naming Guidelines** options page to ensure a more precise review (see "Setting Naming Guidelines Options" on page 74).

- **Hungarian**: Patterned after the Hungarian Notation naming convention (see "Understanding the Hungarian Naming Analyzer" on page 101).

Note: You must also choose a valid Hungarian name set. The name set choice does not apply to the **Naming Guidelines** naming analysis.

- **None**: DevPartner will bypass naming analysis, and the **Naming** tab will be empty following the code review.

Selecting Name Sets

If you perform a Hungarian naming analysis on your source code, make sure that you also choose a valid Hungarian name set (by default, the **Default** name set is associated with the default DevPartner-supplied rule sets).

You can create and manage name sets using the **Rule Manager**. (see "Using the Code Review Rule Manager" on page 103).

Collecting McCabe Metrics

When you select **Collect metrics**, code review collects data that displays code complexity statistics, including complexity, bad fix probability, and understanding level. These metrics follow the industry-standard McCabe Metrics (see "Understanding McCabe Metrics" on page 86). The Metrics tab displays an aggregate of all items pertaining to the node selected on the Code Review Solution Tree.

Collecting Call Graph Data

When you select the **Collect call graph data** check box, code review collects information about all potential inbound and outbound calls to methods or properties, and displays a graphical representation of the results on the **Call Graph** tab. Individual nodes in the call graph represent the inbound and/or outbound call path for the selected method or property. The call graph shows a static representation of the potential method calls in the call path, rather than the dynamic calls made during program execution.

Generating Batch Files

When you select **Always generate a batch file**, DevPartner generates a batch file during the next interactive code review performed in Visual Studio. You can use this batch file to run a batch review from the command line on the same solution.

Note: If you use the `/r` option when running reviews in a batch file or from the command line, you should turn off **Always generate a batch file**, or backup and rename your batch file. Otherwise, your batch file will be overwritten. See "Using the Command Line Interface" on page 93

Saving Review Results

When you select the **Always save review results** check box, DevPartner saves the session file as *`SolutionName`*`.dpmdb` in the same location as your solution following a code review. DevPartner displays the saved session file the Visual Studio **Solution Explorer**.

Prompting for Session File Name

When you select the **Prompt for session file name** check box, DevPartner will prompt you to specify a location and name for the session file before it begins the review.

Setting Naming Guidelines Options

The **Naming Guidelines** options page includes choices that ensure a more precise review. To access the **Naming Guidelines** options, from the **DevPartner** menu select **Options**, then select **DevPartner > Code Review > Naming Guidelines** from the Tree View.

Note: Selections on this page are disabled until you select the **Naming Guidelines** naming analyzer from the **Naming analysis to use** list on the **General** options page (Figure 3-4 on page 70).

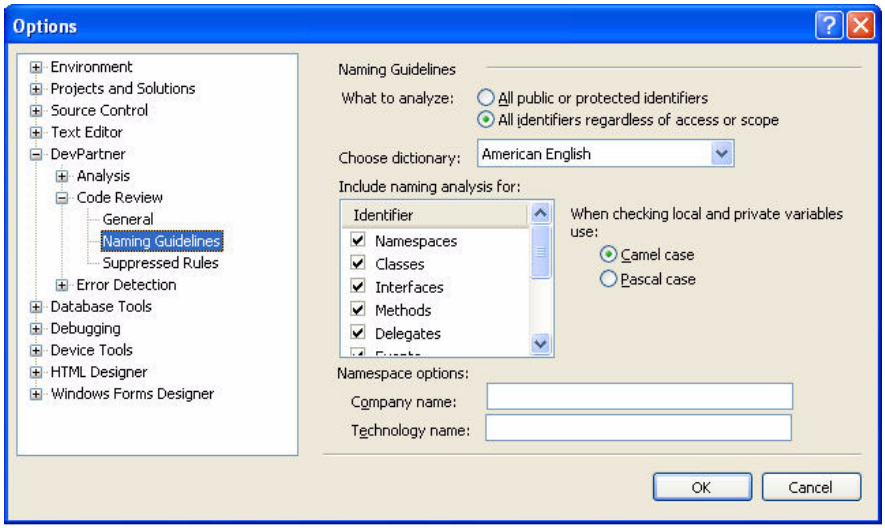


Figure 3-5. Naming Guidelines Options Page

Choosing Identifiers to Analyze

In the **What to analyze** section, select the type of identifiers to include in the analysis:

- **All public or protected identifiers (default)**: DevPartner code review will examine public or protected identifiers and internal protected identifiers. However, this option excludes local and private identifiers.
- **All identifiers regardless of access or scope**: DevPartner code review will examine all identifiers, regardless of access or scope.

Choosing a Dictionary

From the **Choose dictionary** list, select the dictionary database to apply to the naming analysis. DevPartner will search for naming violations based on the selected dictionary. **American English** is the default dictionary.

Choosing the Scope of Naming Analysis

In the **Include naming analysis for** list, select the corresponding check boxes for one or more identifiers for DevPartner to analyze. By default, all identifiers are selected.

Note: Checking the **Variables** check box might affect other variable-specific selections on this options page (such as **What to analyze**).

Selecting Camel Case or Pascal Case

Select your capitalization preference for DevPartner to use when validating named Variables. The two options are Camel case and Pascal case. Camel case refers to a variable where the initial word is lower-case but the secondary word is capitalized, such as `integerBonus`. Pascal case refers to a variable where each word in the name is capitalized, such as `IntegerBonus`.

Note: This option is unavailable (grayed out) if you did not already select **Variables** from the **Include naming analysis for** list. It is also unavailable if you have selected **All public or protected identifiers**.

Selecting Namespace Options

If you checked the **Namespaces** check box in the **Include naming analysis for** field, you can specify additional namespace options.

- **Company name**: Enter a string for your company's name.
- **Technology name**: Enter a string for your company's technology.

DevPartner code review will verify namespaces for appropriate use of capitalization, complete words, presence of reserved words, use of numbers, etc. DevPartner code review will also verify that each namespace follows the recommended namespace syntax: `CompanyName.TechnologyName[.Feature][.Design]`. When you provide a company name and/or technology name, code review will check that the namespace is constructed using these entries.

Managing Suppressed Rules

The **Suppressed Rules** options page contains a list of rules that have been suppressed in the **Problems** tab (see Figure 3-6). Suppressed rules may be temporarily unsuppressed by selecting the check box next to the suppressed rule in the **Suppressed Rules** options page. To access the **Suppressed Rules** options, from the **DevPartner** menu select **Options**, then select **DevPartner > Code Review > Suppressed Rules** from the Tree View.

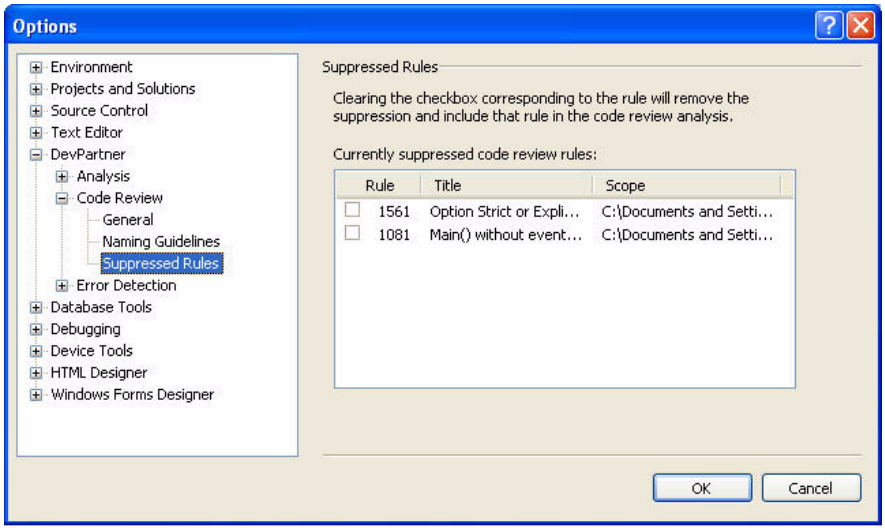


Figure 3-6. Suppressed Rules Options Page

Suppressing Rules

Suppressing a rule tells code review not to fire that rule in future sessions. Suppressing a rule is very different from filtering a code violation:

- When you suppress a rule, it is never fired, no data is collected, and nothing is preserved in the session file.
- When you filter code violations, the underlying rules still fire, the data is collected and saved in the session file, but is not displayed.

You can save rule suppressions locally in an individual solution or universally across all solutions. You must first perform a code review before you can select a rule to suppress.

1. Click the **Problems** tab on the Results window.

   The **Problems** tab lists the code violations.

2. Select a code violation to suppress its underlying rule.

3. Access the **Suppress Rule** dialog box in one of two ways:
   - Click the **Suppress Rule** toolbar button.
   - Right-click on the highlighted rule line, and select **Suppress Rule** from the context menu.

4. Choose the scope where you want to suppress the selected rule:
   - **Suppress this rule everywhere in this solution**: Affects future reviews of the current solution

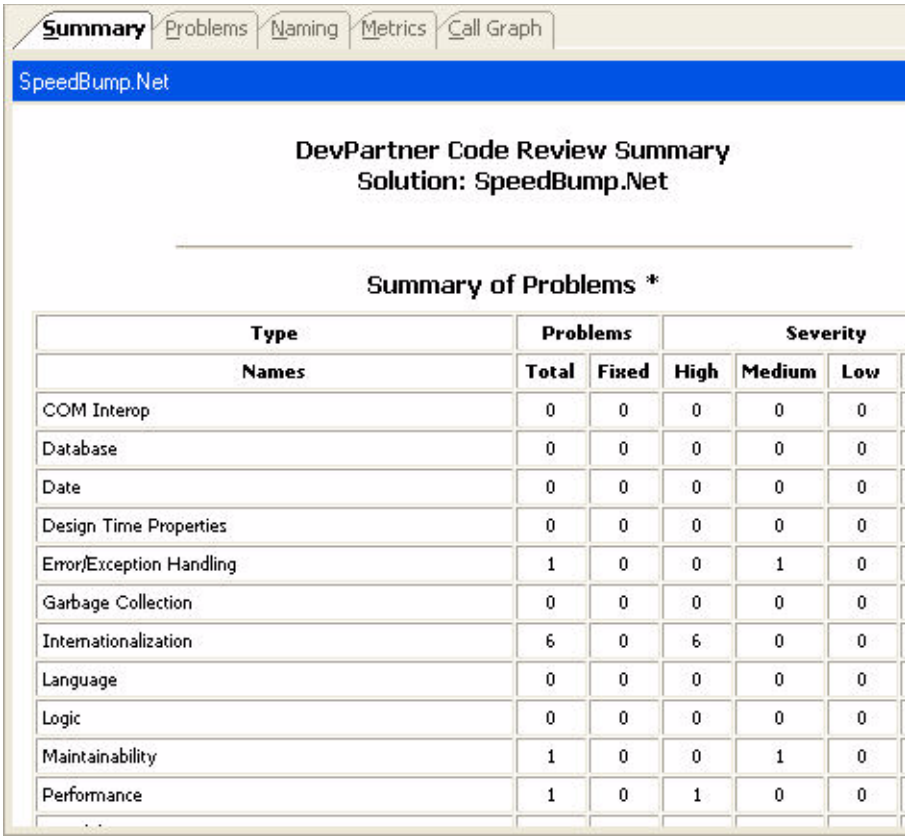
- ◇ **Universally across all solutions**: Universal effect on future reviews of all solutions

Note: When you select universal suppression, the preference database clears any solution-based suppressions for the rule and applies this universal setting across all solutions.

If you attempt to suppress a rule in the current solution and code review determines that the rule has already been suppressed in other solutions, the **Suppress Rule** dialog box will prompt you to apply universal suppression instead. You still can choose to suppress it only in the current solution.

Viewing Summary Data

The **Summary** tab consolidates summarized results data in a single location, while details about each aspect of the session are displayed on the other corresponding tabs. Some items on the **Summary** tab are dynamic. As items on the **Problems** or **Naming** tabs are marked as Fixed, the **Summary** tab dynamically reflects the update. If the review included unusual exceptions (such as running a review with an empty rule set), the **Summary** tab reflects that message in the header section. Scroll down the **Summary** tab to view each summary table.



Type	Problems		Severity		
Names	Total	Fixed	High	Medium	Low
COM Interop	0	0	0	0	0
Database	0	0	0	0	0
Date	0	0	0	0	0
Design Time Properties	0	0	0	0	0
Error/Exception Handling	1	0	0	1	0
Garbage Collection	0	0	0	0	0
Internationalization	6	0	6	0	0
Language	0	0	0	0	0
Logic	0	0	0	0	0
Maintainability	1	0	0	1	0
Performance	1	0	1	0	0

Figure 3-7. **Summary** Tab

- The **Summary of Problems** table lists the categories of rules that were assessed in your review. It indicates the number of violations discovered and the number you have marked as fixed. It then breaks down the total number of violations by severity category.
- **Summary of Naming Guidelines** lists the categories that you originally selected on the **Naming Guidelines** options page to be included in the review (Figure 3-5 on page 75). The table displays a summary of the naming identifiers selected on the **Naming Guidelines** options page, and indicates the number of violations found.

Note: This table only appears on the **Summary** tab if you selected **Naming Guidelines** on the **General** options page prior to the review (Figure 3-4 on page 70). This table is not available for the Hungarian naming analyzer.

- **Summary of Call Graph Data** summarizes information about the call graph analysis captured during the review, including the total number of methods and properties analyzed, and the number that appear to be uncalled.

Note: This table only appears on the **Summary** tab if you selected **Collect Call Graph Data** on the **General** options page prior to the review (Figure 3-4 on page 70).

- **Summary of Counts** includes individual statistics gathered about the code review session itself, including how long it took to run, the number of lines in the solution, the number of comparisons made, etc.
- **Review Settings** lists configuration and review-related data. This information is useful for record keeping and troubleshooting.
- **Project List** provides information for each project in the solution, including whether each project had compile errors, or was successfully reviewed.

Viewing Code Violations

By default, the **Problems** tab has focus in the Results window following a code review. The **Problems** tab displays code violations found in the current solution. A Details pane below the list of code violations provides further explanation, examples, and possible repairs when you select a specific violation.

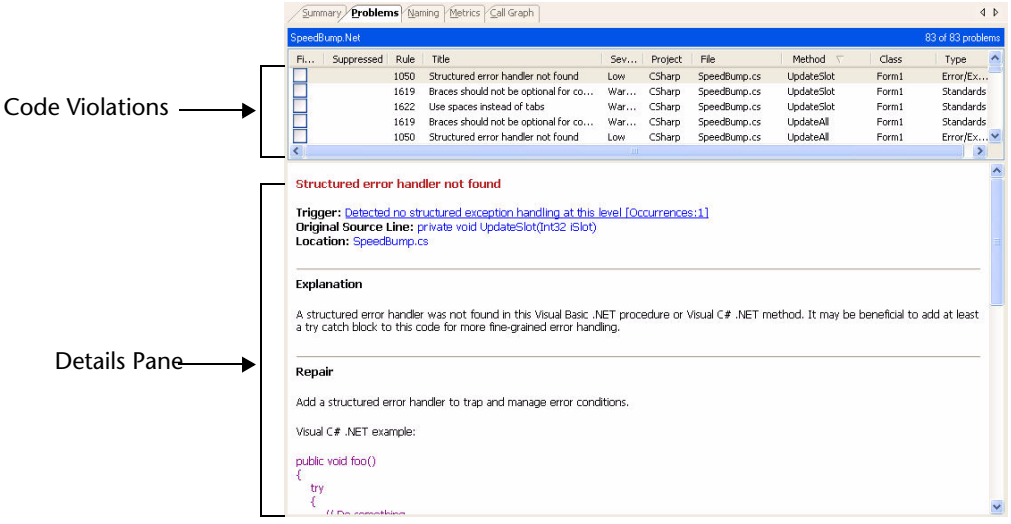


Figure 3-8. Problems Tab and Details Pane

Understanding the Problems Tab

The following table describes the information provided on the **Problems** tab.

Table 3-3. Contents of **Problems** Tab

Column	Description
Fixed	Status of the code violation The checkbox is checked when fixed
Suppressed	Status of the rule suppression Suppressed, or blank for not suppressed
Rule	Number assigned to that code violation
Title	Title of the rule
Severity	Severity level (High, Medium, Low, Warning)
Project	Project where the violation exists
File	File where the violation exists
Method	Method where the violation exists
Class	Class of the fired rule
Type	Rule type

Details Pane

Tip: Each code violation can include additional hyperlinks for Trigger, Original Source Line, and Location.

When you select a code violation on the **Problems** tab, more detailed information appears in the Details pane (see Figure 3-8 on page 80). The contents are generated from the rules stored in the code review rules database (system-supplied and user-configured). The following table lists the information provided in the Details pane.

Table 3-4. Contents of Details Pane

Heading	Description
Rule title (shown in red)	Title of the rule
Trigger	Name of the trigger; appears as a hyperlink that lets you go to the original source line (see "Configuring Triggers" on page 106)
Original Source Line	Line of code that caused the rule to fire
Location	Origin of the code violation
Explanation	Code violation description

Table 3-4. Contents of Details Pane (Continued)

Heading	Description
Repair	Recommendation to fix the problem
Notes	Additional comments, such as external links to Microsoft MSDN knowledge base articles

Viewing Naming Violations

The **Naming** tab lists naming violations that code review finds during a review. The appearance of the **Naming** tab varies depending on the type of naming analysis you selected on the **General** options page prior to the review (Figure 3-4 on page 70). See "Understanding Naming Analysis" on page 98 for more information about each naming analyzer.

Note: The **Naming** tab displays results from one or the other, but not from both naming analyzers. If **None** was selected, the **Naming** tab will be empty following a code review.

Analyzing Hungarian Results

Figure 3-9 shows how the **Naming** tab appears when the Hungarian naming analyzer is selected on the **General** options page (Figure 3-4 on page 70).

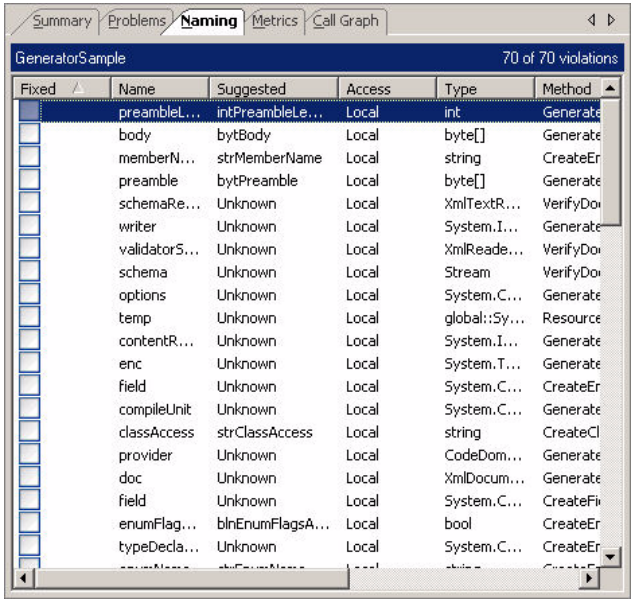


Figure 3-9. Naming Tab for Hungarian Naming Analysis

Analyzing Naming Guidelines Results

Figure 3-10 shows a two-panel representation of the naming results when the Naming Guidelines naming analyzer is selected on the **General** options page (Figure 3-4 on page 70). Notice the **Naming** tab in the upper panel and the Naming Details pane in the lower panel. Naming Guidelines analysis also enables the **View by** list above the **Naming** tab.

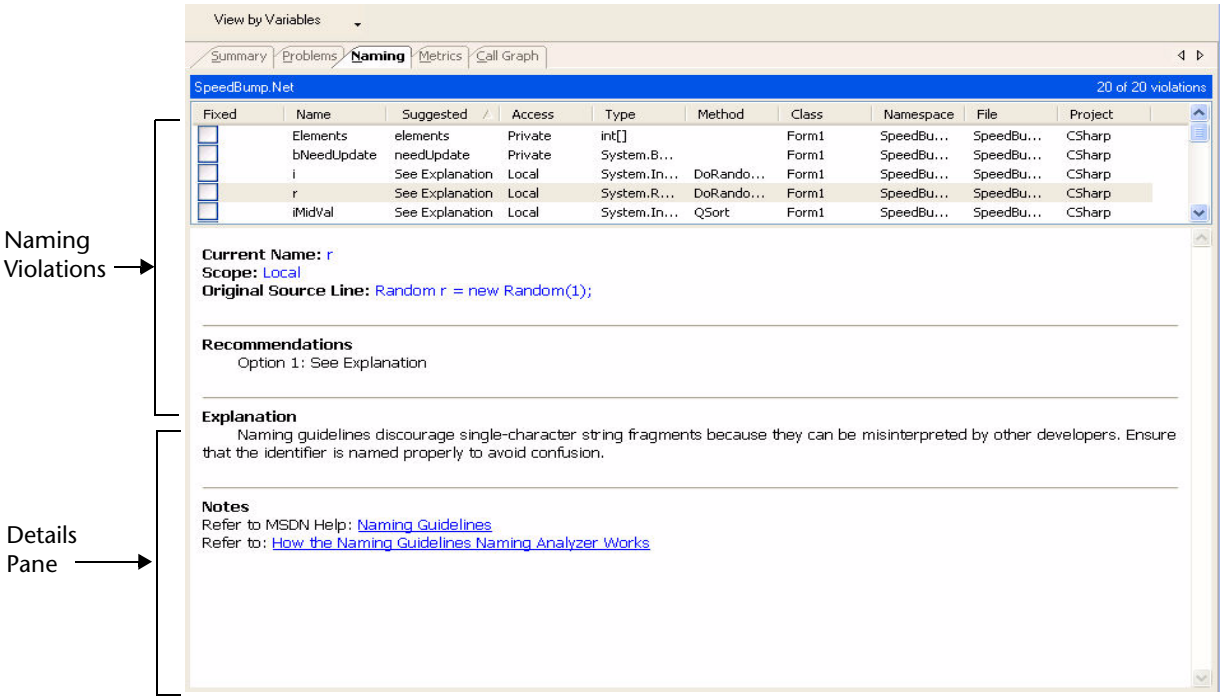


Figure 3-10. Naming Tab for Naming Guidelines Naming Analysis

The following table lists the information provided on the **Naming** tab, regardless of the naming analyzer selected.

Table 3-5. Contents of Naming Tab

Column	Description
Fixed	Status of the naming violation Select this check box when a violation is fixed.
Name	User-defined name for the data type

Table 3-5. Contents of Naming Tab (Continued)

Column	Description
Suggested	Suggested name Suggested names vary, depending on which naming analyzer is selected (see "Understanding Naming Analysis" on page 98) • If code review cannot suggest a name based on Hungarian naming conventions, Unknown appears in this column. • If code review cannot suggest a name based on Naming Guidelines, asterisks appear in this column. An explanation also appears on the Naming Details pane (Figure 3-10 on page 83).
Access	Category of access within the current solution
Type	Type of identifier
Method	Method where the data type is declared
Class	Class where the data type is declared
Namespace	Namespace where the data type is declared
File	File where the data type is declared
Project	Project where the data type is declared

Understanding the Naming Details Pane

If you selected Naming Guidelines and made additional choices on the **Naming Guidelines** options page (Figure 3-5 on page 75), a Details pane appears below the **Naming** tab, providing additional details about the selected naming violation.

Note: The Details pane is only available for the Naming Guidelines naming analyzer, not Hungarian.

Table 3-6. Contents of Naming Details Pane

Item	Description
Current name	Corresponds to the item selected in the upper panel
Scope	Indicates the scope of the identifier
Original Source Line	Displays the source line that pertains to the selected naming violation in the upper panel
Recommendations	Suggests one or more suitable names, based on the Naming Guidelines naming analyzer (see "Understanding the Naming Guidelines Naming Analyzer" on page 98)

Table 3-6. Contents of Naming Details Pane (Continued)

Item	Description
Explanation	Provides an explanation for why this violation was flagged as a problem **Note**: If code review cannot suggest a better name, an explanation appears in this pane. DevPartner code review also shows a series of asterisks in the **Suggested** column of the upper panel of the **Naming** tab.
Notes	Optionally includes a hyperlink to the Naming Guidelines knowledge base in the .NET Framework General Reference

Viewing Collected Metrics

The **Metrics** tab (Figure 3-11) displays code complexity results (complexity, bad fix probability, and understanding level), based on McCabe Metrics (see "Understanding McCabe Metrics" on page 86).

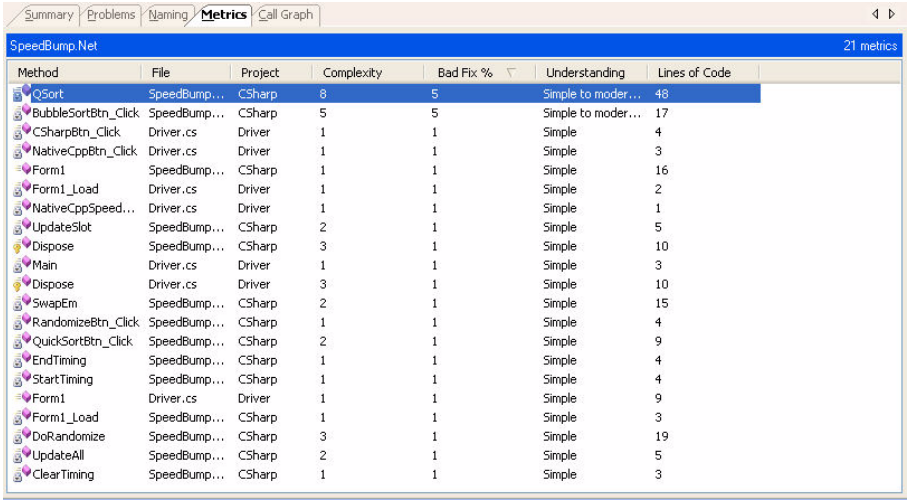


Figure 3-11. Metrics Tab

The **Metrics** tab only displays data if you selected the **Collect metrics** check box on the **General** options page prior to the review (Figure 3-4 on page 70). Table 3-7 lists the information provided on the **Metrics** tab.

Table 3-7. Contents of Metrics Tab

Heading	Description
Method	Method name where the code complexity issue originated
File	File name where the issue originated
Project	Project where the issue originated
Complexity	Degree of complexity regarding a particular component; this metric is related to McCabe Cyclomatic Complexity
Bad Fix %	Likelihood that a new bug will occur in the code when trying to fix a known bug
Understanding	How straightforward the code logic is to decipher and maintain
Lines of Code	Total lines of code within the selected component; breakdown of individual line counts appear on the **Summary** tab

Understanding McCabe Metrics

When you collect McCabe Metrics, the **Metrics** tab displays code complexity statistics, including: complexity, bad fix probability, and understanding level. These metrics follow the industry-standard McCabe Metrics. The **Metrics** tab displays an aggregate of all items pertaining to the node selected on the Code Review Solution Tree.

Complexity

Complexity (also called Cyclomatic Complexity or McCabe's complexity) represents an industry standard established as part of McCabe Metrics. Complexity is considered a broad measure of soundness and confidence for a program. This measure provides a single ordinal number that can be compared to the complexity of other programs. It is often used in concert with other software metrics. As one of the more widely accepted software metrics, it is intended to be independent of language and language format. The complexity number denotes a stronger measure of a program's structural complexity than counting the number of lines of code.

Complexity measures the degree of complexity in a module's decision structures by measuring the number of linearly-independent paths through a program module. Each component is analyzed individually and then all possible decision points are calculated, e.g., If-Then-Else and Select Case statements. With Select Case, each case is a separate decision point.

McCabe Metrics defines Cyclomatic Complexity for each module as `e - n + 2`, where:

`e`: is the number of edges in the control flow graph

`n`: is the number of nodes in the control flow graph

Cyclomatic complexity represents the minimum number of paths that should be tested. The more complex the code, the more intense the testing effort will be for that component.

Bad Fix Probability

Bad fix probability represents the likelihood of inadvertently inserting a new bug while attempting to fix a known one. Bad fix probability looks at a procedure and assesses the odds of introducing a new bug. Well-written code would typically generate a lower bad fix probability percent. Derived from McCabe Metrics, bad fix probability correlates with the understanding level and complexity results.

Understanding Level

Similar to complexity and bad fix probability, understanding level evaluates how easily a developer can interpret and maintain the code. Understanding level evaluates code as follows:

Table 3-8. Understanding Level Metric

Range	Understanding Level
Less than 5	Simple
Between 5 and 10	Simple to moderate
Between 11 and 20	Moderate
Between 21 and 30	Moderate to high
Between 31 and 50	High
Between 51 and 94	High to untestable
Greater than 94	Untestable

Correlating All Metrics

The following table shows how all three metrics correlate with each other.

Table 3-9. Correlation of McCabe Metrics

Code Complexity Range	Bad Fix Probability Percent	Understanding Level Interpretation
Less than 5	1%	Simple
Between 5 and 10	5%	Simple to moderate
Between 11 and 20	10%	Moderate
Between 21 and 30	20%	Moderate to high
Between 31 and 50	30%	High
Between 51 and 94	40%	High to untestable
Greater than 94	60%	Untestable

Viewing Call Graph Data

The **Call Graph** tab displays a static view of the inbound and outbound call path corresponding to the method or property selected from the **Code Review Solution Tree** (see Figure 3-12 on page 88).

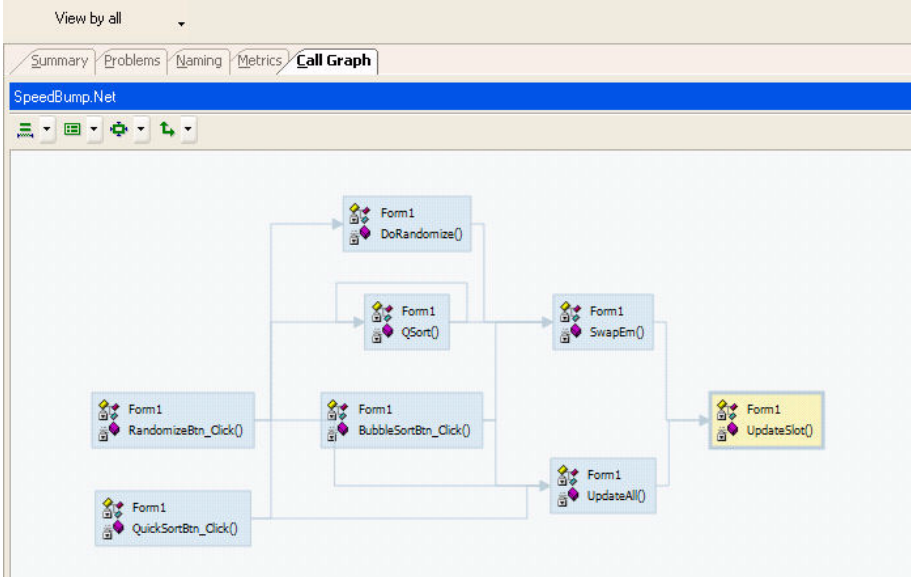


Figure 3-12. Call Graph Tab Showing Example of Call Graph Representation.

Note: Call paths are statically generated, not dynamically. This means that the graph shows the potential method calls in the call path, rather than the dynamic calls made during program execution.

The **Call Graph** tab is empty if:

- You did not select the **Collect call graph data** check box on the **General** options page (Figure 3-4 on page 70) prior to the code review. Call graph data was not collected during the review. To perform call graph analysis and collect call graph data, select this option and then perform another code review.
- You selected the check box, but did not select a method or property on the **Code Review Solution Tree** (see Figure 3-2 on page 65). Data was collected but no call graph appears until you select a method or property node on the **Code Review Solution Tree**.

Understanding Call Graph References

The **Call Graph** tab depicts potential inbound/outbound call references in a call path by tracing the call hierarchy for the selected method or property. The display area shows the potential entry and exit points for each method or property. The call references start at the root node with all calls performed in reference to the root node. The call references continue until control returns to the root node, or the call is completed from the root node. The following types of call references appear in the display area:

Root Node

The root node refers to the method or property selected to be the starting point of the call graph. All other nodes either call into the root node or are called by it. The root node (Figure 3-13) appears as a light yellow rectangle with a wide blue border, which distinguishes it from all other nodes in the display area.

Figure 3-13. Example of Root Node

Inbound Calls

Inbound refers to methods or properties that directly or indirectly call into the root node. The inbound calls (Figure 3-14) are shown as light blue rectangular nodes, which differentiates them from the root node.

Outbound Calls

Outbound refers to methods or properties that are directly or indirectly called by the root node. As with the inbound calls, the outbound calls (Figure 3-14) appear as light blue rectangular nodes. They are connected by a series of arrows, pointing away from the root, to show the potential direction of the call path.

Figure 3-14. Example of Inbound or Outbound Call Node

Uncalled References

Uncalled refers to a method or property that is defined in the code but never referenced within the files that form an application component. The **Call Graph** tab identifies uncalled methods on a node using either the label **Uncalled** or the symbol (!).

with label

with icon

Figure 3-15. Two Examples of Uncalled Identification

Recursive and Circular Call References

The **Call Graph** tab can graphically show instances of recursive or circular call references that exist in the selected path of execution.

- Recursive: Method or property that calls itself in the path of execution.

  A calls B;

  B calls B

Figure 3-16. Example of Recursive Call Graph

- Circular: Method or property that indirectly calls back into a previously called method or property in the path of execution.

A calls B;
B calls C;
C calls back to A

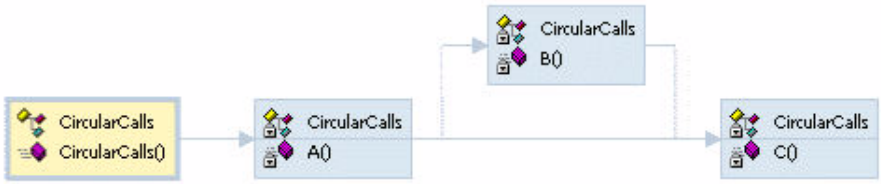


Figure 3-17. Example of Circular Call Graph

Setting Call Graph Configuration Options

DevPartner code review provides four ways to configure how a call graph appears in the **Call Graph** tab. Access these options either from the Call Graph toolbar or by right-clicking on the background area of the **Call Graph** tab.

Number of Levels

Choose the number of levels to be displayed on the **Call Graph** tab. The call graph shows a specified number of levels of methods or properties that call into (inbound) and are called from (outbound) the root node. You can choose between one and six levels (six, default). The following example shows two levels selected. The plus signs (+) on the nodes to the right of the call graph indicate that more levels of call references are available for viewing.

Figure 3-18. Shows Two-level Configuration

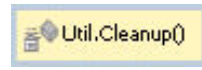
Node Style

You can choose the node style that will be applied to the **Call Graph** tab. All call graph node styles show the class name, as well as the method or property name. Some node styles also include icons indicating the access type of the class, method, or property: public, private, internal, or protected. These are standard Solution Tree icons. Other icons, representing uncalled methods and properties, only appear in the call graph.

The following table shows examples of the various node styles.

Note: Some examples show root node and others use standard node (inbound or outbound). See "Understanding Call Graph References" on page 89 for more information on how nodes are differentiated.

Table 3-10. Node Styles

Node Style	Description	Uncalled Representation	Examples
Single label	Shows the class name, then a period, followed by the method or property name, but without icons	The designation – `Uncalled` appends the method or property name.	 Inbound/outbound
Top and bottom labels	Shows the class name appearing on the first line and the method or property name appearing on the next, but without icons	The designation – `Uncalled` appends the method or property name on the second line.	 Inbound/outbound
One image and label	Shows a standard method or property icon, plus the class name, then a period, followed by the method or property name, all on the same line	The corresponding icon includes an exclamation point icon (**!**).	 Root
One image and two labels	Shows an icon for the method or property, along with the class name on the first line and the method or property name on the second line	The corresponding icon includes an exclamation point icon (**!**).	 Root
Two images and two labels	Shows an upper-level icon for the class followed by the class name, and a lower-level icon for the method or class, followed by its name	The explanation point icon (**!**) icon appears between the data type icon and the name.	 Root

Scaling

Choose the relative size of the call graph on the **Call Graph** tab. Two scaling options are available:

- To fit in available space (default)

  This selection lets you scale the call graph so that all the nodes fit within the display area. By default, scroll bars are not available with this choice. If you reconfigure the call graph using the other options, the contents will be resized without the inclusion of scroll bars.

- By percent of full size

  This selection lets you enlarge or shrink the contents in the display area by one of these fixed percentage values: 100%, 80%, 75%, 66%, or 50%. This choice allows you to zoom into sections of a large or complicated call sequence. Moreover, when the contents are redrawn, the selected method or property (root node) is clearly visible in the display area. Scroll bars are also available.

Layout

Choose how the call graph nodes will be laid out on the **Call Graph** tab. Your choices include:

- Horizontal

  The nodes appear in a left-to-right orientation in the display area. The methods or properties calling into the selected node (also called the root node) are located to its left. The methods or properties that the selected node calls into branch to the right.

- Vertical

  The nodes appear in a top-to-bottom orientation in the display area. The methods or properties calling into the selected root node are located above the root node. The methods or properties that the selected node calls into are located below it.

Using the Command Line Interface

You can run a batch script from the command line interface (using `CRBatch.exe`) to review large solutions with many managed projects, or as an overnight or automated build process. The command line interface streamlines the code review process by bypassing user interaction.

Note: If the solution file is set to read-only, Visual Studio will interrupt the batch review with an error message.

When you select **Always generate a batch file** on the **General** options page, code review generates a batch file during the next interactive code review performed in Visual Studio. You can use this batch file to run the batch review on the same solution.

Note: If you use the /r option, you should disable **Always generate a batch file**, or backup and rename your batch file. Otherwise, your batch file will be overwritten.

The command line interface generates an HTML-formatted summary file (`CR_solution-name.htm`) in the solution directory after a review completes. This file is identical in content to the session file generated interactively.

You can script a batch procedure that reviews your solution, and then:

- E-mails the generated summary and session files to another location
- Saves the summary file to a local intranet for later viewing from that location, or from an external Internet Web site
- Calls `CRExport.exe` to export the data to XML for even more formatting and display options (see "Exporting Data to XML" on page 96)

If code review cannot execute a batch review, it creates an error file, `CR_solution-name.err`. If the batch file fails on an attempted export to XML, it creates an error file `CREXPORT_sessionfiledatabasename.err`. Both error log files are created in the same path as the session file.

Syntax and Options

Run a code review session from the command line or batch file using the following command line syntax and options:

```
CRBatch.exe [/?] /f filename [/v] [/r] [/vs version]
```

Table 3-11. Command Line Options

Option	Definition
/?	Displays the list of command line options for `CRBatch.exe`
/f *filename*	Identifies the configuration file to use in the review (mandatory)
/v or /verbose	Instructs the command line interface to report errors in a message box and to set the exit code used by the batch procedures (optional, although useful when physically debugging configuration files)
/r or /results	Instructs the command line to examine the results of the review for coding problems and naming violations, and return a specific error code if either or both error types were found (optional)

Table 3-11. Command Line Options

Option	Definition
/vs "9.0" or /vs "8.0"	Indicates the Visual Studio .NET Framework version where the batch review will execute: 9.0 (2008) or 8.0 (2005)

Understanding the Error File

The following error codes are returned to a calling batch process when the command line interface exits.

Table 3-12. Command Line Error Codes

Error Number	Message
0	Successful
1	No configuration file specified
2	Configuration file does not exist
3	No solution file was specified
4	Solution file does not exist
5	CRBatch initialization error
6	Invalid command line argument
7	Create Visual Studio process failed
8	License check failed
9	Visual Studio exited with an error
10	Visual Studio version number incorrect
11	Unexpected error
12	Coding problems found
13	Naming violations found
14	Coding problems and naming violations found
70	Attempt to create error file (`.ERR`) failed

If a batch-generated review encounters a build error or compile errors exist in the solution being reviewed, the batch review will stop unexpectedly without generating a session or summary file. An error message is appended to the error file.

Note: Error 11 is returned for unexpected runtime errors. The error details (error message and stack-trace) are written to the `.ERR` file.

Exporting Data to XML

DevPartner code review allows you to export session results data to XML, providing you with a simple way to port your results data into report formats, e-mail, an internal Web page, etc. You can export your data to XML:

- From code review, after running a code review session
- From the command line, using a saved session file
- In an automated batch process, using a saved session file

The `DPCRExport.xsd` schema file, located in the CodeReview installation directory, describes the contents and XML format for exported data.

Exporting Session Data from within DevPartner

After completing a code review, you can export all data from the current session file to an XML file. Select **Export DevPartner Data** from the **File** menu and provide a name for the export file. By default the file is saved in the same location as the solution, but the file will not appear in the solution explorer.

Note: You must maintain focus in the code review session window to export code review data.

This process always exports all session data, including inbound methods from the call graph data. To be more selective about what categories of data you export to XML, use the command line.

If code review cannot export your session data to XML, it generates an error message describing the problem it encountered.

Exporting Session Data from the Command Line

DevPartner code review includes a command line utility, `CRExport.exe`, that exports the results of a code review session to an XML file. To export session data you must specify the session file and the output file using the mandatory command line arguments. For example:

```
CRExport.exe /f C:\MyResults\WebApp1.DPMDB /e C:\MyXML\WebAppData
```

Optional command line arguments also let you specify the categories of data to export from the session database file.

Note: If you call `CRExport.exe` without passing it any of the optional arguments, it exports all session data, including inbound methods.

This behavior is equivalent to passing `CRExport.exe` the `/a i` arguments, or initiating the data export from within DevPartner.

If the export utility cannot create the export file, it generates an error log file, `CREXPORT_`*`sessionfiledatabasename`*`.err`, in the same path as the session file.

Syntax and Options

Export your session data to XML via the command line or batch file using the following command line syntax and options:

`CRExport.exe [/?] /f `*`sessionfile`*` /e `*`xml_exportfile`*` [/a | /a i | /p | /m | /n | /s | /c | /c i]`

Table 3-13. Command Line Options

Option	Definition
/?	Displays the list of command line options for `CRExport.exe`
/f *sessionfile*	Identifies the session database to use for this export (mandatory)
/e *xml_exportfile*	Identifies the XML file to receive the exported data (mandatory)
/a	Exports all data for the specified session, including the outbound methods for call graph data, but Inbound methods are not exported
/a i	Exports all data for the specified session, including inbound and outbound methods for call graph data
/p	Exports the problems data for the specified session
/m	Exports the metrics data for the specified session
/n	Exports the naming analysis data for the specified session
/s	Exports the code size data for the specified session
/c	Exports the outbound, or called, methods in the call graph data for the specified session
/c i	Exports the call graph data, including inbound and outbound methods, for the specified session

Exporting Session Data from a Batch Process

You can use `CRExport.exe` along with `CRBatch.exe` as a single batch process to conduct a code review, and then export the session data to XML. This feature is especially useful when you already run a code review via batch process:

- As part of a nightly build process
- On very large applications
- To automate your quality control testing

Understanding Naming Analysis

The code review feature incorporates two kinds of naming analysis capabilities:

- Naming Guidelines

  The naming analyzer supports the .NET Framework. See "Understanding the Naming Guidelines Naming Analyzer" on page 98.

- Hungarian

  The Hungarian naming analyzer is a legacy naming analyzer in code review. See "Understanding the Hungarian Naming Analyzer" on page 101.

Note: You can also choose **None** from the **Naming analysis to use** list on the **General** options page (Figure 3-4 on page 70) to bypass naming analysis altogether.

Understanding the Naming Guidelines Naming Analyzer

The Naming Guidelines naming analyzer is patterned after the Visual Studio .NET Framework naming guidelines. These naming guidelines ensure that consistent, predictable, and manageable naming practices are applied to .NET Framework types in a managed class library.

Note: Choose **Naming Guidelines** from the **Naming analysis to use** list on the **General** options page (Figure 3-4 on page 70), plus make additional selections on the **Naming Guidelines** options page (Figure 3-5 on page 75) to ensure a more precise review.

The Naming Guidelines naming analyzer examines:

- Parameters
- Classes
- Namespaces
- Methods
- Delegates
- Enums
- Structs
- Interfaces
- Variables

The naming analyzer looks for naming violations in the source code related to capitalization, case sensitivity, abbreviations and acronyms, and syntax for namespaces and other .NET Framework identifiers.

The following sections describe guidelines that the Naming Guidelines naming analyzer follows.

Capitalization

When it finds a naming violation, code review attempts to suggest a more appropriate name on the **Naming** tab using the capitalization style that you selected on the **Naming Guidelines** options page — Camel or Pascal.

Table 3-14. Capitalization Styles Used in Naming Guidelines Naming Analyzer

Capitalization Style	First Concatenated Word	Subsequent Concatenated Words	Examples of Suggested Names
Camel case	Not initial-capped	Initial-capped	**r**ed**C**olor
Pascal case	Initial-capped	Initial-capped	**R**ed**C**olor

Case Sensitivity

DevPartner code review discourages using case sensitivity to differentiate identifiers in the source code. Case insensitivity is strongly encouraged because it supports interoperation between case-sensitive and case-insensitive programming languages and also reduces confusion between two similarly-named identifiers. Developers should avoid names that vary only by case. Rather, they should use names that are functional in either case-sensitive or case-insensitive programming languages.

Abbreviations and Acronyms

DevPartner code review supports the use of generally accepted abbreviations and acronyms. DevPartner code review determines proper naming based on:

- The number of letters for the abbreviation or acronym
- The position of the abbreviation or acronym in the identifier name

Namespace Syntax

DevPartner code review supports the .NET Framework naming convention for namespaces. The namespace name starts with the company name, followed by the technology name, and optionally ends with the feature and/or design name. Here is an example of the syntax:

```
CompanyName.TechnologyName[.Feature][.Design]
```

By default, code review recommends Pascal case for namespaces (see "Selecting Camel Case or Pascal Case" on page 76). The period character (.) separates each logical concatenated word. Enter the namespace information in the **Namespace options** field on the **Naming Guidelines** options page (Figure 3-5 on page 75) prior to the review.

Syntax for Other .NET Framework Identifiers

DevPartner code review checks for properly named .NET Framework identifiers in the source code. Here are some examples of what code review looks for:

- Numeric characters

  DevPartner code review checks whether numbers are part of the identifier name. While code review does not remove the numeric characters, it does flag the name as a violation.

- Underscore characters

  DevPartner code review looks for instances of the underscore character (_) in the identifier name. The underscore character is discouraged in the Naming Guidelines naming analyzer. DevPartner code review removes the underscore character except in the following cases:

  - If the underscore is a leading character (i.e., _redColor)
  - If it is used in a method name
  - If its removal introduces another naming violation

- Casing for constants

  DevPartner code review follows Pascal or Camel casing for constants (depending on the case selection you made on the **Naming Guidelines** options page), rather than all uppercase. For example, code review would change the constant HTTP_PORT in:

  ```
  private const int HTTP_PORT = 80
  ```

  - To HttpPort based on Pascal
  - To httpPort based on Camel

- Delegate

  If a delegate identifier name includes the word delegate (regardless of case) along with one or more identifiable words, code review removes the word delegate as long as it does not introduce another violation. For example, the name, `MyDelegateWord`, would be renamed as `MyWord`.

Understanding the Hungarian Naming Analyzer

DevPartner code review includes the Hungarian naming analyzer, patterned after the Hungarian Notation naming convention.

With Hungarian naming, variable names include specific character(s) that identify a particular scope-level or data-type prefix for the variable in question. For example, the data-type prefix `int` signifies an integer, such as integer variable `Port`; and the scope-level prefix `g_` signifies global, as in `g_intPort`.

DevPartner code review uses the Hungarian naming analyzer in a code review when the **Hungarian** option is selected from the **Naming analysis to use** list on the **General** options page (Figure 3-4 on page 70). DevPartner code review also uses the currently selected name set. When you start a code review, the naming analyzer evaluates scope-level prefixes and data-type prefixes for every variable in the code. If applicable, code review makes recommendations consistent with the name set (*Default* preferred) and displays the naming results on the **Naming** tab (Figure 3-9 on page 82) following the code review.

Note: The Hungarian naming analyzer does not evaluate parameter names.

The following tables list examples of scope-level and data-type prefix combinations that are evaluated in the Hungarian naming analyzer, as specified in the current name set.

Table 3-15. Scope Prefix

Scope	Prefix
Global	g_
Member	m_
Local	""

Table 3-16. Data Type Prefix

Data Type	Prefix
string	str
int	int
int	i
boolean	bool
bool	bln

The qualifiers on a variable declaration determine the scope, such as the boundaries where the variable exists. For example, code review considers a variable with public status as having a global scope because it is accessible outside the class.

The default name set contains scope prefixes that you can edit using the Rule Manager. You can also customize variable and object names, based on Hungarian Notation, using the Rule Manager.

Constructing a Hungarian Naming Suggestion

The Hungarian naming analyzer makes a more appropriate suggestion when it encounters one or more of the following anomalies in your source code:

- It finds an incorrect or missing scope prefix (e.g., `m_` for global, instead of `g_`)
- It finds an incorrect or missing data type prefix (e.g., `Short`, instead of `intShort` for integer type)
- You selected the **Warn if the first letter after the prefix is not capitalized** check box (on the **New Rule Set** or **Edit Rule Set** dialog box in the **Rule Manager**) to apply to the Hungarian name set, but the first letter of the variable name following the prefix, is not capitalized.

The naming analyzer combines the following: **Scope Level Prefix + Data Type Prefix**. If you have not specified a scope-level prefix in the Hungarian name set, the suggested name would begin with the data type prefix.

DevPartner code review will display **Unknown** on the **Naming** tab, rather than attempt to suggest a name if code review cannot recognize the data type for a variable because:

- The data type does not exist in the current Hungarian name set
- You have selected the **Warn if unknown objects are found** check box on the **New Rule Set** or **Edit Rule Set** dialog box in the **Rule Manager** to apply to the name set

See "Using the Code Review Rule Manager" on page 103 for more information on managing name sets.

Using the Code Review Rule Manager

DevPartner code review contains an extensible rules database that is based on the Microsoft Visual Studio programming standards. The rules database is maintained and stored in the Rule Manager standalone application. With Rule Manager, you can configure rules, triggers, and rule sets. You can also configure Hungarian name sets that the Hungarian naming analyzer uses during a code review. The Rule Manager automatically stores any modifications you make to the code review rules database. These modifications become immediately available when you configure and perform your next code review.

Access Rule Manager by selecting **Compuware DevPartner Studio > Utilities > Code Review Rule Manager** from the **Start** menu.

Configuring Rules

Use the Rule Manager to create, edit, and delete rules. You can also add HTML links to the rule descriptions to provide more information for developers trying to resolve violations.

Creating Rules

Use the **New Rule** dialog box to create and configure a new rule. To create a new rule, complete the following steps:

1 Select **Rule > New Rule**.

The **New Rule** dialog box opens with the **General** tab displayed by default. The title bar shows the pre-assigned rule number. The status bar shows the current **Owner** and **Last Edit** details (see Figure 3-19).

Note: Until you create a Trigger and Expression for the rule, it will not fire.

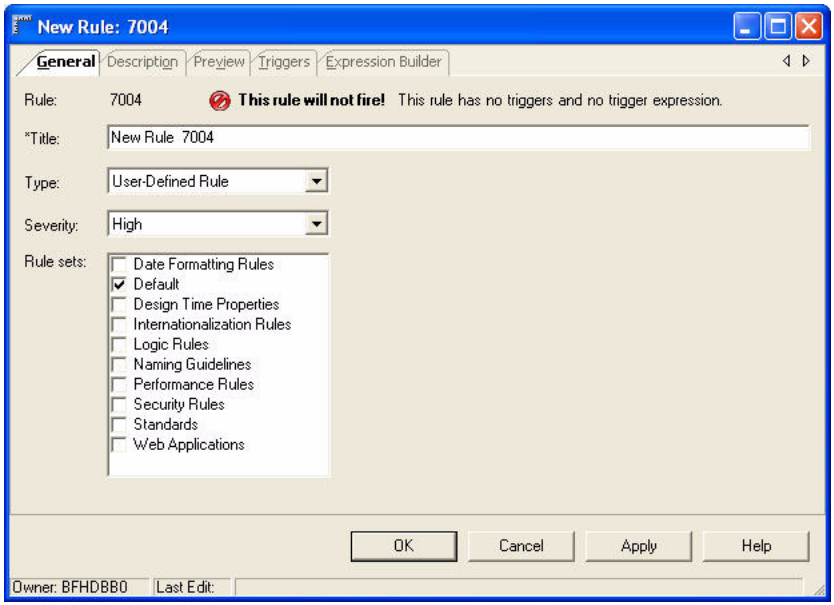


Figure 3-19. New Rule Dialog Box

2 Set up the new rule using the following tabs (in this order):

   a **General** — to enter general rule properties

   b **Description** — to enter details about the rule

   c **Preview** — to review current entries

   d **Triggers** — to configure up to five triggers for the rule

   e **Expression Builder** — to build trigger expression(s) for each trigger

3 Click the **Description** tab and add a description for the rule.
You can use the Description tab to provide HTML links that direct developers to external resources to help resolve coding issues. These links will appear in the lower panel (**Description** pane) of the **Problems** tab following a code review session.

4 Click the **Triggers** tab, and add a trigger for your rule.
See "Configuring Triggers" on page 106 for more information on creating a trigger.

5 Select the **Expression Builder** tab to build a trigger expression.
You can build an expression for each trigger you just configured on the **Triggers** tab. For more information on building trigger expressions, refer to the Rule Manager online help.

Editing Rules

Use the **Edit Rule** dialog box to modify existing rule properties. The Edit Rule dialog box contains all the same fields as the New Rule dialog box (see Figure 3-19 on page 104). To edit an existing rule, complete the following steps:

1 Select **Rule** > **Edit Rule**.

The **Edit Rule** dialog box opens with the **General** tab displayed by default. The title bar shows the rule number and title. The status bar shows the current **Owner** and **Last Edit** details.

2 Modify the existing rule using the following tabs (in this order):

- a **General** — to modify existing rule properties
- b **Description** — to modify details about the rule
- c **Preview** — to review current entries
- d **Triggers** — to modify settings for the existing triggers
- e **Expression Builder** — to modify trigger expression(s) for each trigger

Deleting Rules

You can only delete user-configured rules that reside in **All Rules**, not any DevPartner-supplied rules. When you delete a user-defined rule from **All Rules**, the Rule Manager automatically deletes it from any other rule sets where it also resides.

Note: Editing a DevPartner-supplied rule removes it from system ownership but does not change it to user-defined status. You cannot delete it from **All Rules**.

To delete a rule, complete the following steps:

1 Select **All Rules** from the **Rule Set** list.

The rules in **All Rules** appear in the **Rule List** pane.

Rule	Title	Severity	Type	Language	Owner
1002	Return value from Main() may be inco...	Medium	Logic	Visual C#....	DevPartner
1003	Method contains multiple string conca...	Medium	Performance	Visual Basi...	DevPartner
1004	Use of @ symbol found	Medium	Maintainab...	Visual C#....	DevPartner
1005	Hidden method found	Warning	Maintainab...	Visual Basi...	DevPartner
1006	Main() called from within application	High	Logic	Visual Basi...	DevPartner
1007	Fully qualified name used	Warning	Maintainab...	Visual Basi...	DevPartner
1008	Identifier names differing only in case f...	Warning	Maintainab...	Visual C#....	DevPartner
1010	Redim of array found	Medium	Performance	Visual Basi...	DevPartner
1012	Passing classes and structs to or from...	Warning	COM Interop	Visual Basi...	DevPartner
1013	Potential performance problem with cl...	High	Garbage C...	Visual Basi...	DevPartner
1014	Possible reference to self created in o...	High	Garbage C...	Visual Basi...	DevPartner

Figure 3-20. Rules List Pane

2 Select one or more user-defined rules in the **Rule List** pane.

3 Select **Rule > Delete Selected Rules from Rules Database**.
The Rule Manager deletes the selected rule(s) from the **All Rules** rule set.

Note: This action cannot be undone.

Note: **Delete Selected Rules from Rule Database** is only enabled in the **Rule** menu once you have selected **All Rules** from the **Rule Set** list.

Configuring Triggers

Select the **Triggers** tab to configure up to five triggers that will fire a rule.

Note: Although some DevPartner-supplied rules use macros, you cannot edit or configure a trigger for any rules that are macro-based.

If no triggers are associated with the rule you are configuring, the **Existing Triggers** list box is the only visible field and appears empty. In addition, the **Add** button becomes available so that you can add a new trigger to the setup.

If one or more triggers already appear in **Existing Triggers**, the other fields applicable to the trigger's **Type** are displayed, and required fields appear with an asterisk. The **Add** and **Delete** buttons are available for setup.

Adding a Trigger

Complete the following steps to add a trigger:

1 Click the **Add** button to add a new trigger.

The **Rule Manager** displays a default name, *New Trigger n*, in the **Trigger Name** field. For example, if this is your first trigger, the name will be **New Trigger 1** (Figure 3-21).

Note: When you reach the five trigger limit, the **Add** button on this pane automatically becomes unavailable.

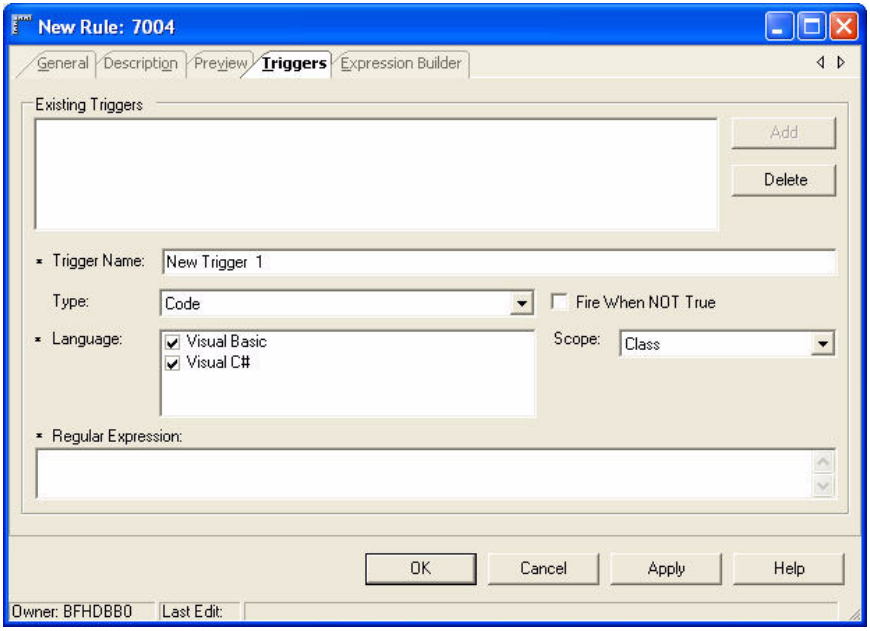


Figure 3-21. New Trigger Tab

2 Enter or change the trigger name.

Do not use left `[` or right `]` brackets, such as in `[CheckString]`. If you type in bracket characters, the Rule Manager will ignore these keystrokes. Brackets delimit multiple triggers in a trigger expression within the **Expression** field on the **Expression Builder** pane. An attempt to manually insert brackets invalidates a trigger expression.

3 Select a trigger type from the **Type** list.

The trigger type selection determines the remaining parameters for the trigger being configured (see Table 3-17).

Table 3-17. Trigger Types

Type	Function
Code	Detects problems in the actual source code
Web Form Page	Ensures compliance with HTML and/or ASP.NET tag construction

Table 3-17. Trigger Types

Type	Function
Design Time Property	Isolates the trigger firings to specific Visual Studio .NET properties
Web.config	Ensures compliance with elements in ASP.NET Web.config files

4 Configure all the required fields for the selected trigger type. Depending on the **Type** selected, you will have to supply different parameters for your trigger. For more information on configuring your specific trigger type, refer to the Rule Manager online help.

5 Add a regular expression for your rule to the Regular Expression text box (see "Creating New Rules Using Regular Expressions" on page 116).

Deleting a Trigger

To delete a trigger listed in **Existing Triggers**, complete the following steps:

1 Select the trigger and click **Delete**.

A confirmation message appears.

2 Click **Yes** to confirm or **No** to abort this action.

Note: You cannot delete a trigger if it is already being used in a trigger expression.

Configuring Rule Sets

Rule sets are collections of rules you can use in a code review session. DevPartner code review includes a selection of pre-configured rules sets. You might find you want to work with custom rule sets, and you can use the Rule Manager to create, edit, or delete rule sets.

Creating Rule Sets

The Rule Manager includes a master rule set called **All Rules**. However, you can create additional rule sets tailored to your project-specific requirements. To create a new rule set, complete the following steps:

1 Select **File > New Rule Set**.

The **New Rule Set** dialog box appears (Figure 3-22).

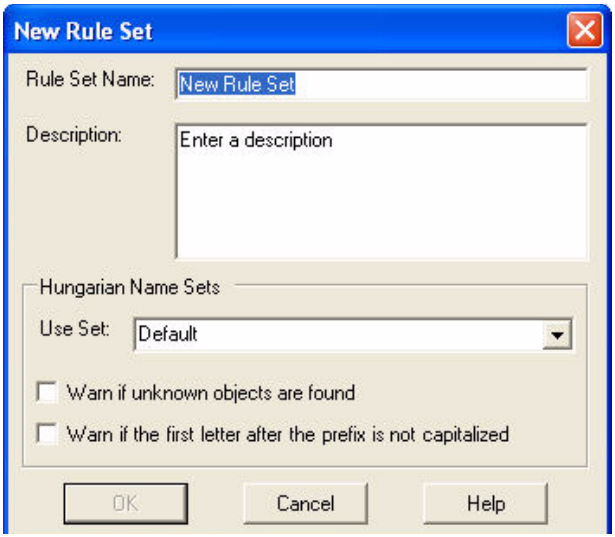


Figure 3-22. New Rule Set Dialog Box

2 Enter a rule set name in the **Rule Set Name** field (up to thirty characters).

3 Enter a brief description for the new rule set in the **Description** field (optional).

4 Select a Hungarian name set from the **Use Set** list in the **Hungarian Name Sets** section of the dialog box.

Note: Name sets in the Rule Manager only support the Hungarian naming analyzer, patterned after the Hungarian naming convention. They do not support the Naming Guidelines naming analyzer, patterned after the Visual Studio .NET naming guidelines.

5 Choose how you prefer Hungarian naming violations to appear on the **Naming** tab:

- ◇ If you select **Warn if unknown objects are found**, code review will specify a naming violation as **Unknown** if it cannot make a suggestion.
- ◇ If you select **Warn if the first letter after the prefix is not capitalized**, code review will make a suggestion.

6 Click **OK**.

The Rule Manager validates the new rule set.

7 Populate the rule set with rules by:

- ◇ Creating new rules (see "Creating Rules" on page 103).

- ◇ Opening an existing rule set in order to select, copy, and paste rules into the new rule set.

Editing Rule Sets

To edit the properties of a rule set, complete the following steps:

1. Select an existing rule set from the **Rule Set** list.
2. Select **File > Rule Set Properties**.

   The **Edit Rule Set** dialog box appears. The Edit Rule Set dialog box has the same available fields as the New Rule Set dialog box (see Figure 3-22 on page 109).
3. Enter a rule set name in the **Rule Set Name** field (up to thirty characters).
4. Enter a brief description for the new rule set in the **Description** field (optional).
5. Select a Hungarian name set from the **Use Set** list in the **Hungarian Name Sets** section of the dialog.

Note: Name sets in the Rule Manager only support the Hungarian naming analyzer, patterned after the Hungarian naming convention. They do not support the Naming Guidelines naming analyzer, patterned after the Visual Studio .NET naming guidelines.

6. Choose how you prefer Hungarian naming violations to appear on the **Naming** tab:
   - ◇ If you select **Warn if unknown objects are found**, code review will specify a naming violation as **Unknown** if it cannot make a suggestion.
   - ◇ If you select **Warn if the first letter after the prefix is not capitalized**, code review will make a suggestion.
7. Click **OK**.

   The Rule Manager validates the changes to the rule set properties.

Deleting Rule Sets

To delete an existing rule set, complete the following steps:

1. Select a rule set from the **Rule Set** list.

Note: You can delete user-defined rule sets, but not DevPartner-supplied rule sets.

2. Select **File > Delete Rule Set**.

   The **Delete Rule Set** dialog box appears.

3 Click **Delete**.

Note: This action cannot be undone.

Configure Hungarian Name Sets

Use the Rule Manager to create, edit, duplicate, or delete Hungarian Name Sets used by the Hungarian Naming Analyzer during a code review session. To access the **Hungarian Name Sets** dialog box, select **File > Hungarian Name Sets**.

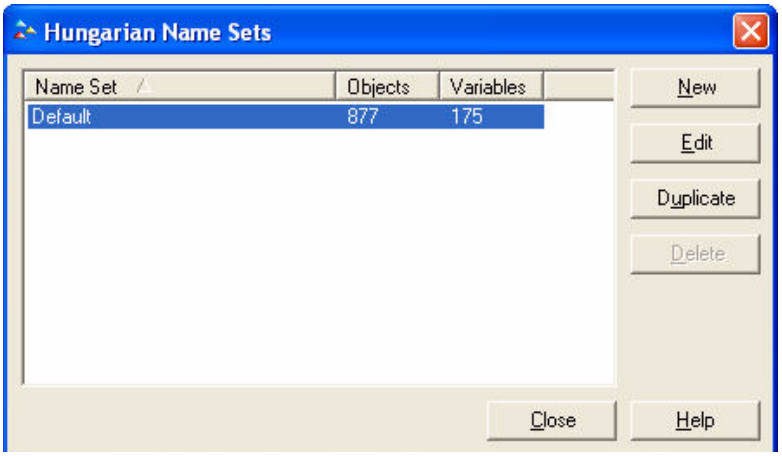


Figure 3-23. Hungarian Name Sets Dialog Box

Creating a Hungarian Name Set

Complete the following steps to create a new Hungarian Name Set:

1 Click **New**.

The **New Hungarian Name Set** dialog box opens (Figure 3-24 on page 112).

2 Replace **Untitled** in the uppermost field with a unique name for the name set.

3 Click **Create**.

After you click **Create**, the **Add**, **Edit**, and **Delete** buttons are enabled.

4 Select the applicable language to apply to this new name set.

Once you select the language, the Rule Manager verifies the new name.

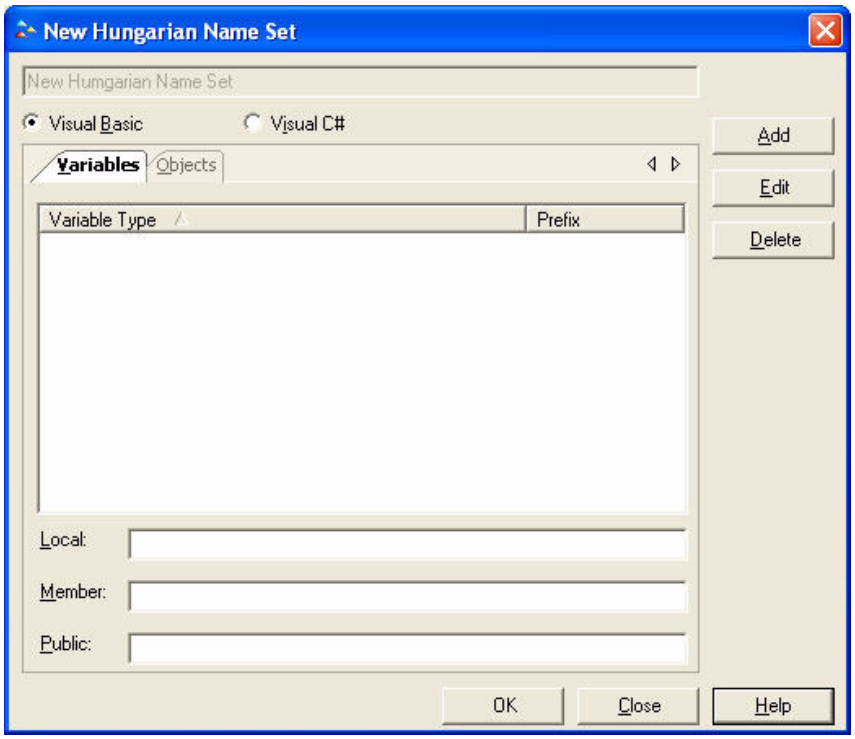


Figure 3-24. New Hungarian Name Set Dialog Box

Editing a Hungarian Name Set

Complete the following steps to edit an existing Hungarian name set:

1. Select a name set on the **Hungarian Name Sets** dialog box (see Figure 3-23 on page 111).
2. Click **Edit**.

   The **Edit Hungarian Name Set** dialog box opens. The **Edit Hungarian Name Set** dialog box is much like the **New Hungarian Name Set** dialog box (see Figure 3-24 on page 112)
3. Edit the language, variables, and objects associated with the name set as you see fit.

Note: You cannot edit the name of a Hungarian name set.

Duplicating a Hungarian Name Set

You can duplicate a Hungarian name set, allowing you to create a new name set following an existing name set as a template. To duplicate a Hungarian name set complete the following steps:

1. Select a name set on the **Hungarian Name Sets** dialog box (see Figure 3-23 on page 111).
2. Click **Duplicate**.

   The **Duplicate Hungarian Name Set** dialog box opens (see Figure 3-25).
3. Replace **Copy of <*name*>** in the uppermost field with a unique name.
4. Click **Create**.

   After you click **Create**, the **Add**, **Edit**, and **Delete** buttons are enabled. Rule Manager verifies the name set.

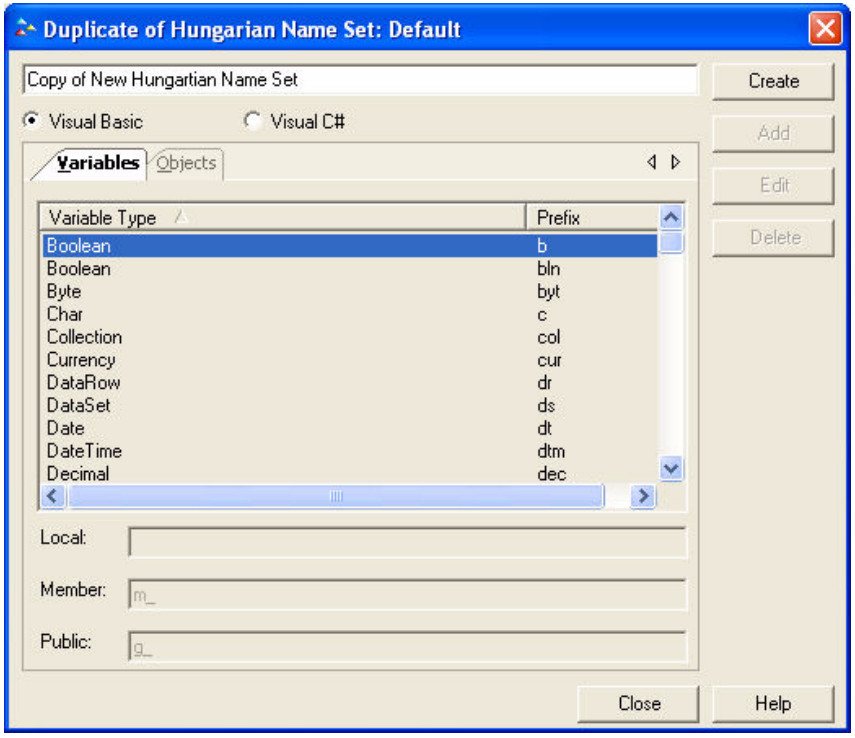


Figure 3-25. Duplicate Hungarian Name Set Dialog Box

Deleting a Name Set

To delete a Hungarian Name Set, complete the following steps:

Note: You can only delete a user-defined Hungarian Name Set that is not currently in use by a rule set.

1 Select **File > Hungarian Name Sets**.

The **Hungarian Name Set** dialog box opens (see Figure 3-23 on page 111).

2 Select the name set to delete.

The Rule Manager highlights all the variables and objects associated with that Hungarian name set within each tabbed pane, and disables the **Add**, **Edit**, and **Duplicate** buttons.

3 Click **Delete**.

The **Delete Hungarian Name Set** dialog box opens.

4 Click **OK** to delete the selected name set.

The **Hungarian Name Sets** dialog box reappears.

Note: This action cannot be undone.

5 Click **OK**.

Manipulating the Rule List

There are two ways you can manipulate the rules displayed in the Rule List:

Filter the Rule List View

Use the **Filter** pane, located on the left side of the Rule Manager window below the **Rule Set** list, to filter contents appearing in the **Rule List** pane (see Figure 3-20 on page 106).

1 Select a rule set from the **Rule Set** list.

The Rule Manager automatically lists all rules in the database when you select **All Rules in Set**. Select an individual rule set to filter selections.

2 Click the **Filter** tab (Figure 3-26 on page 115).

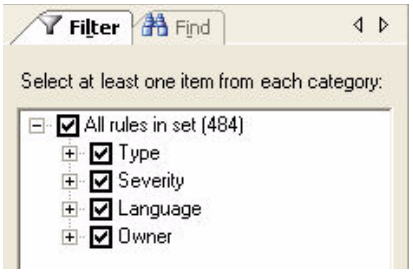


Figure 3-26. Filter and Find Tabs

3 Select (or clear) at least one item from each group at **Filter** options.

You can select the group check box or click + to expand and make individual choices from within the group.

You must pick at least one item from each group. If you do not, then a mouse pointer will direct you to the area needing attention. The groups include:

- **Type** — Rules coincide with programming technologies.
- **Severity** — Choices include **High**, **Medium**, or **Low**, and **Warning**. Use **Warning** to call attention to a particular coding problem.
- **Language** — Only languages that apply to the selected rule set will appear.
- **Owner** — DevPartner-supplied rules reference the identifier DevPartner. All other rules become the ownership of the individual who created the rule. The Rule Manager will only display owners that apply to the selected rule set.

4 Click **Apply** to filter the current view.

Find a Specific Rule

Use the **Find** tab, located on the left side of the Rule Manager window below the **Rule Set** list, to search for one or more rules.

1 Select a rule set to search in from the **Rule Set** list.

If you choose **All Rules in Set**, all rules in the rules database appear.

2 Click the **Find** tab to display search options (see Figure 3-26 on page 115).

3 Select a criteria from the **Search Rule Set For** list.

*Tip: You can also select recent search strings from the **Contains** list.*

4 Enter a string at **Contains** to define the specific search condition.

5 Click **Find**.

To perform a subsequent search, choose either of the **Search In** options:

- **All rules in set** — To initiate a new search
- **Current results** — To continue searching within the current results

You can optionally change search criteria, noted above, and then click **Find** again.

Creating New Rules Using Regular Expressions

You can create your own rules in code review and use them to identify many suspect coding practices. DevPartner code review rules make extensive use of regular expressions, which provides a robust and versatile method for searching text.

Regular expressions are widely used, well-documented, and can be written to match patterns in HTML, Visual Basic, and Visual C# syntax. DevPartner code review uses the same regular expression engine as Microsoft Visual Studio and supports the same syntax.

DevPartner code review makes it easier to use regular expressions in its rules by limiting the scope of any given rule to certain parts of the code. For example, a rule can apply to the entire file, just methods, or only `While` blocks. Since rules can specify a scope, the regular expressions can focus on a targeted part of the code.

DevPartner code review also assists the regular expression search by removing comments from a code block. Removing comments before executing the review reduces false positives.

The following sections provide examples of actual code review rules and explain the regular expressions that drive them.

Note: To learn more about how to write regular expressions for your code review rules, refer to the following resources:

- Forta, Ben. *Teach Yourself Regular Expressions in 10 Minutes*. Indiana: Sams Publishing, 2004.
- Friedl, Jeffrey E.F. *Mastering Regular Expressions*. 2nd ed. California: O'Reilly, 2002.
- Goyvaerts, Jan. *Regex Tutorial, Examples and Reference*. 1 Feb. 2006 <http://www.regular-expressions.info>.
- Microsoft Corporation. *.NET Framework Regular Expressions*. 2006. <http://msdn.microsoft.com/library/default.asp?url=/library/en-us/cpguide/html/cpconcomregularexpressions.asp>

Matching Lines Exceeding 90 Characters

Best practice coding standards recommend that a line of code should not exceed 90 characters. A code review rule enforces this standard by searching for lines that exceed 90 characters. The following regular expression ensures lines do not exceed 90 characters in length:

```
(?-s).{91,}
```

This regular expression first sets the **Single Line** option to **False**, causing the expression to evaluate all characters up to, but not including, the newline character (`\n`) as a single line. This evaluation treats each line of code, from its beginning to the newline (`\n`) character, as a distinct and different line.

Next, the rule incorporates the most elementary aspect of regular expressions — matching single characters. This rule uses the period (`.`) metacharacter to match any single character on the line.

The rule follows the period (`.`) with a repeating match metacharacter `{91,}`. Repeating match metacharacters specify that a match must repeat a certain number of times, or within a certain range of instances. In this rule, it specifies the expression is true only if any single character is matched 91 or more times; the second value in the range is left empty, because the rule only cares if the number of matches exceeds 90 characters. Table 3-18 describes the basic repeating match metacharacters.

Table 3-18. Repeating Match Metacharacters

Character	Meaning
+	Matches one or more instances of the preceding character
*	Matches zero or more instances of the preceding character
?	Matches zero or one instance of the preceding character
{*n*} {2,6} {*n*,}	Matches an exact number of instances of the preceding character where *n* represents the number of required repetitions These braces are also used to designate a range of repetition, such as from two to six times, by including the upper and lower limit separated by a comma Omitting the upper limit matches against a minimum number of instances without an upper bound

Matching Tabs Used Instead Of Spaces

Best practice coding standards recommend that spaces be used instead of tabs. The number of spaces represented by a tab can differ between editors, and this difference can cause the source code to have a different appearance in each editor. To enforce a consistent appearance of the source, spaces should be used. The following regular expression is used in a code review rule that searches for the use of tabs inside of methods:

```
(?s)\t.*
```

This regular expression sets the **Single Line** option to **True**, causing the expression to evaluate every character on every line up to and including newline characters (`\n`), as part of a single line.

Next, the rule specifies a match against the tab character by using a metacharacter (`\t`). Without further change, the regular expression would find every occurrence of a tab character in the method. Instances where multiple tabs are used in a method, such as for indenting lines, would fire the rule for each tab in that method. That is not the intended behavior of the rule.

This rule should evaluate to true if at least one tab is used in the method, but not every time it encounters a tab in the method. To accomplish this result, the rule needs the period (`.`) metacharacter followed by a repeating match metacharacter specifying zero or more instances. Table 3-18 on page 117 shows the repeating match metacharacter to use is the asterisk (`*`). Adding these last two metacharacters specifies that the rule must evaluate to true the first time it encounters a tab character, and then capture every following character in the method.

Matching Instances Where Code Catches System.Exception

Avoid catching `System.Exception` to handle your errors because it does not catch errors at a fine enough level of detail to allow for the proper differentiation of error types. Error handling code blocks should intercept and handle errors at the finest granularity as possible, since doing so can make a program more robust and less likely to crash. The following regular expression is used in a code review rule designed to find instances in the code where Visual Basic syntax is used to catch `System.Exception`:

```
Catch\s\w+\sAs\s(System\.)?Exception
```

The first part of this expression locates any instance of the literal word `Catch` in the code. Since the rule should not match instances where `Catch` is the first part of a longer word, the literal text is followed by the metacharacter for whitespace (`\s`).

Visual Basic syntax uses the word `Catch` followed by a variable name (used to hold the exception object). The variable is followed by more whitespace, and the literal word `As`.

The rule needs regular expression functionality to locate a legal variable name, followed by more whitespace, and the word As. The metacharacter `\w`, paired with the repeating match metacharacter `+`, will locate one or more instance of any alphanumeric character (upper or lower case) or the underscore character. Adding `\sAs\s` finishes the search for a legal variable name followed by whitespace and the word As.

So far, the regular expression will locate the following code:

```
Catch MyExceptionObject As
```

This regular expression would successfully locate all code that is catching exceptions. However, the rule should only match against code that catches `System.Exception`. The regular expression requires further refinement.

To ensure that the regular expression only matches instances where the code catches `System.Exception`, it searches for the literal words `System` and `Exception` separated by a period. Since the period is a metacharacter, the rule needs to specify a match on a literal period by preceding it with the backslash, removing its special character status.

If the rule now has `System\.Exception` as part of the regular expression, there is still a problem. It is acceptable syntax for the catch of `System.Exception` to leave off the `System.` and only use the term `Exception`. One last modification to the regular expression makes the matching of `System.` optional. Wrapping `System\.` in parenthesis makes it a subexpression, which can be followed by the `?` metacharacter to specify zero or one match.

Matching Methods Having More Than One Return Point

Best practice coding standards recommend that methods have only one return point. Having more then one return point could cause code to be hard to understand. The following regular expression is used in a code review rule that locates instances where a method has more than one return point. Most of the pieces making up this expression have been used in previous rules, but there are a couple of new things to examine.

```
(?s)(\breturn\b.*){2,}
```

First the rule sets the **Single Line** option to true, using `(?s)`, to focus on the entire method. To consider the method as a whole, the rule needs to evaluate every character on every line, up to and including newline characters (`\n`), as part of a single line.

Another part of the expression used in earlier rules is the repeating match metacharacter at the end. This expression uses `{2,}` to modify the preceding subexpression (contained in parenthesis), requiring that there must be two or more matches within the method.

The subexpression, `(\breturn\b.*)`, is the part of the regular expression doing most of the work. It is written as a subexpression to allow the whole block to be modified by the repeating match metacharacter. The metacharacter `\b` is a word boundary. By surrounding the literal text `return` with the word boundary metacharacters, the regular expression looks for instances of the word standing alone, not as part of a larger word.

Note: The previous example followed the literal text `Catch` by the whitespace metacharacter `\s` to ensure it would only find instances where Catch was a whole word. This is a good example of flexible regular expressions. That rule could have used the word boundary metacharacter `\b`, but did not.

The final `.*` within the subexpression searches for a match of zero or more instances of any character. The rule is now complete, and will search entire methods for two or more instances of the word `return`, followed by zero or more characters.

Enforcing Initialization Of Variables When They Are Defined

As a best practice, to keep code concise and easy to understand, variables should always be initialized when they are defined. The following regular expression is from a code review rule that locates instances where a variable is defined, but not initialized:

```
(?-s)\bDim\b(?!.*=)(?!.*\bnew\b)
```

Since the rule needs to evaluate each line of code by itself, the first thing it does is set the **Single Line** option to false.

Next, the regular expression is going to look for the word `Dim`. It wraps the literal text `Dim` with word boundary metacharacters `\b` to ensure it only considers whole words.

The subexpression implements the concept of looking ahead or behind. The ability for regular expressions to look ahead or behind gives them additional flexibility.

Looking ahead or behind means that a subexpression in the regular expression is searching for a match. Instead of matching and returning the specified text itself, like a simple string match would, the subexpression only verifies that the match exists. Finding a match causes the subexpression to evaluate to true, which then allows the rest of the regular expression to succeed or fail according to its other qualifiers. This kind of looking ahead and behind is referred to as a *positive look ahead* or *positive look behind*, because the subexpression evaluates to true when it finds text that matches.

The syntax for the positive look ahead and positive look behind is:

- Positive look ahead `(?=subexpression)`
- Positive look behind `(?<=subexpression)`

Similarly, *negative look ahead* and *negative look behind* work by searching for text that does not match the subexpression specified in the statement.

The syntax for the negative look ahead and negative look behind is:

- Negative look ahead `(?!subexpression)`
- Negative look behind `(?<!subexpression)`

The regular expression for this rule needs to use the negative look ahead construct to detect when there is *not* an equal sign (=) to the right of the `Dim` keyword, with or without a space preceding it. The subexpression `(?!.*=)` handles that negative look ahead.

The last part of the expression, `(?!.*\bnew\b)`, uses another negative look ahead to evaluate to true if the word `new` does not exist to the right of the `Dim` keyword, with or without a preceding space.

The complete rule now has a regular expression that evaluates to true whenever it encounters a line of code where the word `Dim` is not followed by an equal sign (=) or the word `new`.

Matching Instances Of More Than One Statement Per Line

In order to increase readability and maintainability of code, only one statement should ever be placed on a single line (with the exception of loop syntax). The following regular expression is from a code review rule that locates instances where a line contains more than one statement:

```
(?<!for.*);.*;
```

It might appear that the easiest way to detect more than one statement on a given line would be to determine if any line contains more than one semicolon. In fact, this search is the essence of the regular expression in this rule, but it needs to also take into account the possibility of a semicolon being associated with the `for` keyword.

To exclude any instances where the keyword `for` is associated with a semicolon, the rule uses the negative look behind construct `(?<!for.*)` to look back on any line where it encounters a semicolon, making sure the word `for` is not there. The remaining part of this regular expression (`;.*;`) will search for a semicolon followed by any number of other characters, and then another semicolon.

Ensuring Open Braces Are Placed On A Separate Line

Best practice coding standards recommend that open braces should be placed at the beginning of their own separate line following the statement that begins the block. The following regular expression is from a code review rule that locates instances where open braces are not placed on their own separate line:

```
(?m)^\s*\w+(?=.*?\{).*?$
```

There are several new concepts at work in this expression. The rule first sets the **Multi Line** option to true with `(?m)`. This setting changes the behavior of two other metacharacters — **Line Beginning** (`^`) and **Line End** (`$`). By enabling the multi-line option, `^` and `$` capture the beginning and end of each line rather than the entire string being searched.

Once multi-line mode is enabled, the regular expression searches for the beginning of the line (`^`), followed by one or more whitespace characters (`\s*`), and one or more word characters (`\w+`). This sets up the basis that the regular expression will use. If it finds one or more word characters, there should be no open braces on the line.

The positive look ahead subexpression `(?=.*?\{)` searches through each line looking for any character followed by an open brace. The backslash before the open brace removes its metacharacter status. Once the rule determines that a line contains a character followed by an open brace, and the open brace is not on a line by itself, `.*?` at the end of the regular expression allows it to capture the remaining text right to the end of the line (matched by the `$` metacharacter).

Ensuring Loop Counters Are Not Modified Inside the Loop Bodies

Changing the loop counter inside the body of the loop could cause unpredictable results, and makes code harder to understand. The following regular expression is from a code review rule that locates any instance where a loop counter is modified inside of the loop body:

```
(?s)\bfor\b\s*\(\s*\w+\s+(?<VARNAME>\w+).*\).*\b\k<VARNAME>\b\s*=
```

This regular expression is extremely long because it has to do a lot of work to enforce the rule. To identify and store the loop counter variable name, the regular expression must first capture the `for` keyword, left parenthesis, and loop counter type.

The first half of the regular expression is gathering required information. It locates a line with the `for` keyword, followed by any number of whitespace characters, a left parenthesis, more whitespace characters, one or more word characters, more whitespace, and finally uses a subexpression to capture the variable name.

The subexpression `(?<VARNAME>\w+)` captures the name of the loop counter and store it in the variable, `VARNAME`.

Note: This construct can use any variable name, as long as the name does not contain any punctuation and does not begin with a number.

Once it has captured the name of the loop counter, the last part of the regular expression captures any remaining characters and the right parenthesis. It then begins searching through the loop body for an instance of the loop counter, followed by an equal sign, using the following construct:

```
.*\b\k<VARNAME>\b\s*=
```

This part of the expression is the essence of the rule. Prior to reaching this point, the regular expression has determined the name of the loop counter and has placed the scope of its search within the loop body. This final part of the expression now matches all characters up to the value of `VARNAME` (the loop counter), and then looks for an equal sign following the counter.

The fact that the loop counter is followed by an equal sign indicates it is being set to some value, or modified. Since the counter should never be modified inside of the loop body, the rule has found a violation.

Submitting Data to Visual Studio Team System

DevPartner Studio supports Microsoft Visual Studio Team System if the Team Explorer client is installed and a Team Foundation Server connection is available.

Visual Studio Team System Support in DevPartner Code Review

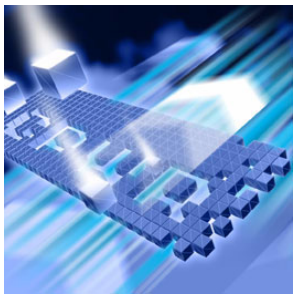
You can submit data to Visual Studio Team System as a **Work Item** of the type **Bug** for an item selected in any of the following tabs in a code review session file:

- Problems tab (see "Viewing Code Violations" on page 80)
- Naming tab (see "Viewing Naming Violations" on page 82)

When you submit a **Bug**, DevPartner populates the **Work Item** form with data from the tab. For more information about DevPartner Studio integration with Visual Studio Team System, see "Visual Studio Team System Support" on page 8.

Chapter 4

Automatic Code Coverage Analysis



- What is Coverage Analysis?
- Using Coverage Analysis Out of the Box
- Setting Properties and Options
- About Instrumentation
- Collecting Data from Various Types of Applications
- Merging Session Data
- Exporting Coverage Data
- Controlling Data Collection
- Analyzing from the Command Line
- Using the Coverage Analysis Viewer
- Integration with DevPartner Error Detection
- Submitting Data to Visual Studio Team System

This chapter contains two sections. The first section provides a quick-start procedure to get first-time users up and running with coverage analysis. The second section provides reference information for an in-depth understanding of DevPartner Studio's coverage analysis feature.

Refer to the DevPartner Studio online help for additional task-oriented information about coverage analysis.

What is Coverage Analysis?

DevPartner Studio's coverage analysis feature allows developers and test engineers to be sure that they are testing all of an application's code. When you run your tests with coverage analysis, DevPartner tracks all components, images, methods, functions, modules, and individual lines of code covered by your tests. When your tests end, DevPartner displays information showing you what code was exercised and what code was not exercised.

DevPartner can collect coverage data for managed applications, including Web and ASP.NET applications, as well as unmanaged (native) C++ applications.

Using Coverage Analysis Out of the Box

The following Ready, Set, Go procedure introduces you to using DevPartner to analyze code coverage.

To get up and running quickly, follow the steps presented in shaded boxes. If you would like more information about the subject being described in the shaded box, read the additional text following the box.

Note: Analyzing an application with DevPartner Studio does not require elevated system privileges. The system privileges you use to create and debug your application are sufficient for DevPartner to analyze the application.

Ready: Consider What You Want to Analyze

Before using code coverage, consider what you want to analyze.

The following procedure assumes:

- You are working in Visual Studio 2005 or 2008.
- You are testing a single-process, managed application.
- You can build and run your application.
- Your solution includes a startup project.

Note: Refer to "DevPartner Studio Supported Project Types" on page 335 for a comprehensive list of supported project types for DevPartner coverage analysis.

When analyzing your applications, decide what data you are interested in collecting before beginning your coverage session. In some cases, there are steps you need to take before beginning a session. For example, some set-up would be required if:

- there are modules you want to omit from the coverage analysis
- if there are unmanaged modules that you would like analyzed
- if you want to include code run on a remote server

For this procedure, all managed, local code in your application will be analyzed.

Set: Properties and Options

Once you have decided what code you want included in the coverage analysis, you can set several properties and options to focus your data collection.

For this procedure, you can use the default DevPartner properties and options. No additional set-up is required.

Using Solution Properties and Project Properties, you can choose whether your analysis session data should include information for .NET assemblies and COM that runs outside your application. Using DevPartner Options, you can change display options, exclude parts of your application from analysis, or create a session control file to manage data collection. Refer to "Setting Properties and Options" on page 134 if you would like more information about customizing your settings.

Go: Collect Coverage Data

After considering what you want to analyze and setting the appropriate properties and options, you are ready to collect coverage data.

1. From Visual Studio, open the solution associated with your application.
2. Select **DevPartner > Start with Coverage Analysis** to begin a coverage analysis session.

   During a session, the **Session Control Toolbar** options are active.

   DevPartner session controls let you focus your coverage analysis on any phase of your application. You can use the session controls to stop data collection, take a snapshot of the data currently collected and then continue recording, or clear data collected but not yet saved in a snapshot.
3. Run the code you want to analyze.
4. Click the **Snapshot** icon  . (Click twice if necessary to bring focus to the session window.) When you take a snapshot, DevPartner creates a file containing the collected data, called a session file, and displays the session file data.
5. Return to your application and continue running your tests.
6. When you are finished running your tests, exit your application. The final session file displays in Visual Studio.

Note: If a security exception message displays when attempting to collect data for a managed application, refer to page 138 for information about changing your security policy.

You can analyze coverage in conjunction with the DevPartner error detection feature. Knowing how much of your code was covered by your tests helps you gauge the comprehensiveness of your error detection data. Refer to "Integration with DevPartner Error Detection" on page 154 for more information about running a session with both error detection and coverage analysis.

Analyze the Data

When you take a snapshot or exit your application, DevPartner displays the session file in Visual Studio, as shown in Figure 4-1 on page 129. The session window consists of:

- The filter pane, which lists the source files and images in your application and shows the lines covered in each as a percentage of the total lines in the file.
- The session data pane, which contains three tabs and two coverage meters that display data for the item selected in the filter pane.
- The coverage meters, displayed above the tabs in the session data pane, summarize the line and function coverage for the item selected in the filter pane.

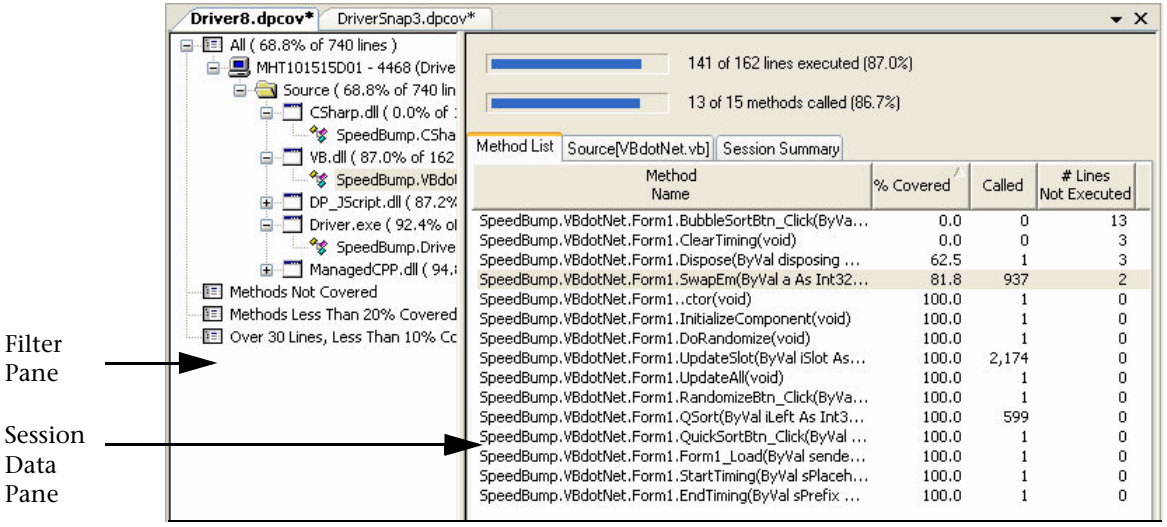


Figure 4-1. Coverage Analysis Session Window

Using the Filter Pane and the Session Data Pane

In addition to listing files and images in your application, the filter pane also included a set of filters you can use to help you focus on the data that is most significant to you.

To begin evaluating your data, start by using a filter to reduce the amount of data displayed, and then examine the **Method List** to find methods that were least covered by your tests.

1. In the **filter** pane, click on the **Methods Less Than 20% Covered** filter. This will reduce the displayed data and help you focus on methods that were least exercised.
2. Examine the data on the **Method List** tab to discover how much of each method was adequately covered by your tests.

   If there are aspects of your application that were inadequately covered, you can revise your tests to cover more of your application's functionality.

Viewing Source Code

The **Source** tab displays the source code for the item selected in the filter pane. Use the **Source** tab to help you identify the functionality that requires more test coverage.

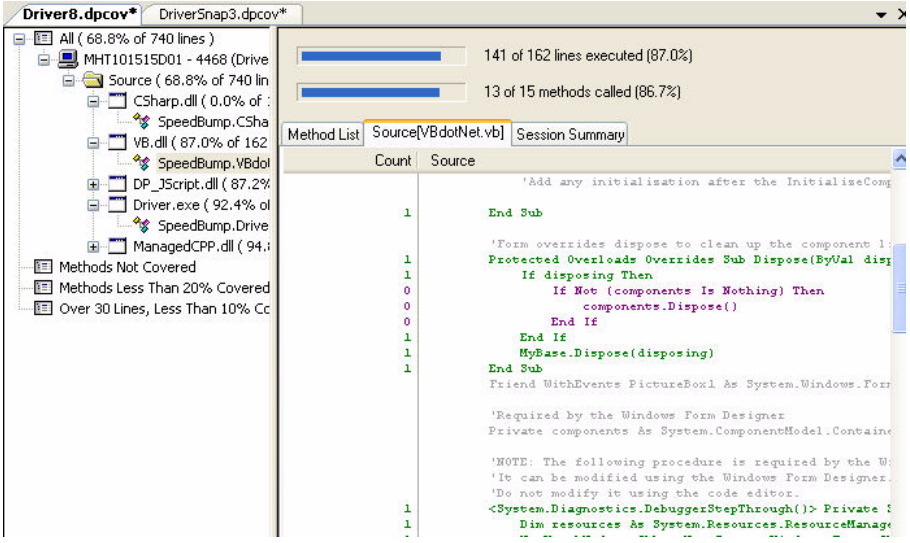


Figure 4-2. The Source Code Tab

You can display the code for a specific method in a source file by double-clicking on the method in the **Method List**.

3 On the **Method List** tab, double-click a method with a low value in the **% Covered** column. The source code for that method is displayed on the **Source** tab, as shown in Figure 4-2

The **Source** tab indicates coverage data for each line of code. DevPartner highlights the lines that were executed (green by default), not executed (purple by default), and lines that cannot be executed, such as comments (gray by default).

The **Count** column displays the number of times the line was executed.

Note: To present source code data for managed applications, DevPartner requires program database file (PDB) information.

On the **Source** tab, you can right-click on a line to view the context menu, from which you can go to the previous unexecuted line, the next unexecuted line, choose the columns to display, or choose another source file to view.

Viewing Session Summary Data

The **Session Summary** tab displays a synopsis of the coverage analysis session.

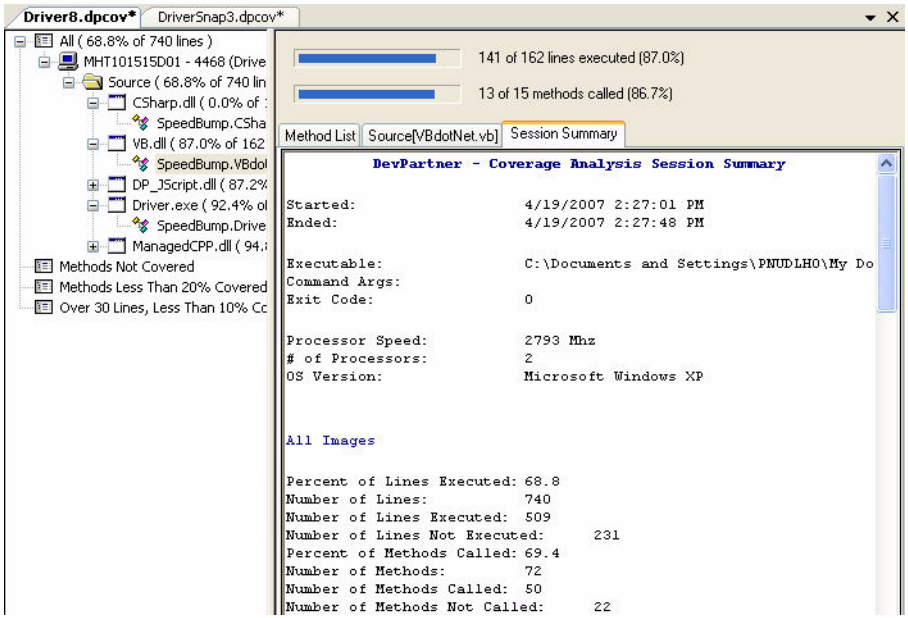


Figure 4-3. The Session Summary Tab

4 Click on the **Session Summary** tab.

The Session Summary includes contextual information about the session, such as the date and time of the session, the processor speed and operating system, and so on. This information can be useful when viewing an older session file, particularly one that was created by someone else.

The summary also includes coverage data from the filter pane and the Method List tab, showing data for both the files and the methods that were analyzed.

5 Scroll through the tab to view the session summary data.

Saving Session Files

When you have finished reviewing coverage data you can save the session file. If you have created more than one session file, you can merge the coverage data from multiple session files.

1. Close the session file window in Visual Studio to save the session file. When prompted, accept the default file name and location. By default, the file is saved in the project's output directory.
2. If there are multiple coverage session files for this solution, you might be prompted to merge the files, or the merge might occur automatically, depending on the **Merge** setting in your solution properties. Refer to "Solution Properties" on page 134 for information about the **Automatically Merge Session Files** property.

DevPartner saves session files as part of the active solution. They appear in the DevPartner Studio virtual folder in Solution Explorer. Coverage session files take the `.dpcov` extension.

By default, DevPartner physically saves the session files in your project's output folder. DevPartner automatically increments the file name based on the contents of the default directory (for example, `MyApp.dpcov`, `MyApp1.dpcov`, and so on). If you save session files to a location other than the default directory, you must manage the file naming and numbering.

For projects that do not have an output directory, such as a Visual Studio 2005 Web site project, DevPartner physically saves the files to the project directory.

Session files generated from the command line are not automatically added to the project's solution. You can manually add externally generated session files to an open solution in Visual Studio.

This concludes the Ready, Set, Go section of this chapter. Now that you have a basic understanding of the mechanics of running a coverage analysis session, continue reading the rest of this chapter for additional information, or refer to the DevPartner online help for task-based information.

Setting Properties and Options

Before beginning a coverage analysis session, it is often useful to fine-tune data collection to include or omit certain types of information. Use Solution Properties, Project Properties, and DevPartner Options to better focus your analysis session.

Solution Properties

To view coverage properties available at the solution level, select the solution in the Solution Explorer and press F4 to view the **Properties Window**.

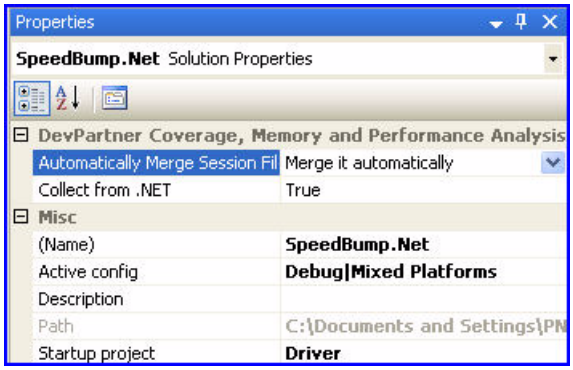


Figure 4-4. Solution Properties

The following solution properties affect coverage analysis:

- **Automatically Merge Session Files** - Controls merge behavior for coverage analysis sessions (described in "Merging Session Data" on page 148).
- **Collect from .NET** - Visible only for managed code applications. Set this property to false if you do not want DevPartner to collect information for .NET assemblies.

  This property affects only coverage analysis and performance analysis sessions. Memory analysis and Performance Expert always collect data from managed applications, even when this value is set to false.

Note: The **Collect from .NET** property is not available with DevPartner for Visual C++ Boundschecker Suite.

- **Startup project** - Your solution must include a startup project. If the solution contains multiple startup projects, DevPartner will prompt you to choose a startup project for the session.

Project Properties

To review project level properties, select a project in the Solution Explorer and review the properties that can be set for projects within the solution.

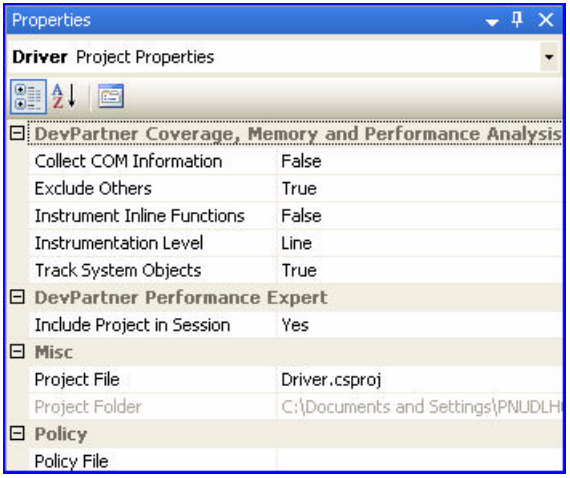


Figure 4-5. Project Properties

The following project properties affect coverage analysis:

- **Collect COM Information** - DevPartner collects method level data based on DLL exports and COM interfaces. Select False if you do not want DevPartner to collect information for COM that runs outside your application.
- **Instrument Inline Functions** - DevPartner always collects coverage data for inline functions in managed applications.
- For unmanaged code, set this property to **True** to instrument inline functions. Inline functions are not instrumented by default if inline optimizations are enabled.

All properties persist unless you explicitly change them.

Options

To review DevPartner option settings for coverage analysis sessions, choose **DevPartner > Options > Analysis**.

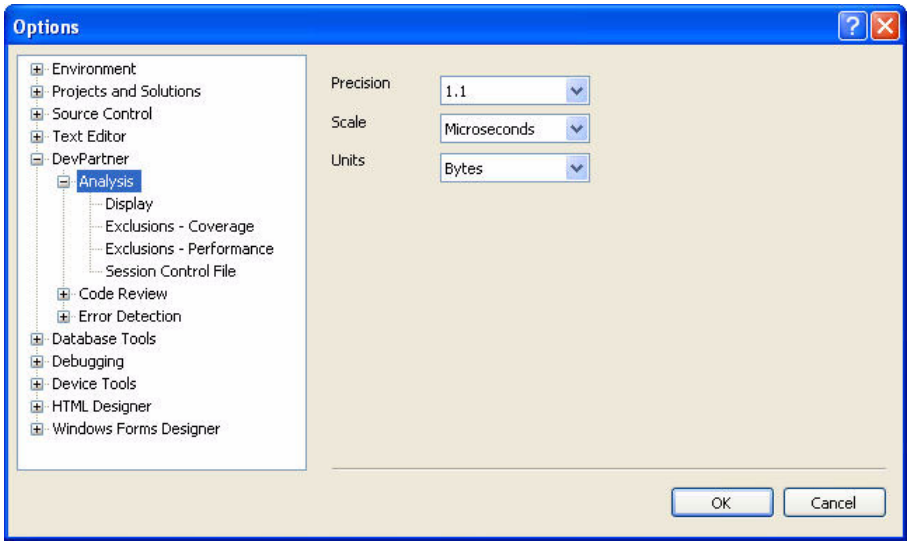


Figure 4-6. Analysis Options

- The **Display** option allows you to set the precision, scale, and units used when displaying your data.
- The **Exclusions** option allows you to omit one or more images from data collection. Refer to "Excluding Images" for more information on excluding images.
- The **Session Control File** option allows you to create a set of rules and actions to control the data that DevPartner collects as your application or module runs. Refer to "Analysis Session Controls" on page 365 for more information about session control files.

Other Visual Studio options, such as the **Environment** > **Fonts and Colors** options, also affect DevPartner features.

Excluding Images

When you run an application under coverage analysis, DevPartner collects data for all source and system images. However, you can use Exclusions to omit one or more images from analysis.

While viewing Analysis Options (**DevPartner** > **Options** > **Analysis**) select **Exclusions - Coverage**.

From the **Show** list at the top of the page, select one of the following:

- Global exclusions
- Local exclusions in current user directory
- Local exclusions in executable directory

The **Local exclusions in current user directory** and **Local exclusions in executable directory** options are available only when a solution is open and the executable directory differs from the current working directory.

Click **Insert**  to add an image to the exclusion list. Type a name, or browse to the image you want to exclude. Allowable file types for exclusion are `.exe`, `.dll`, `.ocx`, and .netmodule. Use the **Files of type** list to limit the types of files displayed.

If you choose a .NET module (`.netmodule`), only the unmanaged parts of the module are excluded.

To remove an image from the list of exclusions, select the item and click **Delete**  .

To save a copy of the exclusion list (`nmexclud.txt`) to another location, click **Save To**. Global exclusions are saved in `nmexclud.txt` in the `\Analysis` subdirectory in the DevPartner installation directory. Local exclusions are saved in `nmexclud.txt` for the application in the current working directory or in the application executable directory.

Exclusions do not apply to files compiled with Native C/C++ Instrumentation. For example, if you attempt to exclude an instrumented unmanaged C/C++ image, DevPartner still collects information for that file, although no system call information is collected. If you wish to exclude an unmanaged C/C++ image from data collection, do not instrument that image.

About Instrumentation

When you run a managed application, DevPartner inserts hooks into the byte code for each assembly as it is loaded by the compiler, a process called instrumentation. This code contains instructions that DevPartner uses to collect coverage data while your application is running. DevPartner instrumentation does not change the actual files on disk; it only modifies the in-memory representation of files as they execute.

Unlike managed code, which DevPartner instruments at runtime, you must instrument unmanaged C/C++ code when you compile it. To instrument unmanaged code, DevPartner inserts hooks directly into your source code. DevPartner provides an Instrumentation Manager in which you specify the type of instrumentation to be used and specify any projects in the solution to exclude from instrumentation. (Refer to "Collecting Data for Unmanaged Code" on page 139 for more information about the Instrumentation Manager.) When you rebuild the unmanaged project, the hooks are inserted. To remove the hooks, turn off instrumentation by deselecting the Native C/C++ Instrumentation option from the DevPartner menu, and rebuild the project.

Collecting Data from Various Types of Applications

This section provides information about using DevPartner coverage analysis to collect data from different types of applications.

DevPartner supports all Visual Studio managed code languages, as well as unmanaged C/C++. DevPartner can also collect coverage data for JScript and VBScript Web applications when using Internet Explorer (IE) or Internet Information Services (IIS).

Refer to "DevPartner Studio Supported Project Types" on page 335 for a complete list of languages and project types supported in each version of Visual Studio.

Collecting Data From Managed Code

Many applications you will develop in Visual Studio will be managed applications, such as C#, Visual Basic, and managed C++ applications.

When attempting to collect data for a managed application, a security exception message will display if your security policy prevents DevPartner instrumentation of your code. By default, assemblies must have the `SkipVerification` permission to be profiled. If you remove this permission from the permission set of the policy under which the code executes, or add imperative security declarations to the assembly that cause this permission to be revoked, you will not be able to profile the assembly.

To remedy this condition, enable secure profiling in one of two ways.

- Set the following global environment variable and retry profiling the application:

```
NM_NO_FAST_INSTR=1
```

This solution allows you to work around this issue, although it does exact a slight performance penalty.

- Change the policy for the assembly using the .NET Framework Configuration tool MMC snap-in, or by temporarily removing any imperative security declarations in the assembly.

See the *.NET Framework Developers Guide* in the Visual Studio online help for more information on security policy in Visual Studio.

Collecting Data for Unmanaged Code

When you build your unmanaged C++ application for coverage profiling with **Native C/C++ Instrumentation**, DevPartner works with the compiler to add instructions to your application image to collect coverage data at run time.

To instrument unmanaged code, open the solution that contains the unmanaged C/C++ project for which you want to collect data and choose **DevPartner** > **Native C/C++ Instrumentation Manager**.

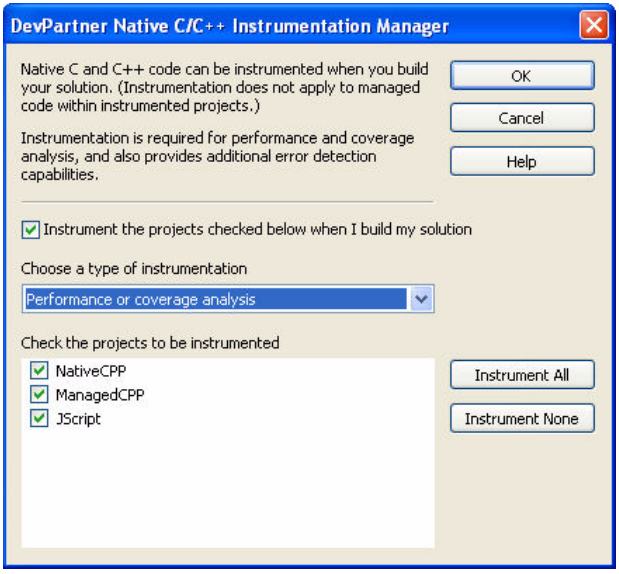


Figure 4-7. The Instrumentation Manager

Select the **Instrument the projects checked below when I build my solution** check box and select a type of instrumentation. The type of instrumentation you choose must match the type of analysis you subsequently run.

Select the projects to be instrumented. By default, DevPartner will instrument all unmanaged code in the solution. Deselect modules to be omitted.

Click **OK** and rebuild the solution. DevPartner instruments the unmanaged C/C++ projects you selected. Select **Start with Coverage Analysis** to begin the analysis session.

DevPartner saves the project selections you make in the Instrumentation Manager with the solution. Once you use the Instrumentation Manager to configure instrumentation, you can turn instrumentation on and off with the **Native C/C++ Instrumentation** option from the DevPartner menu or the **Native C/C++ Instrumentation** button on the DevPartner toolbar. Use the **Instrumentation Manager** only to change settings.

To remove instrumentation from your application at a later time, deselect the **Native C/C++ Instrumentation** option from the DevPartner menu. The next time you start a coverage analysis session or rebuild the solution, Visual Studio will rebuild the solution without instrumentation.

Note: If your application calls unmanaged Visual Studio components, you must compile these components with DevPartner instrumentation for coverage analysis in Visual Studio. See the DevPartner Studio online help in Visual Studio for more information.

Mixed-mode C++ Files

With unmanaged (native) C++, you can compile your application as managed code with the `/clr` option, but mark sections of your code with `#pragma` (native). The compiler generates native code for any methods defined in the `#pragma` section. DevPartner does not support mixed-mode C++ files. When profiling a program that includes a C++ file with both managed and unmanaged (native) sections, DevPartner collects coverage data only for the managed code portions, not the native code portions from `#pragma`. To collect data for unmanaged C++ code, place the unmanaged code in a separate file and instrument it, as described in "Collecting Data for Unmanaged Code" on page 139.

Collecting Data from Multiple Processes

Applications may run more than one process. For example, when you profile an ASP.NET application you may see the browser process (`iexplore`), the IIS process (`inetinfo`), and the ASP worker process (`aspnet_wp` or `w3wp`).

When you run a multi-process application under coverage analysis, the DevPartner Session Control toolbar displays the active processes in the process selection list.

Figure 4-8. Session Control Toolbar with the Process Selection List

Use the process selection list to focus data collection. When you take a snapshot, DevPartner creates a session file with data for the process selected in the process selection list.

Collecting Data from Remote Systems

You can use DevPartner to enable coverage data collection for application components running on a remote system. For example, you might want to collect coverage data for both client and server portions of a client/server application. With DevPartner, you can collect coverage data for client and server processes as you run the client application.

To collect data simultaneously from a client system and a remote system, install DevPartner on the client and install DevPartner and the DevPartner Remote Server license on the remote system. See *Installing DevPartner* (`DPS Install.pdf`) and the *Distributed License Management Licensing Guide* (`Compuware Licensing Guide.pdf`) for more information about the Remote Server license.

Note: A server connected through a Terminal Services connection does not require the DevPartner Remote Server license. See "Using Terminal Services and Remote Desktop" on page 9 for information on Terminal Services.

On the remote system, select the relevant projects and review the DevPartner properties to ensure that they match the options set on the client system. DevPartner restarts server processes, such as IIS, after you change options. This restart is necessary for changes to take effect.

Be sure to specify instrumentation if you are analyzing an unmanaged C++ application. If your application calls unmanaged C++ components, you must instrument those components if you want to collect data from them, as described in "Collecting Data for Unmanaged Code" on page 139.

Correlated Data

When you use IE and IIS as browser and Web server, or you use COM to make inter-process calls, DevPartner automatically recognizes a client/server relationship between the processes. To preserve the relationship between the methods of DCOM objects or the relationship between HTTP client and server (IE and IIS), DevPartner automatically correlates the data from those sessions. It then combines the correlated data with the client session data into a single session file.

The correlated session file contains the coverage data for both the client and server portions of your application. The correlated session file appears in Visual Studio, like any other session file, with `_co` appended to the file name, as in `appname_CO.dpcov`.

You can use **DevPartner > Correlate > Coverage Files** to manually combine data from different session files when there is no COM-based relationship or client/server relationship between IE and IIS. You can also use the `NMCORRELATE` command line utility to manually combine data.

Collecting Data From .NET Web Applications

If you develop Web Forms, XML Web Services, or ASP.NET applications, you can use DevPartner to collect coverage data for both client and server portions of your application. You can configure DevPartner to collect data for IIS and ASP.NET running on the local machine or on a remote server.

If your Web application calls unmanaged (native) C++ components, you must instrument them using the DevPartner commands in Visual Studio. To collect data for native C++ components called by your application, you must instrument and rebuild the objects with Native C/C++ Instrumentation, as described in "Collecting Data for Unmanaged Code" on page 139. Be sure to instrument for coverage analysis. DevPartner collects data for only one analysis type in a session.

Note: DevPartner session files are saved with the current solution. Opening a Web project from IIS directly, as opposed to opening the project through Visual Studio, may cause a different solution file to be used. DevPartner session files created in the first solution would not be visible in the second solution.

Prerequisites

For DevPartner coverage analysis to successfully profile an ASP.NET application, the following two conditions must be met:

- The project must include a `web.config` file.
- The `web.config` file must include a compilation element with the debug attribute set to true. For example:
  `<compilation debug="true"/>`

DevPartner can also collect data for in-process or out of process components called by your application.

Analyze ASP.NET Applications without Debugging

For optimum results, run coverage analysis without debugging.

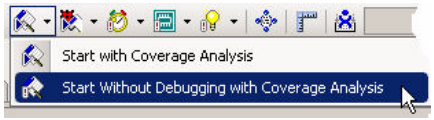


Figure 4-9. Start Without Debugging Option

Only one script debugger can be active at one time. If you debug a Web application with debugging, both Visual Studio and DevPartner attempt to load a script debugger. A message displays indicating that the script debugger failed to attach to IE. The session continues without interruption despite the error message.

To avoid the error message, you can either disable script debugging in `iexplore` or run coverage analysis without debugging.

Unexpected File Save Dialogs or Saved Session Files

Under certain circumstances, you may see an unexpected **File Save** dialog box after quitting an ASP.NET application, or find that unexpected session files have been saved if you have configured DevPartner to automatically save session files.

When you run coverage analysis on an ASP.NET application, DevPartner collects data for IE as the primary profiled process. DevPartner also saves session data for secondary processes, such as an ASP.NET worker process (`w3wp` or `aspnet_wp`). When the primary process terminates, DevPartner stops data collection and generates a final correlated session file that contains both client data (for IE) and server data (for IIS and ASP.NET) worker processes. You can also take a snapshot of the server process alone by selecting the process in the Session Control toolbar.

In most cases the client and server processes are terminated by user action. However, the ASP.NET worker process can also shut down automatically during profiling. This can occur if you have edited the `processModel Attributes` section of the `machine.config` file on the system on which the process runs in one of the following ways:

- Changed the value of the `requestLimit` or `requestQueueLimit` attribute from "Infinite" to a value low enough to cause the process to be shut down during the session
- Changed the value of the `timeout` or `idleTimeout` attribute from Infinite to a value low enough to cause the process to be shut down during the session
- Changed the value of the `memoryLimit` attribute to a percentage low enough to cause the process to recycle during the session

When the process is shut down, DevPartner takes a final snapshot and generates a session file. DevPartner handles the session file in one of the following ways:

- If the ASP.NET worker process is the selected process in the Session Control toolbar, DevPartner opens the session file in Visual Studio and adds it to the solution. This action is repeated for each instance of the ASP.NET worker process that is spawned and terminated.
- If the ASP.NET worker process is not the selected process, the session file is cached. When the IE client process is terminated, or when a snapshot of the IE process is taken, DevPartner creates a session file for IE, and a correlated session file that includes data for IE, IIS, and all instances of the ASP.NET worker process spawned and terminated up to that point.

When the analysis session has ended, DevPartner will continue to display the **File Save** dialog box or automatically save session files for instances of the ASP.NET worker process that are spawned and terminated.

To avoid generation of extra session files due to frequent termination of the ASP.NET worker process, you can edit the `machine.config` file and set the limiting attribute to a value high enough to prevent premature termination of the process.

Caution: Always make a backup copy before editing the `machine.config` file.

Collecting Data from Classic Web Script Applications

When you run a classic Web script application with DevPartner coverage analysis enabled, DevPartner gathers data for HTML files and JScript and VBScript source files. If the scripting languages invoke in-process or out-of-process components, such as COM objects, DevPartner can collect data for these as well.

Instrumentation for the scripting languages occurs at run-time, just as it does for managed .NET languages. However you do need to instrument any unmanaged code components, such as COM objects, that you want monitored.

Note: The following procedure is unique to classic Web script applications. To collect data for Web Forms, XML Web services, and ASP.NET applications you develop in Visual Studio, run the application just as you would run any other managed application.

To collect data for a classic Web script application, choose **Start > Programs > Compuware DevPartner Studio > Utilities > Web Script Coverage**.

IE opens with DevPartner Coverage Analysis loaded. In addition to IE, a Session Control toolbar appears, which you can use to control data collection.

In the DevPartner-enabled instance of IE, open the HTML page or Web application for which you want to collect coverage data and exercise the application. Optionally, use the Session Control toolbar to focus data collection as the application executes.

Exit IE or, if using the Session Controls, execute a **Stop** action. The **Save Session** dialog box displays and the session file is automatically saved.

Web Service Requirements

For DevPartner coverage analysis to detect a Web service, the service must meet at least one of the following requirements:

- The Web service must be derived from the `System.Web.Services.WebService` base class.
- The Web service must contain the `WebService` attribute.

For DevPartner coverage analysis to detect a Web method, the method must contain the `WebMethod` attribute.

Deleting Temporary Files from NMSource

While analyzing scripts for coverage under IE or IIS, DevPartner creates an `NMSource` directory to hold temporary copies of the script source. This source is displayed in the Source tab of the Session window when you are analyzing session data.

Because this source may be needed at any time, DevPartner does not delete files from `NMSource`. The size of this directory can grow quickly, particularly when you are analyzing server programs under IIS.

You should regularly review the source files in the `NMSource` directory and delete any related to projects that are no longer active. `NMSource` is located in the `\Program files\Internet Explorer` directory.

Configuring IIS for Data Collection

To collect coverage data for IIS/ASP.NET applications running on a remote server, set the following configuration options.

Note: If IIS runs on a remote server, you must install DevPartner (and a Remote Server license) on that system and set the options described below on the remote system.

Script Debugging

You can set the following options in the Default Web Site Properties, or in the WebApplication Properties for a specific application, of the IIS manager. The following options apply to IIS 5.0 or 6.0.

On the Home Directory or Directory tab, click **Configuration**. On the **Application Debugging** tab, set the **Debugging Flags** to:

- Enable ASP server-side script debugging
- Enable ASP client-side script debugging

Host Process Settings

If your Web application runs in the `dllhost` process, you may need to change the Application Protection options to enable DevPartner to collect coverage analysis data. You can set these options in the Default Web Site Properties, or in the WebApplication Properties for a specific application, of the IIS manager. The following options apply to IIS 5.0 or 6.0.

On the Home Directory or Directory tab, in the Application Settings section, set the Application Protection to one of the following:

- Low (IIS Process) Your application runs in the `inetinfo` process. DevPartner restarts IIS when you enable data collection and collects data from this process as your application runs.
- High (Isolated) Your application runs as a separate instance of `dllhost`. DevPartner recognizes the new process and collects data as your application runs.

When you have finished collecting data, restart IIS to remove DevPartner data collection from the process.

Configuring Internet Explorer for Coverage Analysis

To collect coverage analysis data from IE, select **Tools > Internet Options...** On the **Advanced** tab, set **Disable script debugging (Internet Explorer)** to OFF and set **Disable script debugging (Other)** to OFF.

Collecting Data from a Service

To run a coverage analysis session for a service, use `DPAnalysis.exe`. With `DPAnalysis.exe`, you can run sessions directly from the command line or through an XML configuration file.

Collecting Data from COM and COM+ Applications

You can collect data for an application that makes calls to COM or DCOM components with DevPartner.

If you profile an application that uses a mix of unmanaged COM and .NET objects (COM+), DevPartner collects line-level data for .NET portions of the application. DevPartner collects line-level data for unmanaged code components if they have been instrumented with **DevPartner Native C/C++ Instrumentation**. DevPartner can also collect line-level data for your unmanaged COM objects, if you first instrument them for coverage data collection. You can do this by building the project with instrumentation for coverage analysis in Visual Studio.

If you profile a C++ object, or any unmanaged code component that has not been instrumented, DevPartner collects only method-level data based on COM interfaces and DLL exports.

Merging Session Data

When you are testing your application using DevPartner, it is unlikely that you will execute all of your code in one session. It is important to be able to gather coverage data collected in several sessions and analyze your total coverage statistics. To accumulate coverage data, you can merge the session files. Merging is the process of accumulating data from multiple sessions into a single file.

Files that contain merged session data are called **merge files** (`.dpmrg`). DevPartner can associate many merge files with a single project. DevPartner saves merge files as part of the active solution. They appear in the DevPartner Studio virtual folder in Solution Explorer.

Note: You cannot merge correlated session files or Web Script session files produced from running IE. You can merge server-side session files from IIS.

To create a merge file, select **DevPartner > Merge Coverage Files** to create a new merge file or add data to an existing merge file. Merge files can also be created automatically, as described in "Merge Settings" on page 152.

When you merge session data, DevPartner:

- Maintains a record of all the images and methods that were loaded in any of the contributing session or merge files.
- Compares percent covered values and returns the superset of the data. For example, if you merge a session with 30% methods covered and a session with 20% methods covered, you probably have not reached 50% coverage. There are likely parts of the code that were executed in both sessions.
- Uses data from the session or merge file that ran the latest image to determine if the methods and images are new, changed, or removed. DevPartner uses the time stamps of the images to determine the latest image.
- Calculates percent volatility values for each source and image. Percent volatility represents the percent of methods that changed in your code between sessions. It demonstrates your code stability.
- Maintains information about the files involved in the merge, when the merge occurred, and who performed the merge.

Reviewing Merge Data

DevPartner displays merge data in the Merge Data window. The Merge Data window contains the filter and Merge Data panes. The Merge Data pane contains the **Method List**, **Source**, **Merge History**, and **Merge Summary** tabs.

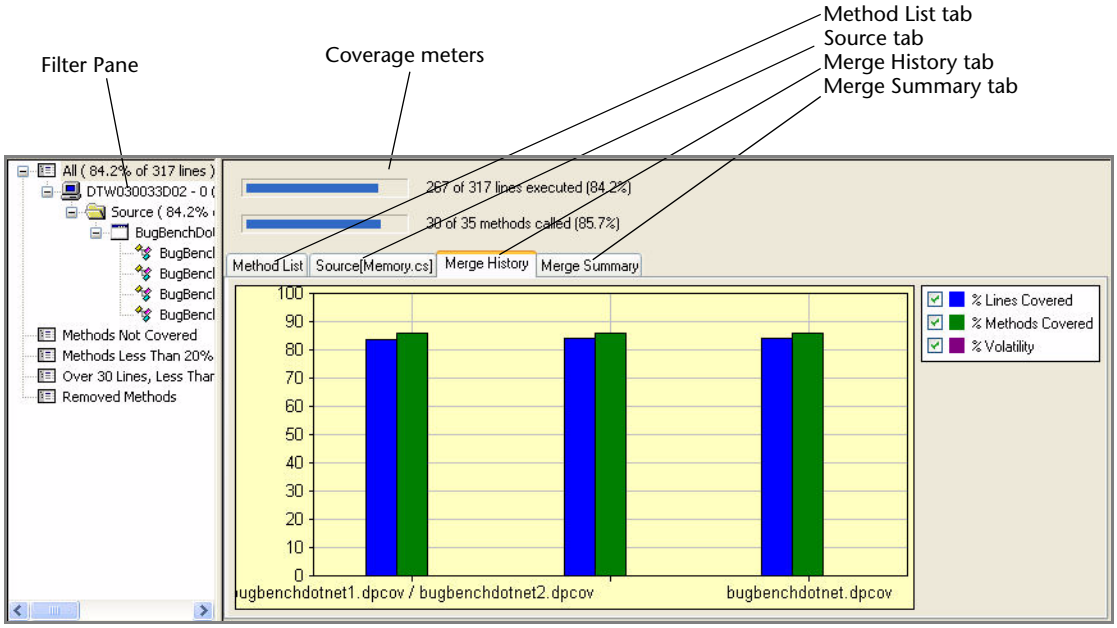


Figure 4-10. Merge Data Window

- The **Method List** tab uses the State column in merge files. DevPartner uses the State column to distinguish methods that are new, changed, or removed between sessions.
- The **Merge History** tab displays a graphical representation of the progression of the **% Lines Covered**, **% Methods Covered**, and **% Volatility** values for the current merge file.
  - **% Lines Covered** is the percentage of lines in your source code that were executed.
  - **% Methods Covered** is the percentage of methods in your source code that were called.
  - **% Volatility** is the percentage of methods whose source code has changed since the last merge.

If you have performed less than five merges in a merge file, DevPartner displays the **Merge History** tab as a bar chart. If you have performed five or more merges in a merge file, DevPartner displays the **Merge History** tab as a line chart.

Hold your cursor over a point on the graph to see specific data for that merge.

To show or hide a bar or line, choose or clear the check box in the key

- The **Merge Summary** tab displays summary information about the sessions and merge files that were merged into the file. It also contains information about each of the instrumented images used during the sessions, including the **Percent Volatility** for each image.

Note that if the source files have changed, merging coverage session files affects the synchronization of the method data that appears on the Method List tab and the line data that appears on the Source tab.

Merge States

If you change your code, DevPartner tracks those changes and adjusts the coverage data accordingly. It uses merge states to distinguish between changed, new, and removed methods and images. DevPartner displays information about these states in the **State** column on the **Method List**.

Methods

A method's state can be new, changed, removed, or unchanged. The **State** column indicates new and changed methods; a blank entry in the **State** column indicates that the method has not changed.

Removed methods are displayed in the **Removed Methods** filter. They are not used to calculate coverage statistics.

DevPartner does not distinguish between major and minor code changes. For example, when you make a change to a method that changes the number of lines in the method (for example, add or remove a comment), DevPartner marks the method as **Changed**. When you merge sessions that used executable files with different optimization options, DevPartner interprets this difference as a change and might mark some methods as **Changed**.

Images

Images can be loaded in one session and not in another. When an image is not loaded, DevPartner cannot determine what methods are in the image, or compare the image and its methods to find changes in relation to another session.

An image's state can be new, activated, or inactive. Activated images are images that were present in another session in the merge file and have been reloaded. An inactive state can result from several conditions.

- DevPartner marks an image as inactive if the image has been removed.
- DevPartner marks an unmanaged code image as inactive any time it is not loaded. For example, if your application uses an unmanaged DLL but you do not load it during a session, when you merge that session with an earlier session that did load the DLL, DevPartner marks it as inactive. To obtain a complete coverage picture for an application that includes both unmanaged and managed code projects, make sure you run the unmanaged code portions of the application in the final coverage session you add to the merge file.
- DevPartner marks an unmanaged code image as inactive if the image was excluded from coverage data collection using the **Exclude** option, described on page 136.
- In managed applications, DevPartner marks an assembly as inactive only if the assembly (and all references to it) are removed from the application.

*Tip: To quickly determine the last session file you merged, examine the Merge History on the merge file **Merge Summary** tab.*

Inactive images are displayed in the Inactive Source filter in the filter pane. They are not used to calculate coverage statistics. DevPartner displays a value of 0% for the **Inactive Source** filter. When the **Inactive Source** filter is expanded, DevPartner shows coverage values for the individual inactive images. These values reflect coverage data for the sessions in which the images were active.

ASP.NET Modules in Merge Files

When you run a coverage session, DevPartner uses a repeatable algorithm to generate names for `.aspx` files compiled into an assembly. Because the algorithm is repeatable, DevPartner assigns the same name each time the assembly is registered. This feature provides a consistent name for each assembly, allowing you to accurately track changes for the assembly.

This naming operation takes place only when you run a coverage session. The default Visual Studio behavior remains unchanged when you build or rebuild a project that includes an `.aspx` file. Visual Studio assigns a randomly generated eight-character name to each `.aspx` file. When you edit the `.aspx` file and rebuild the assembly, Visual Studio assigns a new random eight-character name.

Merge Settings

When you generate session files, you control the default merge behavior by setting the merge property for the solution.

To set the merge property, select the solution in the Visual Studio Solution Explorer and display the Visual Studio Properties window. Choose a property under **Automatically Merge Session Files** in the **DevPartner Coverage, Memory and Performance Analysis** properties.

- If you want to selectively accumulate coverage data and be prompted to merge sessions you did not merge, use the **Ask me if I would like to merge it** setting.
- If you want to selectively accumulate coverage data and not be prompted about sessions you did not merge, use **Close without prompting**.
- If you want to accumulate coverage data in a merge file automatically for every session, use **Merge it automatically**.

Exporting Coverage Data

You can export coverage data in XML format or in CSV format. Exporting data in XML or CSV format facilitates using your own or third-party software to analyze the data, integrate the data with data produced by other tools, and archive the data in a data warehouse.

- You can export DevPartner coverage session files (with the `.dpcov` extension) and merged coverage files (with the `.dpmrg` extension) to XML format. When a saved coverage session file is open, the **Export DevPartner Data** command is available on the **File** menu. Refer to "Exporting Analysis Data to XML" on page 375 for information about exporting in XML format.

  You can also export data from the command line, as described in "Exporting Analysis Data to XML" on page 375.

- You can export **Method List** data to a comma-delimited (CSV) text file. Click the **Method List** tab, display the columns you want to export, right-click in the Method List and choose **Export Method List** from the context menu. You can open the comma-delimited text file in Microsoft Excel or another spreadsheet application.

Controlling Data Collection

DevPartner gives you three ways to control when coverage data is collected during the use of your application:

- You can use the session control toolbar to interactively control data collection as your program runs.
- You can use a session control file to assign session control actions to specific methods in your application modules.
- You can use the Session Control API to control data collection in your program.

Using the session control toolbar or Session Control API allows you to control data collection anywhere within a method. Using a session control file allows you to control collection only at the entrance to or exit from a method.

Using a session control file and using the Session Control API are described in "Analysis Session Controls" on page 365.

Analyzing from the Command Line

To automate data collection or run analysis sessions from the command line, use `DPAnalysis.exe`, the DevPartner command-line executable. For information on using `DPAnalysis.exe`, refer to "Starting Analysis from the Command Line" on page 345.

Using the Coverage Analysis Viewer

DevPartner Studio provides a lightweight Coverage Analysis Viewer for analyzing coverage session files independently of Visual Studio. To launch the viewer, do any of the following:

- On the Start menu, select **Programs > Compuware DevPartner Studio > Coverage Analysis Viewer**.

- Double-click a `.dpcov` session file in Windows Explorer.
- Run a coverage analysis session using `DPAnalysis.exe` on the command line. DevPartner displays the session data in the Coverage Analysis Viewer.

What You Can Do in the Coverage Analysis Viewer

With a session file open, you can view, sort, save, or print coverage session data. In addition, you can:

- View the source code for a method
- Sort the data on the **Method List** tab
- Export the contents of the file as XML
- Export the contents of the **Method List** in CSV format

What you Cannot Do in the Coverage Analysis Viewer

- Instrument an unmanaged application for coverage analysis
- Start a coverage session
- Add files to a Visual Studio solution

Note: Session files generated outside of Visual Studio are not automatically added to the project's solution. You can manually add externally generated session files to an open solution in Visual Studio.

Integration with DevPartner Error Detection

You can use DevPartner error detection with coverage analysis to collect coverage data and check for errors during the same session when you run your managed application or unmanaged C/C++ application. You must instrument unmanaged C/C++ applications for **Error Detection and Coverage** with the **Native C/C++ Instrumentation Manager** before collecting data.

Refer to "Error Detection" on page 13 for more information about error detection with DevPartner.

Submitting Data to Visual Studio Team System

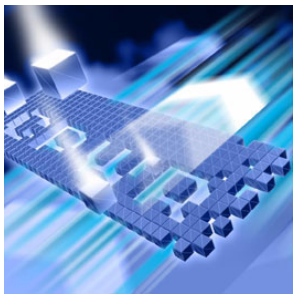
DevPartner Studio supports Microsoft Visual Studio Team System if the Team Explorer client is installed and a Team Foundation Server connection is available. Refer to "Visual Studio Team System Support" on page 8 for general information about Team System support.

In a coverage analysis session file, you can submit data for a method selected in the Method List tab in a DevPartner coverage analysis session file as a **Work Item** to Visual Studio Team System.

When you submit a **Bug**, DevPartner populates the **Work Item** form with data from the visible columns in the **Methods List** tab. To change the method data you submit in the **Work Item**, change the columns displayed in the **Method List**.

Chapter 5

Finding Memory Problems



- What is Memory Analysis?
- Using Memory Analysis Out of the Box
- Memory Problems in Managed Visual Studio Applications
- Setting Properties and Options
- Starting a Memory Analysis Session
- Using the Session Control Window in Memory Analysis
- Identifying Memory Problems
- Running a Memory Analysis Session
- Locating Memory Leaks
- Solving Scalability Problems with Temporary Objects
- Using RAM Footprint to Improve Performance
- Analyzing Web Applications with Memory Analysis
- Using Memory Analysis In Your Development Cycle
- Submitting Data to Visual Studio Team System

This chapter contains two sections. The first section provides a quick-start procedure to get first-time users up and running with memory analysis. The second section provides reference information for an in-depth understanding of how to use DevPartner memory analysis.

Refer to the DevPartner online help for additional task-oriented information about memory analysis.

What is Memory Analysis?

The DevPartner memory analysis feature enables you to analyze memory allocation in your managed Visual Studio application.

DevPartner memory analysis presents memory data in context, enabling you to navigate chains of object references and calling sequences of the methods in your code. This provides an in-depth view of how your program uses memory and the critical information that you need to optimize memory use.

When you run your application under memory analysis, DevPartner shows you the amount of memory used by an object or class, tracks the references that hold an object in memory, and identifies the lines of source code within a method that are responsible for allocating the memory.

DevPartner memory analysis includes three analysis types: Memory Leaks, Temporary Objects, and RAM Footprint. You can perform all three types of memory analysis in a single memory analysis session.

Each analysis type contains a real-time graph, a dynamically updated class list, and several session controls that enable you to control data collection and other memory-related events, such as forcing a garbage collection on the active process and creating a detailed view of the heap.

Note: The DevPartner memory analysis feature analyzes managed code only, and is therefore not supported in the DevPartner for Visual C++ Bounds-Checker Suite.

Because memory analysis is integrated into Visual Studio, you can use it to test applications as you develop them. You can also run memory analysis sessions from the command line, or as part of an automated test scenario, by using the DevPartner command-line executable `DPAnalysis.exe` with traditional command-line switches or an XML configuration file. For information, see "Starting Analysis from the Command Line" on page 345.

Using Memory Analysis Out of the Box

The following Ready, Set, Go procedure introduces you to using one of the three DevPartner Studio memory analysis features: Memory Leaks analysis.

To get up and running quickly, follow the steps presented in shaded boxes. If you would like more information about the subject described in a shaded box, read the additional text following the box.

Analyzing an application with DevPartner Studio does not require elevated system privileges. The system privileges you use to create and debug your application are sufficient for DevPartner to analyze the application.

Ready: Consider What You Want to Analyze

Does your application performance slow down over time or when you perform certain operations? Does your application perform poorly under load conditions or when other applications are running? If you see any of these symptoms in your application you may be experiencing memory-related issues.

DevPartner memory analysis collects data only from managed applications. In order to collect memory analysis data for your application, the solution must contain at least one managed code project (for example, C#, Visual Basic, or managed C++). It must also include a startup project. If the solution includes multiple startup projects, DevPartner prompts you to choose a startup project for the session.

The following procedure assumes:

- You are working in Visual Studio 2008 or Visual Studio 2005.
- You are testing a single-process, managed application.
- You can build and run your application.
- Your solution contains at least one managed code project.
- Your solution includes a startup project.

Note: Refer to "DevPartner Studio Supported Project Types" on page 335 for a comprehensive list of supported project types for DevPartner memory analysis.

The amount of memory consumed by your application has a major impact on how well the application performs. The larger the amount of memory allocated, the more likely it is that the application will run slowly and scale poorly.

Leaked memory—the allocation of memory that is not reclaimed—can bloat your application's RAM footprint. Automatic garbage collection relieves you of the responsibility to explicitly free the objects that you create, so memory is not "leaked" in the classic C++ sense, but it is still possible to retain references to objects that the program will never use again.

As long as a reference to an object exists, the referenced object is considered to be a **live object** by the garbage collector; a live object cannot be collected. This condition, like leaked memory in C++, is undesirable. Such references can be difficult to track down and that is where memory analysis helps you.

This procedure assumes a single process application, but you can use DevPartner Studio to analyze complex, multi-process applications. Refer to "Collecting Data from Multiple Processes" on page 212 for additional information on how to profile multi-process applications.

Set: Properties and Options

There are a minimal set of configuration settings specific to memory analysis sessions.

> For this procedure, you can use the default DevPartner properties and options. No additional set-up is required.

If you find that your application slows down too much while running memory analysis, you may be able to improve performance by excluding system objects from the analysis. See "Setting Properties and Options" on page 171 for details on changing the **Track System Objects** setting and other memory analysis settings.

Go: Collect Memory Analysis Data

Before starting a Memory Leaks analysis, it is useful to understand the workflow of the analysis.

By clicking **Start/Stop**, you will mark the beginning and end of a tracking period for new memory allocations, excluding all other memory allocations by the application.

When you click **View Memory Leaks** some or all objects that were allocated during the tracking period are done with their tasks and are ready to be garbage collected.

Memory analysis analyzes all of the allocations collected during the tracking period and identifies leaks as objects that still have live references and cannot be collected.

View Memory Leaks forces a garbage collection and creates a session file to display these leaked objects in several graphic and list views. In the scenario depicted in Figure 5-1, Memory Leaks Analysis Workflow Timeline, on page 161, the Memory Leaks session file would contain two leaked objects B and C that survived garbage collection. From the data, you will need to decide which leaked objects are expected and which ones are real leaks.

Note: Garbage collection can be a system garbage collection or user-initiated by selecting either the **Garbage Collection** icon or the **View Memory Leaks** icon.

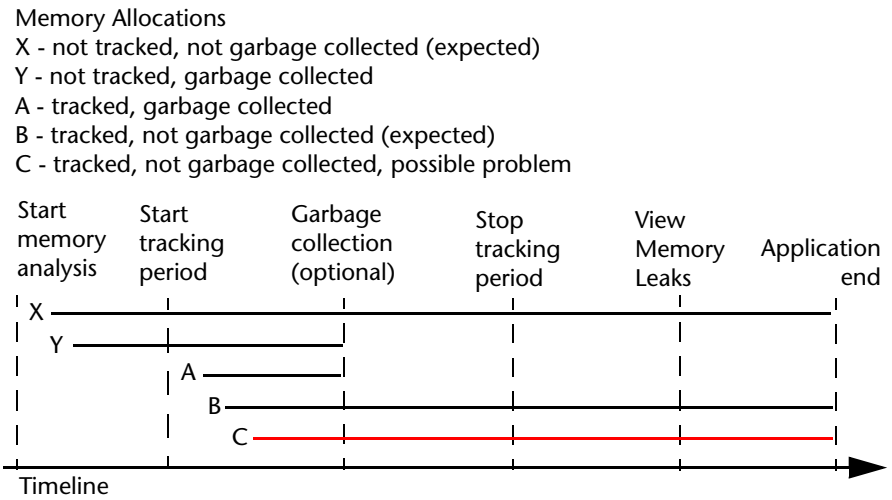


Figure 5-1. Memory Leaks Analysis Workflow Timeline

You are now ready to perform a Memory Leaks analysis.

1. In Visual Studio, open the solution associated with your application.
2. Choose **DevPartner > Start Without Debugging with Memory Analysis**. Wait for the application to start and for the **DevPartner Memory Analysis** window to display the **Session Control Window**.

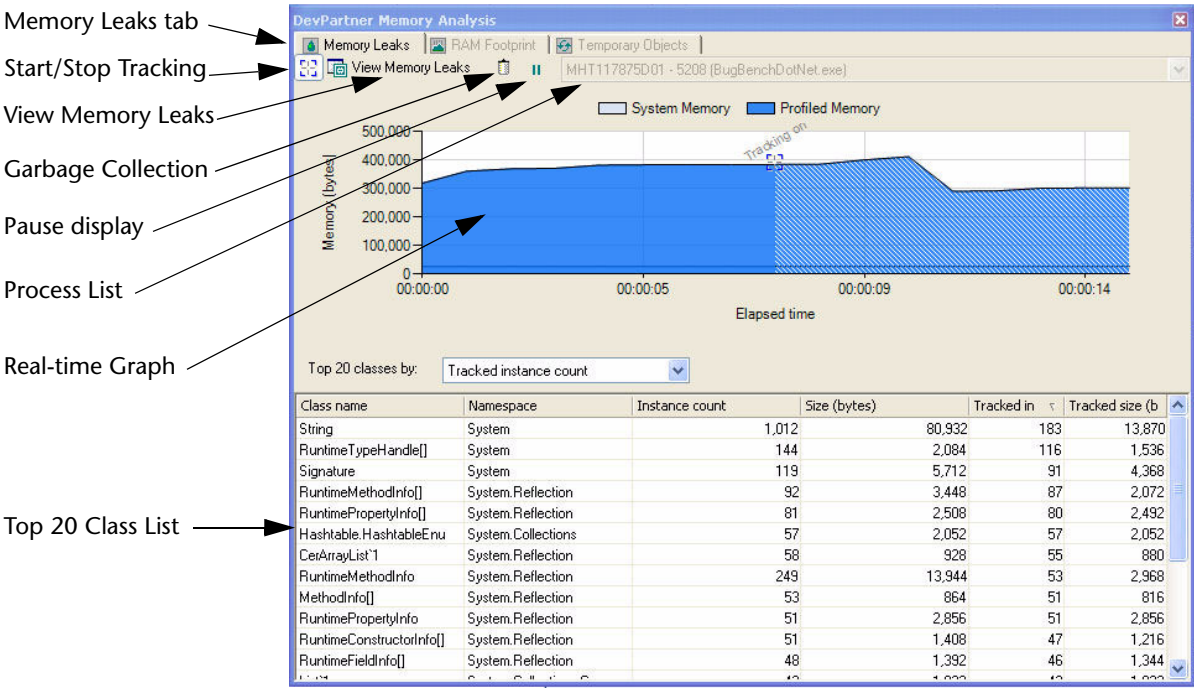


Figure 5-2. Memory Analysis Session Control Window

3 Click the **Memory Leaks** tab.

4 Warm up the application by exercising the features that you plan to test. Warming up the application eliminates initialization allocations from the tracking period.

5 Click **Start/Stop** to start tracking new memory allocations and exclude previous memory allocations.

6 Exercise the application feature that you are collecting data from and run it through a complete cycle, but do not stop the application.

For this procedure, limit the tracking period to exercising a single feature within your application. This reduces the complexity of the session data and improves performance.

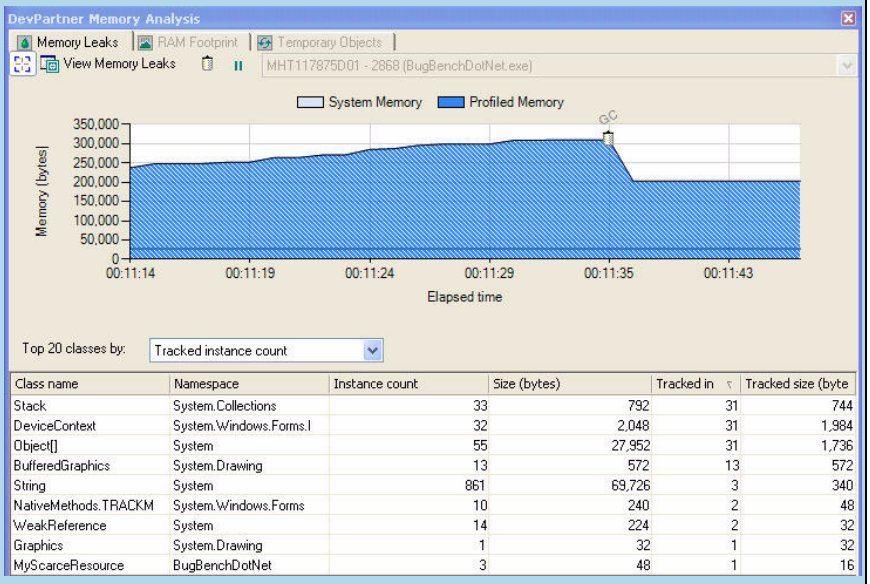
The patterns that appear in the session control window graph as you exercise your application provide the initial diagnosis of the way your application is using memory. Different memory problems show characteristic patterns, so the real-time graph provides an important clue as to the existence and nature of a problem. This helps determine what kind of memory analysis to perform.

For example, a steadily rising pattern that does not return to baseline or respond as expected to garbage collection may indicate leaked memory.

For in-depth information on other characteristic patterns in the real-time graph, see "Using the Session Control Window in Memory Analysis" on page 175.

For a complex application, the number of classes displayed in the list may be large. Right-click in the list and choose **Show Top 20 Classes with Source** from the context menu to limit the class list to your application's source code methods.

7 Click **Force Garbage Collection** to issue a garbage collection on the active process.



Class name	Namespace	Instance count	Size (bytes)	Tracked in	Tracked size (byte
Stack	System.Collections	33	792	31	744
DeviceContext	System.Windows.Forms.I	32	2,048	31	1,984
Object[]	System	55	27,952	31	1,736
BufferedGraphics	System.Drawing	13	572	13	572
String	System	861	69,726	3	340
NativeMethods.TRACKM	System.Windows.Forms	10	240	2	48
WeakReference	System	14	224	2	32
Graphics	System.Drawing	1	32	1	32
MyScarceResource	BugBenchDotNet	3	48	1	16

Figure 5-3. Session Control Window After Garbage Collection

8 Examine the list in the lower half of the **Session Control window**. The list shows information about the classes that contain objects with active references after the garbage collection.

9 Click **Start/Stop** to stop the tracking period and exclude new memory allocations. If your application is active in the background, the values contained in the list may change, but the tracked instances do not increase.

10 Click **View Memory Leaks** to force another garbage collection and create a Memory Leaks analysis session file.

11 Close the application.

Memory analysis automatically creates a second file, a **Temporary Objects** analysis session file, which is in focus in Visual Studio.

12 Click the **Leak...Analysis Snap.dpmem** tab to bring the Memory Leaks snapshot session file into focus.

Analyze the Memory Analysis Data

The Memory Leaks analysis session file records all objects allocated during the tracking period that had an active reference at the time you clicked **View Memory Leaks**. Use the session file to examine objects, methods, and critical execution paths so you can answer the question "Why are these objects still in memory?".

Memory Leaks analysis helps you identify unneeded objects in the context of the application and to find the best point in the reference chain to remove the references that keep these objects in memory.

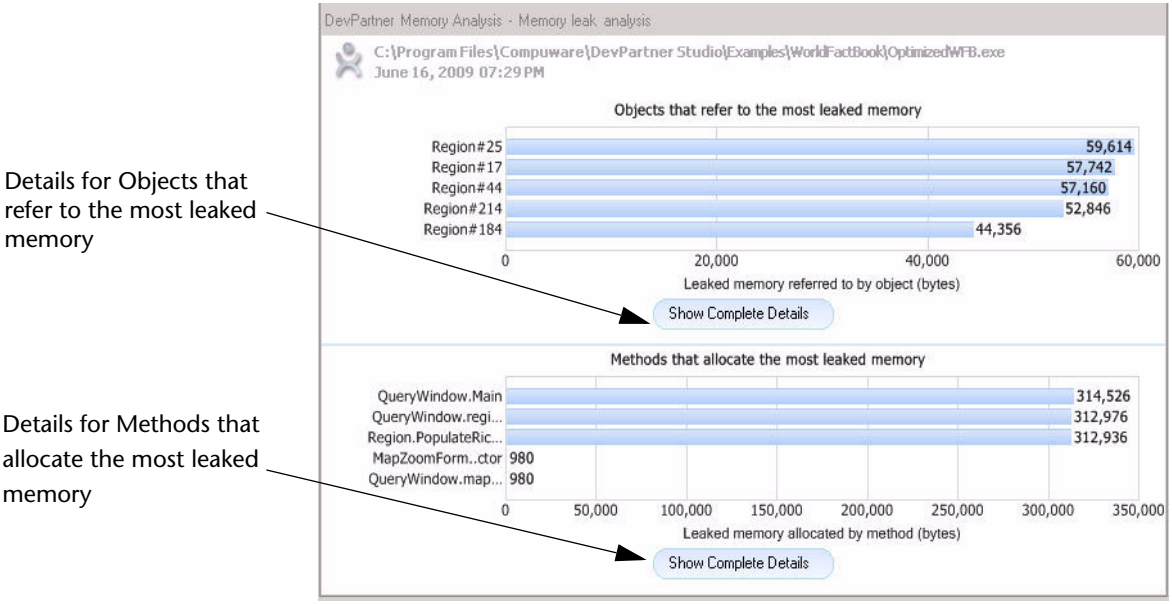


Figure 5-4. DevPartner Memory Analysis - Memory Leaks Analysis Summary

The **DevPartner Memory Analysis - Memory leaks analysis** summary contains bar charts for **Objects that refer to the most leaked memory** and **Methods that allocate the most leaked memory**.

The remainder of this procedure guides you through inspecting details in both summaries.

1 Click **Show Complete Details** below **Objects that refer to the most leaked memory**.

Note: Refer to "Using the Object Reference Graph" on page 179 for in-depth information on working with memory analysis session files.

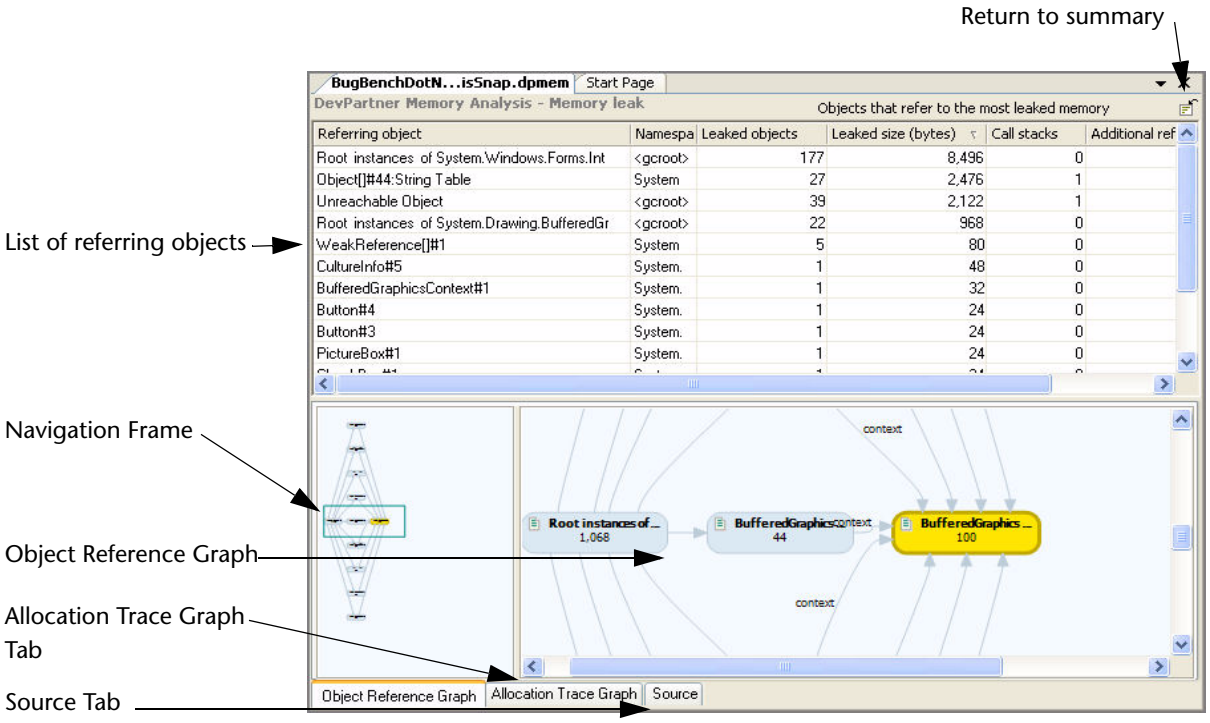


Figure 5-5. DevPartner Memory Analysis - Memory Leaks Object Reference Details

2. Examine the **DevPartner Memory Analysis - Memory Leaks** view that displays a list of referring objects sorted by **Leaked size (byte)**. The **Referring object** responsible for the most leaked memory appears at the top of the list.

   The tabs at the bottom of the window display an **Object Reference Graph**, **Allocation Trace Graph**, and a **Source** window.

3. Choose the **Object Reference Graph** tab and then select a referring object in the list at the top.

   When you select a referring object from the list, the **Object Reference Graph** highlights the selected object.

4. In the **Object Reference Graph**, hover the mouse over an object node to get information about the leaked memory associated with that object.

5. Drag the **navigation frame** in the **overview pane** to focus on various parts of the **Object Reference Graph.**

6. Right-click a **Referring object** in the list and choose **View leaked objects referenced by this object**. The default sort order is **Referenced size (bytes)**, which highlights the amount of memory that could be freed if the object was collected.

   You should understand why the objects are still referenced and at this stage, you can decide where in the code you want to break the references (if needed).

If you need more information or deeper program understanding, use the tabbed views to examine object references, identify the execution paths that allocated the memory, and locate the lines responsible for source code.

- The **Object Reference Graph** provides a graphical representation of objects and the related object references. The display depicts each object with related information such as memory used by itself and its children, or the percentage of memory used by the object.
- The **Allocation Trace Graph** provides a graphical representation of the execution paths in your code. This gives you the context of where the object was allocated.
- The **Source** window displays the related source code for each object.

Consider the expensive object references and decide whether or not the application can be optimized by managing the object references differently.

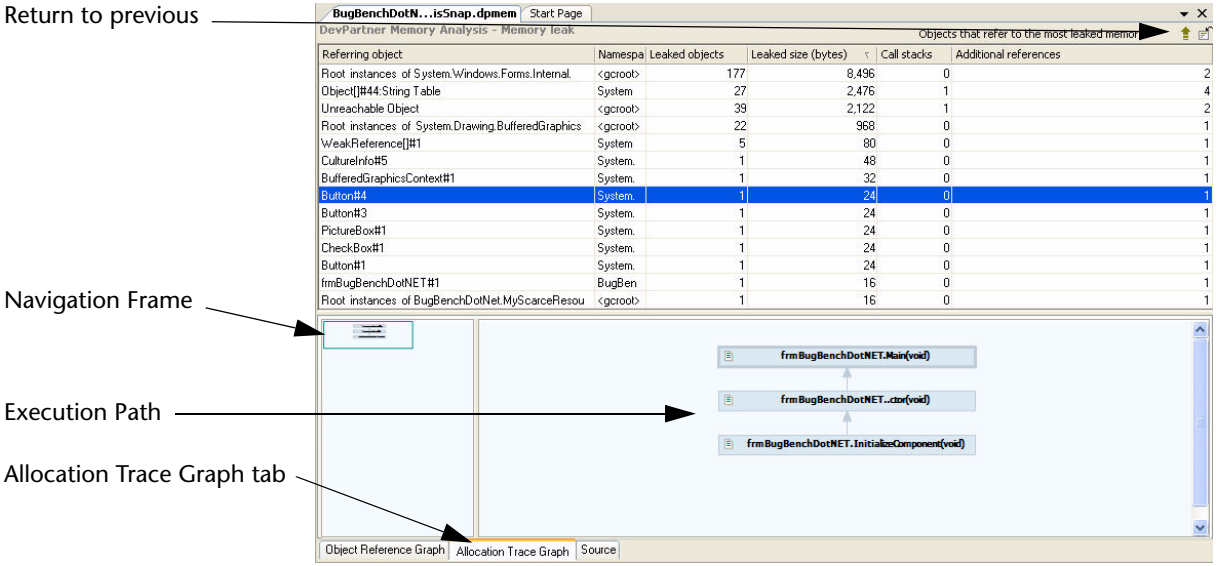


Figure 5-6. DevPartner Memory Analysis - Allocation Trace Graph

7 When you decide that you want to make changes, select the **Allocation Trace Graph** tab to see the execution paths that created the object and allocated the memory.

8 Choose the **Source** tab and select an object in the **Object List**. Notice the source code reference change for each object that you select.

9 Right-click an object in the list and choose **Edit source** to display the related source code line in the Visual Studio editor.

Note: There is no editable source code available for system objects.

10 Close the Visual Studio editor.

For an in-depth example, see "Objects that Refer to the Most Leaked Memory" on page 193. For various techniques to access source code, see "Navigating the Source Tab" on page 184.

After you identify source code that correlates to an object reference, you start to see memory management beyond the object level to the inter-relationships between objects and object references. From here, begin making decisions on whether or not the object references can be managed differently to improve application performance.

Object reference management changes could involve using smaller objects, weak references, different sequencing of object references, or limiting the number of layers of abstraction.

For Web applications, awareness of a client-server relationship may allow you to capitalize on a garbage collection on the server when scalability is a focus.

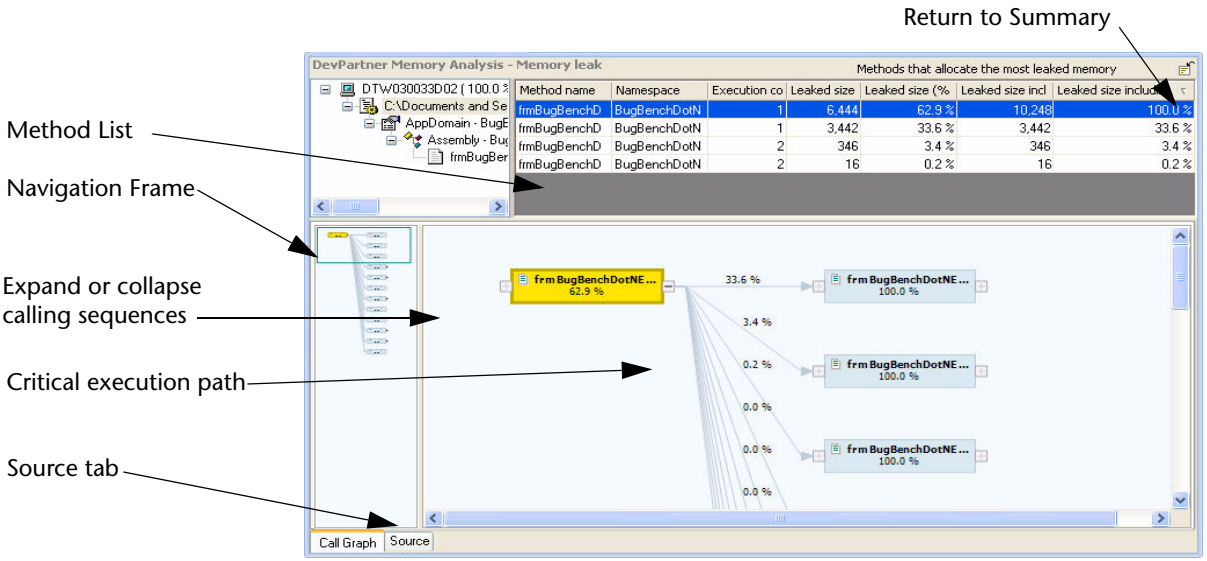


Figure 5-7. DevPartner Memory Analysis - Method List Call Graph

11 Select the **DevPartner Memory Analysis - Memory leaks analysis session file** tab and click to return to the Summary page.

In addition to the **Objects that refer to the most leaked memory**, you can analyze the **Methods that allocated the most leaked memory**.

12 From the Summary page, choose **Show Complete Details** for **Methods that allocate the most leaked memory**.

The **Method List** displays source methods that allocated the most leaked memory.

13 Select a method in the **Method List** to display the **Call Graph**.

14 In the **Call Graph** window, hover your mouse over a method node or the line between method nodes. Compare the leaked size contributed by the method node and its children.

   The critical execution path is highlighted with a bold, gold-colored line.

15 Use the + and - controls to expand and collapse the calling sequences to various levels for method nodes.

16 In the list above, right-click on a method name and select **View Source** from the context menu.

17 In the list, right-click on a method name and choose **View Summary**.

For an in depth example, see "Methods that Allocate the Most Leaked Memory" on page 196.

Saving Session Files

When you have finished reviewing memory analysis data you can save the session files.

1 Close both session file windows in Visual Studio. DevPartner prompts you to save the session file.

2 Click **Ok** to save the file with the default file name and location.

DevPartner saves session files as part of the active solution. They appear in the DevPartner Studio virtual folder in Solution Explorer. Memory analysis session files take the `.dpmem` extension.

By default, DevPartner physically saves the session files in your project's output folder. DevPartner automatically increments the file name based on the contents of the default directory (for example, `MyApp-TemporaryObjectSnap1.dpmem`, `MyApp-LeakAnalysisSnap1.dpmem`, and so on). If you save session files to a location other than the default directory, you must manage the file naming and numbering.

For projects that do not have an output directory, such as a Visual Studio 2005 Web site project, DevPartner physically saves the files to the project directory.

Session files generated from the command line utility are not automatically added to the project's solution. You can manually add externally generated session files to an open solution in Visual Studio.

The remainder of this chapter provides reference information and an in depth exploration of each DevPartner memory analysis feature: Memory Leaks, Temporary Objects, and RAM Footprint.

This concludes the Ready, Set, Go section of this chapter. Now that you have a basic understanding of the mechanics of running a memory analysis session, continue reading the rest of this chapter for additional information, or refer to the DevPartner online help for task-based information.

Memory Problems in Managed Visual Studio Applications

Managed Visual Studio applications benefit from a sophisticated memory management environment with garbage collection. Unlike unmanaged (native) C++, in which you explicitly free the memory that you allocate, the garbage collector frees memory once the object for which it was allocated is no longer in use, or more accurately, no longer "reachable" by the application.

Because of the built-in memory management in managed code projects, many developers assume that managed languages relieve them of the headaches traditionally associated with memory management. However, memory allocation and use in managed Visual Studio programs can still cause performance bottlenecks and resource depletion.

Does your application exhibit any of the following symptoms?

- Performance slows down over time
- Runs slowly, or slows down noticeably when you perform certain operations
- Performs poorly under load conditions
- Performs poorly when other applications are running

Any of these symptoms indicate that your application has a performance problem. Refer to the following lists of questions to better understand if the problem is related to memory use.

- Several application classes must load before the program executes a particular function and each application class uses memory.
  - Does your program load classes that are only related to performing current tasks?
  - How many instances of a particular class does your application create and are all instances needed?

- Object allocation also incurs memory use which may lead to performance problems.
  - Do you know if your program allocates too many objects, or allocates them efficiently?
  - Does the garbage collector clear the objects that your program allocates?
  - Are the objects being collected as expected, or do the objects remain in memory long past their usefulness?

How Memory Analysis Helps You

The DevPartner memory analysis feature provides a comprehensive view of memory use in your managed application. DevPartner provides three different types of memory analysis to help you isolate different kinds of memory-related problems. Regardless of which type of analysis you use, all types include the following features:

- **Real-time graph** — DevPartner presents a live view of memory use in your application while it runs. This view appears in the **Session Control Window**. You can see how much memory is being used by your application code (profiled code), system and other application code (excluded code), and how memory consumption compares to the memory reserved for the managed heap.
- **Dynamic list of classes** — DevPartner updates the list of profiled classes in real time while your application runs. This shows you the number of objects allocated and number of bytes used by each class, as your application runs.
- **Detailed heap views** — You can capture a snapshot of a detailed view of the managed heap at any time during program execution. DevPartner stores this data in a session file that you can then use to analyze memory problems in depth. DevPartner provides multiple ways to drill down into the session data, so you can see how your application uses memory and ultimately identify the methods or lines of code responsible for the most memory use.

Setting Properties and Options

Before beginning a memory analysis session, it is often useful to fine-tune data collection to include or omit certain types of information. Use Solution Properties, Project Properties, and DevPartner Options to better focus your analysis session.

Solution Properties

To view properties that affect memory analysis at the solution level, select the solution in the Solution Explorer and press F4 to view the **Properties Window**.

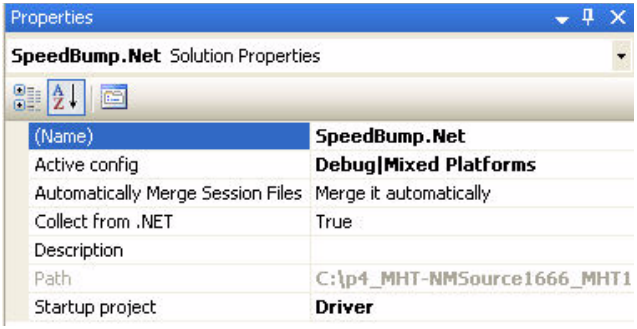


Figure 5-8. **Solution Properties**

The following Solution properties may affect memory analysis:

- **Collect from .NET** - Running your managed application with memory analysis overrides this property if it is set to **False**. Memory analysis always collects data from managed applications.
- **Startup project** - If your solution includes multiple projects, you can change the startup project. The **Project** properties for the startup project govern data collection for all projects active in the session.

Note that your solution must include a startup project. If the solution contains multiple startup projects, DevPartner prompts you to choose a startup project for the session before analysis begins.

Only projects for which the **Action** in the **Common Properties** > **Startup Projects** page of the solution properties is set to **Start** are included in the prompt dialog. If the desired startup project does not appear in the prompt, open the solution properties page and set the **Action** for the project to **Start**. If you choose a new startup project for a subsequent session, review the properties for the new startup project to ensure the data collection options are correct.

Project Properties

To review project level properties, select a project in the Solution Explorer and review the properties that can be set for projects within the solution.

Changes that you make here affect coverage analysis, memory analysis, performance analysis, and Performance Expert.

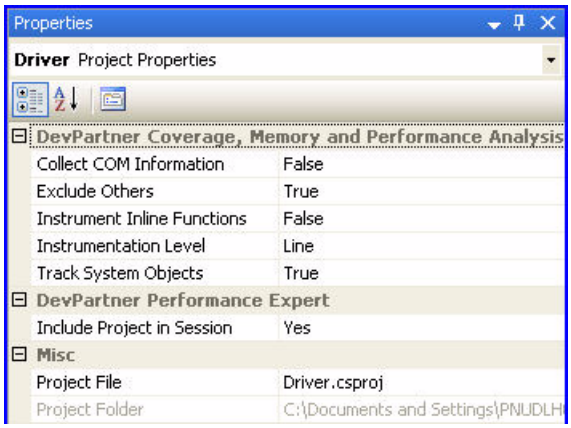


Figure 5-9. Project Properties

The following project-level property affects memory analysis:

- **Track System Object** - Set this property to **False** to ignore system or third-party object allocations when tracking allocated objects in memory analysis sessions.
  The default state, **True**, enables you to see memory allocations made by system or other non-profiled resources

Options

To review DevPartner option settings for memory analysis sessions, choose **DevPartner > Options > Analysis**.

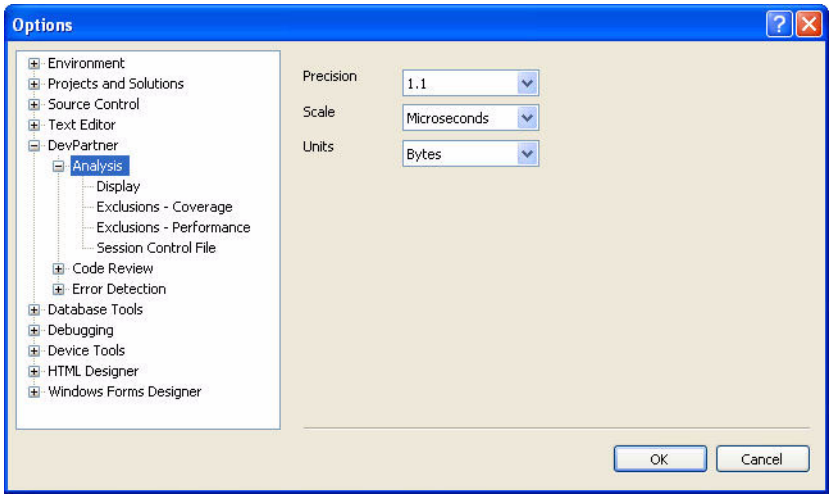


Figure 5-10. **Analysis Options**

- **Precision** - Choices are one, two, three, or four decimal places
- **Units** - Choices are Bytes, Kilobytes, or Megabytes
- The **Session Control File** option allows you to create a set of rules and actions to control the data that DevPartner collects as your application or module runs. Refer to "Creating a Session Control File Within Visual Studio" on page 366 for more information about session control files.

Other Visual Studio options, such as the **Environment > Fonts and Colors** options, also affect DevPartner features.

Starting a Memory Analysis Session

You may choose to run a memory analysis session with or without debugging. From the DevPartner menu, the only option is to start a memory analysis session without debugging. After you open a project or solution, the selection to the right of the memory analysis icon allows you to start the session with or without debugging.

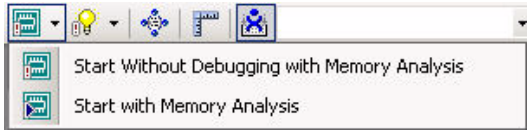


Figure 5-11. Memory Analysis Icon With Option To Start With Or Without Debugging

Start Without Debugging with Memory Analysis is the default setting for memory analysis due to ease of understanding analysis results, and improved performance. You may instrument your code with break points and **Start with Memory Analysis with debugging** to isolate the performance of specific sections in your code.

An alternative to setting break points to isolate sections of your code is to use either the `SessionControl.txt` file or the Session Control API to perform memory analysis actions while your program runs. Refer to "Creating a Session Control File Within Visual Studio" on page 366 for more information about session control files.

Using the Session Control Window in Memory Analysis

When you start a new memory analysis session, DevPartner opens the **Session Control Window**. Each tab in the **Session Control Window** corresponds to one of the types of memory problems you can analyze: Memory Leaks, Temporary Objects, and RAM Footprint. Each tab contains a view of the real-time graph, the dynamically updated class list, and several session controls that enable you to control data collection and other memory-related events, such as garbage collection. The data shown in the class list and the session controls available differ slightly, depending on the tab selected.

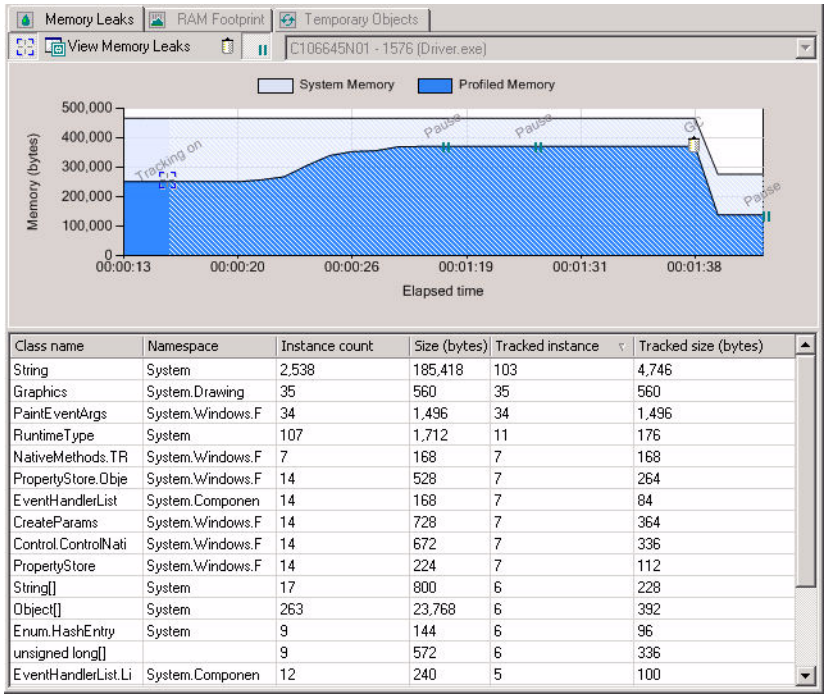


Figure 5-12. DevPartner Memory Analysis Session Control Window

Patterns in the Real-time Graph

Observe the real-time graph when you start a session. The pattern that appears in the graph as you exercise your application shows initial diagnosis of how your application is using memory. Different memory problems show characteristic patterns, so the real-time graph provides the first clue as to the existence of a problem and the nature of the problem. This helps determine what kind of memory analysis to perform.

- A steadily rising pattern that does not return to baseline or respond as expected to garbage collection may indicate leaked memory. Run **Memory Leaks** analysis.
- A pattern that does return to baseline but is characterized by periodic spikes in memory use indicates that your application is creating lots of objects as it runs. Run **Temporary Objects** analysis.
- If your application consistently consumes nearly all the reserved system memory in the managed heap, and the amount is large relative to the anticipated resources of your target users' systems, you may want to reduce the overall memory footprint of your application. Run **RAM Footprint**.

Dynamic Class List

The class list shows the 20 profiled classes that consume the most memory. The list is updated dynamically as your application runs under memory analysis. Use the class list to observe which classes are associated with increases in memory consumption or increases in object creation. Because the list is updated in real time, you may be able to spot potential problem areas as you exercise your application.

The following columns are available in the class list. Columns that indicate data is displayed in units present data in bytes, kilobytes, or megabytes, depending on the options that you set in **DevPartner Analysis Display Options**.

- To change the sort order of the class list, select a column heading in the **Top 20 Classes by** list.
- To limit the class list to classes for which source code is available, right-click anywhere in the list and choose **Show Top 20 Classes with Source** from the context menu.

Note: When you display the class list with the **Show Top 20 Classes with Source** option, array classes appear in the list if the array element type is in the source code.

Table 5-1. Column Headings In The Dynamic Class List For Memory Analysis

Columns	Data Displayed
Class names	Name of the class
Namespace	Namespace of the class
Instance count	Number of objects of this class currently in memory
Size (units)	Amount of memory used by instances of this class. Default sort for Temporary Object and RAM Footprint analysis.
Tracked instance count (Visible in Memory Leaks analysis only)	Number of tracked objects of this class currently in memory. Default sort in Memory Leaks analysis.
Tracked size (units) (Visible in Memory Leaks analysis only)	Amount of memory used by all of the tracked objects of this class that are currently in memory.

Note: Tracked objects are objects allocated after the user clicks Start Tracking and before the user toggles the selection to Stop Tracking.

DevPartner Memory Analysis Session Control Window

The Session Control window provides a number of ways to interactively control data collection and display.

Table 5-2. Memory Analysis Session Control Window Features

Session Control	Function
Process	Use the list of processes at the upper right of the tabbed area to choose a process to monitor. New processes (that are configured to be profiled) are added to the list as they begin to execute. The default selection is the launched (start-up) process.
Start/Stop Tracking  (Memory Leaks only)	Starts or stops tracking memory allocations (toggle). When you click this button, the graph changes color to indicate the portion tracked.
Clear All Memory  (Temporary Objects only)	Clears all memory data collected to this point. Does not affect garbage collection.
Force Garbage Collection 	Forces a garbage collection on the active process.
Pause Display 	Pauses the display (toggle) but does not stop data collection. When Pause is clicked again, the graph display begins redrawing the current memory use activity.

View Session Results

As your application runs, you can capture a snapshot of memory use by clicking the appropriate **View...** button. This creates a session file that contains memory usage data. You can create as many session files as you need during a given run of your application. Capturing a snapshot does not stop data collection.

Table 5-3. Snapshot Commands For Memory Analysis View Session Results

Snapshot Command	Function
View Memory Leaks	Forces a garbage collection on the active process and opens a session file that displays detailed memory leaks data.

Table 5-3. Snapshot Commands For Memory Analysis View Session Results

Snapshot Command	Function
View Temporary Objects	Creates a session file that displays detailed temporary objects data. Does not force a garbage collection on the active process.
View RAM Footprint	Forces a garbage collection and opens a session file displaying detailed RAM footprint data.

Unsaved session files open automatically in Visual Studio after they are created and all session files become part of the active solution when saved. They appear in the DevPartner Studio virtual folder in the Solution Explorer pane.

Session files first appear in the form of a Results Summary. Use the Results Summary to drill into the session data and locate problem areas in source code.

Session File Integration

When your application execution stops, DevPartner displays the results of the memory analysis sessions in a Session window in Visual Studio. DevPartner stores the collected data in a memory analysis session file, with a `.dpmem` extension.

DevPartner automatically adds the session files to the DevPartner Studio folder that you can view in the Solution Explorer for the active solution. To review an existing memory analysis session file, double-click the file in Solution Explorer.

From the Session window, you can analyze results within the development environment. Drill down into the data to examine object references or the call relationships of the methods that allocated the objects, jump to the source code for a particular method, and open the source code for any method for editing in Visual Studio.

Using the Object Reference Graph

When analyzing objects that remain in memory, you want to understand what prevents them from being collected by the garbage collector. The **Object Reference Graph** shows the complete chain of objects between the selected object and the garbage collection root or roots that are keeping the selected object alive.

Note: The **Object Reference Graph** does not show all referring objects, but those referring objects that point to a garbage collection root. For reasons of completeness, the graph also occasionally shows objects in the object reference path even if they are not on the shortest path to a garbage collection root.

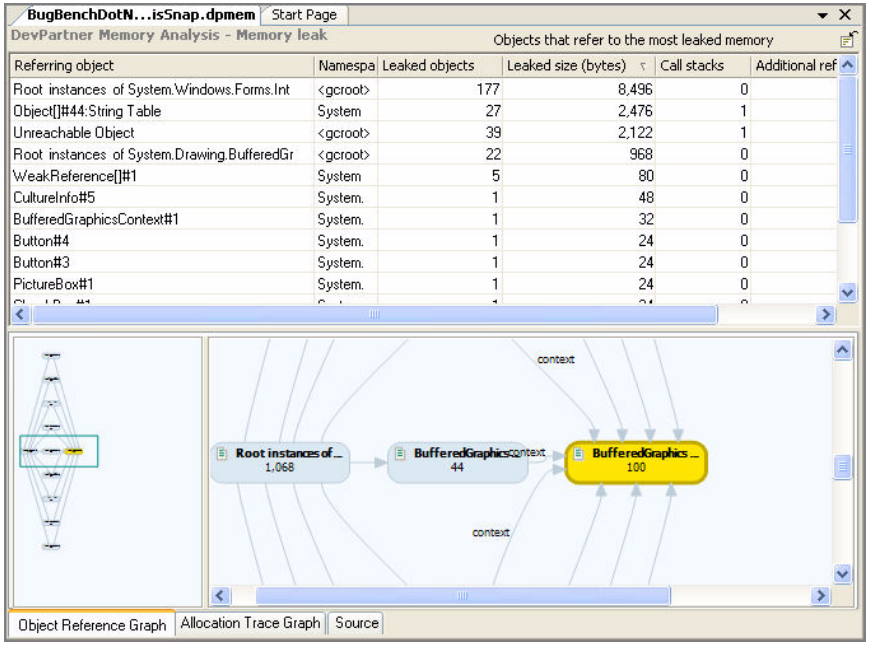


Figure 5-13. Memory Analysis Object Reference Graph

The **Object Reference Graph** automatically redraws when you select an object in the **Object List**.

The **Object Reference Graph** consists of two frames:

- The left frame presents an **overview pane** of the **Object Reference Graph**. The **overview pane** contains a **navigation frame** that allows you to quickly locate and view different parts of a large graph.
- The right frame presents the object reference relationships for the object you selected in the **Object List**.

The node highlighted in yellow represents the selected object. Numeric data on the node indicates leaked size or referenced size, depending on context. Object reference paths are indicated by lines with arrows indicating the order of reference. Labels on the connecting lines indicate the member variable that holds the reference.

Using the Call Graph to Identify Execution Paths

The **Call Graph** consists of two frames:

- The left frame shows an **overview pane** of the **Call Graph** that is useful to navigate a large graph. As you move the **navigation frame** in the overview, the view in the right frame changes dynamically.
- The right frame shows the **Call Graph**. Methods are shown as nodes. Links between nodes represent calling relationships. Expand nodes to view the order of program execution.

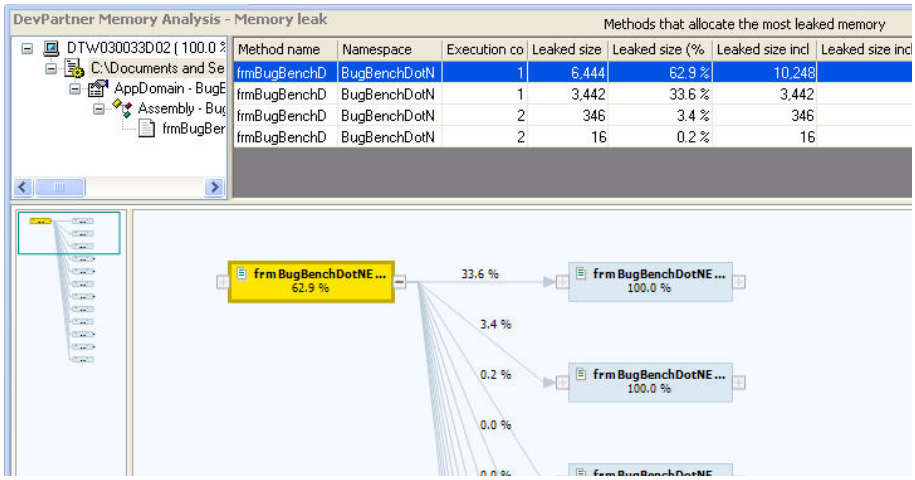


Figure 5-14. Memory Analysis Call Graph

Call graphs are read left to right. The first node initially shown in the **Call Graph** is the base node. This represents the method selected in the **Method List**. Nodes to the left of the selected node are called parent nodes. Nodes to the right of a node are called child nodes.

The upper half of the node shows the node name, which is the name of the function or method being displayed by the node. The bottom half shows the node value, which is a percentage value associated with the node. This value is the percentage of memory the node is using of the total memory being used by the node (and all of its child nodes).

The smaller rectangles on the left and right sides of the nodes are called links. They represent either a method call or invocation. The percentages on the lines tying nodes together are called link values and show a percentage value associated with the link. The link value shows the percentage of memory that child (and its children) are using of the total memory being used by its parent node.

Nodes that have no associated parent/child nodes are called “dead end nodes”. They represent the end of a path of execution, either at the start or end of an order of method calls.

To show the **Method name list** and associated **Call Graph** for temporary objects, click **Show Complete Details** from the **Entry points that allocate the most memory** graph or the **Methods that use the most memory** graph.

Once the **Method name list** and associated **Call Graph** appears, you can display **Call Graphs** for the methods in the **Method name list** by selecting a method in the **Method name list**. To view the source code for a method, select the node representing a method and click the **Source** tab at the bottom of the **Call Graph** window.

Critical Paths

When you display a **Call Graph**, DevPartner Studio computes the critical path for the selected method and all of its children. The critical path is the sequence of child method calls that resulted in the largest cumulative memory allocation. The critical path is highlighted with a bold, gold-colored line.

Using the Allocation Trace Graph

DevPartner displays the method calls that allocated memory in the **Allocation Trace Graph**. The **Allocation Trace Graph** is available in RAM Footprint and Memory Leaks session files. It is visible in any view that includes an object list.

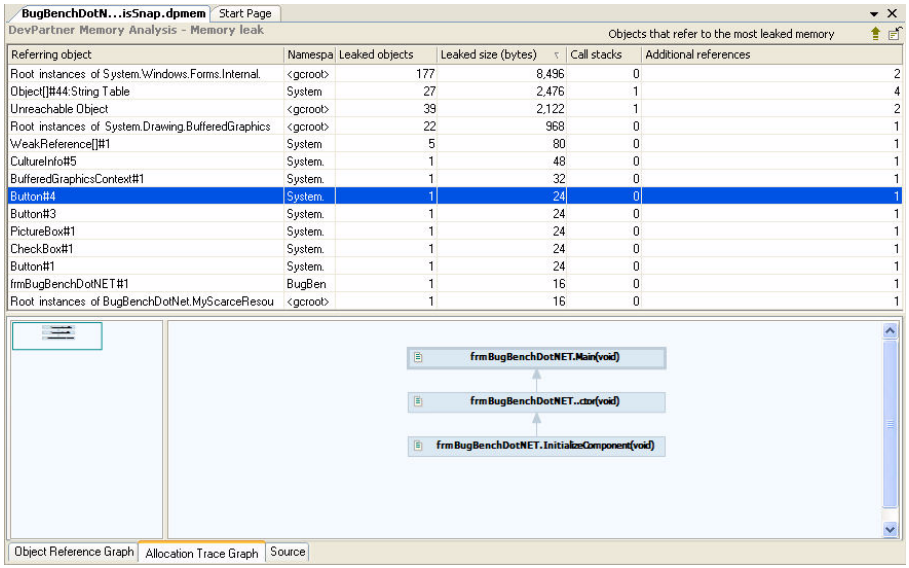


Figure 5-15. Memory Analysis Allocation Trace Graph

To display the **Object List** and associated **Allocation Trace Graph**, do one of the following:

- Click **Show Complete Details** under the **Objects that refer to the most leaked memory** (Memory Leaks) or **Objects that refer to the most allocated memory** (RAM Footprint) graph in a memory analysis **Results Summary**.
- Drill down from the **Methods that allocate the most leaked memory** (Memory Leaks) or the **Methods that allocate the most memory** (RAM Footprint) view in a **Memory Analysis Results Summary**.

To view the **Allocation Trace Graph** for an object, do one of the following:

- Select the object in the **Object List** and click the **Allocation Trace Graph** tab at the bottom of the session file window.
- Right-click an object in the **Object List** and choose **View Allocation Trace Graph** from the context menu.

DevPartner redraws the **Allocation Trace Graph** for the selected object.

To view and edit the source code for any node in the **Allocation Trace Graph**, right-click on the node and choose **Edit Source** from the context menu. DevPartner opens your source code for editing, at the selected method.

Viewing and Editing Source Code

Selecting the **Source** tab displays source code for the profiled application.

A **Source** tab view can be accessed from many points in the DevPartner memory analysis session windows, either by context menus, or by simply clicking the **Source** tab at the bottom of the session window. In addition to source code, the **Source** tab includes data about the individual lines of source code. The data available on the **Source** tab will vary, depending on the type of memory analysis performed and your data column display choices.

In addition to viewing data about your source code, you can jump directly to the source code in the Visual Studio editor by choosing **Edit Source** from one of the DevPartner memory analysis context menus. DevPartner opens the source file for editing at the line that corresponds to the object node, method node, or line of code in the **Source** tab from which you executed the **Edit Source** command.

Note: If the source code does not display or contains unintelligible characters, DevPartner may not have been able to determine the encoding of the source file.

If you know the encoding, right-click in the source pane and choose **Encoding...** from the context menu. Select the correct encoding in the dialog and click **OK** to display the source file.

From this context menu, you can also change to a different source file.

The **Source** tab consists of a view of application source code and includes data columns that contain information about the source methods used by your application. The data columns available are tailored to the context in which the **Source** tab appears. Different sets of data columns are available in Memory Leaks analysis, Temporary Objects analysis, and RAM Footprint analysis sessions.

Navigating the Source Tab

You can jump to the relevant line of source code on the **Source** tab from any object or method (for which you have source code) in the session window.

- From any Memory Leaks, RAM Footprint, or Temporary Objects results summary, click **Show Complete Details** to drill down into the session data
- In the session window, click the **Source** tab (at the bottom of the window)

Viewing Source Code

Use the following techniques to view the related source code in memory analysis.

Table 5-4. Viewing Source Code

View or Graph	Viewing Source Code
Object View	Select an object in the **Object List** and click the **Source** tab.
Object Reference Graph or **Allocation Trace Graph**	Right-click an object node and choose **View Source** on the context menu.
Method View	Select a method in the **Method List** and click the **Source** tab.
Call Graph	Right-click a method node in the **Call Graph** and choose **View Source** on the context menu

Editing Source Code

Use the following techniques to edit related source code in memory analysis.

Table 5-5. Editing source code

Graph or List	Editing Source Code
Object Reference Graph or **Allocation Trace Graph**	Right-click an object node and choose **Edit Source** on the context menu. DevPartner opens the source file in Visual Studio for editing
Call Graph, **Object List**, or **Method List**	Right-click a method in the **Object List**, **Method List**, or a node in the **Call Graph** and choose **Edit Source** on the context menu. DevPartner opens the source file in Visual Studio for editing.

Customizing the Source Tab Data Columns

- Right-click on a column heading and use **Choose Columns** to change the data columns displayed in the **Source** tab. **Source** tab columns are not sortable.

Changing the Source File

- Right-click on the title bar of the **Source** tab window and use **Choose Another Source File...** to select a different source file. This creates a new mapping for the source file. It does not affect any other source paths.

Identifying Memory Problems

Consider the following scenario:

When your Quality Assurance team reports the first test results for your new managed application, you are pleased to learn that it does what it is supposed to do. But in later tests, QA runs longer test cycles and reports that the longer the application runs, performance slows down.

That is not what you want to hear. How do you know what part of your application to examine first? When you find the problem, how do you correct it?

To find problems in your application, run the application under DevPartner memory analysis. You do not have to wait until you suspect a memory problem to use DevPartner. Make testing your application's memory use with DevPartner a routine part of the development process.

DevPartner helps you quickly learn how your application uses memory resources, revealing current or potential problem areas.

After you start a memory analysis session without debugging, use the **Session Control Window** to observe how your program uses memory.

The real-time graph presents a visual representation of memory use. The class list updates dynamically to show the classes that use the most memory as your program runs. Right-click the class list to switch between the **Top 20 classes** and the **Top 20 classes with source**.

The **Session Control** buttons in the user interface allow you to take a snapshot of the managed heap for detailed analysis.

When you run a memory analysis session, you can choose to examine one of three important potential problem areas:

- Memory leaks
- Temporary object creation
- Overall RAM footprint

Table 5-6. Symptoms And Analysis Tools

Symptom	Analysis Tool
Performance degrades over time; recovers on restart. Performance improves after restarting the application, but degrades again.	Memory Leaks
Scalability problems; temporary performance degradation.	Temporary Objects Memory Leaks
Sluggish performance, does not improve after restarting the application.	RAM Footprint Temporary Objects

First choose the appropriate memory analysis feature for the symptom that your application exhibits. You eventually want to run your application under all three types of memory analysis. Even if you do not find a problem, the thorough analysis enhances your understanding of how your program uses memory resources.

Running a Memory Analysis Session

The first thing you notice when running any memory analysis session is the real-time graph on the **Session Control Window**. The real-time graph provides a visual representation of how your application uses memory resources. Observe the pattern the graph takes as you exercise your application. Different memory usage scenarios create characteristic patterns, so the real-time graph provides the first clue to the existence and nature of a memory problem.

Tip: Pay careful attention to the shape of the real-time graph as you run your application. You can often diagnose a memory problem immediately by observing and learning from the pattern of the graph.

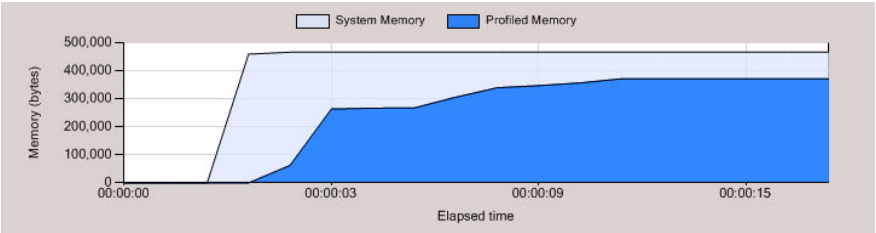


Figure 5-16. Memory Analysis Session Control Window Real-time Graph.

For example, if the graph shows a rising pattern that never returns to baseline, as in Figure 5-16, your application is probably leaking memory. You may suspect that the progressive slowdown of your application that your QA team noticed is consistent with a memory leak, but the real-time graph confirms that diagnosis.

If the graph returns to the baseline, but you see periodic spikes in memory use, your application is creating large numbers of objects as it runs. Granted, the allocated memory is being freed, but such an application may not scale well under load.

If your application slows down in response to an increase in users or inputs, the slowdown could indicate a scalability issue. Again, the real-time graph indicates the nature of the problem, enabling you to immediately point your diagnostic efforts in the right direction.

Even in the absence of a suggestive pattern, the real-time graph provides important information. For example, if your application consistently consumes nearly all of the memory allocated for the managed heap, and that amount is large relative to the anticipated resources of your target users' systems, you may want to reduce the overall memory footprint of your application. The next sections in this chapter provide detailed information about such cases and their implications for application performance.

Locating Memory Leaks

The amount of memory consumed by your application has a major impact on how well the application performs. The larger the amount of memory allocated, the more likely it is that the application will run slowly and scale poorly.

Leaked memory—the allocation of memory that is not reclaimed—can bloat your application's RAM footprint. Automatic garbage collection relieves you of the responsibility to explicitly free the objects that you create, so memory is not "leaked" in the classic C++ sense, but it is still possible to retain references to objects that the program will never use again.

As long as a reference to an object exists, the referenced object is considered to be a **live object** by the garbage collector; a live object cannot be collected. This condition, like leaked memory in C++, is undesirable. Such references can be difficult to track down and that is where memory analysis helps you.

Consider **Memory Leaks** analysis.

Running a Memory Leaks Analysis Session

The Ready, Set, Go section "Using Memory Analysis Out of the Box" on page 159 also includes a procedure for using the Memory Leaks feature. The following is a quick summary of that process.

Isolating Memory Leaks with the Memory Leaks Feature

1. Start your application under memory analysis. Use the **Memory Leaks** tab in the **Session Control Window**.
2. Exercise the relevant features of your program to force any startup initialization to complete. The application warm-up also excludes initialization memory allocations from your analysis.
3. Click **Start/Stop** to begin tracking only newly allocated objects.
4. Exercise the feature of your program that you wish to test.
5. Click **Force garbage collection** to force a garbage collection on the active process.
6. Click **Start/Stop** again to end the tracking period and to exclude any new memory allocations.
7. Check the **Tracked instance count** and **Tracked size** columns in the **Class List**. If you see that objects have been allocated but not collected, click **View Memory Leaks** to capture a view of the managed heap that shows the tracked objects that remain after garbage collection.

Note: **View Memory Leaks** appears only after you click **Start/Stop** tracking for the first time.

DevPartner displays a snapshot of the state of the managed heap. The data is displayed as a **Memory Leaks Results Summary**. From the results summary page, you can drill into the memory use data, identify the problem, and locate the method(s) responsible in the source code.

Note: To enable DevPartner to properly identify most garbage collection roots in Memory Leaks or RAM Footprint sessions, **Start Without Debugging with Memory Analysis**. If you attempt to collect Memory Leaks or RAM Footprint data for an application started under **Start with Memory Analysis** (with debugging), all garbage collection roots will appear as "`unidentified GC roots`" in the session data.

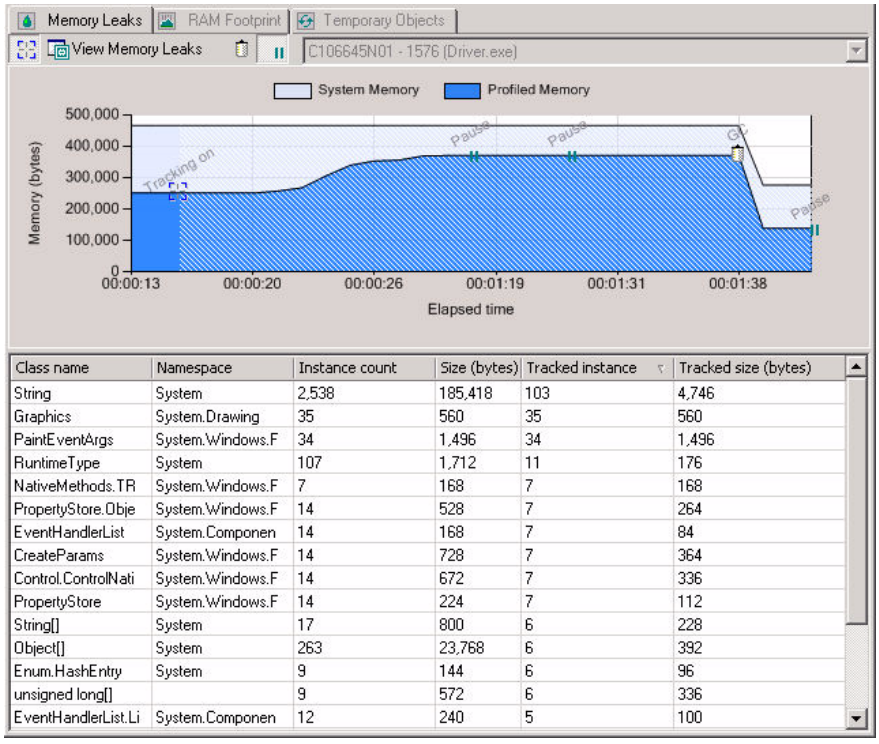
Understanding Memory Leaks Analysis Results

DevPartner Memory Leaks analysis defines a memory leak as any object that is allocated on the managed heap during a specified period of time, and has not been freed when you collect memory data. Memory Leaks analysis helps to reveal where your application holds memory that should be freed. Use this information to determine how to change your code so this memory will be freed.

To uncover memory leaks, run your application under the DevPartner Memory Leaks analysis feature and exercise the application in a way that should free previously allocated objects.

If memory use consistently rises and does not decrease (or does not decrease as you would expect it to) in response to garbage collection, your application could be leaking memory.

For example, see Figure 5-17. The real-time graph in this figure shows a rise in memory use that did not return to baseline after garbage collection. If you look at the **Tracked instance count** column for the classes that belong to your application, you notice that garbage collection is not collecting some tracked objects. Look for the number of uncollected instances in the **Tracked instance count** column in the **Session Control Window**.



Class name	Namespace	Instance count	Size (bytes)	Tracked instance	Tracked size (bytes)
String	System	2,538	185,418	103	4,746
Graphics	System.Drawing	35	560	35	560
PaintEventArgs	System.Windows.F	34	1,496	34	1,496
RuntimeType	System	107	1,712	11	176
NativeMethods.TR	System.Windows.F	7	168	7	168
PropertyStore.Obje	System.Windows.F	14	528	7	264
EventHandlerList	System.Componen	14	168	7	84
CreateParams	System.Windows.F	14	728	7	364
Control.ControlNati	System.Windows.F	14	672	7	336
PropertyStore	System.Windows.F	14	224	7	112
String[]	System	17	800	6	228
Object[]	System	263	23,768	6	392
Enum.HashEntry	System	9	144	6	96
unsigned long[]		9	572	6	336
EventHandlerList.Li	System.Componen	12	240	5	100

Figure 5-17. Session Control Window Data Display

Once DevPartner alerts you to a possible leak, use the **Memory Leaks Results Summary** (session file) that DevPartner creates to locate the source of the leak so you can fix it. The Memory Leaks analysis results summary gives you the following ways to drill down into your data:

- **Objects that Refer to the Most Leaked Memory**
- **Methods with the Most Leaked Memory**

Each chart shows the top five objects or methods that are associated with leaked memory. To see more information about the top five objects or methods, click **Show Complete Details** for that chart.

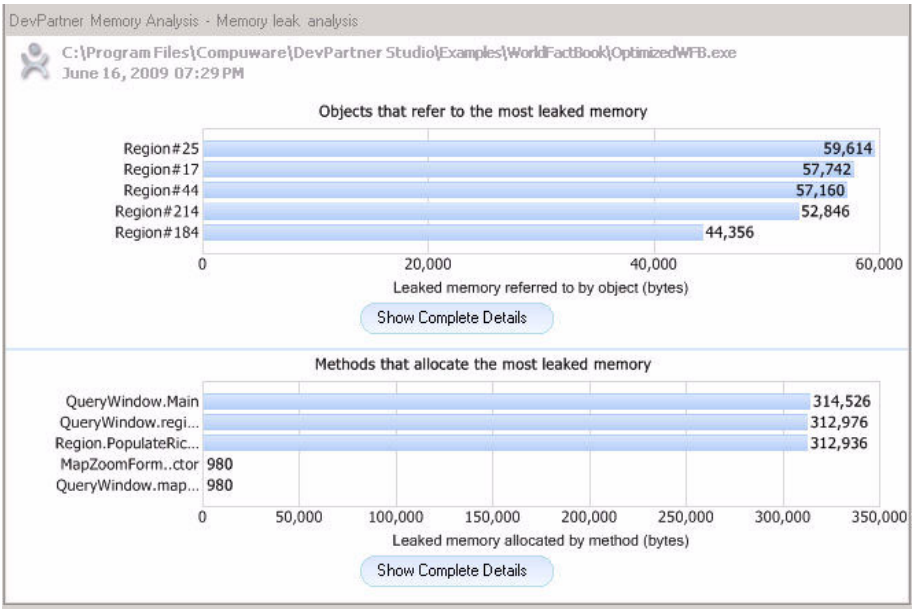


Figure 5-18. Results Summary Appears When You Click View Memory Leaks

The starting point you choose depends on the problem that you want to solve and your preferred approach to the problem. For example:

- If you notice that a limited set of specific objects are being leaked, you can use the **Objects that refer to the most leaked memory** graph to quickly see which objects hold references to the leaked objects.
- If you are familiar with the source code for the allocating method and can tell by examining the source code whether the leaked object should have been cleared, you may want to start with the **Methods that allocate the most leaked memory** chart.

From both the objects and methods charts, you can quickly switch to a view that shows another aspect of your data.

When viewing complete details for **Objects that refer to the most leaked memory**, you can select these views:

- **Object Reference Graph**
- **Allocation Trace Graph**
- **Source**

When viewing complete details for **Methods that allocate to the most leaked memory**, you can select these views:

- **Call Graph**
- **Source**

The following example uses **Objects that refer to the most leaked memory** as a starting point.

Objects that Refer to the Most Leaked Memory

The following example shows a case where a limited set of objects causes leaked memory. The example also presents other possible approaches for problem diagnosis.

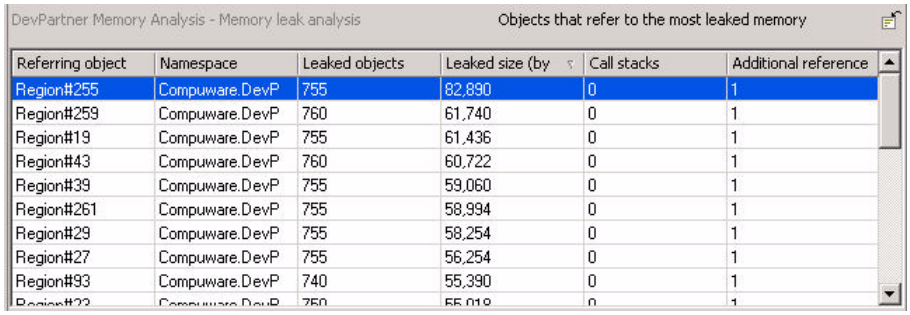
The garbage collector cannot clear an object as long as there is at least one existing reference to that object. When your application runs, it creates objects. Some objects are needed for as long as the program runs. These are permanent, or long-lived objects. However, most objects should become eligible for garbage collection once they are no longer referenced by another object.

Figure 5-19. Objects That Refer To The Most Leaked Memory

The chart in Figure 5-19 shows the top five objects that hold references to the most leaked memory. These objects prevent the leaked objects from being freed. Referring objects that account for the biggest memory hit appear at the top of the chart. The data indicates that a particular set of objects is responsible for the leaked memory. Use this chart as the starting point to drill into session data and locate the source of the memory leaks.

Clicking **Show Complete Details** (below the bar graph; see Figure 5-20 on page 194) opens a detailed display for objects that refer to leaked memory.

The top panel of this display lists all of the objects that refer to leaked memory, as displayed in the chart in Figure 5-20. This list includes the top five objects displayed in the original bar graph and other objects that refer to smaller amounts of leaked memory.



Referring object	Namespace	Leaked objects	Leaked size (by	Call stacks	Additional reference
Region#255	Compuware.DevP	755	82,890	0	1
Region#259	Compuware.DevP	760	61,740	0	1
Region#19	Compuware.DevP	755	61,436	0	1
Region#43	Compuware.DevP	760	60,722	0	1
Region#39	Compuware.DevP	755	59,060	0	1
Region#261	Compuware.DevP	755	58,994	0	1
Region#29	Compuware.DevP	755	58,254	0	1
Region#27	Compuware.DevP	755	56,254	0	1
Region#93	Compuware.DevP	740	55,390	0	1

Figure 5-20. List Of Objects That Refer To The Most Leaked Memory

The default setting is to sort the objects by the **Leaked size** (total size of the leaked objects referred to by the selected object) column. You can also sort the list by any of the other columns to help you see patterns in the data. If you right-click an item in the list and choose **View leaked objects referenced by this object**, you see the objects that were actually leaked.

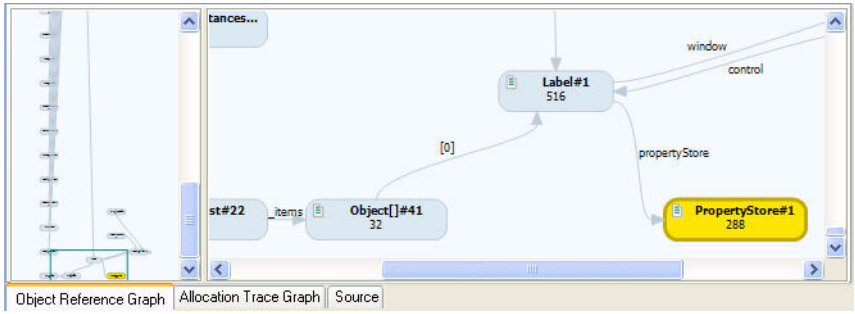


Figure 5-21. The Object Reference Graph Shows Why an Object is Still in Memory

Select a referring object that you want to examine. It is important to be able to quickly understand the sequence of references that keep these objects in memory. Click the **Object Reference Graph** tab to view the reference graph. The **Object Reference Graph** shows why the garbage collector did not clear the selected object. The display shows the chain of objects between the selected object and the garbage collection root(s) that are keeping the object alive.

Scroll down the list of objects to evaluate the other objects. Some object reference graphs are quite simple, while others may be quite complex. You may find evidence that indicates conditions such as many references to small objects or a few references to large objects. The goal is to use this graph to determine the point in the chain of referring objects where it is most efficient to eliminate the leak.

The chain of referring objects shown in the **Object Reference Graph** can range greatly in complexity. In many cases, there are multiple referrers and the graph becomes very complex. Drag the **navigation frame** in the **overview pane** or click on a node to change the nodes displayed in the detail pane. If an analysis presents you with a complex graph, simplify the view by right-clicking a node and selecting **Show Fewer Referrers**. You can also drag nodes within the graph for easier viewing.

The labels such as **elements** on the connecting arrows represent the referring data member in the next class in the graph. Bracketed numbers identify arrays. If you know your code well, the labels speed up the process of identifying potential problem areas.

You can also right-click a node and select **Edit Source** to open the related source code within Visual Studio, or view the related source code by selecting the **Source** tab. DevPartner highlights the line in the method that allocated the object in the graph.

To increase program understanding, you can view the source for each node in the graph sequentially and see the events that led to the allocation of the memory that leaked. DevPartner offers alternate ways to view these program events. For example, the **Allocation Trace Graph** shows who called each method that allocated the selected object.

You can go directly from the object in the list to the source code. In real-world problem solving, you should drill down using an appropriate method for the problem that you are trying to solve or that corresponds to the way you think about your code.

Alternate Methods of Solving the Problem

The preceding example focused on use of the object reference path to locate the source of a leak. There are other ways to approach the memory leak source. For example:

- Look at the **Allocation Trace Graph** to determine who called the method that allocated the object. From there go to the source code.
- Go directly to the source code from the list of objects.

Remember that DevPartner presents different views of your data on the **DevPartner Memory Analysis - Memory leaks analysis** summary. The first example used **Objects with the Most Leaked Memory**. However, depending on the complexity of the data, or on your own preferences, you could examine a problem from any of the following graphs on the **DevPartner Memory Analysis - Memory leaks analysis** summary.

Methods that Allocate the Most Leaked Memory

The following graph, which appears in the lower half of the **DevPartner Memory Analysis - Memory leaks analysis** summary, shows the top five methods that allocated objects that were leaked. When you click **Show Complete Details**, DevPartner provides a list of all methods that leaked objects, with access to a **Call Graph** view and to the source code for the method, if available.

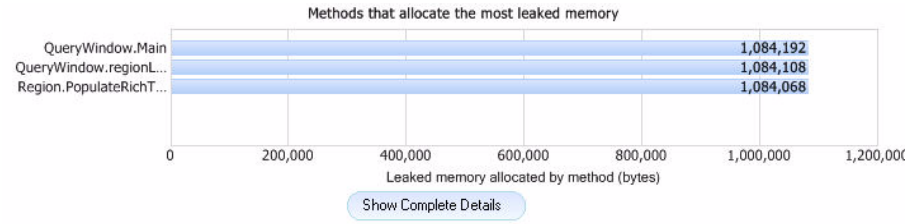


Figure 5-22. Methods That Allocate The Most Leaked Memory

Select a method in the **Method List** to see the objects that were allocated from the method that were leaked. You can also view the source code for the method which shows the lines that allocated the leaked objects along with statistics about the number and size of objects leaked on the line.

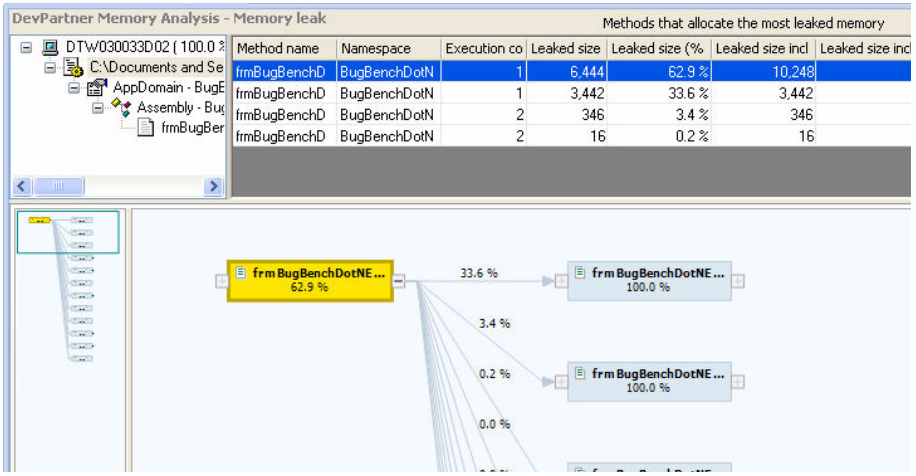


Figure 5-23. Details For Methods That Allocate The Most Leaked Memory

For example, to drill into to the data:

- Right-click a method in the **Method List**.
- From the selected method, go to a list of the objects allocated by the method or to a **Call Graph** for the method.

- From an object in the **Object List**, view a list of referenced objects, an **Object Reference Graph**, or an **Allocation Trace Graph.**
- From a method, or a node in a **Call Graph** or **Allocation Trace Graph**, view source code with object allocation data for individual lines.
- From a method or object in a list, or a node in a **Call Graph**, **Object Reference Graph**, or **Allocation Trace Graph**, or a line of source code; choose **Edit Source** to open the source to the appropriate line for editing.

Solving Scalability Problems with Temporary Objects

When performing memory analysis with DevPartner, you can use Temporary Objects analysis to diagnose and correct scalability problems.

Examples of Scalability Problems

Scalability problems surface when an application runs well until users work with the application more intensively. For a client-server application, this might happen when the number of users increases. For a standalone application, this might happen after numerous text manipulations or mathematical computations. These can be labeled as *scalability* problems. As the scale of the work done by the application increases, performance degrades.

A Possible Cause: Temporary Objects

One possible cause of scalability problems is the creation of too many temporary objects. In this case, object creation becomes a performance bottleneck—a problem that requires correction.

Creating and using objects is important within managed Visual Studio programs. Unfortunately, some coding techniques have the side-effect of creating many objects.

Part of the problem is the creation of objects such as those created with the `String` class. It takes processing cycles to create objects and later destroy these objects. If you can reduce the number of objects created, you can generally expect better performance.

Object Life Span

DevPartner tracks the objects allocated by your code and categorizes them based on how long it takes for them to be collected. There are three categories:

- Short-lived — collected at the first garbage collection after the object was allocated (generation 0)
- Medium-lived — collected at the second garbage collection after allocation (generation 1)
- Long-lived — survives across many (or all) garbage collections during the run of the program (generation 2)

Note: The Microsoft .NET Framework garbage collector supports three generations, designated 0, 1, and 2. Objects allocated since the last run of the garbage collector are in generation 0. Objects that survive one garbage collection after allocation become generation 1 objects. Generation 1 objects that survive one or more additional garbage collections become generation 2 objects.

DevPartner combines short- and medium-lived object allocations in a temporary objects category.

Medium-lived objects have the greatest impact on performance, and cause the garbage collector to work harder than necessary. Individual short-lived objects have less impact on garbage collection, although there is still a performance penalty for calling the object's constructor. However, creating large numbers of short-lived objects may cause bottlenecks and memory shortages.

If you believe that your code has scalability issues, use DevPartner to monitor memory used by your code as it executes. If the real-time graph in the **Session Control Window** shows an up-and-down, wavelike pattern—which suggests that your application is creating many temporary objects—you can use DevPartner to analyze the application for temporary object creation.

DevPartner categorizes the results of temporary object analysis by entry points and by methods. Regardless of which technique that you use to drill into the data, DevPartner helps you see how much memory the temporary objects consume and identify the specific lines of code that allocate the temporary objects.

Running a Temporary Objects Analysis Session

Use the following procedure to analyze your application for problems caused by temporary object creation:

1. Start your application under memory analysis. Use the **Temporary Objects** tab in the **Session Control Window**.
2. Exercise your application, then do one of the following to see the parts of your program that have allocated the most temporary objects:
   a. Click **View Temporary Objects** when you observe a system garbage collection (the falling pattern) in the **Session Control Window**.
   b. Click the **Force Garbage Collection** icon, then immediately click **View Temporary Objects**.
   c. Quit the program. DevPartner forces a garbage collection and creates a temporary objects session file.

Note: If you are running your application in the debugger, do not use the debugger to stop your application. DevPartner will not produce a session file in response to this action. Quit the application normally to generate a session file.

3. To examine the temporary object allocation behavior for a specific part of your application, click **Clear all memory** to clear the collected temporary object allocation data. Afterwards exercise the relevant part of your application, force a garbage collection, and click **View Temporary Objects**.

Note: DevPartner always creates a temporary objects session file when you quit an application running under memory analysis. DevPartner also creates a temporary objects session file in response to the snapshot action executed in a session control file or the Session Control API.

DevPartner displays a snapshot of the state of the managed heap. The data is displayed as a **Temporary Objects Results Summary**. From the results summary page you can drill into the object creation data, identify the problem, and locate the method(s) responsible in the source code.

Identifying Scalability Problems

DevPartner enables you to locate potential trouble spots and then drill down into your application's use of temporary objects to identify problems and improve the overall quality of your code.

Real-time Graph

The real-time graph provides a high level view that enables you to identify problematic areas.

If your application is creating large numbers of short- and medium-lived objects, you see a peak in profiled memory in the real time graph which diminishes when the garbage collector runs. If you exercise the feature again after garbage collection, you see another peak which is caused by creating a new group of temporary objects.

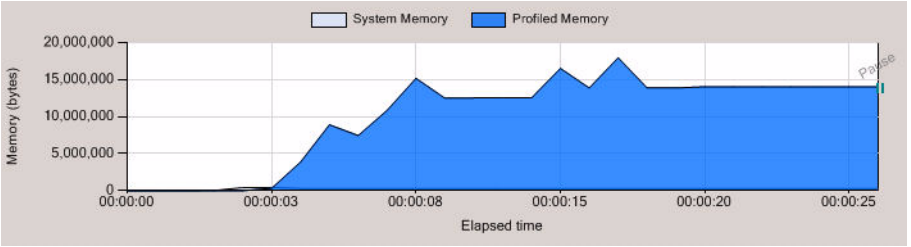


Figure 5-24. Real-time Graph Showing a Pattern that Suggests Excessive Temporary Object Creation

The classes responsible for the most objects appear in the list of profiled classes which are sorted by the **Size** column. This highlights the classes whose objects consume the most temporary memory. Also notice the **Instance Count** which shows how many object instances were created for each class.

Figure 5-24 shows a real-time graph that suggests excessive temporary object creation. Spikes in the graph show where your application is creating lots of objects. Excessive object creation can create major performance or scalability issues in a managed application and especially in server applications. Even if scalability is not an issue, methods that allocate many short-lived objects often indicate easy-to-fix performance problems.

Viewing Temporary Objects

Click **View Temporary Objects** to collect data at a specific point in your application. DevPartner displays a **Temporary object analysis** page that categorizes the data by entry points and by methods that create the most temporary objects.

An **entry point** is a profiled method that is called by excluded (that is, system or third-party) code. When your application runs, monitoring begins with the first call to a profiled, or user-code, method. (User-code methods are methods in your application source code.) This is called an entry point. All calls made to other user-code methods from that point are considered to be part of the entry point.

Methods that are called only by other user-code methods are not entry points. However, such methods could be responsible for large amounts of temporary memory use. The second chart on the **Results Summary** highlights methods that allocate lots of temporary memory, but are not necessarily entry point methods. Thus, if a child method called by an entry point is the major memory allocator in your application, you can locate that method in **Methods that use the most memory** without having to follow the **Call Graph** for the entry point method that called it.

From the **Results Summary** view you can drill into the data in order to understand how much memory the objects allocated by these methods are consuming, and to identify the lines of code that are creating the short- and medium-lived objects.

Analyzing Temporary Object Data

Clicking **Show Complete Details** that is below either chart opens a detailed view of all the entry points, or all the methods in your application that allocated temporary memory. In addition to the complete list of methods, the view includes a **Call Graph** and a **Source** tab.

The available data columns in the Method List provide more extensive data about your application's methods than those in the list of profiled classes on the **Session Control Window**.

Call Graph

Click on an entry point in the entry points list or a method in the method list to view a **Call Graph** for the method. The **Call Graph** shows the selected method and its child methods, and highlights the **critical path** with a bold, gold-colored line. The **critical path** is the sequence of child method calls that resulted in the largest cumulative memory allocation for the selected method.

Methods appear as nodes in the **Call Graph**. Each node can display data about memory allocated by the method. In addition, the links between nodes can display data about memory allocated by that branch of the graph. The data is expressed as percentages of memory allocated.

- **Nodes** - The percentage of memory allocated by the method that is attributable to the body of the method itself.
- **Links** - The percentage of memory allocated by the method that is attributed to child methods that are executed in that branch.

This is how DevPartner shows you not only which methods are responsible for the temporary objects your application creates, but exactly where in the paths of execution the allocations occur.

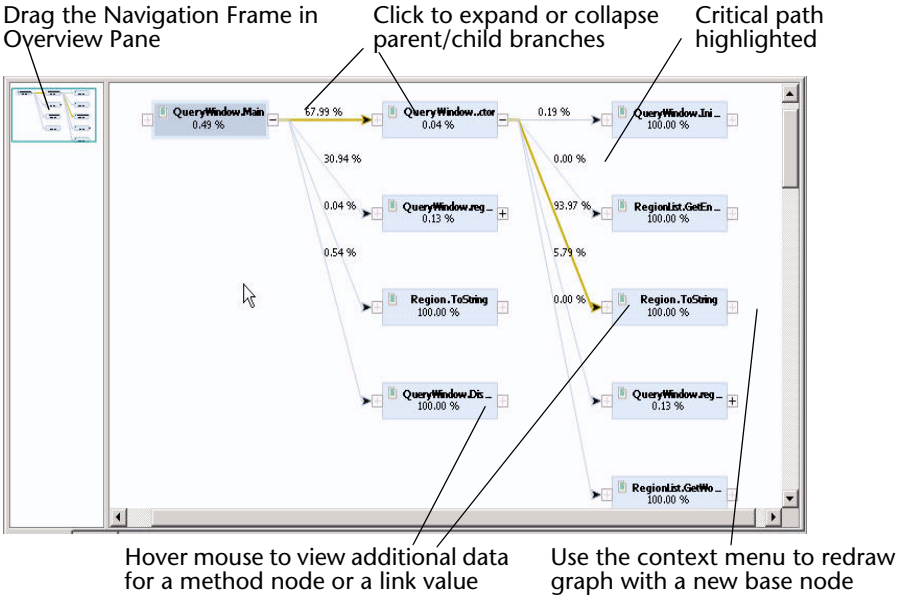


Figure 5-25. A Call Graph for an Entry Point Method Shows the Critical Path

Right-click on any node in the **Call Graph** to:

- Redraw the **Call Graph** for the selected node
- View source code for the selected node
- Edit source code for the selected node

Source View

When you view the source code for an entry point or method in the **Entry points that allocate the most memory** or the **Methods that use the most memory** method lists, DevPartner opens the **Source** tab view to the selected method. In addition to the source code, DevPartner provides detailed information about the memory allocated by individual lines in your application code. The information includes how often the line executed; the number of short-, medium-, and long-lived objects, including or excluding child objects, allocated on the line; and the accumulated sizes (memory load) of these objects.

Interpreting Results to Fix Scalability Problems

The following list suggests some of the possible ways to interpret memory analysis results to fix memory-related scalability problems.

- Look at the **Temporary Objects analysis** page to determine if an entry point or non-entry point method consumes the most temporary memory.
- If the largest consumer of temporary objects is an entry point, drill down using the **Entry points that allocate the most memory** view to determine which methods in the entry point's execution path require the most temporary space and should be modified or called less often.
- If the largest consumer is a non-entry point method, drill down using the **Methods that use the most memory** view to determine which parts of your code to modify.
- Compare the number of short- and medium-lived objects, as well as the amount of temporary space they consume. Use this information to determine which parts of your code to modify.
- If both short- and medium-lived objects consume similar amounts of temporary space, you can run a performance analysis to find out how much time the constructor uses to create the temporary object.
- Use the **Call Graph** to understand the relationship between methods that allocate temporary memory. Examine characteristics of different methods: percentages of memory consumed; actual bytes used; and numbers of temporary objects created. Use this information to identify which method to modify.
- Use the **Source** tab to identify specific lines in your code that allocate temporary objects. Examine the kind and sizes of objects created, and how often the line is executed. Use this information to identify more efficient ways to use objects.

Using RAM Footprint to Improve Performance

Some managed applications consume hundreds of megabytes of RAM while they are running. This chapter examines some specific memory problems in this chapter: memory leaks, which can cause your application to consume more and more memory as it runs until it eventually exhausts the heap, and periodic spikes in memory use caused by excessive temporary object creation, which can lead to scalability issues. These problems adversely impact your application's memory use.

These problems also contribute to your application's memory footprint. Your application may be well-behaved with respect to these errors—but performance may still seem slow, especially when run in various end-user environments.

One possible cause of sluggish performance is that your application may use excessive amounts of memory as it runs. What is excessive? That depends on the environment—hardware and software—in which your application is used. You may have a good idea of the end user environment, but the environment can change. For example, the end user may run several other applications at the same time as they run yours which competes for memory resources. Nor can you force hardware upgrades on your users every time you release a new version of your application. All of this makes a strong argument for keeping your application's memory footprint small.

More specifically, the memory use addressed here is the RAM footprint, not just overall memory use. The biggest effect to application performance—and your end-users' perception of your application—is to force the application to rely on the operating system's virtual memory system. Paging managed objects into virtual memory greatly decreases application performance.

What can you do to optimize your application's use of RAM resources? DevPartner provides RAM Footprint analysis as part of its memory analysis capability. Run RAM Footprint analysis regularly as you develop your application. The way your application uses RAM resources is most likely a result of application design and architecture. It is much easier to re-design a feature early in the development process than to wait until the application is ready for beta release.

Measuring RAM Footprint

DevPartner helps you focus your performance tuning effort on the areas that have the greatest impact on RAM consumption. When you run your application under RAM Footprint analysis, DevPartner enables you to:

- View the real-time graph of your application's RAM consumption, and view the real-time list of profiled classes associated with the most bytes of memory.
- Take snapshots of the managed heap which you use to examine the objects responsible for the most memory use.

Tip: See the DevPartner Studio online help for procedures related to measuring a RAM Footprint.

To measure RAM footprint:

1. Start your application under memory analysis. Use the **RAM Footprint** tab in the **Session Control Window**.
2. Exercise your application to get it into a steady state for which you wish to examine memory use.
3. Click **View RAM Footprint** to see a detailed snapshot of the managed heap at that point in time.
4. Remember that the garbage collector only runs when available memory is exhausted, so the memory graph may not accurately represent the amount of memory in use at a given time. When your program is in an idle steady state, click **Force garbage collection** to force the garbage collector to run and update the memory graph.

DevPartner displays a snapshot of the state of the managed heap. The data is displayed as a **RAM Footprint Results Summary**. From the results summary page you can drill into the session data and locate the objects and methods responsible for the most memory use.

Note: To enable DevPartner to properly identify most garbage collection roots in Memory Leaks or RAM Footprint sessions, **Start Without Debugging with Memory Analysis**. If you attempt to collect Memory Leaks or RAM Footprint data for an application started under **Start with Memory Analysis** (with debugging), all garbage collection roots will appear as "`unidentified GC roots`" in the session data.

Use the RAM Footprint analysis page to gain an in-depth understanding of how your application uses memory. The **RAM Footprint Results Summary** gives you the following ways to examine and drill down into your data:

- **Object Distribution**
- **Objects that refer to the most allocated memory**
- **Methods that allocate the most memory**

Which you use first will depend on the data presented and, to some extent, on the way you tend to think about your application.

Object Distribution

DevPartner presents the distribution of objects in memory as a pie chart so you can immediately see the proportion of memory used by your application (**Profiled objects**) relative to that used by system code (**System objects**).

Interpreting the **Object Distribution** chart:

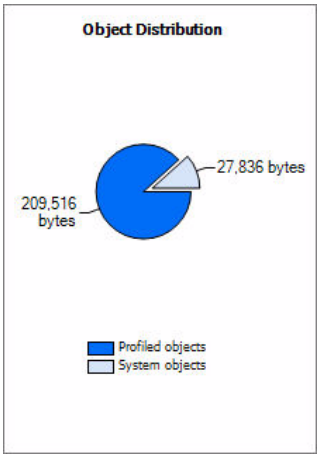


Figure 5-26. DevPartner Memory Analysis Object Distribution Chart

- If your application (**Profiled objects**) is the largest wedge in the pie, and memory use is moderate to high relative to expected resources in the target deployment environment, you should determine which parts of your application allocate the most memory. To do this, use the **Objects that refer to the most allocated memory** or the **Methods that allocate the most memory** chart to drill down into the data. Ultimately, you want to locate in source code those parts of the application that you can change or restructure to use less memory.
- If the **Profiled Objects** part of the pie chart is small, your application is not the main allocator of memory. This is a good thing. But if the application still seems sluggish or if overall memory use is high, you may want to investigate how your application is using unmanaged code or system resources. Unmanaged code can pin objects in memory. Visual Studio applications often spend a great deal of time in the .NET Framework; you may find that you can call .NET Framework methods more efficiently, or less often.

Drill into the RAM footprint data by using either of the following two analysis paths:

- **Objects that refer to the most allocated memory**
- **Methods that allocate the most memory**

Objects that refer to the most allocated memory

Objects that refer to the most allocated memory shows the objects that held references to live objects at the time the session file was generated. The size displayed is the total of all objects referenced from this instance.

- Click **Show Complete Details** to drill into the data for these objects.

Objects that refer to the most allocated memory enables you to focus on instances of objects that are responsible for the largest amounts of memory. Organizing the data by instances of objects that hold references to allocated memory highlights **large objects**, that is, the objects for which a maximum amount of memory would be reclaimed if the object could be garbage collected.

While an individual object might be small, it becomes much larger, i.e., a large object, when you include the memory consumed by the objects to which it refers. When the garbage collector runs, it cannot collect objects that are referenced by other objects. Thus an object that refers to many other objects may account for a considerable amount of memory. If you can collect such an object, you can also collect any other objects to which it holds a unique reference. Such large objects are obvious targets when you are trying to reduce an application's RAM footprint.

The **Objects that refer to the most allocated memory** view includes a list of live object instances with data about each object's impact on memory at the time the session file was created. It also includes a tabbed window in which you can view an **Object Reference Graph**, **Allocation Trace Graph**, and **Source** view.

This view helps you identify the largest objects in memory. **Referenced Size** data includes memory attributable to all child objects for which the object is the only parent. Considered singly, objects tend to be small. However, an object with several child objects, each of which may also have child objects, plus per-object overhead for parent and child objects, may actually consume a large amount of memory.

DevPartner uses the **Object Reference path** to roll up the bytes associated with child objects and attributes them to the parent object. The advantage of this view is that the view lets you focus on those objects that provide the biggest benefit if you can change the way they are allocated.

Once you zero in on the objects that consumed the largest amount of memory, you may immediately see changes that you could make to reduce memory consumption. However, you may want to investigate further to understand the implications of freeing or changing the way the application uses a particular object.

- Double-click the selected object in the instance list, or use the context menu to view the live objects referenced by the selected object.

Live Objects Referenced by *<object name>*

The **Live objects referenced by object** view shows you all of the live objects which are referenced in memory that are referenced by the selected parent object. In other words, these child objects could also be collected if the parent object could be collected.

All Objects Referenced by *<object name>*

The **All objects referenced by object** view displays an instance list of the objects referenced by an object selected in the **Live Objects Referenced by object** window.

Like its parent windows, the data presented in **All Objects Referenced by object** is organized by instances of objects that hold references to allocated memory. This view enables you to further examine the chain of references that are keeping objects in memory. In the **All Objects Referenced by object** window, you can examine the entire chain of objects referenced by any of the child objects in **Live Objects Referenced by object**.

You can continue to drill down from any object and view all the objects to which it holds a reference through the entire sequence of object references.

The Object Reference and Allocation Trace Graphs

All of the Object views discussed above include an **Object Reference Graph** and an **Allocation Trace Graph**.

The **Object Reference Graph** shows live objects in memory at the time that the session file was created. A live object is an object on which methods can be invoked. When the garbage collector runs, the collector identifies the objects that have valid references. A valid reference means that an object is reachable from the application's garbage collection roots. Reachable objects are marked as live objects and cannot be collected. The **Object Reference Graph** shows these object references and helps to explain why the objects are still in memory.

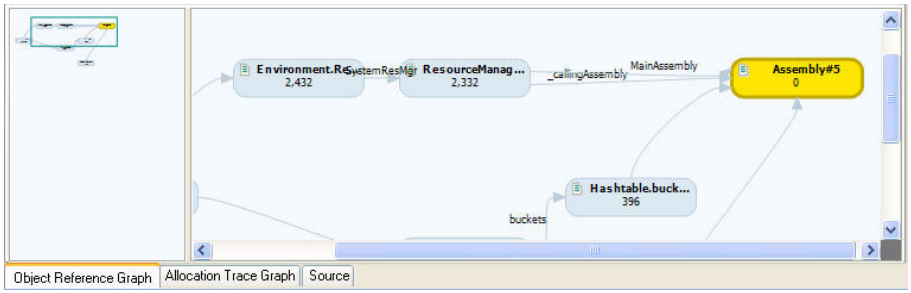


Figure 5-27. The Object Reference Graph

Methods in your application allocate objects and the memory that the objects use. It is useful to know the sequence of method calls that allocated memory. The **Allocation Trace Graph** shows the method calls that allocated an object.

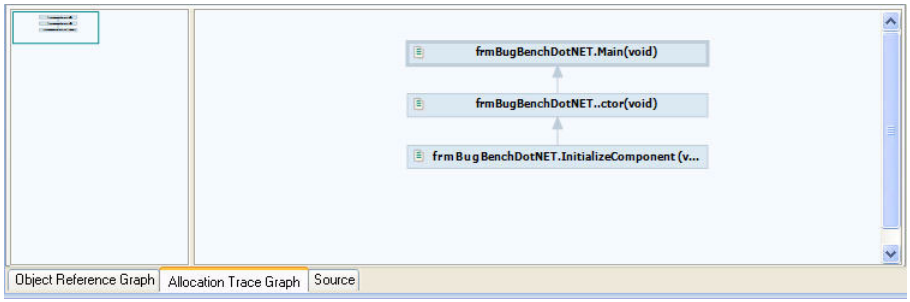


Figure 5-28. The Allocation Trace Graph

Methods that Allocate the Most Memory

The **Methods that allocate the most memory** view displays a **Method List** showing the source methods that allocated the most live memory for the application. This view displays methods that allocate the most memory in the managed heap, but cannot be freed by garbage collection while the application is in its current state.

The **Live size including children (%)** column indicates the percentage of memory used by the method (and its child methods) relative to total allocated memory in the managed heap at the time the session file was created. The display focuses attention on the most memory intensive methods.

In addition to a view of the source code, this view also includes a **Call Graph** which shows the execution path responsible for the memory allocation. See "Call Graph" on page 201 for more information.

Live Objects Allocated by This <*method name*>

The **Live objects allocated by this <*method name*>** view displays a list of the live object instances allocated by the method that you selected in the **Methods that allocate the most memory** view. In this case the view is limited to live objects allocated by the methods that were selected in the previous window. This enables you to drill down from the methods in your application that were the largest allocators of live memory. From here, examine the objects that were not available for garbage collection when the RAM footprint snapshot was taken.

Note: The list of allocated objects includes objects created by non-profiled (system) methods that are called by the user-code method selected in the **Methods That Allocate the Most Memory** view. For example, if your method uses methods in the WinForms library, objects allocated by those methods appear in the list of allocated objects.

In order to understand how your application allocates objects, drill down to examine all of the objects referenced by any live object allocated by the method under study. The **All objects referenced from this instance** view is identical to the view described under "All Objects Referenced by <object name>" on page 208.

Through an entire sequence of object references, continue to drill down from any object and view all the objects to which it holds a reference.

Optimizing Memory Use

Once you understand how your application uses memory, you can begin to optimize memory use. Objects are typically the largest memory consumers, so start your analysis with them.

Your application probably creates several objects as it runs. To optimize performance, do you simply reduce the number of objects created? How do you know where to focus your performance tuning efforts?

Fortunately, DevPartner does much of the cost/benefit calculating for you. Remember that individual objects may be small, but when you consider objects with their children, some objects are much larger than others. DevPartner uses the concept of large object to alert you to those objects which, with their child objects, are large consumers of memory. Focusing your tuning efforts on these object allocations promises the most rapid route to a reduced RAM footprint.

Be aware of medium-lived objects. Medium-lived objects survived the first garbage collection to move to generation 1; they are collected during the second garbage collection after the transaction completes. This is the new amount of memory your transaction requires. If you could reduce the number of objects allocated, you could probably improve performance.

Look at live objects at several points as your application executes. Have you allocated objects that are unneeded for the remainder of the transaction? Could you share any live objects between multiple transactions? Have you allocated any objects that the application will not need until a later time? If the answer is yes to any of these questions and you can change how your application allocates objects, you can probably reduce the RAM footprint and improve performance.

Analyzing Web Applications with Memory Analysis

With DevPartner Studio, you can analyze memory use in managed Web applications developed in Visual Studio, including applications that use Web Forms, XML Web services, and ASP.NET. To collect server-side data, DevPartner Studio must be installed on the server system.

If the server application runs on a remote machine, install DevPartner Studio and the DevPartner Studio Remote Server license on the remote system to collect the server data. See *Installing DevPartner Studio* (**`DPS Install.pdf`**) and the *Distributed Licensing Management Installation Guide* (**`CPWR License Install.pdf`**) for more information. To configure data collection on the server, use the DevPartner memory analysis properties in Visual Studio.

Note: DevPartner session files are saved with the current solution. Opening a Web project from IIS directly, as opposed to opening the project through Visual Studio, may cause a different solution file to be used. DevPartner session files created in the first solution would not be visible in the second solution

Collecting Server-side Memory Data

You may want to collect memory analysis data for parts of a Web or client/server application. With DevPartner, you can collect memory data for managed code in any process as you run the client application.

To collect remote process data, install DevPartner on the client and DevPartner and the DevPartner Remote Server license on the remote machine. Use this configuration to collect data for a distributed application as it is actually deployed. See *Installing DevPartner* (**DPS Install.pdf**) and the *Distributed Licensing Management License Installation Guide* (**LicInst4.pdf**) for more information.

Collecting Data from Multiple Processes

Web or client/server applications may run more than one process, but DevPartner collects memory analysis data for only managed applications. For example, when you profile an ASP.NET application, DevPartner does not collect data for the browser process (**iexplore**). However, DevPartner collects data for managed code that runs in the **aspnet_wp** or **w3wp** processes.

Note: DevPartner session files are saved with the current solution. Opening a Web project from IIS directly, as opposed to opening the project through Visual Studio, may cause a different solution file to be used. DevPartner session files created in the first solution would not be visible in the second solution.

When you run such applications under memory analysis, the memory analysis session control window in Visual Studio displays the server and surrogate processes in the process selection list. Use the process list to focus data collection.

See "Starting Analysis from the Command Line" on page 345 for information on using **DPAnalysis.exe** and an XML Configuration file to profile multi-process applications.

Prerequisites for Analyzing Web Applications

For DevPartner memory analysis to successfully profile an ASP.NET application, the following two conditions must be met:

- The project must include a **web.config** file.
- The project must be configured for debugging. To do this, the **web.config** file must include a compilation element with the debug attribute set to true. For example:

```
<compilation debug="true" />
```

Running a Memory Analysis Session on a Web Application

Follow these steps to analyze memory use in a Web application:

1. In Visual Studio, open the Solution that contains the project for the application.
2. Review the **DevPartner Coverage, Memory and Performance** properties for the projects within the solution.
3. Select the project in the Solution Explorer.
4. To display the Properties Window, select **View > Properties Window**.

Note: Logging off or rebooting the system changes the analysis option only if you are connected to a Terminal Server through a Terminal Services Client or to any system through Remote Desktop.

If you reboot or start up slower computers with memory analysis enabled, the Service Control Manager may report hangs in the startup of SMTP, FTP, and WWWP services. You can safely ignore these messages. All of the services will start up successfully. The hangs are reported because DevPartner instruments IIS when memory analysis is enabled and these services depend on IIS.

5. If the server components do not run on the local machine, use the DevPartner data collection properties to set up remote data collection options.
6. Depending on the type of data you wish to collect, and the version of IIS on the server, you may need to make configuration changes to IIS.

Tip: See the online help for information about configuration changes for IIS.

7. In Visual Studio, choose **DevPartner > Start Without Debugging with Memory Analysis**, or click **Start with Memory Analysis** on the DevPartner toolbar.

   Use the memory analysis session control window to select which of the following types of analysis to perform:
   Memory Leaks
   Temporary Objects
   RAM Footprint

   For further guidance on selecting the type of analysis to perform, see "Identifying Memory Problems" on page 186.

8. In the **Session Control Window**, select a server process for which you want to collect data. Exercise the application from the client and click **View...** to take snapshots of the managed heap as desired. You can select another server process in the same session and take additional snapshots if desired.

9 DevPartner collects memory data for the ASP.NET or IIS process as you exercise the client. No data is collected for the Internet Explorer (client) process.

10 Use the **Session Control** buttons on the memory analysis **Session Control Window** to control data collection. As an alternative, you can use a session control file or the Session Control API to automate data collection.

If You Get Unexpected File Save Dialogs or Saved Session Files

Under certain circumstances, you may see an unexpected **File Save** dialog after quitting an ASP.NET application, or find that unexpected session files have been saved if you have configured DevPartner to automatically save session files.

In memory analysis sessions, DevPartner does not collect data for Internet Explorer. (DevPartner collects memory analysis data only for managed code.) Thus, the ASP.NET worker process (`w3wp` or `aspnet_wp`) becomes the primary profiled process when running memory analysis on an ASP.NET application. DevPartner stops data collection and generates a final session file whenever the primary profiled process ends. In most cases, this occurs in response to a user action. However, the ASP.NET worker process can also shut down automatically during profiling if you have edited the process **Model Attributes** section of the `machine.config` file on the system on which the process runs in one of the following ways:

- Changed the value of the `requestLimit` or `requestQueueLimit` attribute from "Infinite" to a value low enough to cause the process to be shut down during the session
- Changed the value of the `timeout` or `idleTimeout` attribute from "Infinite" to a value low enough to cause the process to be shut down during the session
- Changed the value of the `memoryLimit` attribute to a percentage low enough to cause the process to recycle during the session

When the process is shut down, DevPartner takes a final snapshot, generates a session file, and ends the session. If IE (the client process launched by the user) is still active, the IE process can spawn new instances of the ASP.NET worker process. Each of these ASP.NET worker processes will generate a session file when it terminates, resulting in a saved session file, or a File Save dialog. However, this session data is not part of the original memory analysis session, and is usually of little value.

To remedy this situation, you can edit the **`machine.config`** file and set the limiting attribute to a value high enough to prevent premature termination of the process.

Caution: Always make a backup copy before editing the `machine.config` file.

DevPartner will continue to collect analysis data whenever the ASP.NET worker process runs and terminates until you explicitly disable analysis under **DevPartner Coverage, Memory, and Performance Analysis** in the Visual Studio properties window.

If You Get a Security Exception

When attempting to collect data for a managed application, a security exception message displays if your security policy prevents DevPartner instrumentation of your code. By default, assemblies must have the `SkipVerification` permission to be profiled. If you remove this permission from the permission set of the policy under which the code executes, or add imperative security declarations to the assembly that cause this permission to be revoked, you will not be able to profile the assembly.

To remedy this condition, enable secure profiling in one of two ways.

- Set the following global environment variable and retry profiling the application:

  `NM_NO_FAST_INSTR=1`

  This solution allows you to work around this issue, although it does exact a slight performance penalty.

- Change the policy for the assembly using the .NET Framework Configuration tool MMC snap-in, or by temporarily removing any imperative security declarations in the assembly.

See the *.NET Framework Developers Guide* in the Visual Studio online help for more information on security policy in Visual Studio.

Using Memory Analysis In Your Development Cycle

You do not have to wait until you suspect that you have problem to begin testing. If you run DevPartner memory analysis early and often, and know what to look for when you analyze your application, you can correct problems early, at a point when problems are both easier to identify and require less risk to fix.

Memory problems in managed applications are often the result of larger design and architecture decisions, rather than simple coding errors. For example, one source of memory loss is an object that is not collected because of an out-dated reference to it that is not freed. This can be the result of revisions made in another part of the code. The later these problems are identified in the development cycle, the more difficult and expensive they are to fix.

As a result, it is valuable to use memory analysis as part of a continuous testing program throughout the development cycle. You will benefit from using memory analysis during unit testing to get an understanding of how the individual modules handle memory. Once you identify and fix areas that need improvement, retest to verify the fix. Then, as you integrate the modules into your application, repeat your memory testing again to ensure that new memory problems do not appear.

Submitting Data to Visual Studio Team System

You can submit data for a method selected in any method list view in a DevPartner memory analysis session file as a **Work Item** to Visual Studio Team System. Valid work items include a selected method on the following analysis types:

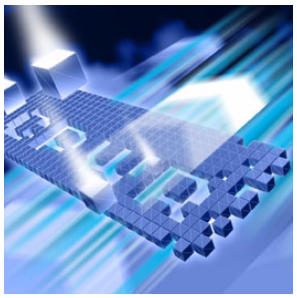
- Memory Leaks - methods that allocate the most leaked memory
- RAM Footprint - methods that allocate the most memory
- Temporary Objects - methods that use the most memory and entry points that allocate the most memory.

When you submit a **Bug**, DevPartner populates the **Work Item** form with data from the visible columns in the view. To change the method data you submit in the **Work Item**, right-click any column header and select **Choose Columns...** from the context menu.

For more information about DevPartner Studio integration with Visual Studio Team System, "Visual Studio Team System Support" on page 8.

Chapter 6

Automatic Performance Analysis



- What is Performance Analysis?
- Using Performance Analysis Out of the Box
- Setting Properties and Options
- Collecting Data from Various Types of Applications
- Analyzing a Call Graph
- Comparing Sessions
- Exporting Performance Data
- Controlling Data Collection
- Analyzing from the Command Line
- Using the Performance Analysis Viewer
- Performance Analysis Tips for .NET Applications
- Submitting Data to Visual Studio Team System

This chapter contains two sections. The first section provides a quick-start procedure to get first-time users up and running with performance analysis. The second section provides reference information for an in-depth understanding of DevPartner Studio's performance analysis feature.

Refer to the DevPartner Studio online help for additional task-oriented information about performance analysis.

What is Performance Analysis?

DevPartner Studio's performance analysis feature allows you to find bottlenecks that slow down the performance of your application, regardless of whether the bottleneck is in your code, in third party components, or in the operating system.

DevPartner performance analysis:

- analyzes performance as your components are really used, even if the components are on distributed systems.
- allows you to target data collection on a specific phase of your application, so you can focus your performance tuning efforts.
- can distinguish between time spent in threads of your application and time spent in threads of other running applications, so you get accurate, reproducible results that are independent of outside influences.

Using Performance Analysis Out of the Box

The following Ready, Set, Go procedure introduces you to using DevPartner to analyze code performance.

To get up and running quickly, follow the steps presented in shaded boxes. If you would like more information about the subject being described in the shaded box, read the additional text following the box.

Note: Analyzing an application with DevPartner Studio does not require elevated system privileges. The system privileges you use to create and debug your application are sufficient for DevPartner to analyze the application.

Ready: Consider What You Want to Analyze

Before using performance analysis, consider what you want to analyze.

The following procedure assumes:

- You are testing a single-process, managed application.
- You can build and run your application.
- Your solution includes a startup project.

Note: Refer to "DevPartner Studio Supported Project Types" on page 335 for a comprehensive list of supported project types for DevPartner performance analysis.

When analyzing your applications, decide what data you are interested in collecting before beginning your performance session. In some cases, there are steps you need to take before beginning a session. For example, some set-up would be required if:

- there are modules you want to omit from the performance analysis
- there are unmanaged modules that you would like analyzed
- you want to include code run on a remote server

For this procedure, all managed, local code in your application will be analyzed.

Set: Properties and Options

Once you have decided what code you want to analyze, you can set several properties and options to focus your data collection.

For this procedure, you can use the default DevPartner properties and options. No additional set-up is required.

Using Solution Properties and Project Properties, you can choose whether your analysis session data should include information for .NET assemblies, COM that runs outside your application, time spent in threads of other running applications, line-level or method-level analysis, and so on. Using DevPartner Options, you can change display options, exclude parts of your application from analysis, or create a session control file to manage data collection. Refer to "Setting Properties and Options" on page 227 if you would like more information about customizing your settings.

Go: Collect Performance Data

After considering what you want to analyze and setting the appropriate properties and options, you are ready to collect performance data.

1. From Visual Studio, open the solution associated with your application.
2. Select **DevPartner > Start without Debugging with Performance Analysis** to begin a performance analysis session.

   During a session, the **Session Control Toolbar** options are active.

   DevPartner session controls let you focus your performance analysis on any phase of your application. You can use the session controls to stop data collection, take a snapshot of the data currently collected and then continue recording, or clear data that has been collected but not yet saved in a snapshot.
3. Run the code you want to analyze.
4. Click the **Snapshot** icon . (Click twice if necessary to bring focus to the session window.) When you take a snapshot, DevPartner creates a file containing the collected data, called a session file, and displays the session file data.
5. Return to your application and continue running your tests.
6. When you are finished running your tests, exit your application. The final session file displays in Visual Studio.

Note: If a security exception message displays when you attempt to collect data for a managed application, refer to page 232 for information about changing your security policy.

You can analyze performance with or without debugging. Generally, run performance analysis without debugging as results from non-debug sessions are easier to interpret. If you run your application in the debugger, some timing values might be larger than expected, especially if breakpoints were hit during the session.

When you take a snapshot or exit your application, DevPartner displays the session file in Visual Studio, as shown in Figure 6-1. The session window consists of:

- The filter pane, which lists the source files and images in your application. The filter pane shows the time spent in each file as a percentage of the time spent in the session. The filter pane also provides a set of filters you can use to focus on the most significant data.
- The session data pane, which contains the **Method List**, **Source**, and **Session Summary** tabs. The session data pane displays data for the file or filter selected in the filter pane.

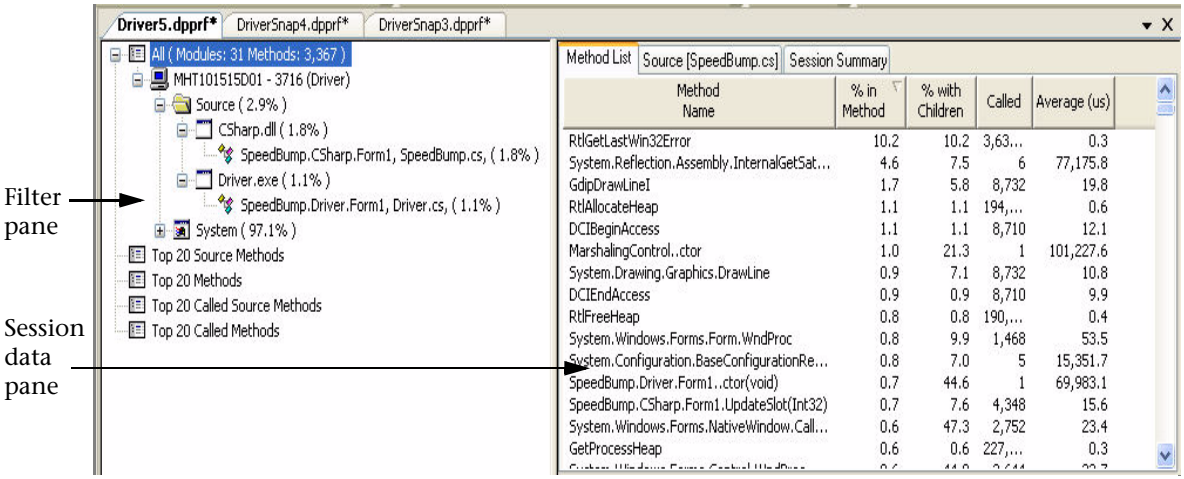


Figure 6-1. Performance Analysis Session Window

Using the Filter Pane and the Session Data Pane

To begin evaluating your data, start by using a filter and examining the **Method List** to find methods that occupied a significant percentage of your program's processing time.

1 In the **Filter** pane, click on the **Top 20 Source Methods** filter. This will reduce the displayed data and help you focus on your source methods.

Knowing the time spent in system files is useful when assessing performance, but using this filter to eliminate system files from the display can help you focus your performance tuning efforts.

2 Examine the data on the **Method List** tab. The **Method List** tab displays information about the amount of time spent in each method.

Scanning the **Method List** for methods with high values in one or more of the columns will help you target specific areas for performance improvement.

3 On the **Method List** tab, look at the **% in Method** column, which shows the time spent in the method as a percentage of the time spent in the session. (By default, the data is sorted in descending order by the **% in Method** column. If not, click the column header.)

4 Look at the **% with Children** column, which shows time spent in the method and its child methods as a percentage of the time spent in the session.

5 Look at the **Average** column, which shows the average execution time of the method.

After you examine the values in these columns, you will have an idea of which areas of your code to target for improvement.

Viewing a Call Graph

Some performance issues become apparent only when seen in the context of the calls made between parent and child methods. In these cases, examining a **Call Graph** can be helpful. A **Call Graph** is a graphical representation of the calling relationships of your application's methods.

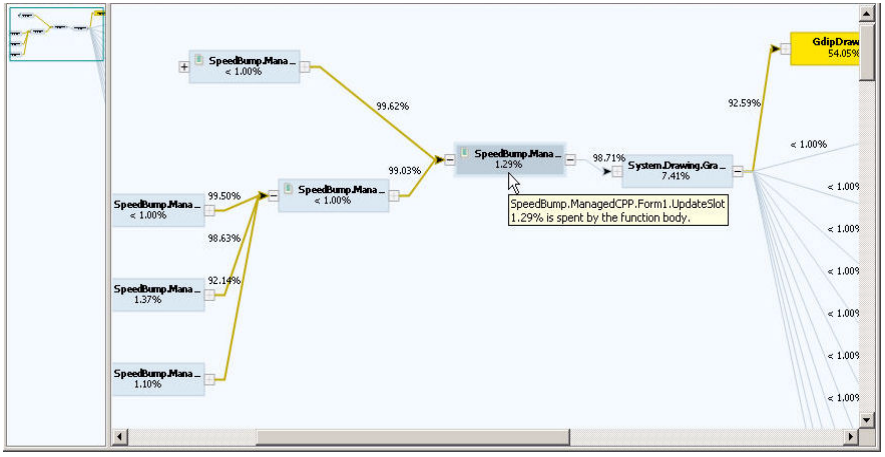


Figure 6-2. The Call Graph

You can access the **Call Graph** from the context menu in the **Method List**, **Source** tab, or from the **Call Graph** icon  .

6 Right-click on a method in the **Method List** and choose **Go to Call Graph** on the context menu. The method's **Call Graph** displays, with the critical path highlighted in your default system color.

Note: The following steps are an introduction to using **Call Graphs**. More information about **Call Graphs** is presented in "Analyzing a Call Graph" on page 243.

7 Click the plus/minus icons at the edges of any node to expand or collapse the view of parent (left) or child (right) nodes. Compare the percentage figure shown in a node with the percentage shown on the lines to child nodes to follow the path(s) that might be causing performance problems.

8 Hover the mouse-pointer over a node or over the percentage value on a link between method nodes to view a more detailed description.

9 Identify a method that is a target for potential performance improvement. Right click and select **Go to Method Source** from the context menu. (If you select a system method, the source will not be available.)

The method's source code is displayed on the **Source** tab in the session window, but the call graph still has focus.

10 Close the **Call Graph** to begin working with the source code.

Viewing Source Code

The **Source** tab displays the source code for the selected file or method. Use the **Source** tab to help you identify the lines of code that might be causing performance problems.

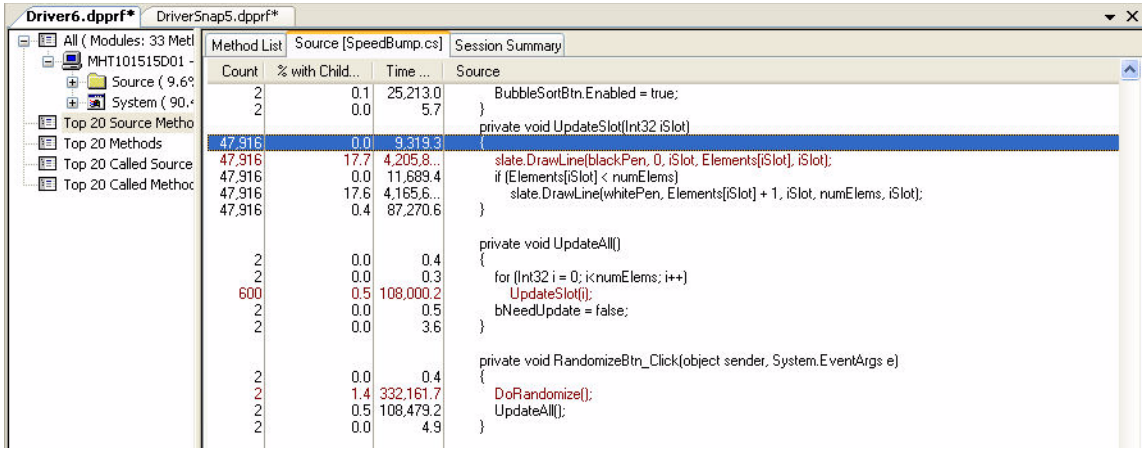


Figure 6-3. The Source Code Tab

11 The source code for the selected method is displayed on the **Source** tab, as shown in Figure 6-3. The **Source** tab displays performance session data about each executed line of code.

DevPartner highlights the slowest line in each method. Determine if there is an opportunity for performance improvement and modify the code accordingly.

Comparing Sessions

After locating and correcting performance problems, you can run another performance session and compare the session files from before and after your changes. DevPartner displays a comparison window showing the differences between the sessions. For more information about comparing sessions, refer to "Comparing Sessions" on page 246.

Viewing Session Summary Data

The **Session Summary** tab displays a synopsis of the performance analysis session.

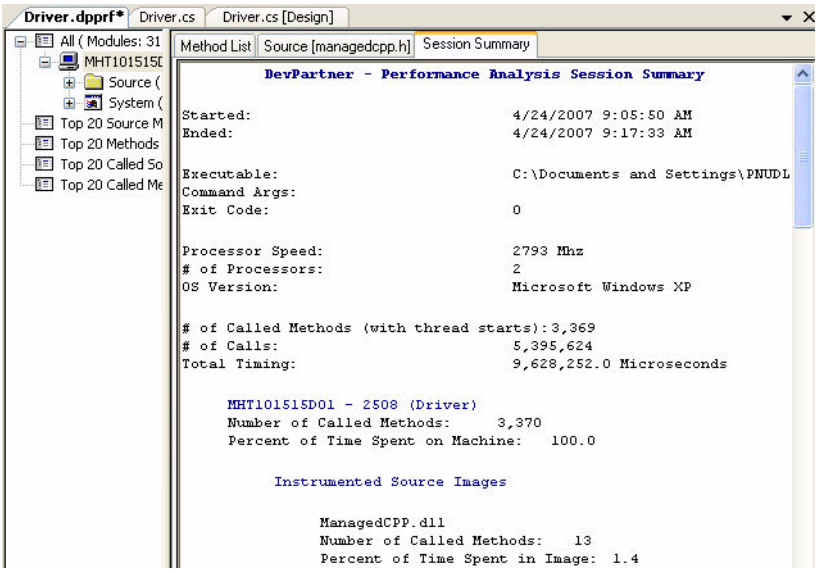


Figure 6-4. The Session Summary Tab

12 Click on the **Session Summary** tab.

The **Session Summary** includes contextual information about the session, such as the date and time of the session, the processor speed and operating system, and so on. This information can be useful when viewing an older session file, particularly one that was created by someone else.

The summary also includes performance data from the filter pane and the **Method List** tab, showing data for both the files and the methods that were analyzed.

13 Scroll through the tab to view the session summary data.

Saving Session Files

When you have finished reviewing performance data you can save the session file.

1. Close the session file window in Visual Studio. DevPartner prompts you to save the session file.
2. Click **Ok** to accept the default file name and location.

DevPartner saves session files as part of the active solution. They appear in the **DevPartner Studio** virtual folder in Solution Explorer. Performance analysis session files take the `.dpprf` extension.

By default, DevPartner physically saves the session files in your project's output folder. DevPartner automatically increments the file name based on the contents of the default directory (for example, `MyApp.dpprf`, `MyApp1.dpprf`, and so on). If you save session files to a location other than the default directory, you must manage the file naming and numbering.

For projects that do not have an output directory, such as a Visual Studio 2005 Web site project, DevPartner physically saves the files to the project directory.

Session files generated from the command line are not automatically added to the project's solution. You can manually add externally generated session files to an open solution in Visual Studio.

This concludes the Ready, Set, Go section of this chapter. Now that you have a basic understanding of the mechanics of running a performance analysis session, continue reading the rest of this chapter for additional information, or refer to the DevPartner online help for task-based information.

Setting Properties and Options

Before beginning a performance analysis session, it is often useful to fine-tune data collection to include or omit certain types of information. Use **Solution Properties**, **Project Properties**, and **DevPartner Options** to better focus your analysis session.

Solution Properties

To view performance properties available at the solution level, select the solution in the Solution Explorer and press F4 to view the **Properties Window**.

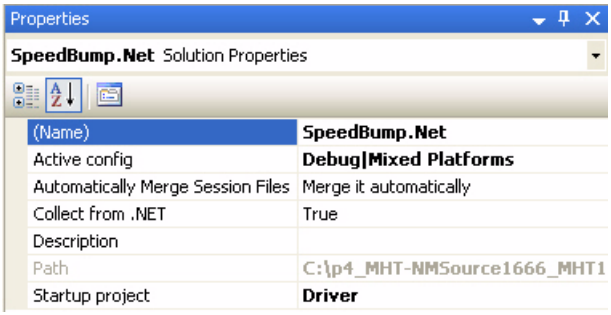


Figure 6-5. Solution Properties

The following solution property affects performance analysis:

- **Collect from .NET** - Visible only for managed code applications. Set this property to false if you do not want DevPartner to collect information for .NET assemblies.

  This property affects only coverage analysis and performance analysis sessions. Memory analysis and Performance Expert always collect data from managed applications, even when this value is set to false.

Note: The **Collect from .NET** property is not available with DevPartner for Visual C++ Boundschecker Suite.

- **Startup project** - Your solution must include a startup project. If the solution contains multiple startup projects, before analysis begins DevPartner prompts you to choose a startup project for the session.

Project Properties

To review project level properties, select a project in the Solution Explorer and review the properties that can be set for projects within the solution.

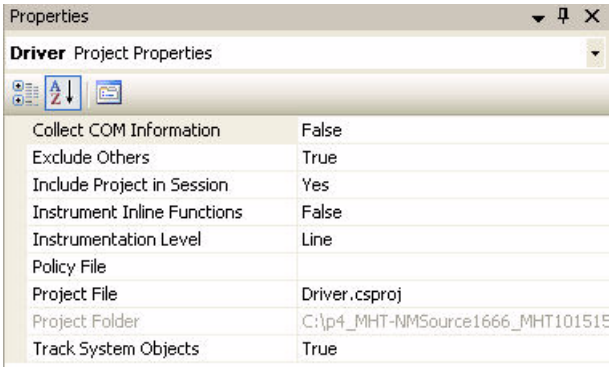


Figure 6-6. Project Properties

The following project properties affect performance analysis:

- **Collect COM Information** - DevPartner collects method level data based on DLL exports and COM interfaces. Select False if you do not want DevPartner to collect information for COM that runs outside your application.
- **Exclude Others** - Excludes time spent in threads of other running applications. The resulting session data includes only time spent in threads of your application.

  While collecting performance information, DevPartner monitors context switching and tracks how much of the CPU time is spent working in threads outside of the application. After collecting the timing data, DevPartner subtracts the time spent in other threads from the clock time to determine exactly how much time was spent in your application.

  Select True to enable this feature; select False to disable it.
- **Instrument Inline Functions** - Set this property to True to instrument inline functions. (Instrumentation is described in "About Instrumentation" on page 231.) Inline functions are not instrumented by default if inline optimizations are enabled.

  When working with managed C++ applications, DevPartner does not collect data for functions explicitly inlined with the `__forceinline` keyword, even if you choose **True** for the **Instrument Inline Functions** property.

- **Instrumentation Level** - Choose **Method** or **Line**. (Instrumentation is described in "About Instrumentation" on page 231.)
  - **Method**: Method-level instrumentation allows your performance analysis session to run faster, but provides only method-level data.
  - **Line**: Line-level instrumentation enables you to drill down to specific lines in your source code. When working with .NET applications, if you choose Line as your Instrumentation Level and install a JIT-compiled assembly in the global assembly cache (GAC), DevPartner performance analysis cannot provide line-level data about the assembly. DevPartner is unable to instrument the JIT-compiled assembly. To collect line-level data, do not pre-JIT assemblies when running performance analysis.

All property settings persist unless you explicitly change them.

Options

To review DevPartner option settings for performance analysis sessions, choose **DevPartner > Options > Analysis.**

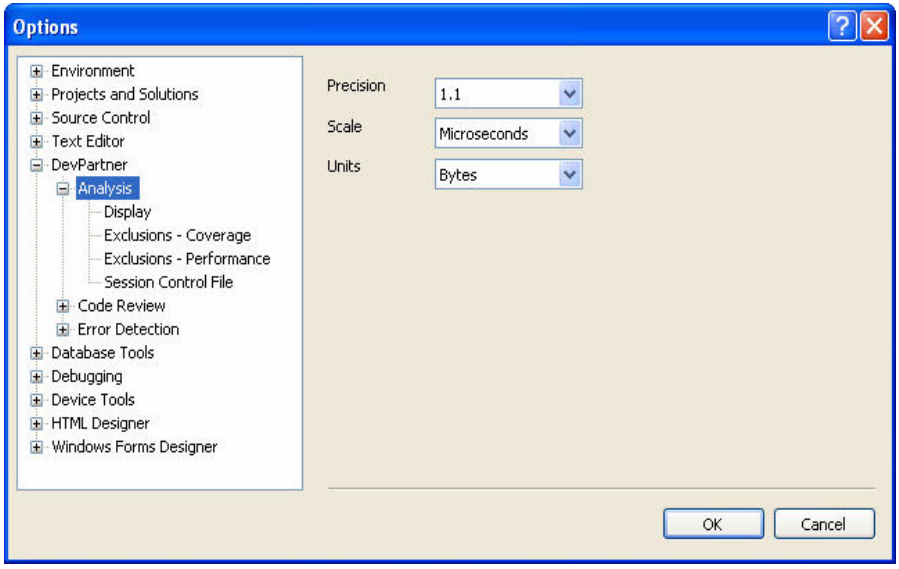


Figure 6-7. Analysis Options

- The **Display** option allows you to set the precision, scale, and units used when displaying your data.

- The **Exclusions** option allows you to omit one or more images from data collection. Refer to "Excluding Images" on page 230 for more information on exclusions.
- The **Session Control File** option allows you to create a set of rules and actions to control the data that DevPartner collects as your application or module runs. Refer to "Analysis Session Controls" on page 365 for more information about session control files.

Other Visual Studio options, such as the **Environment > Fonts and Colors** options, also affect DevPartner features.

Excluding Images

When you run an application under performance analysis, DevPartner collects data for all source and system images. However, you can use the Exclusions option to omit one or more images from analysis.

While viewing Analysis Options (**DevPartner > Options > Analysis**) select **Exclusions - Performance**.

From the **Show** list at the top of the page, select one of the following:

- Global exclusions
- Local exclusions in current user directory
- Local exclusions in executable directory

The **Local exclusions in current user directory** and **Local exclusions in executable directory** options are available only when a solution is open and the executable directory differs from the current working directory.

Click **Insert**  to add an image to the exclusion list. Type a name, or browse to the image you want to exclude. Allowable file types for exclusion are `.exe`, `.dll`, `.ocx`, and `.netmodule`. Use the **Files of type** list to limit the types of files displayed.

If you choose a .NET module (`.netmodule`), only the unmanaged parts of the module are excluded.

To remove an image from the list of exclusions, select the item and click **Delete**  .

Select the **Exclude system images check-box** to exclude uninstrumented system DLLs from DevPartner performance profiling.

Global exclusions are saved in `nmexclud.txt` in the `\Analysis` subdirectory in the DevPartner installation directory. Local exclusions are saved in `nmexclud.txt` in the application executable directory or in the current working directory. To save a copy of the exclusion list (`nmexclud.txt`) to another location, click **Save To**.

Note: To fully monitor a running application, DevPartner always profiles a few specific Win32 APIs. As a result, certain system DLLs cannot be excluded individually and will always appear in the System Images list of the session file, unless you select **Exclude system images** to exclude all system images.

Exclusions do not apply to files compiled with **Native C/C++ Instrumentation**. For example, if you attempt to exclude an instrumented unmanaged C/C++ image, DevPartner still collects information for that file, although no system call information is collected. If you wish to exclude an unmanaged C/C++ image from data collection, do not instrument that image.

About Instrumentation

When you run a managed application, DevPartner inserts hooks into the byte code for each assembly as it is loaded by the compiler, a process called instrumentation. This code contains instructions that DevPartner uses to collect performance data while your application is running. DevPartner instrumentation does not change the actual files on disk; it only modifies the in-memory representation of files as they execute.

Unlike managed code, which DevPartner instruments at runtime, you must instrument unmanaged C/C++ code when you compile it. To instrument unmanaged code, DevPartner inserts hooks directly into your source code. DevPartner provides an Instrumentation Manager in which you specify the type of instrumentation to be used and specify any projects in the solution to exclude from instrumentation. (Refer to "Collecting Data from Unmanaged Code" on page 233 for more information about the Instrumentation Manager.) When you rebuild the unmanaged project, the hooks are inserted. To remove the hooks, turn off instrumentation by deselecting the Native C/C++ Instrumentation option from the DevPartner menu, and rebuild the project.

Collecting Data from Various Types of Applications

This section provides information about using DevPartner performance analysis to collect data from different types of applications.

DevPartner supports all Visual Studio managed code languages, as well as unmanaged C/C++. DevPartner can also collect performance data for JScript and VBScript Web applications when using Internet Explorer or IIS.

Refer to Appendix B, "DevPartner Studio Supported Project Types" for a complete list of languages and project types supported in each version of Visual Studio.

Collecting Data From Managed Code

Many applications you will develop in Visual Studio will be managed applications, such as C#, Visual Basic, and managed C++ applications.

DevPartner requires PDB (program database file) information to collect detailed information about your managed application source code. If no source data appears on the Source tab or source files do not appear in the **Filter** pane make sure `.pdb` files are being generated.

Managed application files for which no PDB information is available appear in the **System** folder in the **Filter** pane.

When attempting to collect data for a managed application, a security exception message will display if your security policy prevents DevPartner instrumentation of your code. By default, assemblies must have the `SkipVerification` permission to be profiled. If you remove this permission from the permission set of the policy under which the code executes, or add imperative security declarations to the assembly that cause this permission to be revoked, you will not be able to profile the assembly.

To remedy this condition, enable secure profiling in one of two ways.

- Set the following global environment variable and retry profiling the application:

  ```
  NM_NO_FAST_INSTR=1
  ```

  This solution allows you to work around this issue, although it does exact a slight performance penalty.

- Change the policy for the assembly using the .NET Framework Configuration tool MMC snap-in, or by temporarily removing any imperative security declarations in the assembly.

See the *.NET Framework Developers Guide* in the Visual Studio online help for more information on security policy in Visual Studio.

Collecting Data from Unmanaged Code

When you build your unmanaged C++ application for performance profiling with **Native C/C++ Instrumentation**, DevPartner works with the compiler to add instructions to your application image to collect performance data at run time. For example, DevPartner is called each time a method is entered and each time a method is exited. DevPartner uses this information to determine the execution time of the method.

To instrument unmanaged code, open the solution that contains the unmanaged C/C++ project for which you want to collect data and choose **DevPartner > Native C/C++ Instrumentation Manager**.

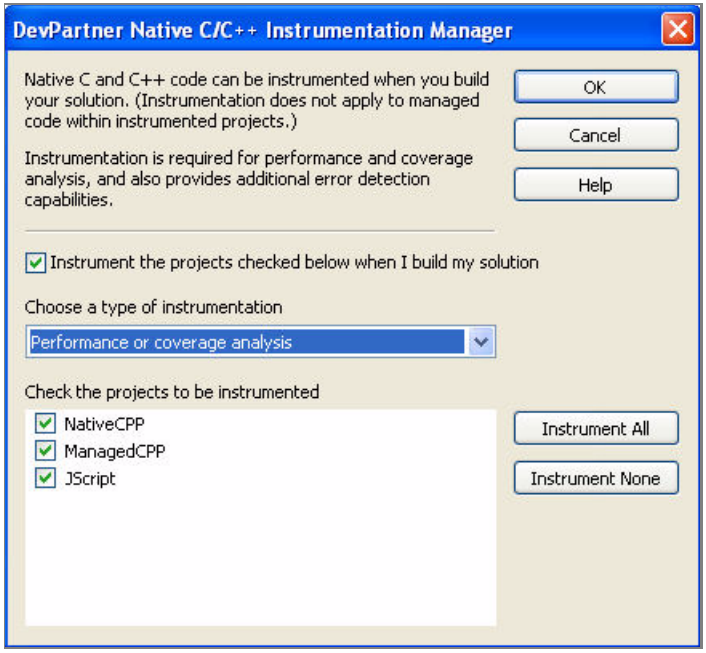


Figure 6-8. The Instrumentation Manager

Select the **Instrument the projects checked below when I build my solution** check box and select a type of instrumentation. The type of instrumentation you choose must match the type of analysis you subsequently run.

Select the projects to be instrumented. By default, DevPartner will instrument all unmanaged code in the solution. Deselect modules to be omitted.

Click **OK** and rebuild the solution. DevPartner instruments the unmanaged C/C++ projects you selected. Click **Start with Performance Analysis** on the DevPartner toolbar to begin the analysis session.

DevPartner saves the project selections you make in the **Native C/C++ Instrumentation Manager** with the solution. Once you use the Instrumentation Manager to configure instrumentation, you can turn instrumentation on and off with the **Native C/C++ Instrumentation** option from the DevPartner menu or the **Native C/C++ Instrumentation** button on the DevPartner toolbar. Use the **Native C/C++ Instrumentation Manager** only to change settings.

To remove instrumentation from your application at a later time, deselect the **Native C/C++ Instrumentation** option from the DevPartner menu. The next time you start a performance analysis session or rebuild the solution, Visual Studio will rebuild the solution without instrumentation.

Note: If your application calls Visual Studio components, you must compile these components with DevPartner instrumentation for performance analysis in Visual Studio. See the DevPartner Studio online help in Visual Studio for more information.

Mixed-mode C++ Files

With unmanaged (native) C++, you can compile your application as managed code with the `/clr` option, but mark sections of your code with `#pragma` (native). The compiler generates native code for any methods defined in the `#pragma` section. DevPartner does not support mixed-mode C++ files. When profiling a program that includes a C++ file with both managed and unmanaged (native) sections, DevPartner collects coverage data only for the managed code portions, not the native code portions from `#pragma`. To collect data for unmanaged C++ code, place the unmanaged code in a separate file and instrument it, "Collecting Data from Unmanaged Code" on page 233.

Collecting Data from Multiple Processes

An application may run more than one process. For example, when you profile an ASP.NET application you may see the browser process (`iexplore`), the IIS process (`inetinfo`), and the ASP worker process (`aspnet_wp` or `w3wp`).

When you run a multi-process application under performance analysis, the DevPartner Session Control toolbar displays the active processes in the process selection list.

Figure 6-9. Session Control Toolbar with the Process Selection List

Use the process selection list to focus data collection. When you take a snapshot, DevPartner creates a session file with data for the process selected in the process selection list.

Collecting Data from Remote Systems

You can collect performance data for application components running on remote systems. For example, you might want to collect performance data for both client and server portions of a client/server application. With DevPartner, you can collect performance data for client and server processes as you run the client application.

To collect data simultaneously from a client system and a remote system, install DevPartner on the client and install DevPartner and the DevPartner Remote Server license on the remote system. See *Installing DevPartner* (`DPS Install.pdf`) and the *Distributed License Management Licensing Guide* (`Compuware License Guide.pdf`) for more information about the Remote Server license.

Note: A server connected through a Terminal Services connection does not require the DevPartner Remote Server license. See "Using Terminal Services and Remote Desktop" on page 9 for information on Terminal Services.

On the remote system, select the relevant projects and review the DevPartner properties to ensure that they match the options set on the client system. DevPartner restarts server processes, such as IIS, after you change options. This restart is necessary for changes to take effect.

Be sure to specify instrumentation if you are analyzing an unmanaged C++ application. If your application calls unmanaged C++ components, you must instrument those components if you want to collect data from them, as described in "Collecting Data from Unmanaged Code" on page 233.

Correlating Data

When you use Internet Explorer (IE) and Internet Information Server (IIS) as browser and Web server, or you use COM to make inter-process calls, DevPartner automatically recognizes a client/server relationship between the processes. To preserve the relationship between the methods of DCOM objects or the relationship between HTTP client and server (IE and IIS), DevPartner automatically correlates the data from those sessions. It then combines the correlated data with the client session data into a single session file.

The correlated session file contains the performance data for both the client and server portions of your application. The correlated session file appears in Visual Studio, like any other session file, with `_co` appended to the file name, as in `appname_CO.dpprf`.

When you view a correlated session file in the **Call Graph** window, you can follow a COM call stack from the calling method to the called method. DevPartner scales the server-side data to match the clock speed of the client system.

You can use **DevPartner > Correlate > Performance Files** to manually combine data from different session files when there is no COM-based relationship or client/server relationship between IE and IIS. You can also use the `NMCORRELATE` command line utility to manually combine data, as described in "Starting Analysis from the Command Line" on page 345.

Collecting Data From .NET Web Applications

If you develop Web Forms, XML Web Services, or ASP.NET applications, you can use DevPartner to collect performance data for both client and server portions of your application. You can configure DevPartner to collect data for IIS and ASP.NET running on a local or remote machine.

To collect data for unmanaged C++ components called by your application, you must instrument and rebuild the objects with **Native C/C++ Instrumentation**, as described in "Collecting Data from Unmanaged Code" on page 233. If your Web application calls C++ components, you must instrument them using the DevPartner commands in Visual Studio. Be sure to instrument for performance analysis. DevPartner collects data for only one analysis type in a session.

Note: DevPartner session files are saved with the current solution. Opening a Web project from IIS directly, as opposed to opening the project through Visual Studio, may cause a different solution file to be used. DevPartner session files created in the first solution would not be visible in the second solution.

Prerequisites

For DevPartner performance analysis to successfully profile an ASP.NET application, the following two conditions must be met:

- The project must include a `web.config` file.
- The `web.config` file must include a compilation element with the debug attribute set to true. For example:

```
<compilation debug="true"/>
```

DevPartner can also collect data for in-process or out of process components called by your application.

Analyze ASP.NET Applications without Debugging

For optimum results, run performance analysis without debugging.

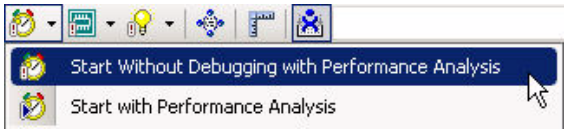


Figure 6-10. Start Without Debugging Option

Only one script debugger can be active at one time. If you debug a Web application with debugging, both Visual Studio and DevPartner attempt to load a script debugger. A message displays indicating that the script debugger failed to attach to IE. The session continues without interruption despite the error message.

To avoid the error message, you can either disable script debugging in `iexplore` or run performance analysis without debugging.

Unexpected File Save Dialogs or Saved Session Files

Under certain circumstances, you may see an unexpected **File Save** dialog box after quitting an ASP.NET application, or find that unexpected session files have been saved if you have configured DevPartner to automatically save session files.

When you run performance analysis on an ASP.NET application, DevPartner collects data for Internet Explorer as the primary profiled process. DevPartner also saves session data for secondary processes, such as an ASP.NET worker process (`w3wp` or `aspnet_wp`). When the primary process terminates, DevPartner stops data collection and generates a final correlated session file that contains both client data (for IE) and server data (for IIS and ASP.NET) worker processes. You can also take a snapshot of the server process alone by selecting the process in the Session Control toolbar.

In most cases the client and server processes are terminated by user action. However, the ASP.NET worker process can also shut down automatically during profiling. This can occur if you have edited the `processModel` Attributes section of the `machine.config` file on the system on which the process runs in one of the following ways:

- Changed the value of the `requestLimit` or `requestQueueLimit` attribute from "Infinite" to a value low enough to cause the process to be shut down during the session
- Changed the value of the `timeout` or `idleTimeout` attribute from Infinite to a value low enough to cause the process to be shut down during the session
- Changed the value of the `memoryLimit` attribute to a percentage low enough to cause the process to recycle during the session

When the process is shut down, DevPartner takes a final snapshot and generates a session file. DevPartner handles the session file in one of the following ways:

- If the ASP.NET worker process is the selected process in the Session Control toolbar, DevPartner opens the session file in Visual Studio and adds it to the solution. This action is repeated for each instance of the ASP.NET worker process that is spawned and terminated.
- If the ASP.NET worker process is not the selected process, the session file is cached. When the IE client process is terminated, or when a snapshot of the IE process is taken, DevPartner creates a session file for IE, and a correlated session file that includes data for IE, IIS, and all instances of the ASP.NET worker process spawned and terminated up to that point.

When the analysis session has ended, DevPartner will continue to display the **File Save** dialog box or automatically save session files for instances of the ASP.NET worker process that are spawned and terminated.

To avoid generation of extra session files due to frequent termination of the ASP.NET worker process, you can edit the `machine.config` file and set the limiting attribute to a value high enough to prevent premature termination of the process.

Caution: Always make a backup copy before editing the `machine.config` file.

Collecting Data from Classic Web Script Applications

When you run a classic Web script application with DevPartner performance analysis enabled, DevPartner gathers data for HTML files and JScript and VBScript source files. If the scripting languages invoke in-process or out-of-process components, such as COM objects, DevPartner can collect data for these as well.

Instrumentation for the scripting languages occurs at run-time, just as it does for managed .NET languages. However you do need to instrument any unmanaged components, such as COM objects, that you want monitored.

Note: The following procedure is unique to classic Web script applications. To collect data for Web Forms, XML Web services, and ASP.NET applications you develop in Visual Studio, run the application just as you would run any other .NET application.

To collect data for a classic Web script application, choose **Start > Programs > Compuware DevPartner Studio > Utilities > Web Script Performance.**

Internet Explorer (IE) opens with DevPartner Performance Analysis loaded. In addition to IE, a Session Control toolbar appears, which you can use to control data collection.

In the DevPartner-enabled instance of IE, open the HTML page or Web application for which you want to collect performance data and exercise the application. Optionally, use the Session Control toolbar to focus data collection as the application executes.

Exit Internet Explorer or, if using the Session Controls, execute a **Stop** action. The **Save Session** dialog box displays and the session file is automatically saved.

Web Application Data Collection Tips

Before you begin collecting data for analysis:

- Warm up the application by exercising it for several minutes. Be sure to include the parts of the application in which you are interested.
- Execute the **Clear** session control action to discard data collected to that point. This eliminates data collection for the many one-time initializations that take place when you launch the application.
- Exercise the modules you are analyzing.
- Click **Snapshot** on the **Session Control** toolbar. This will give you performance data for a representative sample of your code.
- Allow time for HTML pages to completely load. When testing manually, wait for the page to load. When creating scripts for automated testing, build in wait time so pages can load completely. Executing code on a page before the page is fully loaded may skew your profiling data.

- Be aware of caching. A Web application may return a page from the cache instead of running your application code. If your test uses the same input data repeatedly, caching will skew your results. If you do not want to measure the effects of the cache, you can turn caching off by editing the `machine.config` file and commenting out the line that reads:

  ```
  <add name="OutputCache"
  type="System.Web.Caching.OutputCacheModule"/>
  ```

Caution: Always make a backup copy before editing the `machine.config` file.

Web Service Requirements

For DevPartner performance analysis to detect a Web service, the service must meet at least one of the following requirements:

- The Web service must be derived from the `System.Web.Services.WebService` base class.
- The Web service must contain the `WebService` attribute.

For DevPartner performance analysis to detect a Web method, the method must contain the `WebMethod` attribute.

Deleting Temporary Files from NMSource

While analyzing scripts for performance under IE or IIS, DevPartner creates an `NMSource` directory to hold temporary copies of the script source. This source is displayed in the Source tab of the Session window when you are analyzing session data.

Because this source may be needed at any time, DevPartner does not delete files from `NMSource`. The size of this directory can grow quickly, particularly when you are analyzing server programs under IIS.

You should regularly review the source files in the `NMSource` directory and delete any related to projects that are no longer active. `NMSource` is located in the `\Program files\Internet Explorer` directory.

Configuring IIS for Data Collection

To collect performance data for IIS/ASP.NET applications running on the local machine or on a remote server, set the following configuration options.

Note: If IIS runs on the local system, set the options described below on the local system. If IIS runs on a remote server, you must install DevPartner (and a Remote Server license) on that system and set the options described below on the remote system.

Script Debugging

You can set the following options in the Default Web Site Properties, or in the WebApplication Properties for a specific application, of the Internet Information Services manager. The following options apply to IIS 5.0 or 6.0.

On the Home Directory or Directory tab, click **Configuration**. On the **Application Debugging** tab, set the **Debugging Flags** to:

- Enable ASP server-side script debugging
- Enable ASP client-side script debugging

Host Process Settings

If your Web application runs in the `dllhost` process, you may need to change the Application Protection options to enable DevPartner to collect performance analysis data. You can set these options in the Default Web Site Properties, or in the WebApplication Properties for a specific application, of the Internet Information Services manager. The following options apply to IIS 5.0 or 6.0.

On the Home Directory or Directory tab, in the Application Settings section, set the Application Protection to one of the following:

- Low (IIS Process) Your application runs in the `inetinfo` process. DevPartner restarts IIS when you enable data collection and collects data from this process as your application runs.
- High (Isolated) Your application runs as a separate instance of `dllhost`. DevPartner recognizes the new process and collects data as your application runs.

When you have finished collecting data, restart IIS to remove DevPartner data collection from the process.

Configuring Internet Explorer for Data Collection

To collect performance analysis data from Internet Explorer, select **Tools > Internet Options...** On the **Advanced** tab, set **Disable script debugging (Internet Explorer)** to OFF and set **Disable script debugging (Other)** to OFF.

Collecting Data from a Service

To run a performance analysis session for a service, use `DPAnalysis.exe`. With `DPAnalysis.exe`, you can run sessions directly from the command line or through an XML configuration file. Refer to"Starting Analysis from the Command Line" on page 345 for information on `DPAnalysis.exe`.

Collecting Data from COM and COM+ Applications

You can collect data for an application that makes calls to COM or DCOM components with DevPartner.

If you profile an application that uses a mix of unmanaged COM and .NET objects (COM+), DevPartner collects line-level data for .NET portions of the application. DevPartner collects line-level data for unmanaged code components if they have been instrumented with DevPartner native C/C++ instrumentation. DevPartner can also collect line-level data for your Visual Basic COM objects, if you first instrument them for performance data collection. You can do this by building the project with instrumentation for performance analysis.

If you profile a C++ object, or any unmanaged code component that has not been instrumented, DevPartner collects only method-level data based on COM interfaces and DLL exports.

Collecting Data for Recursive Functions

A literal profile of an application that uses recursion contains double counts of recursive functions. DevPartner eliminates this duplication by detecting when it is already timing a function. It stops timing for the first function call and starts a new accumulation for the second call. Refer to the DevPartner Studio online help if you would like an in-depth description of how DevPartner handles collecting data for recursive functions.

Analyzing a Call Graph

A **Call Graph** is a graphical representation of of the calling relationships of your application's methods. Use of call graphs was introduced in the Ready, Set, Go procedure earlier in this chapter. This section provides additional details about using the **Call Graph**.

To view a **Call Graph** from a session file, either click the **Show Call Graph** button or select a method from the **Method List** tab, right-click and select **Go to Call Graph**. A separate **Call Graph** window appears.

DevPartner displays **Call Graphs** showing the chain of calls leading up to a particular method call, and the methods that are subsequently called by that method.

The nodes are displayed sequentially from left to right in the order in which they were called. The first node initially shown in the **Call Graph** is the base node. This represents the selected method or object. Nodes to the left of a node are called "parent nodes." Nodes to the right of a node are called "child nodes."

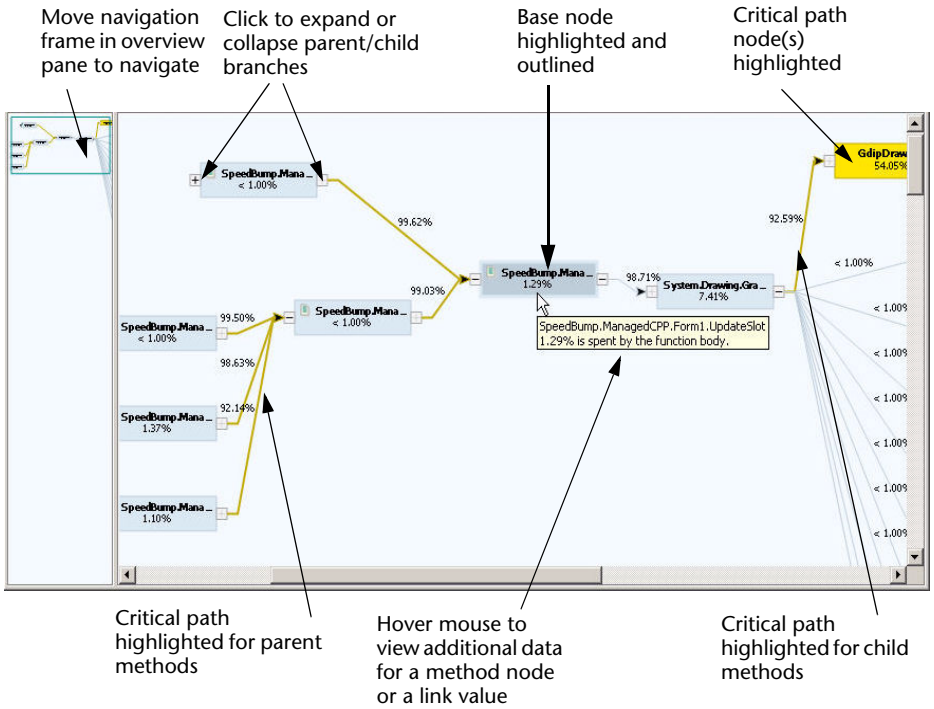


Figure 6-11. Call Graph

The **Call Graph** consists of two frames:

- The left frame shows an overview of the **Call Graph**. This is useful to see the entire **Call Graph** if the **Call Graph** has too many nodes to be shown in the right frame without scrolling. As you expand or collapse nodes in the right frame, the overview automatically refreshes to display the current view. Alternatively, move the navigation frame around in the overview to change the portion of the graph displayed in the right frame. You can close the overview by right-clicking anywhere in the right frame and deselecting the **Show Overview** option.
- The right frame shows the base method node and all the methods either called by it or that call it. Use the expand/collapse boxes to show or hide the nodes to the right or left of the selected node.

  The percentage value shown in each node represents the percentage of time the node is using. The value shown on the lines to each child node represent the time that child path is using, as a percentage of the total time being used by its parent node.

Critical Paths

When you display a **Call Graph**, DevPartner computes the critical path for the selected method and all of its children. The critical path is the sequence of method calls that accounted for the largest percentage of time attributable to the method and all of its child methods.

Navigating the Call Graph

You can drag the nodes to different locations on the window and the **Call Graph** lines are automatically redrawn for you. This is useful if the screen is cluttered with too many methods or if you want to reduce the amount of screen taken up by the initial display of the base, parent, and child nodes.

By default, only the child nodes are shown in expanded form. The parent(s) of the base node are not shown. Click on the plus icon on the left side of the base node to display the parent node for the base node. To display the full path, you will need to expand the left icon for each parent node until you reach the first method executed by the program (typically named `Program Start`).

You can select nodes either individually or in a group. To select multiple nodes, select one node, then while pressing the Ctrl or Shift key, select the other nodes you want. You can then drag them as a group.

Viewing Source Code

To view the source code for the base node, right-click on the base node and select the **Go to Method** option on the context menu. You can only view the source code for the base node.

Child-side Analysis

Analyze the child (right) side of the **Call Graph** to understand what to optimize.

Expand the child nodes to analyze whether the base method or a child method is responsible for the most time.

- If the base node has several parallel branches, look for branches that have the largest values on the link to the first child method. Optimizing branches with higher values is likely to provide more benefit in terms of performance.
- If the base method itself shows a high value, consider optimizing the base method.
- If a child branch is a large contributor to the time spent by the base method, look for child nodes on that branch with high percentage values.

Parent-side Analysis

Analyze the parent (left) side of the **Call Graph** to determine if the base node branch is worth optimizing, or if it is feasible to eliminate or reduce the number of times the base node is called.

Expand the parent nodes to the left of the base node. In particular, examine the base node's contribution to the time spent in its parent branches. This will help you determine if optimizing the base node or its child methods is worthwhile. If the base method is a large contributor to several parents, or to an important parent in terms of overall program execution, it is probably worth considering as a target for optimization.

Note: Values on the links between the base node and its parents are independent, not additive. Each percentage value represents the base node's contribution to the time spent by that parent.

- If the base node has several parents, and one or more values on the links to the base node is high, the base node may be a candidate for optimization.
- If the values on the links to the parents are very small, optimizing the base node branch will probably have little impact on parent method performance.

- To determine if the base node is the best choice to optimize, view a new **Call Graph** with the parent selected as the base node. This will show the importance of the original base node to the parent node's performance, relative to other children of that parent method.

When analyzing either the parent or child side of the **Call Graph**, you can right-click a node and use the context menu to view the source code for the method to see if you can determine why it is using so much time.

Comparing Sessions

To fine tune a program's performance, you first need to locate where execution spends the most time so you can make adjustments to the costliest code fragments. Then you want to compare how those adjustments affect performance.

DevPartner gives you the ability to compare the results of one performance session with those of another so you can see the impact of optimizations you make on individual methods and on application performance as a whole.

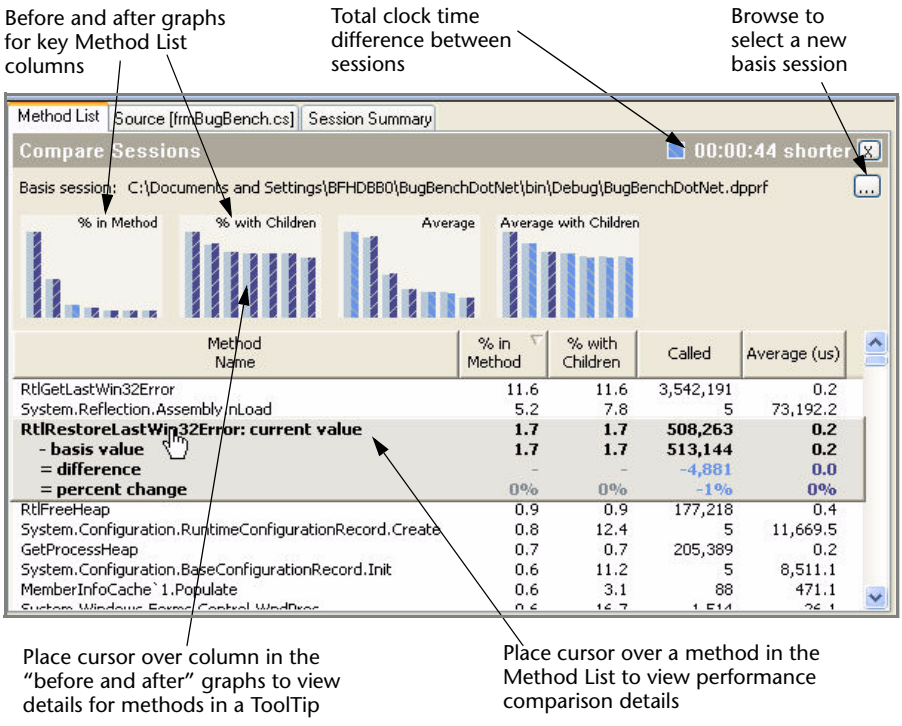


Figure 6-12. Comparing Performance Sessions

You invoke session comparison by toggling the **Compare** command with a session window open. The **Compare** command is available:

- As a tool bar button 
- As a menu item on a performance session window context menu

When you first invoke the **Compare** command, you are prompted to choose a session file to be the basis session. DevPartner defaults to tracking the currently active session as the current session. Once you choose a basis session, the session window transforms to include a frame that you can place over any method in the method list. The frame will display a comparison between the basis and current session versions of that method.

When choosing sessions for comparison, try to ensure that the sessions compared were run in as near an identical fashion as possible. For example, do not compare a session started in the debugger with one run outside the debugger. To create more exact comparisons, consider using the session control file or the Session Control API to control data collection.

The upper right of the comparison window displays the overall time difference between the current session and the basis session. The graphic to left of the time display indicates whether the current session took more or less time than the basis session. This is useful for a quick comparison of sessions in which the application was exercised identically.

The comparison shows the current value, basis value, difference, and percent difference between the two versions of the chosen method. You can use DevPartner performance filters to alter the views of your session data.

At the top of the session window, four bar charts show a graphical view of the same information for the top methods in the current session.

You can copy the information in the session comparison data box by invoking the **Copy Comparison** command from the context menu within the **Method List**. This command copies the data onto the clipboard.

When you finish comparing, press Esc, or click the **Compare** icon.

Interpreting Session Comparison Results

A session comparison shows the current value, basis value, difference, and % difference between a method in the current session and the same method in the basis session. DevPartner uses color to help you see at a glance whether the value in the current session is larger or smaller than that in the basis session. When the values for difference and percent difference are dark blue, the values for the current session were better (faster) than those of the basis session. Light blue means that the performance values were slower in the current session.

Once you have determined what results your code changes accomplished between sessions for any given method, search other methods in the session to uncover any side effects of your initial code changes. Even though an individual method's performance improved, the larger program's performance may have degraded. In performance tuning, no tool can substitute for thorough knowledge of the structure of your code.

When examining session comparison results, be aware of the following:

- A percentage is a ratio of two numbers. Percentages are additive only when computed relative to the same total value.
- If one percentage value decreases, all other percentage values must increase. In a complex program this may be difficult to notice, since the percentage increase must be averaged across all the other methods in the program.
- To interpret a subprogram's timing, you must understand that subprogram's role in the enclosing program.
- Performance measurements have no meaning outside the context of the program that produced them. It is not possible to generalize about the effects of program changes without understanding the program's operation.

Once you are satisfied with the changes to the costliest method in your program, you can turn your attention to other expensive methods.

Exporting Performance Data

You can export performance data in XML format or in CSV format. Exporting data in XML or CSV format facilitates use of your own or third-party software to analyze the data, integrate the data with data produced by other tools, and archive the data in a data warehouse.

- You can export DevPartner performance session files (with the `.dpprf` extension) to XML format. When a saved performance session file is open, the **Export DevPartner Data** command is available on the **File** menu. Refer to "Exporting Analysis Data to XML" on page 375 for information about exporting in XML format.

  You can also export data from the command line, as described in "Exporting Analysis Data to XML from the Command Line" on page 376.

- You can export **Method List** data to a comma-delimited CSV text file. Click the **Method List** tab to make it active, display the columns you want to export, right-click in the **Method List** and choose **Export Method List** from the context menu. You can open the comma-delimited text file in Microsoft Excel or another spreadsheet application.

Controlling Data Collection

DevPartner gives you three ways to control when performance data is collected during the use of your application:

- You can use the session control toolbar to interactively control data collection as your program runs.
- You can use a session control file to assign session control actions to specific methods in your application modules.
- You can use the Session Control API to control data collection in your program.

Using the session control toolbar or Session Control API allows you to control data collection anywhere within a method. Using a session control file allows you to control collection only at the entrance to or exit from a method.

Using a session control file and using the Session Control API is described in "Analysis Session Controls" on page 365.

Analyzing from the Command Line

To automate data collection or run analysis sessions from the command line, use `DPAnalysis.exe`, the DevPartner command-line executable. For information on using `DPAnalysis.exe`, refer to "Starting Analysis from the Command Line" on page 345.

Using the Performance Analysis Viewer

DevPartner Studio provides a lightweight **Performance Analysis Viewer** for analyzing performance session files independently of Visual Studio 2008 and Visual Studio 2005. To launch the viewer, do any of the following:

- On the Start menu, select **Programs > Compuware DevPartner Studio > Performance Analysis Viewer**.
- Double-click a `.dpprf` session file in Windows Explorer.
- Run a performance analysis session using `DPAnalysis.exe` on the command line. DevPartner displays the session data in the **Performance Analysis Viewer**.

What You Can Do in the Performance Analysis Viewer

With a session file open, you can view, sort, save, or print performance session data. In addition, you can:

- View the source code for a method
- Sort the data on the **Method List** tab
- View the **Call Graph** for a method
- Compare session data
- Export the contents of the file as XML
- Export the contents of the **Method List** in CSV format

What you Cannot Do in the Performance Analysis Viewer

- Instrument an unmanaged application for performance
- Start a performance session
- Add files to a Visual Studio solution

Note: Session files generated from the command line are not automatically added to the project's solution. You can manually add externally generated session files to an open solution in Visual Studio.

Performance Analysis Tips for .NET Applications

The following are strategies you can use to make the performance analysis process more productive.

- Analyze source code

  Use the **Top 20 Source Methods** filter to isolate application hotspots.

*Tip: To avoid collecting data for all system (non-source) files, check **Exclude system images** on the DevPartner **Exclusions - Performance** options page. Once you optimize your source code, turn off this option so you can examine how your application uses system code, especially the .NET Framework.*

Use the **Call Graph** to examine the most expensive methods to understand the costs associated with child methods called.

Compare the effect of different algorithms or logic changes by running multiple performance sessions.

- Understand Framework costs

  Use **% with Children** on the **Method List** or **Source** tab to see how much time you are spending in the .NET Framework.

  Drill into the .NET Framework by examining child methods in the **Call Graph** to understand which calls are expensive and why.

  Rework the application to do less work or to call the .NET Framework less often.

- Understand start-up costs

  Use the **Clear** session control before collecting performance data. The .NET Framework performs many one-time initializations. To prevent these from skewing performance results, warm up the application by exercising all the features you want to profile, then **Clear** the data. Next, run a test that exercises the same features to get a more accurate performance picture.

- Understand what you want to measure

  Consider how your application behaves before you begin collecting performance data. For example, if you are profiling a Web service or ASP.NET application, think about how Web caching will affect your results. If your test run inputs the same data repeatedly, your application will fetch pages from the cache, skewing the performance data. In such a case, you could take pains to insure variable input data, or simpler, edit the `machine.config` file to turn off caching while you test. Comment out the line that reads:

  ```
  <add name="OutputCache"
  type=System.Web.Caching.OutputCacheModule"/>
  ```

- Measure performance of mixed-mode applications

  You may choose to write parts of a .NET application in unmanaged C/C++. DevPartner allows you to collect performance data for both managed and unmanaged portions of an application in a single run, provided the unmanaged code is in a separate file and you instrument the code before collecting data. Thus, you can compare the effectiveness of unmanaged and managed code in the context of the total application by comparing performance sessions.

- Collect complete data for distributed applications

*Tip: Use the process list on the **Session Control** toolbar to take performance snapshots of each process in a distributed multi-process application.*

When you analyze performance for a Web application, a multi-tier client/server application, or an application that uses Web services, include all remote application components in the analysis. Use a DevPartner installation to configure performance data collection on remote systems. If your application uses unmanaged C/C++ components, instrument the components for performance analysis before collecting data. Recommendations regarding start-up costs, .NET Framework costs, and awareness of application behavior apply equally to collecting data for server-side components.

- Understand the limitations of micro-profiling

  Once you identify a bottleneck in your application, you may find it convenient to create a smaller sample of code that duplicates the problem area in the main application. You improve performance in that sample by iterative performance comparisons and then move the code back in to the main application. Is your application going to be faster? Maybe. But you cannot know until you rerun your original performance tests.

- Simulate actual running conditions

  Application memory footprint, multi-threading, thread priorities, process security, network latency, server load, and other contingencies can affect the way your code runs in ways that performance testing of a single component may not reveal. You have not measured application performance until you have simulated as closely as possible the conditions under which your application is going to be used.

Submitting Data to Visual Studio Team System

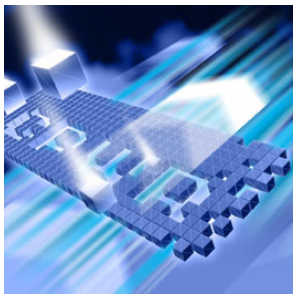
DevPartner Studio supports Microsoft Visual Studio Team System if the Team Explorer client is installed and a Team Foundation Server connection is available. Refer to “Visual Studio Team System Support” on page 8 for general information about Team System support.

In a performance analysis session file, you can submit data for a method selected in the **Method List** tab in a DevPartner performance analysis session file as a **Work Item** to Visual Studio Team System.

When you submit a **Bug**, DevPartner populates the **Work Item** form with data from the visible columns in the **Methods List** tab. To change the method data you submit in the **Work Item**, change the columns displayed in the **Method List**.

Chapter 7

In-Depth Performance Analysis



- What is Performance Expert?
- Using Performance Expert Out of the Box
- Setting Properties and Options
- Finding Application Problems with Performance Expert
- Usage Scenarios
- Collecting Data from Web Applications
- Automating Data Collection
- Collecting Data from Distributed Applications
- Exporting DevPartner Data to XML Format
- Using Performance Expert with Performance Analysis
- Performance Expert in the Development Cycle
- Submitting Data to Visual Studio Team System

This chapter contains two sections. The first section provides a quick-start procedure to get first-time users up and running with Performance Expert. The second section provides reference information for an in-depth understanding of the DevPartner Studio Performance Expert feature.

Refer to the DevPartner Studio online help for additional task-oriented information about Performance Expert.

What is Performance Expert?

DevPartner Studio contains many features designed to assist application development, including a performance analyzer that helps you locate bottlenecks in your code. Performance Expert takes performance analysis a step further for managed Visual Studio applications by providing deeper analysis of the following hard-to-solve problems:

- CPU/thread usage
- File/disk I/O
- Network I/O
- Synchronization wait time

Note: Performance Expert analyzes managed code only, and is therefore not supported in the DevPartner for Visual C++ BoundsChecker Suite.

Performance Expert analyzes your application at run-time and locates the problem methods in your code. It then allows you to view details about individual lines in the method, or to examine parent-child calling relationships to help you determine the best way to fix the problem. When you decide on an approach, Performance Expert enables you to jump directly to the relevant lines in your source code, so you can quickly fix problems.

Because Performance Expert is integrated into Visual Studio, you can use it to test applications as you develop them. You can also run Performance Expert sessions from the command line, or as part of an automated test scenario, by using the DevPartner command-line executable `DPAnalysis.exe` with traditional command-line switches or an XML configuration file. For information, see "Starting Analysis from the Command Line" on page 345.

DevPartner Performance Expert is designed for use by software designers, software developers, and quality assurance (QA) engineers. It can also be used by development management staff to identify problems in an ongoing project.

Performance Expert and Performance Analysis

Why do you need Performance Expert? Think of this feature as a complement to traditional performance profiling. First, run your application with performance analysis to get a baseline view of performance. Next, run an identical session with Performance Expert to better understand the nature of difficult problems, especially problems that involve disk or network I/O, or synchronization issues. When you have fixed the problem, run the application again with performance analysis and use

the performance analysis **Session Comparison** feature to verify the improvement. For information on comparing performance analysis sessions, see "Comparing Sessions" on page 246. For more information on using Performance Expert in conjunction with performance analysis, see "Using Performance Expert with Performance Analysis" on page 291.

Using Performance Expert Out of the Box

The following Ready, Set, Go procedure introduces you to using the DevPartner Studio Performance Expert feature.

To get up and running quickly, follow the steps presented in shaded boxes. If you would like more information about the subject described in a shaded box, read the additional text following the box.

Note: Analyzing an application with DevPartner Studio does not require elevated system privileges. The system privileges you use to create and debug your application are sufficient for DevPartner to analyze the application.

Ready: Consider What You Want to Analyze

What type of application will you be analyzing? Think about what steps, if any, you need to take before beginning a Performance Expert session.

Performance Expert collects data only from managed applications. To collect Performance Expert data for your application, the solution must contain at least one managed code project (for example, C#, Visual Basic, or managed C++). It must also include a startup project. If the solution includes multiple startup projects, DevPartner prompts you to choose a startup project for the session.

The following procedure assumes:

- You are testing a single process, managed application.
- You can build and run your application.
- Your solution contains at least one managed code project.
- Your solution includes a startup project.

Note: Refer to "DevPartner Studio Supported Project Types" on page 335 for a comprehensive list of supported project types for DevPartner memory analysis.

Performance Expert monitors a single process when run from Visual Studio, or when run with `DPAnalysis.exe` using traditional command-line switches. Although you can collect Performance Expert data from more than one process or service in a session by using `DPAnalysis.exe` with an XML configuration file, it is usually best to target a single process in a Performance Expert session. If your application runs in more than one process, rerun the application, targeting the second process. For more information about using `DPAnalysis.exe`, see "Automating Data Collection" on page 284.

You can use Performance Expert to improve performance of any managed Visual Studio application, including:

- ASP.NET Web applications
- ASP.NET Web services applications
- .NET Remoting server applications
- Windows Forms client applications
- Serviced components, e.g. COM+

Decide what data you are interested in collecting before beginning your Performance Expert session. Think about how your application performs. Does it slow down when you use certain features? If so, exercise that feature when you run your application with Performance Expert. Has traditional performance analysis indicated that excessive time is being spent in methods that read or write data, or access network resources? Performance Expert can provide additional information about disk and network I/O, so target that feature in a Performance Expert session.

If your application includes a local client process and a remote server process, are you interested in data from both processes? If so, you must first install DevPartner Studio and a DevPartner Remote Server license on the remote machine to collect the server data. Before collecting server-side data, be aware that some IIS setup might be required.

Set: Properties and Options

Once you have decided what code you want included in the Performance Expert session, you can set several properties and options to focus your data collection.

> For this procedure, you can use the default DevPartner properties and options. No additional set-up is required.

Using Solution Properties or Project Properties, you can choose a startup project for the session or exclude certain projects from the session, if your solution contains multiple projects. Using DevPartner Options, you can change display options or create a Session Control file to manage data collection. Setting up your analysis session is described in "Setting Properties and Options" on page 271.

Go: Collect Performance Expert Data

After considering what you want to analyze and setting the appropriate properties and options, you are ready to collect Performance Expert data.

DevPartner supports the Visual Studio launch model. When you click the Performance Expert icon or choose **Start without debugging with Performance Expert** on the **DevPartner** menu, DevPartner rebuilds the solution, launches the startup project for your application, and begins to collect Performance Expert data.

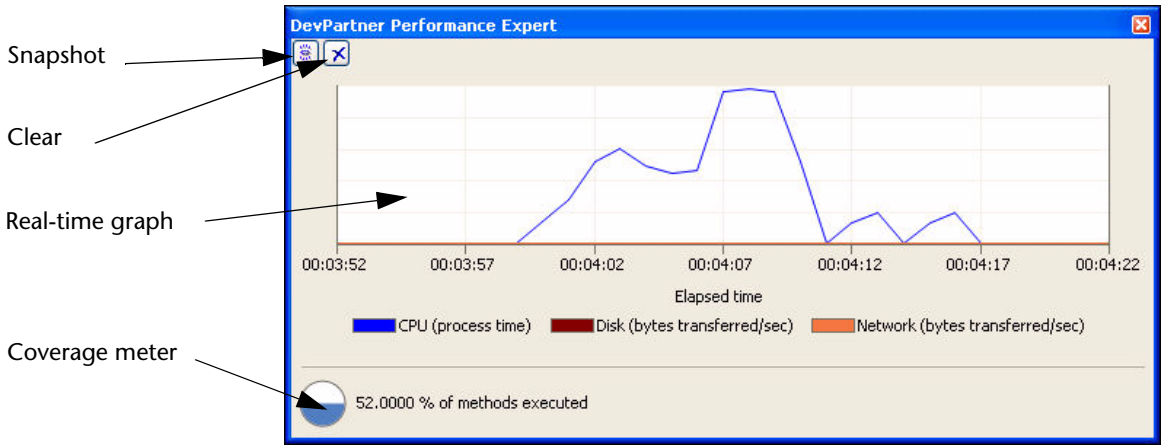


Figure 7-1. Controlling Data Collection with the Performance Expert Window

1. In the **Performance Expert** window, click the **Clear** session control at the upper left to clear startup and initialization data and focus data collection on the problem feature.
2. Exercise the slow portion of your application.
3. Watch the **Performance Expert** window as you exercise your application. The graph displays a line for CPU process time, and if present, lines for disk and network activity. A spike in any of these lines may indicate a potential trouble spot.
4. If you see something interesting, click the **Snapshot** session control. DevPartner generates a Performance Expert session file and displays it in Visual Studio.

Using the Performance Expert Window

Using the Real-Time Graph

The Performance Expert real-time graph presents the last 30 seconds of activity as you run your application. The graph always draws a line reflecting CPU use. If your application does disk or network reads or writes, the graph includes separate lines for disk I/O and network I/O.

Use the real-time graph to monitor application activity. If you see something interesting, for example, a spike in activity in the graph, you can use the **Snapshot** button to take a snapshot of activity to that point. Conversely, if nothing of interest has happened, use the Clear button to clear data collected to that point.

Using Clear and Snapshot

The **Clear** and **Snapshot** buttons are located above the real-time graph, at the upper left of the Performance Expert window. Use these session controls to perform the following actions:

- **Clear** - Clears data collected to that point, or since the last clear action. Use Clear to focus data collection and minimize the size of the session results file.
- **Snapshot** - Creates a session results file that contains data collected up to that point, or since the last clear action. Data collection continues. You can take multiple snapshots as your application runs.

Using the Coverage Meter

The **Coverage Meter** is located below the real-time graph, at the lower left of the session control window. The coverage meter displays the percentage of your application methods that have been executed up to that point in the session. Use the coverage meter to ensure that you have tested all of your code under the Performance Expert. You can also use the coverage meter in conjunction with the session control actions to help focus data collection on certain parts of your application.

Note: Generally, run Performance Expert sessions without debugging. Results from non-debug sessions are easier to interpret and do not include the processing overhead caused by the debugger. If you run your application in the debugger, some timing values might be larger than expected, especially if breakpoints were hit during the session. Expect tracing and other debug-only functionality to figure highly in such session files.

5 When you finish collecting data, close your application.

When you close your application, DevPartner generates a final Performance Expert session file. If you want to capture all the session data in a single session file, it is not necessary to use the **Snapshot** session control. Simply close the application.

Analyze the Data

When you take a data snapshot, or when you finish collecting data and quit your application, DevPartner produces a Performance Expert session file. The initial view of the data DevPartner has collected for your application appears in the form of a results summary.

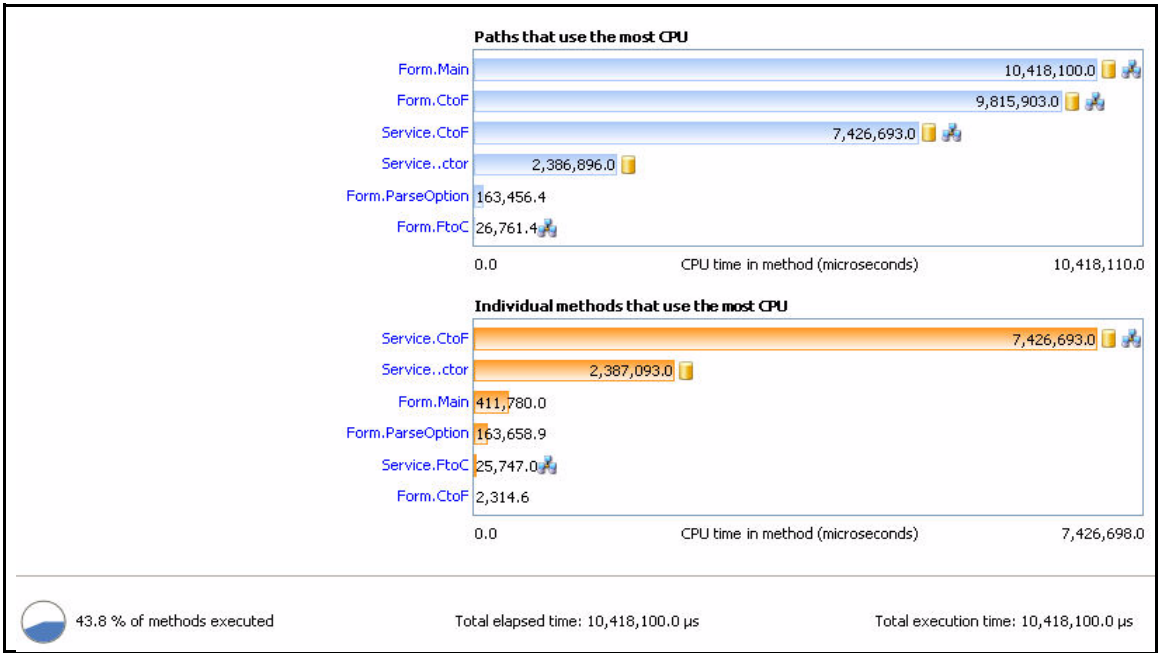


Figure 7-2. The Performance Expert Results Summary

The results summary contains two bar graphs, reflecting two ways to analyze the data to solve application problems:

Tip: An entry point method is a source code method that was not called by another source code method, i.e., an entry point into source code execution.

- **Paths that use the most CPU** displays entry point methods for the top paths, or chains of method calls, that consumed the most CPU cycles in the session. Path analysis enables you to quickly identify the most expensive paths of method execution. You can:
  - Fix the child methods responsible for poor performance
  - Modify other methods in the calling sequence so they call the expensive child methods less often
- **Individual methods that use the most CPU** displays the top methods in terms of CPU cycles consumed. Method analysis enables you to quickly identify individual problem methods so you can fix them.

Notice the icons at the ends of the bars in Figure 7-2 on page 259. These icons indicate that a method caused disk  or network  activity.

Deciding Where to Start

To begin evaluating the session data, compare the two bar graphs on the results summary.

- Is the top path in the **Paths that use the most CPU** chart significantly longer than the other paths in the chart?
- Does the top method in the **Individual methods that use the most CPU** chart stand out from the other methods in the chart?
- Does the time value for a method seem excessive for what the method does?
- Does the same method appear as expensive on both charts?

If the answer is yes to any of these questions, investigate that method.

Before you analyze the data, learn to navigate the data views that you can access from the results summary.

1. In the results summary, click on the top path in the **Paths that use the most CPU** chart. The **Path analysis** window opens.

   Notice that the **Path analysis** window includes **Call Graph** and **Call Tree** tabs, and below, **Source** and **Call Stacks** tabs.

2. Click **Back to Summary** to return to the results summary.

3. In the results summary, click the top method in the **Individual methods that use the most CPU** chart. The **Methods** window opens.

   Notice that the Methods window includes a list of the methods executed in the session, and below, **Source** and **Call Stacks** tabs.

4. Click **Back to Summary** to return to the results summary.

Analyzing Paths that Use the Most CPU

If you drill down from the **Paths that used the most CPU** graph, you can view **Call Graph** and **Call Tree** presentations of the session data. The **Call Graph** shows the child methods called by the entry point method, with the relative contributions of each to the time spent in the path. The **Call Tree** presents a tree view of the same data but adds additional data about each method in the form of user-configurable data columns.

If you choose to examine a method in the **Individual methods that use the most CPU** graph, DevPartner presents a **Methods** table with user-configurable data columns to assist your troubleshooting. To switch between the **Path analysis** and **Methods** table views, click **Back to Summary** in any details view.

The calculation of the Performance Expert session data differs between the **Paths that use the most CPU** and the **Individual methods that use the most CPU** views. In the **Individual methods that use the most CPU** view, DevPartner excludes measurements for source code child methods in computing data for CPU time, disk or network I/O, and synchronization lock wait time. Excluding source code child methods focuses attention on methods that, in themselves, consume large amounts of CPU time. In contrast, DevPartner includes the impact of source code child methods to their parent methods in the **Paths that use the most CPU** view in order to highlight the most expensive paths of execution.

All computations in both views include time or throughput attributable to system or .NET Framework methods called by your source code methods. Managed applications typically spend significant time executing .NET Framework code. Performance Expert charges the system data to the lines in your source code that made the calls in order to focus attention on how your code interacts with the .NET Framework, that is, on the parts of the application that you can modify.

In this procedure, we will first use **Path analysis** to analyze the relative contribution of child methods called in the most expensive paths of execution.

5 In the results summary, click on a method in the **Paths that used the most CPU** chart to drill down to the **Path analysis** view. If the **Call Graph** is not visible, click the **Call Graph** tab, at the left.

DevPartner highlights the **critical** or most expensive path of execution. Start your troubleshooting here.

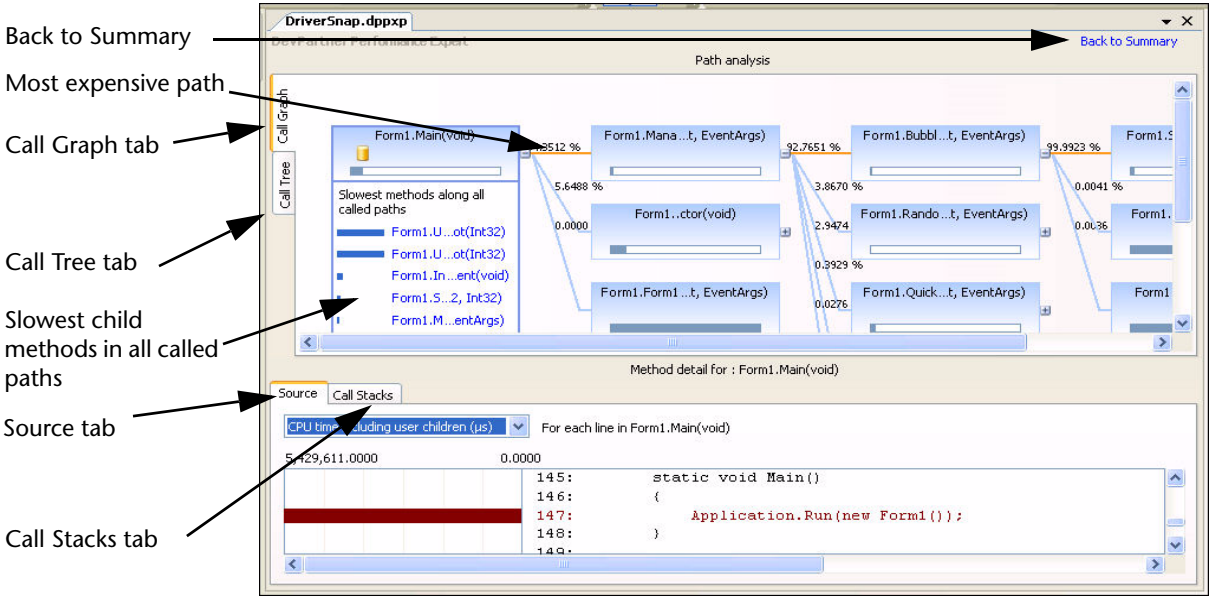


Figure 7-3. Identifying Expensive Execution Paths in the Path Analysis Window

In the **Call Graph**:

6 To investigate a path, click the plus sign on a node to expand the path to the right.

7 Click on any method to see the list of the slowest child methods it called, regardless of path. This list exposes slow methods that may not be part of the critical path.

8 To determine the relative contributions of different paths spawned by the same method, compare the percentage values on the lines that connect the selected method to each of its child paths. Investigate the most expensive (highest percentage) paths first.

9 Hover over the horizontal bar at the bottom of each node with the mouse pointer to see the percentage of time spent in the method versus the time spent executing child methods. For an example, see Figure 7-4 on page 263.

If most of the time is attributable to child methods, continue to investigate the path. If most of the time was local to the method, focus your efforts on that method.

The **Call Graph** helps you quickly locate expensive methods in the calling sequence so you can focus your tuning efforts. In addition to showing the impact of child methods, the nodes in the **Call Graph** provide insight into what your methods do. For more information on using the Call Graph, see "The Call Graph" on page 280.

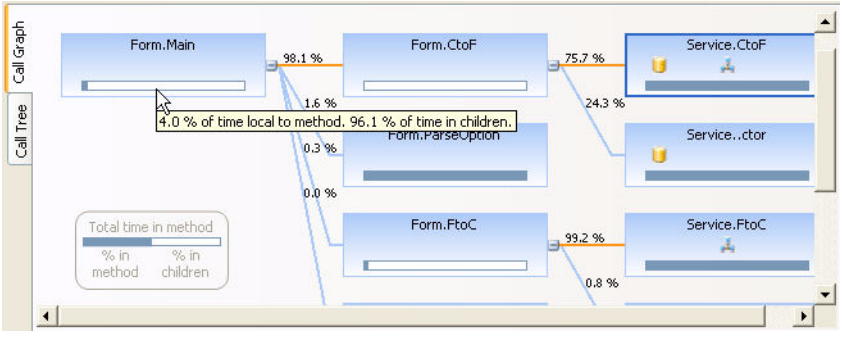


Figure 7-4. Assessing the Impact of Child Methods.

10 Does a node you plan to investigate contain one or more of the following icons?

 Indicates disk activity

 Indicates network activity

 Indicates synchronization wait time

11 If so, hover over the icon with the mouse pointer to view the magnitude of the activity. If you think that the magnitude of the activity merits further investigation, switch to the **Call Tree** tab for more diagnostic help.

12 To view the **Call Tree**, click the **Call Tree** tab on the left side of the session file window.

Tip: The term "user children" refers to your own application source code methods, as opposed to system code or .NET Framework methods also called by your application code.

The **Call Tree** provides information similar to the **Call Graph**, but in the form of a tree view. The most expensive paths are indicated by position in the sort order of the table. The default sort column is **CPU time including user children**.

As you saw above, the **Call Graph** provides information about the relative contribution of child methods to their parent methods. In contrast, the **Call Tree** offers more detailed data about what the methods in your application actually do. This data is presented in the form of sortable, user-configurable data columns. You can add these data columns to the **Call Tree** view by right-clicking in any column header and selecting **Choose Columns...** from the context menu. Before adding data columns, you can preview the data they contain in the Properties window in Visual Studio. To display the Properties window, choose **View > Properties Window**.

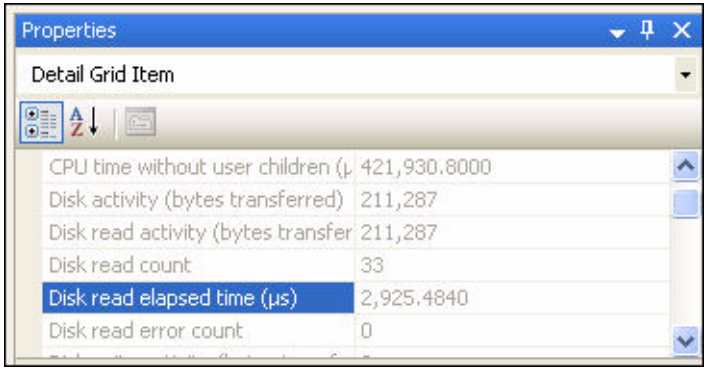


Figure 7-5. Viewing Method Data in the Properties Window.

In the **Call Tree**:

13 To determine the relative contributions of different paths spawned by the same method, compare the values in the **CPU time including user children** column for each of the child paths. When sorted by this column (the default sort), the most expensive paths appear at the top of the tree view.

14 Use the **Call Tree** in conjunction with the **Call Graph**. For example, if an expensive node in the **Call Graph** includes the network I/O icon, switch to the **Call Tree** and add the network-related data columns to the view.

To add data columns to the **Call Tree** view, right-click any column header and select **Choose Columns...** from the context menu.

These data columns show you the number of network reads or writes, how much time was spent reading or writing data across the network, the amount of data read or written, and the number of read or write errors.

If the node in the **Call Graph** included the disk I/O or wait time icon, add those data columns to the **Call Tree** view. In this way, you can quickly pinpoint the reason the problem node is so expensive.

Both the **Call Graph** and the **Call Tree** windows include a **Source** tab and **Call Stacks** tab in the lower part of the window.

The **Source** tab enables you to view source code for your application's methods, with metrics that indicate the expense of the lines that were executed during the session. Use it to view expensive lines of code in context, and to quickly locate lines that would be good candidates for improvement. The **Source** tab includes a metric selector, as shown in Figure 7-6 on page 266. The default metric in the **Path analysis** view is **CPU time including user children**. Additional metrics, including disk I/O, network I/O, and wait time, may be available depending on what the method does. Selecting a new metric in the selector updates the source pane so you can locate the most expensive line for that metric in your source code.

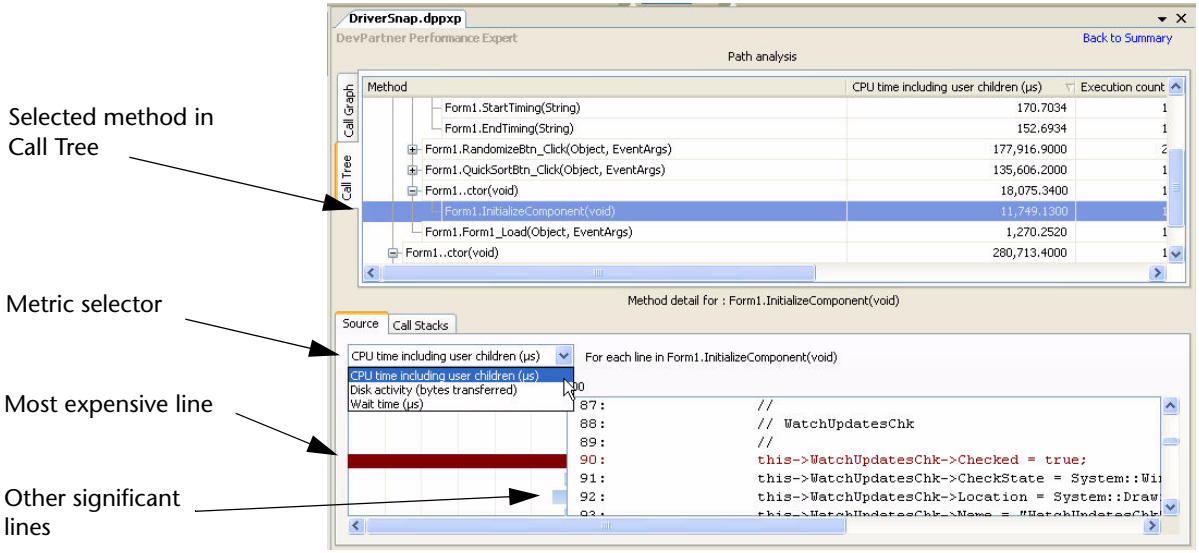


Figure 7-6. Locating the Most Expensive Lines in the Source Tab

Use the **Source** tab in conjunction with the **Call Graph** and **Call Tree**.

15 Select a method of interest in the **Call Tree** tab. (If you have returned to the **Call Graph** tab, you can select a method node.) Select the **Source** tab. Notice that the most expensive line (measured by **CPU time including user children**) is highlighted in dark red. Scroll through the **Source** pane and notice that other expensive lines are highlighted in blue.

16 Did the method you selected have disk, network, or wait time activity? To quickly locate such methods in the **Call Tree**, look for methods with high values in those data columns. (In the **Call Graph**, look for the disk, network, or wait time icon in the method node.)

17 Expand the metric selector (see Figure 7-6 on page 266) at the upper left of the **Source** tab. If the selected method included disk I/O, network I/O, or wait time, the metric appears in the list. Select a new metric and scroll the source display to locate the most expensive line for that metric. An expensive method may present multiple opportunities for improvement.

18 Locate the line you want to fix in the **Source** tab. Double-click the line to open the source file in Visual Studio for editing.

The **Call Stacks** tab enables you to view different instances or usages of the expensive methods of your application. Each call stack is unique. In some cases you may see call stacks that contain the same sequence of method calls. However, if you look carefully, you will see that some of the calls were made from different lines in at least one method.

Notice that as you select different methods in the **Call Graph** or **Call Tree**, the **Source** tab scrolls to the most expensive line in each method. Similarly, the **Call Stack** tab updates when you select a different method

For example, in Figure 7-6 on page 266, a child method is selected in the **Call Tree**. If you plan to address the performance issue by fixing the child method itself, look at the **Source** tab. On the **Source** tab, you would see that the most expensive line in the method is highlighted. If the method did disk I/O or network I/O, or had significant wait time, use the metric selector to locate the most expensive lines for the selected metric. Once you decide what you want to fix, double-click the source line to edit it in Visual Studio.

On the other hand, if you plan to address the performance issue by changing the way your application calls the child method, switch to the the **Call Stacks** tab.

Use the **Call Stacks** tab in conjunction with the **Call Graph** or **Call Tree**. The **Call Stacks** tab shows you all of the paths that called the selected method, so you can evaluate changes to the method in the context of all the ways the method is used in your application. Use the **Call Stacks** tab to quickly locate the most expensive instances (usages) of any method.

19 Select a method of interest in the **Call Tree** tab. (If you have returned to the **Call Graph** tab, you can select a method there.) Select the **Call Stacks** tab. Notice that DevPartner highlights the line that called the selected method.

20 Expand the stack selector at the upper left of the **Call Stacks** tab. Use the stack selector to locate the most expensive usages of the method.

21 Locate the line you want to fix in the **Call Stacks** tab. Double-click the line to open the source file in Visual Studio for editing.

22 If you cannot directly fix an expensive method, modify your code to call the method less often, or not at all.

On the **Call Stacks** tab, you can examine all the calling sequences or paths that called the method you selected in the **Call Tree**. In Figure 7-7 on page 268, note that the stack selector shows the percentage of time attributable to each call stack, so you can quickly locate the most expensive execution path. When you select a call stack, DevPartner shows all of the methods that make up the stack, with the number of the line in each method that called the next method on the stack. Selecting any method in the call stack updates the source pane to highlight the line that called the next child method. Double-click the calling source line to edit it in Visual Studio.

Even if you plan to fix a slow child method rather than change the way it is called, examine the **Call Stacks** tab for the method. It is a good idea to understand all the ways your application uses a method before you change it. Performance Expert makes it easy to do so.

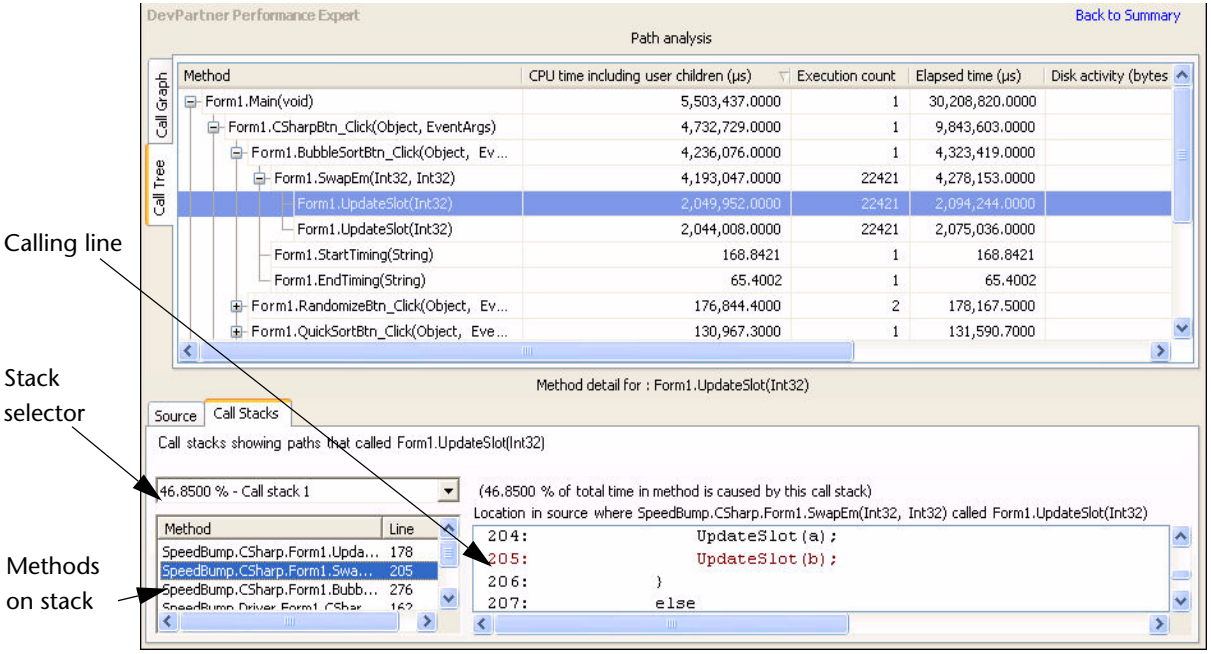


Figure 7-7. Identifying the Most Expensive Calling Paths that Used the Method

Analyzing Individual Methods that Use the Most CPU

So far, we have focused on drilling into the session data from the **Paths that use the most CPU** bar chart on the results summary. You can also analyze Performance Expert data by using the **Individual methods that use the most CPU** bar chart. For example, if you realize that the top method in this chart is consuming more time than you think it should, you can click the method in the chart to examine it immediately.

Clicking the method opens a **Methods** table that lists the methods that executed when you ran your application.

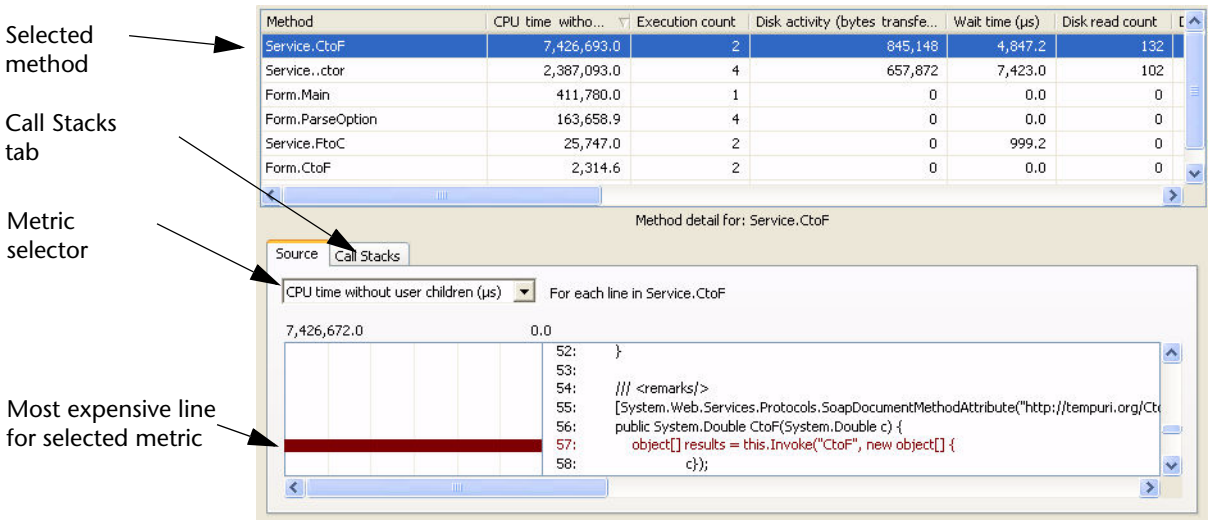


Figure 7-8. Analyzing the Impact of Individual Methods.

23 To access the **Individual methods that use the most CPU** views, click **Back to Summary**.

24 In the results summary, click on a method in the **Individual methods that use the most CPU** chart to drill down to the **Methods** table.

DevPartner highlights the most expensive individual methods in your application. By default, methods are sorted by CPU time spent in the method, without user children, but including system calls.

25 To customize the column selection in the **Methods** table, right-click any column header and select **Choose Columns...** from the context menu.

Use the data columns to determine the most expensive aspects of method performance.

By default, the **Methods** table is sorted by **CPU time without user children**. This metric focuses on the performance of the method itself. In contrast, the **Paths that use the most CPU** views include user, or source code, child methods in the calculation.

Use the **Source** tab in conjunction with the **Methods** table. When you select a method, the **Source** tab guides you directly to the most expensive line in the method and displays the relative cost of other lines. The most expensive line appears in dark red. Other lines that contribute to time spent in the method appear in light blue.

26 Use the metric selector on the **Source** tab to locate the most expensive lines for each available metric. A problem method may present multiple opportunities for improvement.

Use the **Call Stacks** tab in conjunction with the **Methods** table. The **Call Stacks** tab shows you all of the paths that called the selected method, so you can evaluate changes to the method in the context of all the ways the method is used in your application. Use the **Call Stacks** tab to quickly locate the most expensive instances (usages) of any method.

27 Locate the line you want to fix in the **Source** tab or in the **Call Stacks** tab. Double-click the slow line and open the source in Visual Studio for editing.

28 If you cannot directly fix an expensive method, modify your code to call the method less often, or not at all.

Although the percent of time calculation in the **Individual methods that use the most CPU** and **Methods** tables excludes time spent in source code child methods, it includes time spent in **system** child methods. You have probably noticed that managed applications spend a good deal of time in the .NET Framework. Including system children in the calculation focuses attention on methods in your source code that exhibit problems in the way they interact with system code, which can be especially critical in managed applications.

Saving Session Files

When you finish reviewing the Performance Expert data you can save the session file or discard it.

1 Select the unsaved session file in Visual Studio. Choose **File > Save <filename>.dppxp**.

2 If you close the session file window in Visual Studio before saving the session, DevPartner prompts you to save the open session file.

DevPartner saves session files as part of the active solution. They appear in the DevPartner Studio virtual folder in Solution Explorer. Performance Expert session files take the `.dppxp` extension.

By default, DevPartner physically saves the session files in your project's output folder. DevPartner automatically increments the file name based on the contents of the default directory (for example, `MyApp.dppxp`, `MyApp1.dppxp`, and so on). If you save session files to a location other than the default directory, you must manage the file naming.

For projects that do not have an output directory, such as a Visual Studio 2005 Web site project, DevPartner physically saves the files to the project directory.

Session files generated outside of Visual Studio are not automatically added to the project's solution. You can manually add externally generated session files to an open solution in Visual Studio.

This concludes the Ready, Set, Go section of this chapter. Now that you have a basic understanding of the mechanics of running a performance analysis session, continue reading the rest of this chapter for additional information, or refer to the DevPartner online help for task-based information.

Setting Properties and Options

Before beginning a Performance Expert session, it is often useful to fine-tune data collection to include or omit certain types of information. Use Solution Properties, Project Properties, and DevPartner Options to better focus your analysis session.

Solution Properties

To view properties that affect Performance Expert at the solution level, select the solution in the Solution Explorer and press F4 to view the **Properties Window**.

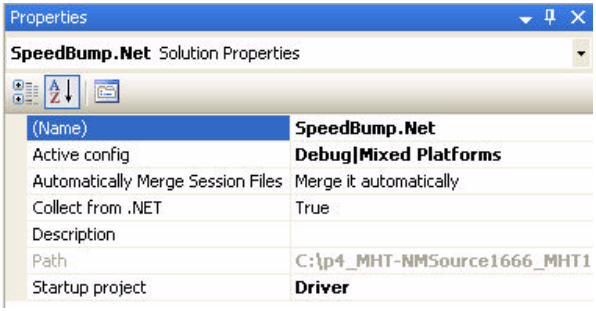


Figure 7-9. Solution Properties

The following Solution properties may affect Performance Expert:

- **Collect from .NET** - Running your managed application with Performance Expert overrides this property if it is set to **False**. Performance Expert always collects data from managed applications.
- **Startup project** - If your solution includes multiple projects, you can change the startup project. The **Project** properties for the startup project govern data collection for all projects active in the session.

Note that your solution must include a startup project. If the solution contains multiple startup projects, DevPartner prompts you to choose a startup project for the session before analysis begins.

Only projects for which the **Action** in the **Common Properties** > **Startup Projects** page of the solution properties is set to **Start** are included in the prompt dialog. If the desired startup project does not appear in the prompt, open the solution properties page and set the **Action** for the project to **Start**. If you choose a new startup project for a subsequent session, review the properties for the new startup project to ensure the data collection options are correct.

Project Properties

To review project level properties, select a project in the Solution Explorer and review the properties that can be set for projects within the solution.

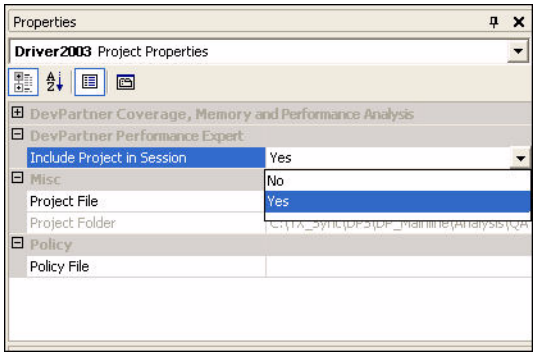


Figure 7-10. Project Properties for Performance Expert

The following project-level property affects Performance Expert:

- **Include Project in Session** - To exclude a project from Performance Expert data collection, select **No**.

Options

To review DevPartner option settings for Performance Expert sessions, choose **DevPartner > Options > Analysis**.

- The **Display** option allows you to set the precision, scale, and units used when displaying your data.
- The **Session Control File** option allows you to create a set of rules and actions to control the data that DevPartner collects as your application or module runs. Refer to "Creating a Session Control File Within Visual Studio" on page 366 for more information about session control files.

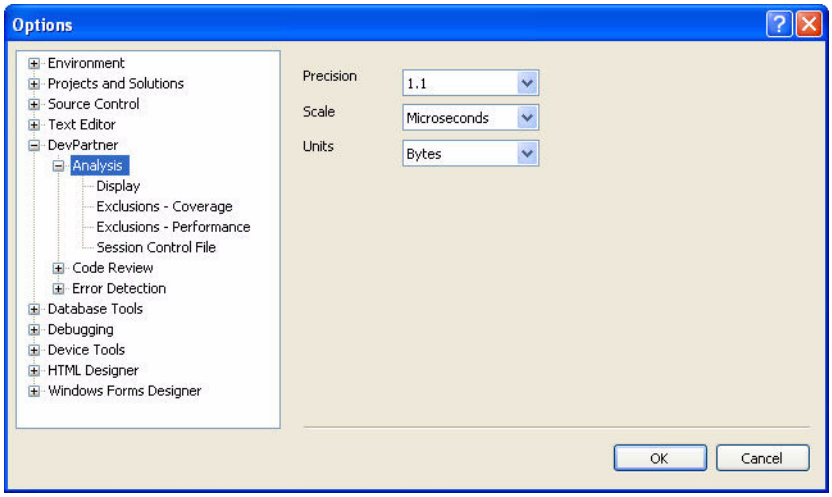


Figure 7-11. Analysis Options

Other Visual Studio options, such as the **Environment > Fonts and Colors** options, also affect DevPartner features.

Finding Application Problems with Performance Expert

DevPartner Performance Expert helps you identify problems in managed Visual Studio applications in the following critical areas:

- CPU/thread use (including wait and synchronization issues)
- File and disk I/O
- Network I/O
- Synchronization wait time

When run from Visual Studio, Performance Expert analyzes a single process at a time. It reports data for any managed threads executing in the selected process. To analyze an additional process, select the second process and rerun Performance Expert. Performance Expert can also analyze a distributed application that spans multiple machines. For information about remote data collection, see "Collecting Data from Distributed Applications" on page 287.

DevPartner supports the Visual Studio launch model. When you click the Performance Expert icon or choose **Start without debugging with Performance Expert** on the **DevPartner** menu, DevPartner immediately launches the startup project for your application and begins to collect Performance Expert data.

In order to collect Performance Expert data for your application, the solution must contain at least one managed code project (for example, C#, Visual Basic, or managed C++). It must also include a startup project. For more information, see "Setting Properties and Options" on page 271

If You Get a Security Exception

If you see a security exception message when you attempt to collect data for a managed application, it means that your security policy prevented DevPartner instrumentation of your code. By default, assemblies must have the `SkipVerification` permission to be profiled. If you remove this permission from the permission set of the policy under which the code executes, or add imperative security declarations to the assembly that cause this permission to be revoked, you will not be able to profile the assembly.

To remedy this condition, enable secure profiling in one of two ways.

- Set the following global environment variable and retry profiling the application:

  ```
  NM_NO_FAST_INSTR=1
  ```

  This solution allows you to work around this issue, although it does exact a slight performance penalty.

- Change the policy for the assembly using the .NET Framework Configuration tool MMC snap-in, or by temporarily removing any imperative security declarations in the assembly.

See the *.NET Framework Developers Guide* in the Visual Studio online help for more information on security policy in Visual Studio.

Accounting for Child Methods

The calculation of the Performance Expert session data differs between the **Paths that uses the most CPU** and the **Individual methods that use the most CPU** views. DevPartner excludes measurements for source code child methods in computing data for CPU time, disk or network I/O, and synchronization lock wait time in the Individual method analysis views. In contrast, DevPartner includes the impact of source code child methods to their parent methods in the Path analysis views.

All computations in both views include time or throughput attributable to system or .NET Framework methods called by your source code methods. Managed applications typically spend a lot of time executing Framework code. Performance Expert charges the system data to the lines in your source code that made the calls in order to focus attention on how your code interacts with the Framework, that is, on the parts of the application that you can modify.

For more tips on collecting and analyzing the session data, see "Usage Scenarios" below.

Usage Scenarios

The typical methodology for resolving performance issues consists of the following steps.

1. Locate the slowest line in a problem method and optimize it.
2. If you cannot optimize the line, remove it or execute it less often.

In the simplest cases, you may be able to locate the slowest line in a method (e.g., by using the DevPartner performance analysis feature) and either optimize it or call it less often. However, in real world application development, many problems have more complex causes. You may be able to identify the slowest method, only to find that a combination of lines within the method is slowing execution. In such a case, additional targeted data can help you analyze the problem quickly.

For example, if the slowest part of your application does a lot of network I/O, the following metrics would likely help you understand the nature of the problem:

- Total number of network reads and writes
- Number of bytes read or written
- Number of read or write errors
- Elapsed time for read or write operations

If your application did a lot of disk I/O, you would want to see metrics that reflected read/write volume and the efficiency of those operations. DevPartner Performance Expert reports exactly this kind of data.

You can use DevPartner Performance Expert to analyze application performance in the areas of CPU and thread performance, disk I/O, network I/O, and synchronization wait time. The following examples will illustrate ways in which you can use Performance Expert to improve application performance.

Identifiable Performance Problem

Scenario: *Usability testers have reported that specific operations in your application are too slow. As a developer, you want to locate the parts of your source code that are responsible for the slow operations taking so long to complete and fix them.*

Assume that you have run the slowest part of your application under Performance Expert as described in "Go: Collect Performance Expert Data" on page 257. When you examine the session file, you immediately see the method that took the longest time to execute at the top of the **Individual methods that use the most CPU** graph. However, in a complex application, a single slow method may affect performance less than a sequence of moderately slow methods. The slowest calling sequences appear in the **Paths that use the most CPU** graph. Do some methods appear in both graphs? If so, these methods definitely deserve scrutiny.

You also notice that some of the methods in the graphs are marked with icons that indicate disk I/O or network I/O activity in the method. These indicators tell you something about the kind of processing done by these methods.

 Disk activity

 Network activity

At the bottom of the results summary, Performance Expert displays the **Total elapsed time** and **Total execution time.** If the execution time is very small relative to elapsed time, and you have exercised the application in such a way that you are reasonably sure the difference is not simply due to waiting on user input, check to see if some methods in your application are spending more time waiting for locks than they should.

Assume that you first decide to examine the top method in the **Individual methods that use the most CPU** graph. You understand that many factors can affect CPU utilization: processor-intensive computations, disk I/O, network I/O, or inefficiently used synchronization objects. Similarly, you know that wait time can have multiple causes: the resource your method is waiting for could be shared within the same process, or with an external process. But how do you quickly determine what is going on in your application?

Click the top method in the **Individual methods that use the most CPU** graph to open the **Methods** detail view for the method. Notice the data in the columns in the **Methods** table. This information should help you determine what the method is doing. If the method was marked with the disk activity icon in the graph, right-click in the table and use

the **Choose Columns...** dialog box to add all of the disk-related columns to the table. You might find that the method is producing read or write errors, or is using a large amount of time to write small amounts of data, and is being executed many times.

The **Source** tab in the lower half of the **Methods** window shows you the source code for any method you select in the table. When you click on a method in the table, the source automatically scrolls to the line that consumed the most CPU time and indicates the time attributable to that line. The view also indicates graphically other lines that used CPU time.

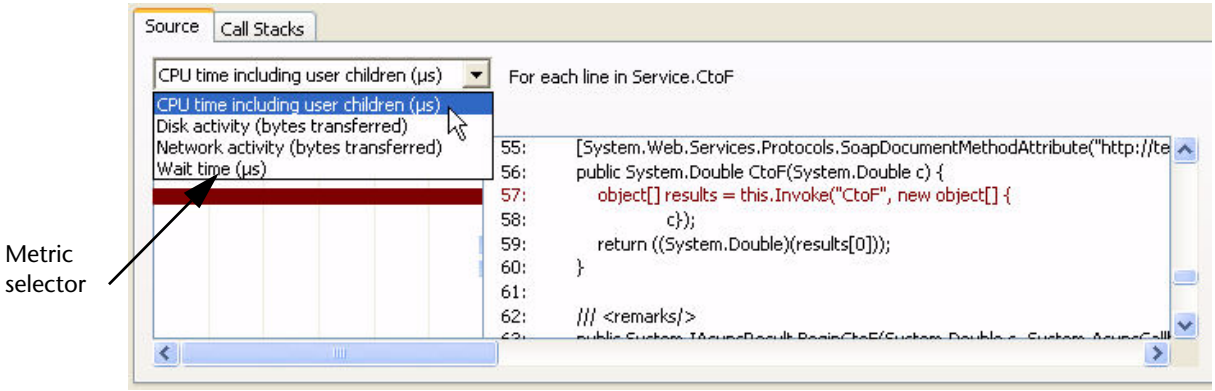


Figure 7-12. Locating Problem Lines in The Source Tab

If the method performed disk or network I/O, or had wait time, expanding the metric selector at the upper left lists those selections, so you can immediately locate the most significant line in the method for that metric. For example, Choose **Disk activity** from the drop-down list to immediately go to the line that transferred the most bytes, and to see relative disk activity for other lines in the method. If the method involves **Wait time**, check that view too. Notice which lines are associated with long wait times. In each view, DevPartner selects the most expensive line by default. Comparing these views of the lines in the method shows you where to focus your efforts much more quickly than traditional debugging techniques.

When you have located an appropriate line to fix, double-click on it to jump to that line in your source code in Visual Studio.

If a way to fix the problem is not obvious, click the **Call Stacks** tab to see all the ways the method was used as your application executed. Is the problem method called by more than one path? If so, examine the call stacks that are responsible for the most time in the method.

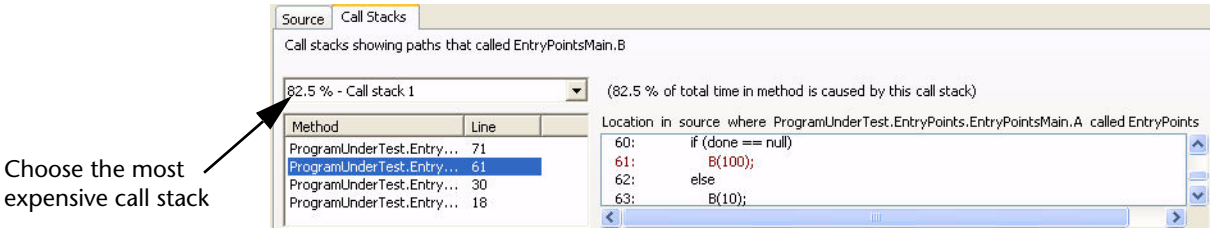


Figure 7-13. Finding the Most Expensive Call Stack

Tip: Performance Expert records a unique parent branch if any method (or calling line in the same method) in the call stack is different.

Obviously, you want to look first at the parent path responsible for the highest percentage of calls. Try to modify your code to eliminate the calls, or call less frequently. The **Call Stacks** tab includes a view of your source code. When you select a method in the stack, the source automatically scrolls to the line where the call to the next method in the stack was made. A double-click opens the line in Visual Studio, so you can quickly modify the calling sequence if necessary. Once you have made the changes to your code, run the application again with Performance Expert to verify the improvement.

Scaling Problem in an Application

Scenario: *Your new Web application runs fine when you test it on your machine. But when you allow additional users to access the application, it is too slow. You have a looming deadline. How do you quickly determine what is wrong?*

You can collect Performance Expert data while stressing your application with a load-testing tool. To do so, you will probably want to start and stop your application with a command line tool or script. DevPartner provides a command line utility called `DPAnalysis.exe` for this purpose. For information on running a Performance Expert session from a command line, see "Automating Data Collection" on page 284. For example, you could do something like the following:

1. Start the application under Performance Expert with `DPAnalysis.exe`.
2. Run the load-testing application.
3. Stop the application.
4. Examine the Performance Expert session data.

Assume that when you look at the session file, no single method in the **Individual methods that use the most CPU** graph stands out as the likely culprit. It is a complex application, and it is probable that several methods contribute to the sluggish performance. Start your analysis with the **Paths that use the most CPU** graph in the results summary. This

graph shows a list of methods, but in this case each method represents an **entry point**. An entry point method is a method that was not called by another source code method. In other words, it is an entry point into the execution of code that you wrote. Most important, it marks the beginning of an execution path that you can change, either by modifying the methods, or the way they are called. The entry point method that corresponds to the most expensive path of execution in your application appears at the top of the graph. Click on the method to open the **Path analysis** view.

The Call Graph

When you open the **Call Graph** from the results summary, notice that DevPartner places the most expensive paths at the top of the **Call Graph**, and highlights the most expensive child path whenever a path branches. As you examine the data, investigate the most expensive child paths first. To investigate a path, expand the nodes to the right.

Tip: The percentages on lines connecting a method to the child methods it called are additive; those on lines connecting the chain of methods in a single path are not.

To determine the relative contributions of different paths spawned by the same method, compare the percentage values on the lines that connect the selected method to each of its child paths. The value on each link represents the percent of time in the parent method attributable to child methods called in that path. Thus, in Figure 7-14 on page 280, the method `Form.Main` called `Form.CtoF`, `Form.ParseOption`, and `Form.FtoC`. The value on the line that links `Form.Main` to `Form.CtoF` is 98.1%, while the remaining 1.9% is spread among the other called paths. This means that the path `Form.Main` calls `Form.CtoF` accounted for 98.1% of the CPU time spent in `Form.Main` that was attributable to the execution of child methods. Start your troubleshooting with this path.

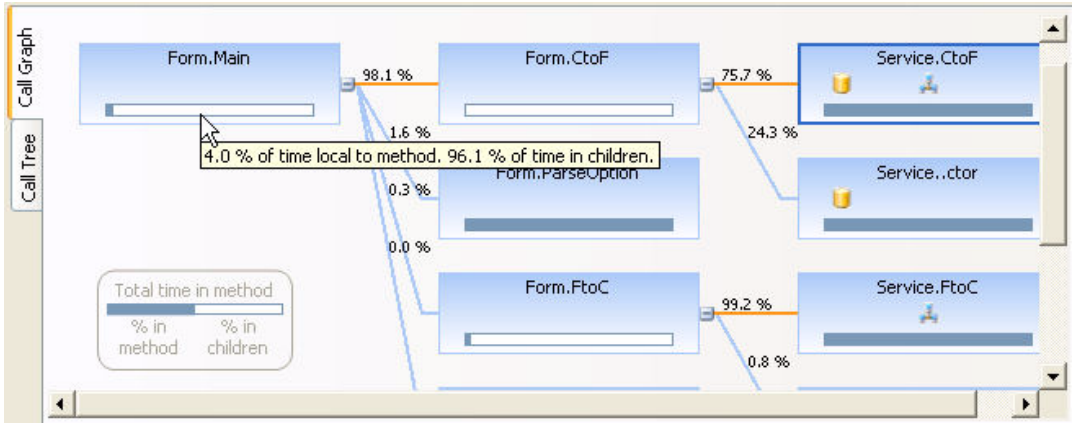


Figure 7-14. Understanding the Impact of Child Methods

As you investigate the called path, notice the horizontal bar at the bottom of each node. The bar shows the relative percentages of time in the method due to the method body compared to the child methods it called. Hover over the bar with the mouse to see the actual percentages. Use this bar to guide your tuning efforts. For example, if 4% of time is spent in the method body, and 96% of time is attributable to child methods, continue to investigate the most expensive called paths to locate the child methods that are affecting performance. Fix those methods or change your code so they can be called less often. If, on the other hand, 96% of the time was spent in the method body, focus your efforts there.

Also notice whether an expensive node contains the disk activity, network activity, or wait time icons. Hover over the icon with the mouse to view the magnitude of the activity. If a node contains one or more of these icons, consider switching to the **Call Tree** view and adding the appropriate data columns for more help in diagnosing the problem.

The Call Tree

The default sort of the **Call Tree** table is by **CPU time including user children**. To gain an idea of where the bulk of the time is being spent, scan the values in the other columns. Doing so will tell you whether wait time, disk or network I/O, or CPU-intensive processing is the major factor. If you need more detail, you can add additional columns, such as disk or network reads, writes, and errors, to the display.

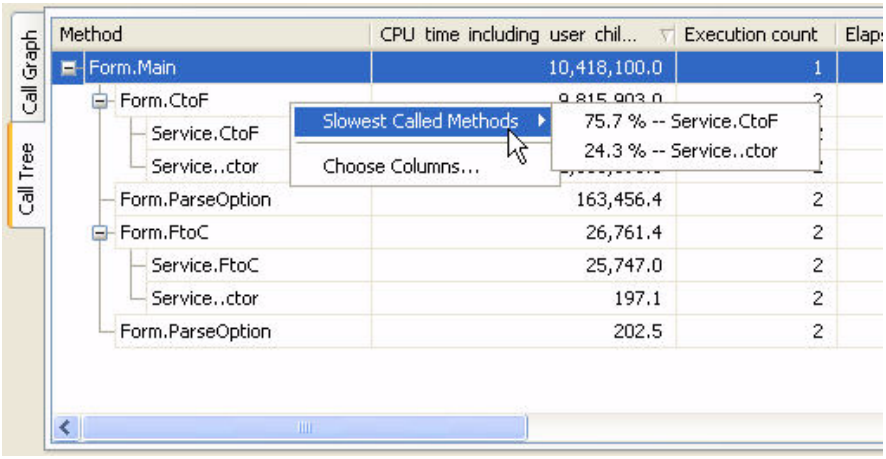


Figure 7-15. Displaying Additional Data for the Selected Method in the Call Tree

For example, if an expensive method in the **Call Graph** showed network I/0, select it, switch to the **Call Tree**, and add all of the network-related data columns to the table. To add columns, right-click in the **Call Tree**

table and select **Choose columns...** from the context menu. For a full explanation of the data reported in each column, see the Performance Expert online help.

Tip: The term "user" in "user children" or "user methods" refers to your source code methods.

Whether you are using the **Call Graph** or **Call Tree**, the session file window includes the **Source** and **Call Stacks** tabs. These tabs function as they do in the **Methods** table, except that the data is calculated to include data attributable to user, or source code, child methods. Use the **Source** tab to immediately locate the most expensive line in any method you select in the **Call Graph** or **Call Tree**. Use the **Call Stacks** tab to see the relative impact of other paths that called the method and to locate the line that called the selected method in the stack. Double-click a line of code in either the **Source** or **Call Stacks** tab to jump to that line in Visual Studio for editing.

Performance Slow but No Specific Issue

Suppose your application is generally sluggish, but you cannot identify a specific issue. Performance tuning is an iterative process. You can still use the techniques described above to try to improve performance.

- Run the application under Performance Expert.
- Go through the **Paths that use the most CPU** and try to optimize the most expensive branches for each critical path.
- Go down the list of **Individual methods that use the most CPU** in the same way and try to optimize the top methods in the list.
- Retest to verify improvement.

Collecting Data from Web Applications

You can collect Performance Expert data for any managed application, including Web applications. When you run a Web application with Performance Expert, be aware of the following.

Managed Code Only

Unlike some other DevPartner features, Performance Expert collects data for managed applications exclusively. Therefore if your application uses Internet Explorer as the client, do not expect to see Internet Explorer data in the session file. DevPartner will display server-side data for your ASP.NET or Web service application.

web.config Requirements

For DevPartner Performance Expert to successfully profile an ASP.NET application, the following two conditions must be met:

- The project must include a `web.config` file.
- The project must be configured for debugging. To do this, the `web.config` file must include a compilation element with the debug attribute set to true. For example:

```
<compilation debug="true" />
```

Multiple Process Profiling

When run from the Visual Studio IDE or from the command line using the DevPartner command line switches, Performance Expert collects data for a single process or service per session. If your application runs in more than one process, or if you need to collect data for a service, such as IIS, as well as the process your target application runs in, you can use `DPAnalysis.exe` (a command line executable version of DevPartner analysis tools) and target an XML configuration file to manage the session. For more information see "Using DPAnalysis.exe with an XML Configuration File" on page 349.

Caution: Although you can collect data (in separate session files) from two or more processes or services simultaneously by using `DPAnalysis.exe` with an XML configuration file, Performance Expert is generally best run on a single process at a time. Data collection overhead for multiple processes can affect interaction of the processes, as well as slowing the applications and inflating elapsed time values. If you collect Performance Expert data for multiple processes simultaneously, large timing values for disk I/O, network I/O, or synchronization wait time may reflect inflation by profiling overhead. Rerun the session targeting a single process to confirm that the timing values are large enough to merit investigation.

Single Process Profiling on IIS 6.0

On IIS 6.0, DevPartner collects Performance Expert data for only one worker process. On IIS there is one worker process per application pool. Therefore, if you run a Web service and a Web service client on your system, and both execute in the same application pool, Performance Expert gathers data for both, even if you started the service under Performance Expert and started the client in a separate instance of Visual Studio without Performance Expert. If you change the application so the

client executes in a different application pool, Performance Expert gathers data only for the application (in this case, the service) launched with Performance Expert.

No Remote Session File for Components Running Under DLLHOST

When running Performance Expert for a process that interacts with `dllhost.exe` on a remote system, a final session file is not generated on the remote system when `dllhost.exe` terminates.

Source Code on Remote Machines

DevPartner Studio assumes that the source file exists on the same machine as the open session file.

- If a **File > Open** dialog appears when you attempt to view the source code, use it to browse to the correct location on the remote machine.
- If you have collected data for a remote ASP.NET application, you may need to look up the value of the **Local Path** entry in the **Virtual Directory** tab of the IIS settings for the target Web site in order to browse to the source file.

Session Files Saved to Open Solution

DevPartner session files are saved with the current solution. Opening a Web project from IIS directly, as opposed to opening the project through Visual Studio, may cause a different solution file to be used. DevPartner session files created in the first solution would not be visible in the second solution.

Automating Data Collection

DevPartner Performance Expert supports command line execution through an executable called `DPAnalysis.exe`. This file is located in your `\Program Files\Compuware\DevPartner Studio\Analysis\` directory.

Note: For installs on 64-bit versions of Windows, DevPartner Studio is located at: `\Program Files (x86)\Compuware\DevPartner Studio\Analysis\`.

You can run an application under Performance Expert from a command prompt, or create batch files to automate data collection. You can launch the Performance Expert session in two ways:

- Specify the target and arguments in standard MS-DOS command line syntax

- Specify an XML configuration file that contains the targets and arguments for the session

Using Command-line Switches

Consider the example we discussed in the section "Scaling Problem in an Application" on page 279. Quality Assurance engineers can monitor scalability (or any other aspects of the application) on a daily basis by setting up an automated test (or suite of tests) to be run on the application every night. To automate the tests, set up a batch file to

1. Start the application under Performance Expert
2. Start the load-testing application and any other tests you want to run
3. Stop the application when the tests are complete

DevPartner automatically generates the session log file when the application exits.

The command line syntax to launch the session is:

```
DPAnalysis.exe /Exp /E /O /W /H [/P or /S] target {target arguments}
```

/Exp Sets analysis type to DevPartner Performance Expert

/E Enables data collection for the specified process/service

/O Specifies the session file output directory and/or name

/W Specifies the working directory for the process

/H Specifies the host machine on which the target runs

/P or /S Specifies that the target is a process or a service; use only one

There is one restriction on the order in which the switches must appear: The /P or /S switch must occur last. Everything that follows either switch is interpreted as an argument to the process or service.

Using an XML Configuration File

To use an XML configuration file, the command line is even simpler: `dpanalyis.exe /C [path]configuration_file.xml`.

The configuration file contains the necessary parameters for any type of DevPartner analysis, including some options that are not available using command line switches. For example, if you want to exclude application components from a Performance Expert session, you must use the `ExcludeImages` element in the configuration file.

```
<?xml version="1.0" ?>
<ProductConfiguration xmlns="http://www.compuware.com/products">
        <RuntimeAnalysis Type="Expert" MaximumSessionDuration="1000"/>
        <Targets RunInParallel="true">
                <Process CollectData="true" Spawn="true" NoWaitForCompletion="false">
                        <AnalysisOptions NO_MACH5="1" NM_METHOD_GRANULARITY=""
                        SESSION_DIR="c:\Sessions" SESSION_FILENAME="ClientApp.dppxp" />
                        <Path>ClientApp.exe</Path>
                        <Arguments>/arg1 /agr2 /arg3</Arguments>
                        <WorkingDirectory>c:\temp</WorkingDirectory>
                        <ExcludeImages>
                                <Image>ClassLibrary1.dll</Image>
                                <Image>ClassLibrary2.dll</Image>
                        </ExcludeImages>
                </Process>
                <Service CollectData="false" Start="true" RestartIfRunning="true"
                RestartAtEndOfRun="true">
                        <AnalysisOptions NM_METHOD_GRANULARITY="0" SESSION_DIR=""
                        SESSION_FILENAME="" />
                        <Name>iisadmin</Name>
                        <Host>remotemachine</Host>
                </Service>
        </Targets>
</ProductConfiguration>
```

Figure 7-16. Specifying Session Details in the XML Configuration File

To collect data for a process that runs on a remote machine, you must specify a directory and file name. Use the `SESSION_FILENAME` and `SESSION_DIR` elements in the Analysis options in the configuration file.

For detailed information about using the configuration file to manage data collection, see "Using DPAnalysis.exe with an XML Configuration File" on page 349.

QA engineers scan the session log file the following morning. If performance numbers have deteriorated, QA sends the session log to the appropriate developers. In this way, QA tracks the health of the application throughout the development cycle. If a problem appears, the development team has the session log file to use in quickly determining the nature of the problem. In addition, the development team knows that the problem was caused by a code change from the previous day, greatly reducing the amount of code it has to review to fix the problem.

For detailed information on using `DPAnalysis.exe`, see C, "Starting Analysis from the Command Line".

Collecting Data from Distributed Applications

DevPartner can collect Performance Expert data from distributed application components that run on remote systems, provided the remote systems are properly licensed for remote data collection. Before you launch a remote session, be aware that a Performance Expert session monitors a single process per run when run from Visual Studio or with `DPAnalysis.exe` from the command line using traditional command line syntax. Although the XML configuration file allows you to target more than one process or service in a single run of the application, it is usually best to target a single process in a Performance Expert session. If your application runs in multiple processes, simply rerun the application targeting the second process. Driving the application with a script or batch file ensures that you exercise the application identically in both sessions. For an overview, see "Automating Data Collection" on page 284.

If necessary, you can collect the data (in a separate session file) for the second process or service in a single run of the application if you use `DPAnalysis.exe` with the XML configuration file option. Although you can collect data from two or more processes or services simultaneously, be aware that data collection overhead for multiple processes can affect interaction of the processes, as well as slowing the applications and inflating elapsed time values. If you collect Performance Expert data for multiple processes simultaneously, large timing values for disk I/O, network I/O, or synchronization wait time may reflect inflation by profiling overhead. Rerun the session targeting a single process to confirm that the timing values are large enough to merit investigation.

Enabling Remote Data Collection with DPAnalysis.exe

`DPAnalysis.exe` cannot be used to spawn remote processes. It can only be used to enable data collection for processes on remote machines. For example, with the following command line:

```
DPAnalysis.exe /host remotemachine /p c:\MyDir\target.exe
```

`DPAnalysis.exe` will set up profiling for `target.exe` but will not attempt to start it on the remote machine. When `target.exe` is started on the remote machine (by whatever means), profiling will begin.

This is not the case for remote services, which can be started remotely. For example:

```
DPAnalysis.exe /host remotemachine /s servicename
```

This command will enable profiling and attempt to start the `servicename` service on `remotemachine`

Optionally, you can use the XML configuration file to specify the parameters in the command line examples above. For detailed information about `DPAnalysis.exe`, see C, "Starting Analysis from the Command Line".

Saving Session Files on Remote Machines

Session files for all four types of analysis (coverage, memory, performance, and Performance Expert) are saved on the remote machine in remote profiling scenarios. A directory and session file name must be provided on the command line or in the XML configuration file for remote processes or services. The directory specified must already exist on the remote machine. If no directory or file name is provided, a **Save As** dialog will appear on the remote machine.

Viewing the session file

Copy the session file to a machine with DevPartner Studio installed, such as the machine where the profiling was initiated and the client file is saved.

On the command line or in the XML configuration file, specify a mapped drive on the remote machine to save the session files to another machine with DevPartner Studio installed, such as the machine where the profiling was initiated.

Collecting Data with Terminal Services or Remote Desktop

DevPartner Studio supports Windows Terminal Services. For information on using DevPartner Studio with Terminal Services, see "Using Terminal Services and Remote Desktop" on page 9.

Remote Profiling and Windows XP Service Pack 2

Windows XP Service Pack 2 increased security levels for remote applications. The new security settings can prevent DevPartner from collecting data on some server-side application components when profiled from Visual Studio. To collect data from application components on a remote machine, you must modify the security settings on all Windows XP SP 2 machines (both the remote machine and the client machine where profiling is initiated) that participate in the session.

The procedures that follow describe three ways to alter Windows XP Service Pack 2 security settings to allow remote profiling.

Add DevPartner Control Service to the Windows Firewall Exclusion List

If the Windows Firewall service is enabled, add the DevPartner Control Service to the Firewall's exclusion list. Follow these steps:

1. From the **Start** menu, select **Control Panel**.
2. From the **Control Panel**, select **Windows Firewall**, then select the **Exceptions** tab.
3. On the **Exceptions** tab, click **Add Program**.
4. In the **Add a Program** dialog box, click **Browse**, then navigate to `NCS.exe`. The default location for this executable is:

   ```
   C:\Program Files\Compuware\DevPartner Studio\Analysis\NCS.exe
   ```

Note: For installs on 64-bit versions of Windows, this executable is located at: `\Program Files (x86)\Compuware\DevPartner Studio\Analysis\NCS.exe`.

5. Click Open in the **Browse** dialog box to select `NCS.exe`, then click **OK** to close the **Add a Program** dialog box.
6. On the **General** tab of the **Windows Firewall** control panel, clear the **Don't allow exceptions** check box.

Modify Security Settings on Both Remote (Server) and Local (Client) Machines

Follow these steps to modify the security settings:

1. In the **Control Panel**, open **Administrative Tools > Local Security Policy > Local Policies > Security Options**.
2. Open the **Properties** page for **DCOM: Machine Access Restrictions in Security Descriptor Definition Language (SDDL) syntax**.
3. Select **Edit Security**.
4. Add an **Anonymous Logon** user, if one does not already exist.
5. Give the **Anonymous Logon** user both **Local** and **Remote** access.

If Visual Studio is running when the settings are changed, you must restart Visual Studio for the new settings to take effect.

Relax COM Security on the Client Machine

To relax COM security, follow these steps on the client machine where profiling is initiated:

1. From the **Start** menu, select **Control Panel**.
2. From the **Control Panel**, select **Administrative Tools**; from the **Administrative Tools** window, open **Component Services**.
3. In the **Component Services** window, navigate to **My Computer**, right-click on **My Computer** and select **Properties**.
4. On **My Computer Properties**, select the **COM Security** tab.
5. Under **Launch and Activation Permissions** on the **COM Security** tab, click **Edit Limits** and make these changes:
6. Click **Add** and enter `NETWORK`.
7. Make sure that the **Allow** check box is selected for **Local Launch**, **Remote Launch**, **Local Activation**, and **Remote Activation**.
8. Under **Launch and Activation Permissions** on the **COM Security** tab, click **Edit Default** and make these changes:
9. Click **Add** and enter `NETWORK`.
10. Make sure that the **Allow** check box is selected for **Local Launch**, **Remote Launch**, **Local Activation**, and **Remote Activation**.

Firewalls and Remote Data Collection

To collect session data from remote machines, the DevPartner software connects to a previously installed service whenever DevPartner runs, either within Visual Studio or via `DPAnalysis.exe`. This service listens for interprocess communication traffic at the internet address `0.0.0.0` port `18441`. This service connection may trigger some firewall alarms. You can configure your firewall to trust this address to discontinue these alarms. If your firewall is set to maximum security levels, it may prevent DevPartner remote data collection. Reconfigure your firewall to enable data exchange at the address `0.0.0.0` port `18441`.

Exporting DevPartner Data to XML Format

You can export Performance Expert data to an XML format. Exporting data in XML format allows you to more easily use your own or third-party software to analyze the data, integrate the data with data produced by other tools, and archive the data in a data warehouse.

You can export DevPartner Performance Expert session files (with the `.dppxp` extension) to XML format. When a saved Performance Expert session file is open, the **Export DevPartner Data** command is available on the **File** menu.

You can also export XML data from the command line, as described in "Exporting Analysis Data to XML" on page 375.

In the DevPartner installation directory, the file `DevPartnerPerformanceExpert`*xx*`.xsd` describes the XML schema that is used by Performance Expert to export session files.

Using Performance Expert with Performance Analysis

Performance tuning is an iterative process. Use Performance Expert in conjunction with the DevPartner Studio performance analysis feature. First, run your application with performance analysis and save the session file to capture a baseline view of performance. Then use Performance Expert to troubleshoot difficult problems, especially problems that involve disk or network I/O, or synchronization issues. When you have fixed a problem, run the application in a performance analysis session and use the performance analysis **Session Comparison** feature to verify the improvement. For example:

1. Run your application with performance analysis.
2. Notice the methods that appear to be slowing performance.
3. If a way to fix the problem methods is not immediately obvious, run an identical session with Performance Expert.
4. Check to see if the problem methods appear in the **Paths that use the most CPU** or the **Individual methods that use the most CPU** graphs.
5. Click the method in the **Paths that use the most CPU** graph to open the **Call Graph**. The **Call Graph** shows the method in context and indicates whether the method itself or its child methods are responsible for the performance issue.
6. Notice whether the problem method is marked with the disk, network, or wait time icons.

   If, for example, the method indicates network activity, switch to the **Call Tree** tab and use the context menu to add the network-related data columns to the view. The additional data can help you determine whether the problem is due to read activity, write activity, or to read or write errors. If you drilled into the data from the **Individual methods that use the most CPU** graph, you can add the data columns to the **Methods** table.
7. Use the **Call Stacks** tab to see how many ways the problem method was called, and which call stack was the most expensive.

8 Use the **Source** tab to locate the offending lines of code and jump to the source file to edit in Visual Studio.

Once you have fixed the problem, run the application in a second performance analysis session. Using the previous performance analysis session file as a baseline, compare the sessions with the performance analysis Session Compare feature to verify the improvement.

Performance Expert and performance analysis are complementary, but there are differences in the way they compute timing data. If you run a performance analysis session that includes system images and a Performance Expert session on the same application, you may notice that the performance analysis **Top 20 Source Methods** and the Performance Expert **Individual methods that use the most CPU** do not contain exactly the same methods, or that the methods do not appear in the same order.

In a performance analysis session, the percent of time spent in a method (**% in Method** column) is computed without user or system child methods. In a Performance Expert session, the percent of time spent in the methods that appear in the **Individual methods that use the most CPU** and **Methods** tables includes time spent in system children.

If you have done any performance profiling, you may have noticed that managed applications spend a lot of time executing methods in the .NET Framework. Including system children in the Performance Expert results focuses attention less on methods that take a long time to execute in themselves, and more on methods in your source code that exhibit problems in the way they interact with system code. You cannot do anything about time spent in system code once it begins to execute, but you can change how and when your code calls system code. Performance Expert helps you quickly identify these problem areas.

Note: You cannot compare a performance analysis session file directly to a Performance Expert session file. You can only compare performance analysis session files.

Performance Expert in the Development Cycle

Use DevPartner Performance Expert throughout the software development cycle. Many members of the engineering team can benefit from using Performance Expert at several points in the software project life cycle.

Software Designers

Software designers must often develop prototypes that meet specific requirements, for example, in response time or scalability. Before producing the final design, the designer must identify the operations and, if possible, the methods, that are preventing the prototype from meeting the performance requirements. Ideally, the designer would like to be able to identify a few methods that, if fixed, would give a dramatic performance boost.

Software designers can use Performance Expert during the design and prototype phase to improve the speed and efficiency of their code. As the design progresses, regular testing helps to ensure that the prototype code meets minimal performance requirements. When the prototype is handed off to the development team, developers can feel comfortable reusing sections of the prototype, knowing that it has been tested for several critical performance issues.

Software Developers

Software developers should use Performance Expert frequently during development. Consider running Performance Expert in addition to unit tests prior to code check-ins. Just as the unit tests ensure that the component does what it is supposed to do without breaking other components, Performance Expert provides early warning of potential performance issues before the component is fully integrated into the application and therefore more difficult to fix.

The software development team builds the application based on the designer's prototype and specification. As soon as the application (or application components) can be tested and run, developers can integrate Performance Expert into their automated testing routines in order to identify potential CPU usage, file I/O, or network I/O issues as they are coding and debugging. Developers can review the Performance Expert session log each morning to see if the previous day's coding has introduced any new performance issues and address issues immediately. When coding is complete, the development team submits the final Performance Expert session log to document that performance goals have been met.

Quality Assurance Engineers

Quality Assurance teams can use Performance Expert to continuously monitor application performance. QA can easily integrate Performance Expert into automated test suites to obtain a daily reading of application performance in critical areas. When problems appear, QA teams can send the session log to the development team or attach the log to a bug report in a defect tracking system such as Compuware TrackRecord.

Designated engineers can review critical metrics in the session log files on a daily basis. If the session log suggests a problem, the QA engineer can send the log file to the responsible developer so the problem can be addressed immediately.

Thus, all members of the software development team can benefit from running Performance Expert, from the design phase to final quality assurance testing. There is even a benefit for product management. At each critical milestone, Performance Expert session logs, coupled with before-and-after performance analysis session files, can be used to document that the product meets performance expectations.

Submitting Data to Visual Studio Team System

DevPartner Studio supports Microsoft Visual Studio Team System if the Team Explorer client is installed and a Team Foundation Server connection is available.

You can submit method-level data from a DevPartner Performance Expert session file as a Visual Studio Team System **Work Item** of the type **Bug**. The **Submit Work Item** command is available on the context menu for a method selected in the following Performance Expert views:

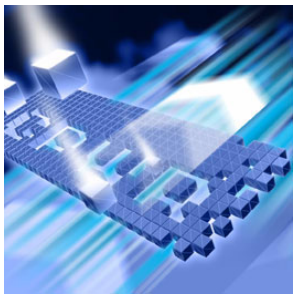
- The **Methods** table in the **Methods** detail view
- The **Call Tree** in the **Path** analysis view

When you submit a **Bug**, DevPartner populates the **Work Item** form with data from the visible columns in the **Methods** table or **Call Tree** view. To change the method data you submit in the **Work Item**, change the columns displayed in the method view.

For more information about DevPartner Studio integration with Visual Studio Team System, see "Visual Studio Team System Support" on page 8.

Chapter 8

System Comparison



- What is System Comparison?
- Using System Comparison Out of the Box
- The System Comparison Service
- Categories of Differences
- Comparing Registry Keys
- Comparing Specific Files
- Installing Without DevPartner
- Running the Comparison Utility from the Command Line
- Software Development Kit
- System Comparison Snapshot API
- Writing a Plug-in

This chapter contains two sections. The first section provides a quick-start procedure to get first-time users up and running with System Comparison. The second section provides reference information for an in-depth understanding of DevPartner's System Comparison feature.

Refer to the DevPartner System Comparison online help for additional task-oriented information about comparing systems.

What is System Comparison?

The DevPartner System Comparison feature compares two computer systems, or compares the current state of a computer with a previous state, allowing you to determine why your application:

- Works on one computer but not on another
- Works differently on different computers
- No longer works on a computer on which it previously worked

To compare systems, System Comparison creates XML files, called snapshot files, that contain information about a computer system, such as its installed products, system files, drivers, and many other system characteristics. It then compares snapshot files and reports the differences between them.

Unlike other DevPartner features, System Comparison is not integrated into the Visual Studio environment. It runs as a standalone utility to minimize its impact on target systems.

System Comparison consists of:

- a service, which takes nightly snapshots of a system,
- a user interface, which enables you to take snapshots manually and to compare snapshots to find differences
- a command line interface
- a Software Development Kit (SDK). The SDK allows software developers to gather additional information for comparison and to embed snapshot functionality in deployed applications.

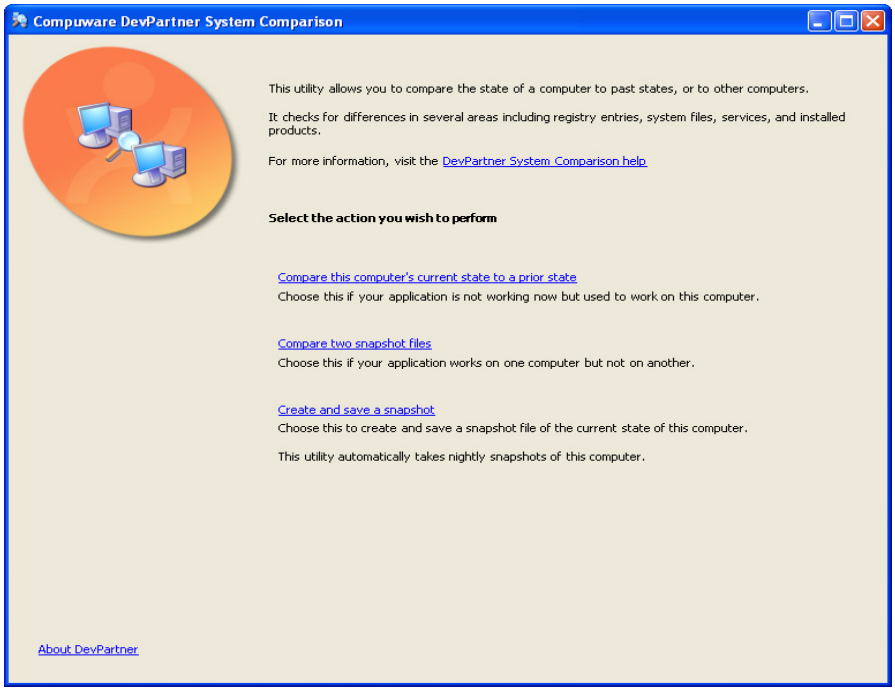


Figure 8-1. The System Comparison User Interface

Using System Comparison Out of the Box

The following Ready, Set, Go procedure introduces you to using DevPartner System Comparison.

To get up and running quickly, follow the steps presented in shaded boxes. If you would like more information, read the additional text following the box.

Note: Analyzing a system with DevPartner System Comparison does not require elevated system privileges. The system privileges you use to create files and work with applications on your system are sufficient for DevPartner to analyze the system.

In the following procedure, you will make a minor change to your computer, then compare your computer's current state with its previous state.

Ready: Consider What You Want to Compare

Before running a system comparison, understand the goal of the comparison.

The following procedure assumes:

- You have installed DevPartner System Comparison.
- The System Comparison service is running and has taken a snapshot.

  When System Comparison is installed, the service is started automatically and takes its first snapshot within a few minutes of starting. The service is listed as DevPartner Differ in your system's Services list.
- You will compare different states of one computer.

By identifying exactly what you want to compare, you will ensure that you set up the comparison appropriately. For example, your goal might be one of the following, some of which might include additional set-up steps:

- To check how installation or removal of a product impacts computer services, settings, registry keys, or files. (Checking registry key or files requires the additional set-up of modifying an XML file.)
- To determine if system changes may have caused a product to stop working on a system on which it previously worked.
- To determine the extent of the impact that changes to a product will make (for example, any impact on automated tests).
- To check that a new development system has all of the tools that were available on a previous development system.
- To determine why a product does not work, or works differently, on a certain system.
- To troubleshoot a product after it has been deployed to an end-user site.

Set: Prepare for System Comparison

Once you have decided on the goal of the comparison, you might have to perform some set-up tasks.

> For this procedure, you can use the default DevPartner System Comparison options. No additional set-up is required.

Some examples of situations that require set-up tasks include the following:

- If you want to compare registry keys or specific files, set-up tasks would include modifying the `RegistrySections.xml` or `FileSections.xml` files, as described on page 308 and page 309
- If you want to compare data that is not gathered by default, set-up tasks would include writing a custom plug-in, as described on page 317. Categories of data gathered by default are described in Table 8-1 on page 305.
- If you want to compare two systems, set-up tasks would include installing System Comparison on the second computer, taking a snapshot, and making that snapshot file available for comparison, as described on page page 312.

Go: Make a Change and Create a Snapshot

You are now ready to begin a system comparison. In this procedure you will make a change to your computer and compare its current state with its previous state.

To demonstrate how system differences are reported, you will have to make some changes to your computer system before creating a snapshot.

1. Navigate to the **Control Panel > Administrative Tools > Services** window, and stop or start several services that will not impact your work environment. For example, you might stop the Automatic Updates service. (Take note of the services you modify so you can restart them later.)
2. From the Start menu, select **Programs > Compuware DevPartner System Comparison**.
3. In the **System Comparison** window, click **Compare this computer's current state to a prior state**.

   A list of snapshot files displays. The System Comparison service (described on page 303) automatically takes a daily snapshot of the state of the machine, and the dates and times of these files are listed.

Note: Assuming it has been more than a few minutes since you installed System Comparison, there will be at least one file in the list. If there are no files listed, check that the System Comparison service is running. The service is identified as `DevPartner Differ` in the services list.

4. From the list, select the date and time of the snapshot to use as the basis of the comparison and click **Compare**.

   System Comparison displays a Results window. The content of the Results window is described in Analyze Results.

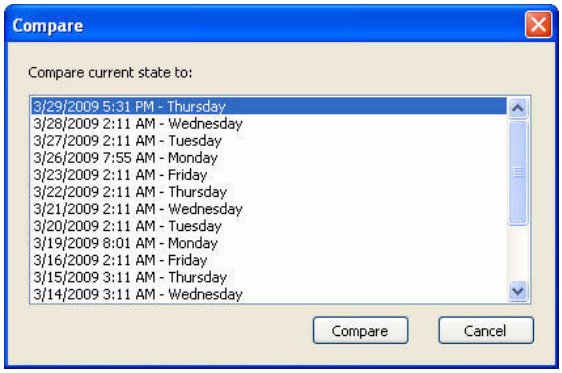


Figure 8-2. List of Snapshot Files

Analyze Results

When System Comparison compares two snapshots, it displays the differences between them and all items in a results window, as shown in Figure 8-3. (The Results window from this Ready, Set, Go procedure might contain far less information than the results shown in the figure.)

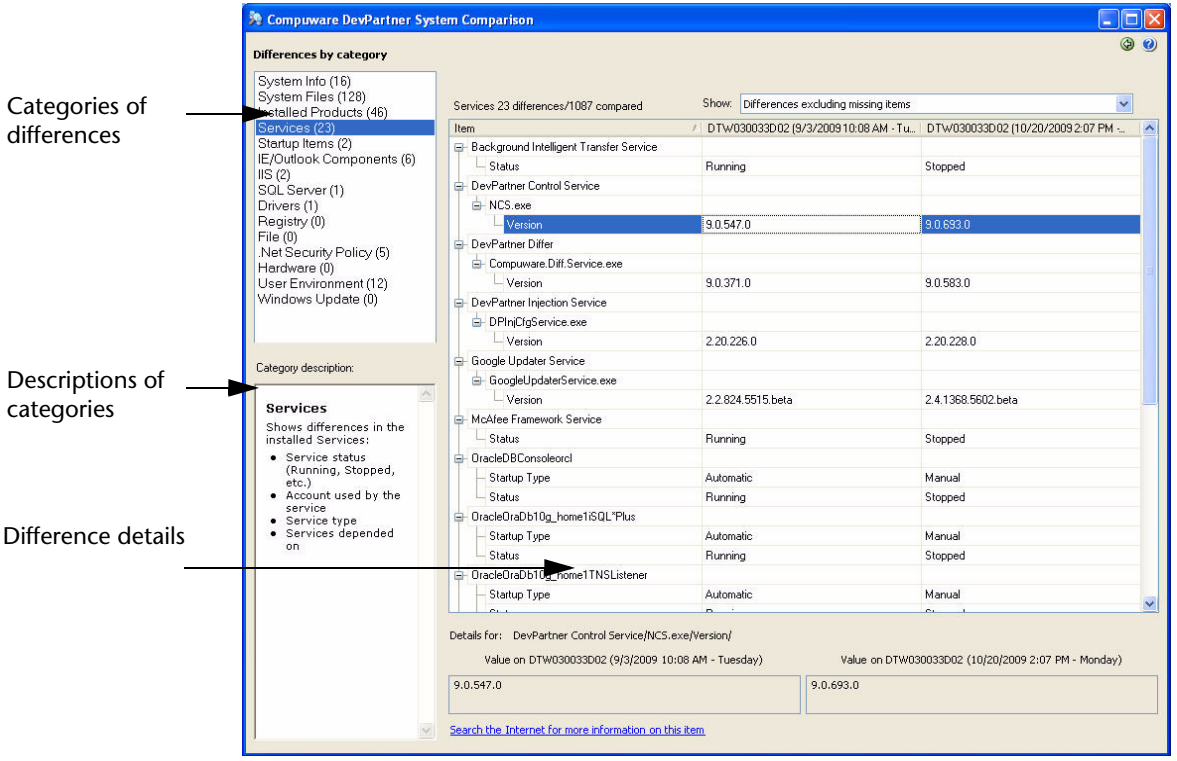


Figure 8-3. Results Window

The upper left pane lists the categories that were compared and the number of differences found in each category. The first category with a non-zero number of differences is selected when the window initially opens.

The bottom left pane displays a description of the selected category.

The right pane displays the details of the differences found in the selected category.

1. Click on several categories to display their descriptions.
2. Click on the **Services** category to display differences in the **Difference details** pane.

   In the **Difference details** pane, the name of the item appears in the first column. The second and third columns list the information from the snapshots, with the name of the machine and full timestamp of the comparison shown in the header row.

   Items not in that snapshot are listed as "[missing]." Items on a computer are indicated by a check mark or the word "installed."
3. The two columns at the bottom of the details pane list the actual data from the first and second snapshots for the selected item.
4. Near the bottom of the screen is the link **Search the Internet for more information on this item**. Click the link to launch an Internet search for items related to the currently selected difference (for example, "windows system environment variables").
5. In the upper right corner of the **Difference details** pane, click on the **Show** list. Use these options to filter the differences shown.
6. When you are done reviewing differences, click the back  button located in the upper right corner of the window, to return to the main **DevPartner System Comparison** window.

The **Results** window shows differences and lists all items that are the same in both snapshots, depending on which option you display in the **Show** list.

Note that System Comparison considers version numbers when evaluating differences. It considers components with different version numbers to be different components. If a component exists in two snapshots but the version number of the component is different, the component is listed as missing.

To compare the current state with a different previous state, select a different snapshot from the **Difference details for current state compared to:** list in the results window.

When you have finished experimenting with System Comparison, remember to restart the services you stopped earlier.

This concludes the Ready, Set, Go section of this chapter. Now that you have a basic understanding of the mechanics of running a system comparison, continue reading the rest of this chapter for additional information, or refer to the System Comparison online help for task-based information.

The System Comparison Service

The System Comparison service, named `DevPartner Differ`, automatically takes a snapshot of the state of your machine at 2:10 a.m. daily if the machine is running. If the machine is powered off, it takes the snapshot five minutes after the next start-up. When you install System Comparison, it will take a snapshot a few minutes after the System Comparison service starts.

The nightly snapshot service collects snapshots for 21 nights, then begins deleting the oldest ones. You can change the number of retained snapshots by modifying the value in the System Comparison utility's settings file, as described in "Changing the Number of Retained Snapshots" on page 304. The size of snapshot files varies depending on the amount of data collected. A typical file size is less than one megabyte.

The System Comparison service runs at minimum priority, but it does consume some system resources for several minutes while it runs. If you prefer, you can set the System Comparison service startup type to manual, but you will lose the functionality of having snapshots created automatically.

Changing Automatic Snapshot Settings

Both the timing of the automatic snapshot taken by the System Comparison service and the number of snapshots retained are determined by the values in the System Comparison utility settings file.

The settings file (`Compuware.Diff.Settings.xml`) is located in the `Program Files\Compuware\DevPartner Studio\System Comparison\bin` directory.

Note: For installs on 64-bit versions of Windows, the settings file is located at: `\Program Files (x86)\Compuware\DevPartner Studio\System Comparison\bin`.

Changing the Number of Retained Snapshots

System Comparison retains 21 automatic snapshot files by default, after which the oldest files are deleted. To change the number of retained snapshot files, modify the `SnapshotsToKeep` key in the settings file. For example, the following key would change the number of retained snapshots to 30:

```
<add key="SnapshotsToKeep" value="30" />
```

Changing the Snapshot Hour and Minute

The System Comparison service takes an automatic snapshot of your machine at 2:10 a.m. daily. (If the machine is powered off, it takes the snapshot five minutes after the next start-up.) To change this default time, specify an alternate time in the Settings file using the `SnapshotHourOTo23` and `SnapshotMinuteOTo59` keys. For example, the following keys would change the automatic snapshot time to 3:42 a.m.

```
<add key="SnapshotHourOTo23" value="3" />
<add key="SnapshotMinuteOTo59" value="42" />
```

Valid settings for the hour are 0 to 23. Valid settings for the minute are 0 to 59.

You must restart the service for the new settings to take effect. If an automatic snapshot has already been taken for the day, the new setting will take effect on the next day. System Comparison takes only one automatic snapshot per day.

Categories of Differences

When taking a snapshot, the System Comparison utility records the existence, version, and status of the items listed in the following table.

You can add additional categories to customize data acquisition by writing a System Comparison Plug-in, as described in "Writing a Plug-in" on page 317.

Table 8-1. Categories of Differences

Category	Differences Detected
System Info	• Operating system • .NET Framework • Global Assembly Cache • The Java Runtime • System Environment variables • File system case sensitivity
System Files	• Operating system files in `Windows\System32` • Windows File Protection Cache in `Windows\System32\dllcache` - This folder contains operating system files that are used to maintain Windows if an operating system file is damaged. If a file is damaged or missing, it is automatically replaced from this folder without any intervention. • Side-by-side assemblies in `Windows\WinSxS`
Installed Products	The products detected. If the version number is available, it is shown. The information is read from the Add/Remove Programs section of the registry.
Services	Differences in the installed services: • Service status (Running, Stopped, etc.) • Account used by the service • Service type • Services depended on
Startup Items	Startup differences. This information is read from the following: • The `Win.ini` file found in the Windows directory. • The following registry key: `HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows\CurrentVersion\Run` • If possible, version information is included from the program file.

Table 8-1. Categories of Differences

Category	Differences Detected
IE/Outlook Components	Internet Explorer and Outlook differences: • Active Setup shows updated or missing Outlook / Internet Explorer components extracted from the registry key `HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Active Setup\Installed Components` • Browser Helper objects extracted from the registry key `HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows\CurrentVersion\Explorer\Browser Helper Objects` • MIME mappings (mapping between MIME type and which application handles the MIME) extracted from the registry key: `HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Active Setup\MimeFeature` objects. • Internet Explorer extensions extracted from the registry key `HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Internet Explorer\Extensions` • Internet settings extracted from the registry key `HKEY_CURRENT_USER\Software\Microsoft\Windows\CurrentVersion\InternetSettings`
IIS	Differences in your Microsoft IIS installation, as available from the IIS metabase, including differences in all installed Web applications and their settings, such as: • Web server differences • SMTP server differences • FTP server differences
SQL Server	Differences in your Microsoft SQL installation: • Microsoft SQL settings from the registry. • Data about Microsoft SQL services and related services. • Settings in the `syscurconfigs` and `sysconfigures` tables in the master database for all installed instances. The System Comparison utility attempts to connect to SQL Server using integrated security. If SQL Server is not running, differences in the master database will not be collected. **Note:** For master database differences to be collected, the account under which you are running must have sufficient privilege to access these two tables.
Drivers	Differences of all Drivers found: • Installed drivers • Status of drivers

Table 8-1. Categories of Differences

Category	Differences Detected

Registry	Differences in specific sections of the registry. By default, no registry sections are collected, but differences in the following registry sections can be collected:
	`HKEY_CLASSES_ROOT`
	`HKEY_LOCAL_MACHINE`
	You can customize the sections of the registry to collect by editing the `RegistrySections.xml` file, found in the `Program Files\Compuware\DevPartner Studio\System Comparison\data` directory.
	Note: For installs on 64-bit versions of Windows, the file is located at: `\Program Files (x86)\Compuware \DevPartner Studio\System Comparison \data.`
	You must have sufficient privilege to collect registry key data.

Files	Differences in the contents of directories and file properties from specific paths. By default, no files are included in the collection. You can customize the paths to collect by editing the `FileSections.xml` file, found in the `Program Files\Compuware\DevPartner Studio\System Comparison\data` directory. **Note:** For installs on 64-bit versions of Windows, the file is located at: `\Program Files (x86)\Compuware \DevPartner Studio\System Comparison \data.`
.NET Security Policy	Determines security policy differences on two separate system configurations, or security policy changes in time on the same machine. • Enterprise • Machine • User
Hardware	• System (Manufacturer, Model, Number of Processors, and System Type) • Memory (in MegaBytes) • Detailed information per processor (Description, Clock Speed, Role, and Status)
User Environment	Differences in user environments that may affect program runs. These are dependent on which user took the snapshot. • Environment Variables • Accessibility Settings • International Settings

Table 8-1. Categories of Differences

Category	Differences Detected
Windows Update	Differences on the state of the Windows Update service. This information may be useful to determine if a suspected update may have changed underlying components.

Comparing Registry Keys

Registry settings are often of interest when comparing systems, but since a system might have thousands of registry keys it is useful to narrow the scope of keys to be compared. The file `RegistrySections.xml`, located in the data directory of your installation path (`Program Files\Compuware\DevPartner Studio\System Comparison\data` by default) specifies the sections of the registry to be compared.

Note: For installs on 64-bit versions of Windows, the file is located at: `\Program Files (x86)\Compuware\DevPartner Studio\System Comparison\data`.

By default, no registry keys are included in your snapshots.

Note: If using this file with the System Comparison utility's Snapshot Application Program Interface (API), this file must be in a `\data` directory one level above the application's executable file. For example, if the executable is in `...\App\bin\MyApp.exe` then this file must be `...App\data\RegistrySections.xml`.

You can compare registry entries in `HKEY_LOCAL_MACHINE` and `HKEY_CLASSES_ROOT`. Comparing other registry keys is not supported.

You can specify as many sections as you need.

You must have sufficient privilege to collect registry key data.

Syntax

```
<Section categoryName="XXX">YYY</Section>
```

Parameters

XXX — A category name that will be displayed in the user interface. This attribute is optional. When not specified the registry key will be used as the category name.

YYY — A registry key from which to start collecting recursively. The key does not specify the prefix HKEY_LOCAL_MACHINE or HKEY_CLASSES_ROOT. For example, to collect all of KEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Rpc use the following:

```
<Section categoryName="Microsoft RPC">SOFTWARE\Microsoft\Rpc</Section>
```

To collect all of LOCAL_MACHINE or CLASSES_ROOT keys you can specify the special character '\'. For example, <Section categoryName="All">\</Section>. Be aware, though, that collecting all registry keys is time consuming.

For keys of type REG_BINARY, only the first 20 bytes of each key are collected.

Example

The following is a sample RegistrySections.xml file.

```
<RegistrySections>
<LocalMachine>
<!-- This is an example that would collect all registry keys under RPC -->

<Section categoryName="Microsoft RPC">SOFTWARE\Microsoft\Rpc</Section>

</LocalMachine>
<ClassesRoot>
<!-- This is an example that would collect everything under ClassesRoot, which would be many megabytes of data -->

<Section categoryName="All">\</Section>
<Section categoryName="Shell Extensions">*\shellex</Section>

</ClassesRoot>
</RegistrySections>
```

Comparing Specific Files

By default, differences in individual files are not collected. Comparing specific files is often of interest when comparing systems, but it is useful to narrow the scope of files to be compared. Use the file FileSections.xml, located in the data directory of your installation path (Program Files\Compuware\DevPartner Studio\System Comparison\data by default) to specify files to be compared.

Note: For installs on 64-bit versions of Windows, the file is located at: `\Program Files (x86)\Compuware\DevPartner Studio\System Comparison\data`.

Required: If using this file with the System Comparison utility's Snapshot Application Program Interface (API), this file must be in a `\data` directory one level above the application's executable file. For example, if the executable is in `...\App\bin\MyApp.exe` then this file must be `...App\data\FileSections.xml`.

Each category of file to be included in the comparison is specified in a separate section of `FileSections.xml`. You can specify as many sections as necessary.

Syntax

```
<Section [categoryName="XXX"] [filterPattern="{*,?}"]
[attributes="{yes,no}"] [programAttributes="{yes,no}"]
[recurseSubDirectories="{yes,no}"]>YYY</Section>
```

Parameters

`categoryName`	An optional attribute. XXX is a name that will be displayed as a sub-category. When this attribute is not present the category name will be the directory path by default.
`filterPattern`	An optional attribute. It specifies a file filter using the wildcard characters * (zero or more characters) and ? (exactly one character). When this attribute is not present, it is equivalent to `filter="*.*"`
`attributes`	An optional XML attribute. When not present, it is equivalent to `attributes="yes"`. If this attribute is equal to "yes", the utility collects the following: flag read only encrypted file length modified date The Company and Product attributes are not collected, nor are boolean file attributes such as read-only or debug, unless they are set.
`programAttributes`	An optional attribute. When not present, it is equivalent to `programAttributes="yes"`. If this attribute is equal to "yes" and the file name extension is any of ".exe", ".dll", ".ocx", "*.cpl" , the utility collects the following program version information: version language Setting programAttributes to "no" is useful, for example, in a Quality Assurance environment where one wants to verify if any files have been deleted or added during the installation of a product but you expect that some files properties (like program version) to change at each installation.
`recurseSubDirectories`	An optional XML attribute. When this attribute is not present, it is equivalent to `recurseSubDirectories="yes"` If this attribute is equal to "yes", the utility collects file information for all sub-directories recursively.
`YYY`	The directory path from which to start collecting file information recursively.

Example

The following is an example `FileSections.xml` file.

```
-->
- <FileSections>
- <!-- These are examples of file sections: -->
<Section categoryName="My Product">c:\somedir\somesubdir</
Section>
<Section categoryName="My bat files" attributes="yes"
filterPattern="*.bat" programAttributes="no"
recurseSubDirectories="no">c:\diff</Section>
<Section categoryName="My Test Files" attributes="yes"
programAttributes="yes" recurseSubDirectories="yes">D:\test</
Section>
</FileSections>
```

Installing Without DevPartner

DevPartner System Comparison installs separately from the rest of the DevPartner features. This option might be useful when you need to compare two different machines to see why an application behaves differently on different systems. When comparing systems to find an discrepancy between them, it is important to minimize the changes made to those systems. Installing System Comparison alone, without the overhead of Visual Studio or the rest of the DevPartner features, makes it easier to focus on important differences between the systems being compared.

To install System Comparison, from the DevPartner installation set-up screen select **Install DevPartner System Comparison** and follow the installation procedure.

System Comparison is included in the DevPartner license agreement, therefore using System Comparison consumes a DevPartner license. Refer to the *DevPartner Studio Installation Guide* for a detailed discussion of license issues, but note the following:

- If you have a node-locked (single-seat) license or a concurrent license, using System Comparison consumes one license while it is performing a comparison. Starting the Comparison service and taking snapshots with the service does not consume a license.

- If you are running DevPartner under a 14-day evaluation period, the 14 days begins when you use the System Comparison user interface to perform a comparison. It does not begin when the Comparison service is installed, started, and takes a snapshot.

Running the Comparison Utility from the Command Line

You can automate data collection and comparison using the two command line interfaces, `CommandLine.exe` and `CommandLineDiff.exe`.

- `Compuware.Diff.CommandLine.exe` takes a snapshot of the current condition of your computer system. By default, it stores the snapshot in the last directory used to store snapshots, but you can specify an alternate directory as a parameter to the command line.

  Examples:

  ```
  C:\Program Files\Compuware\DevPartner Studio\System
  Comparison\bin>Compuware.Diff.CommandLine.exe
  C:\Program Files\Compuware\DevPartner Studio\System
  Comparison\bin>Compuware.Diff.CommandLine.exe c:\MySnaps
  ```

Tip: For installs on 64-bit versions of Windows, the default installation directory is located at: `\Program Files (x86)\Compuware\DevPartner Studio\System Comparison\.`

- `Compuware.Diff.CommandLineDiff.exe` compares the values in two existing snapshot files and writes the resulting differences to an output file.

  Note: If running on Windows Vista, ensure that you have sufficient privileges to write to the output directory.

  Required parameters are `computers` (it is a placeholder) and the names of the files to be compared. Optionally, you can specify the directory in which the output file will be written.

  Examples:

  ```
  C:\Program Files\Compuware\DevPartner Studio\System
  Comparison\bin>Compuware.Diff.CommandLineDiff.exe
  computers SnapFile1 SnapFile2
  C:\Program Files\Compuware\DevPartner Studio\System
  Comparison\bin>Compuware.Diff.CommandLineDiff.exe
  computers SnapFile1 SnapFile2 C:\MyResults
  ```

  The output file is an XML file that can be read programmatically to check the results of the comparison. You cannot open this output file with the System Comparison utility's user interface.

The command line programs are located in the System Comparison utility's `\bin directory (\Program Files\Compuware\DevPartner Studio\System Comparison\bin` by default).

Software Development Kit

System Comparison includes a Software Development Kit (SDK) that provides functionality for software developers, including:

- The ability to use the Snapshot Application Program Interface (API) to embed function calls in an application to trigger a snapshot after the application is deployed

  The Snapshot API enables an application developer to control snapshot capability from within a deployed application. Should problems occur after the application is deployed, embedded API calls can trigger a snapshot that can assist with diagnosing the problem.

- The ability to write a System Comparison Plug-in to specify additional information to be gathered during a snapshot

  The categories of information gathered by the System Comparison utility (described in Table 8-1 on page 305) are sufficient for most comparisons. If you require additional information to adequately compare systems, you can customize the System Comparison utility by writing a data acquisition plug-in.

The API and plug-in functionality are described in the following sections.

System Comparison Snapshot API

The System Comparison Snapshot API enables you to control snapshot capability from within a deployed application. When using the Snapshot API, you can specify:

- where the snapshot will be stored
- what to do with messages or errors
- how progress status is to be reported
- where plug-ins are located, if custom plug-ins are used

Snapshot API information is located in two sub-directories under the System Comparison installation directory:

- The `System Comparison\redistributable` sub-directory contains the assemblies customers are licensed to include in their application's installation.

The Snapshot API assemblies may be redistributed in accordance with the Compuware Software License Agreement terms and conditions. Licensing software is not required to take a snapshot. To be viewed and compared, the snapshot must be sent to a licensed DevPartner system.

- The `\System Comparison\sdk\SnapshotAPI` sub-directory contains a sample application (`SampleSnapshotAPI.cs`) showing use of the API in an application.

  Review `SampleSnapshotAPI.cs` for an understanding of how the API can be used.

The Snapshot API is accessible from VB.NET, C#, and managed C++ and can be used with applications built with .NET Framework 1.1 and 2.0.

The following describes the classes and methods implemented for the Snapshot API, as illustrated in the `SampleSnapshotAPI.cs` application.

Note: If using the Snapshot API, your application's directory path must include a `\data` directory one level above the application's executable file. The `RegistrySections.xml` and `FileSections.xml` files must reside in the `\data` directory, even if those files are not being used. For example, if your executable is in `...\App\bin\MyApp.exe`, then `...App\data\RegistrySections.xml` and `...App\data\FileSections.xml` must exist.

Taking a Snapshot

`Compuware.Diff.Collector` implements the class `SnapshotAPI`. You can use the class `SnapshotAPI` to take a snapshot.

Public SnapshotAPI
(ILoggable logger,
IProgressStatus
progressStatusInterestedParty,
String pluginsSubDirectoryName)

Logger: An instance of a class responsible for handling events and errors. Optionally, pass null, but implementing a logger is recommended as it will make troubleshooting problems much easier.

progressStatusInterestedParty: An instance of a class responsible for handling progress status messages. It may be important in your application to provide feedback to the user, since the snapshot operation may be lengthy. Optionally, pass null.

pluiginsSubDirectoryName: The name of a sub-directory of your executable's directory that contains data acquisition assemblies. If you do not have any plug-ins, you can specify an empty existing directory or pass null.

The `SnapshotAPI` class implements three methods:

public string TakeSnapshot (String snapshotDirectory)	Takes the snapshot and stores it in the specified directory.
public int GetNumberSteps ()	Provides the total number of steps the progress status object will receive. You can then design your progress status accordingly. (See page 317 for information on the `ProgressStatus` interface.)
public void Dispose ()	The snapshot object is a disposable object.

The following example illustrates the most fundamental snapshot functionality:

```
using ( SnapshotAPI snapshoter = new SnapshotAPI( null, null,
null ) )
{
string snapFile = snapshoter.TakeSnapshot ( userSnapshotDirectory
);}
```

This would take a snapshot but would not be very useful in a production setting, as errors, messages, and progress would not be tracked.

Logging Messages

You can control reporting of errors and messages returned during the snapshot process using `Compuware.Diff.LoggableInterface`. In your application, create a logging mechanism to implement this interface to direct the messages to an appropriate output device. The sample application, for example, implements a `ConsoleLogger` class that logs messages to the console.

This interface consists of two methods:

`void Log( string message )`	Call this method to log a normal status message.
`void LogError( string message )`	Call this method to log an error message.

Reporting Progress

You can report and display the progress of the snapshot by implementing the `Compuware.Diff.ProgressStatus` interface. This interface consists of three methods:

`void OneStep ()`	The method to call back to notify the interested party to increment the progress display by one step.
`void MultiSteps ( int nbrSteps )`	The method to call back to notify the interested party to increment the progress display by several steps.
`void UpdateStatus (String newStatus )`	The method to call back to notify the interested party to process a new status. The newStatus string represents the new status, which would typically be displayed as part of a progress status UI element.

Writing a Plug-in

The categories of information gathered by the System Comparison utility (described in Table 8-1 on page 305) are sufficient for most comparisons. If you require additional information to adequately compare systems, you can customize the System Comparison utility by writing a data acquisition plug-in. This section defines a data acquisition plug-in, demonstrates how plug-ins work using supplied samples, and explains how you can create your own data acquisition plug-in.

Required: Existing plug-ins created with versions of DevPartner Studio earlier than 9.0 must be rebuilt before they can be used in DevPartner Studio 9.0

What is a Plug-in?

A plug-in is a .Net assembly that contains one or more types that implement the interface `Compuware.Diff.PluginInterface.IPluggableDataExtractor`. A plug-in defines a high level category of data to be gathered for comparisons. A plug-in extracts data and hands it to its caller in an XML format by adding XML elements to a base element in a hierarchical manner.

Plug-ins reside in `bin/plugins` in the product installation directory. Every .Net assembly in that directory will be automatically loaded by the Comparison service and every type that implements the interface `IPluggableDataExtractor` will be instantiated and placed in the list of plug-ins to call when data is extracted.

To familiarize you with the mechanics of writing a plug-in, System Comparison includes two sample files:

- A sample plug-in, `SamplePlugin.cs`, which demonstrates the structure of a simple plug-in. This sample does not collect significant data, but will always show a timestamp difference in the second data point of the first sub-category. For details about the methods implemented in a plug-in, refer to the file `IPluggableDataExtractor.cs` in `\SDK\Plugin`.
- A program to exercise the sample plug-in, `TestDriver.cs`, which you can use to become familiar with the mechanics of the sample plug-in. You can then use it to exercise your customized plug-ins. Once your plug-ins are retrieving the information you expect, you can then place them in the System Comparison `bin/plugins` directory to exercise them with the System Comparison user interface or command line interface.

Plug-in Sample Step By Step Instructions

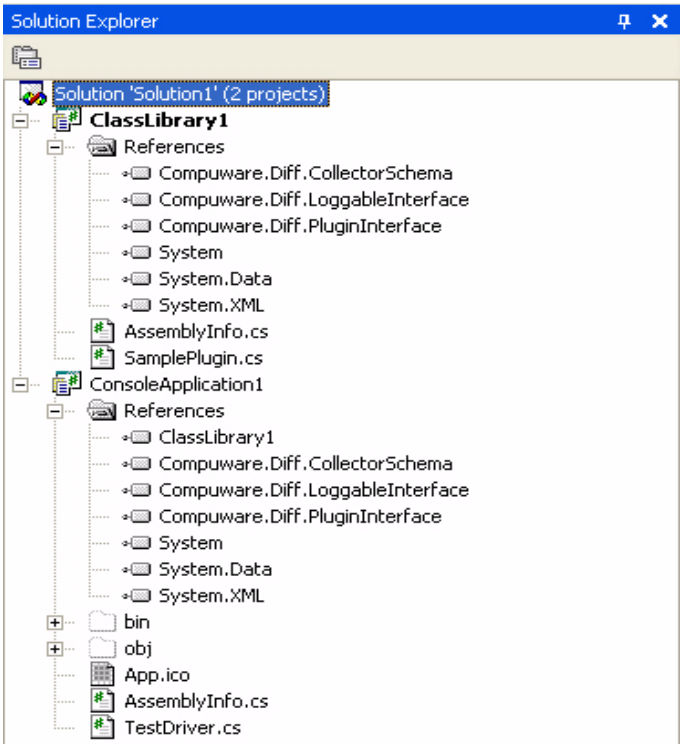
To become familiar with the use of plug-ins, use the `TestDriver.cs` and `SamplePlugin.cs` sample files. Both files are located in the `\sdk\Plugin` directory (`C:\Program Files\Compuware\DevPartner Studio\System Comparison\sdk\Plugin` by default).

Note: For installs on 64-bit versions of Windows, the default directory is located at: `\Program Files (x86)\Compuware\DevPartner Studio\System Comparison\sdk\Plugin`.

Tip: Plug-ins can be created with any currently supported version of Visual Studio. Use the version of Visual Studio that matches the version of .NET Framework containing features you want to use.

To build and test the sample files:

1. Create a solution using VIsual Studio.
2. In this solution, add two C# projects:
   - `ClassLibrary1` (type class library): This project is used to develop your plug-in.
   - `ConsoleApplication1` (type console): This project is used to debug the plug-in.



3 In the ClassLibrary1 project:

   a Add `SamplePlugin.cs` (located in `C:\Program Files\Compuware\DevPartner Studio\System Comparison\sdk\Plugin` by default).

   b Add a reference to the following assemblies (from the redistributable directory, `C:\Program Files\Compuware\DevPartner Studio\System Comparison\redistributable` by default):

```
Compuware.Diff.PluginInterface.dll
Compuware.Diff.LoggableInterface.dll
Compuware.Diff.CollectorSchema.dll
```

Tip: For installs on 64-bit versions of Windows, the default directory is located at: `\Program Files (x86)\Compuware\DevPartner Studio\System Comparison\.`

4 In the `ConsoleApplication1` project:

   a Delete `Class1.cs` from the solution explorer, if it exists.

   b Add the `TestDriver.cs` file to the project (located in `C:\Program Files\Compuware\DevPartner Studio\System Comparison\sdk\Plugin` by default).

   c Add reference to the following assemblies (from the redistributable directory):

```
Compuware.Diff.PluginInterface.dll
Compuware.Diff.LoggableInterface.dll
Compuware.Diff.CollectorSchema.dll
```

d Add a reference to `ClassLibrary1`.

e Set this project as the Startup project.

5 Build and run the solution. You can run in debug mode and step through the sample to understand the basic functioning of a plug-in. You will get an XML output file containing the sample plug-in data. The file is called `pluginOutput.xml` and is in the directory from which you ran the test driver.

```
-<testPlugin>
- <c n="Sample Data Extractor Plug-in">
- <c n="sampleSubCategory1">
<s n="data1">data1 actual value</s>
<s n="data2">data2 actual value 4/3/2006 10:42:34 AM</s>
</c>
- <c n="sampleSubCategory2">
<s n="data1">data1 actual value</s>
<s n="data2">data2 actual value</s>
</c>
</c>
</testPlugin>
```

After exercising the sample plug-in with `TestDriver` you can use it with the System Comparison utility's user interface or command line interface:

1 Copy `ClassLibrary1.dll` to the plugin subdirectory.

2 Use the System Comparison user interface or command line interface to take a snapshot, then take a second snapshot.

3 Compare the two snapshots. Since the `SamplePlugin` collects timestamp data, the two snapshots will show this difference.

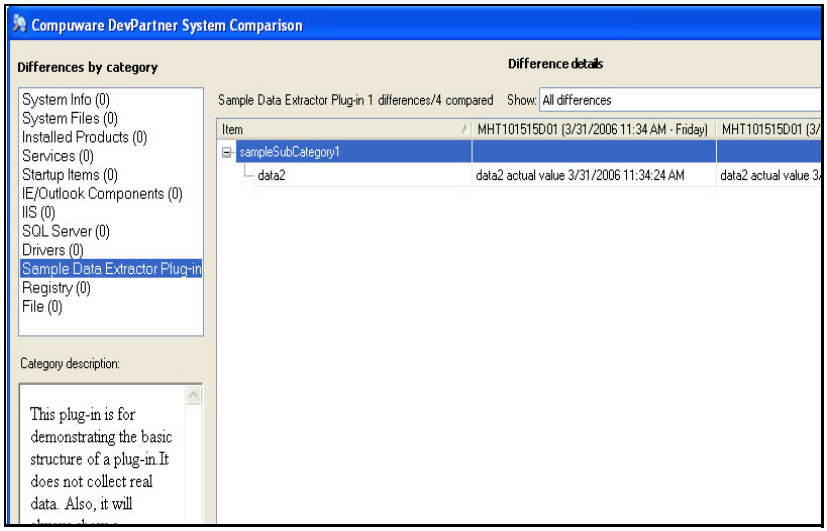


Figure 8-4. Results Window for the Sample Plug-in

Creating and Testing Your Plug-in

Once you are familiar with the mechanics of plug-ins you can begin to design your customized plug-in to gather data that interests you.

When designing your plug-in, pay particular attention to the hierarchy of data collected. Be sure that the hierarchy is designed to provide insight into the values in which you are interested. When a non-matching value is found in a data hierarchy, the rest of the data in that hierarchy is not compared. (Refer to “Modifying a Deployed Plug-in” on page 322 for information about changing the data hierarchy in subsequent versions of a plug-in.)

You can exercise your plug-in with `TestDriver` to simplify troubleshooting. Once you are satisfied with the plug-in output, you can test it with the System Comparison command line interface:

1. Copy your plug-in to the product installation `plugins` sub-directory. (You do not have to copy the `TestDriver.exe` file, which was used only to test your plug-in.)
2. Run the command line program (`<product dir>\bin\Compuware.Diff.CommandLine.exe`) on two machines that have differences in the area your plug-in is collecting.
3. Compare the two snapshots with the System Comparison user interface. You should see your differences.

4 Restart the System Comparison service so it includes the data specified by your plug-in when it creates snapshots.

Review the `DifferEvent.log` in your temporary directory (see the temp environment variable for the exact location) to troubleshoot any problems that occur. An event is logged if your plug-in is found and instantiated. Subsequent errors that occur during load, unload, or get data calls will also generate events in the log.

Also, any error you log via the `ILoggable traceLogger` parameter of the `IPluggableDataExtractor.GetData` call will be written to this file. See `IPluggableExtractor.cs`.

Modifying a Deployed Plug-in

After deploying a plug-in, you may decide to modify the data being collected. When older snapshot files are compared with snapshots created with the new version of your plug-in, the data collected will not match. The System Comparison utility will identify the mismatch as a difference, which could lead to confusion.

You can control how a mismatch is handled through use of major and minor version numbers. When the major version number of a plug-in differs between snapshots, the System Comparison utility will report that the "Plug-in schemas are incompatible." If the minor version numbers differ, the System Comparison utility will identify the status of the new data as being "unknown" in the old snapshot.

If you change a plug-in to delete data or change the hierarchy of data collected, changing the major version number is recommended. If you change the plug-in to add data, changing the minor version is generally sufficient.

To become familiar with this mechanism, you can experiment with changing the version number in the `SamplePlugin`, which is initially set to 1.0:

```
public PluginSchemaVersion PluginVersion
{
get { return new PluginSchemaVersion( 1, 0 );}
}
```

Note: If you need to replace or remove a plug-in, you first need to stop the System Comparison service and exit the System Comparison user interface to prevent the file from been locked by the operating system.

Highlights of the Plug-in Schema

To familiarize yourself with the plug-in schema, you can check any snapshot. A snapshot contains data from the plug-in. For details, refer to the file `diff-plugin-schema.xsd` in `\sdk\Plugin`. The following is an annotated sample XML fragment showing some of the elements and attributes you can use.

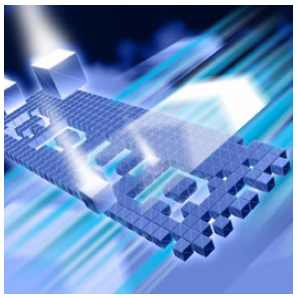
`<c`	Outermost Category node is for your plug-in.
`n="MyApplicatio n"`	The name of your plug-in. This text appears in the list of categories (on left in UI).
`descrip="text"`	This text is shown in the bottom left of the UI when your category is selected.
`schema="1">`	Set this to "1". Change it when new versions of your plug-in are incompatible with prior releases.
`<c`	All nested categories are shown in the main window of the UI.
`n="MyCategory"`	This is the name shown in the main window of the UI, and used for comparison.
`missing="text"`	Optional. This is the text you want shown when this category is missing from the other snapshot. It can be version information or something simple, like "installed".
`error="text">`	Optional. If your plug-in gets an error while fetching data for this category, you can include it here and it will be displayed in the UI.
`<s`	All data is string data.
`n="MyData"`	This is the name shown in the main window of the UI, and used for comparison.
`search="t1 t2"`	Optional. Search terms for the "search" link in the UI. These are passed to Google.
`error="text">`	Optional. If your plug-in gets an error while fetching data, you can include it here and it will be displayed in the UI.
`Actual Data Value`	This is your data from the registry or some other setting.
`</s>`	
`</c>`	
`</c>`	

About the Redistributable Assemblies

The current version of `Compuware.Diff.PluginInterface.dll`, `Compuware.Diff.LoggableInterface.dll` and `Compuware.Diff.CollectorSchema.dll` is 1.0.0.0. Customized plug-ins will continue to work with future versions of the System Comparison utility as long as the version number of these assemblies does not change. If major modifications are made to the assemblies, the version number will be incremented and you will have to rebuild your plug-ins against the new assemblies.

Appendix A

About DevPartner Studio Enterprise Edition and TrackRecord



- What Is DevPartner Studio Enterprise Edition?
- The DevPartner Studio EE Solution
- Feature Overview
- About TrackRecord and DevPartner Studio
- DevPartner Studio Interaction with TrackRecord
- TrackRecord and DevPartner Studio Coverage AnalysisThe DevPartner coverage main dialog box opens and displays a bar graph and statistics about the amount of lines and functions exercised by your unit tests.

What Is DevPartner Studio Enterprise Edition?

DevPartner Studio Enterprise Edition (EE) can increase a manager's ability to predict when projects will reach a goal, such as a specified quality level or a deployment status. It gives project managers the concrete project details they need to keep software projects on schedule, and development team members the tools they need to accomplish their goals.

DevPartner Studio EE combines the features of several existing software solutions, and integrates them to provide a new class of functionality. In addition to the DevPartner features described in this manual, the Enterprise Edition also includes the following components:

TrackRecord	Advanced change request management, task management, and workflow support for development teams
Reconcile	Practical requirements management for software development teams

DevPartner Studio EE provides multiple ways to capture, manipulate, view, and track project data, including:

- Milestone-related summaries that provide a way to interpret and understand critical-path project data
- Customizable work flow for tracking data in a way that fits a company's development process
- Remote access to project information via a World Wide Web interface
- E-mail notification of changes to crucial project information

The Development Process

Each software development group establishes its own process, which is the set of steps that the group uses to get from the idea and design stage of a project to the implementation and delivery stage. DevPartner Studio EE fits in with a team's current process, and provides features to assist the fine-tuning of internal development procedures.

Examples of process include:

- Written requirements
- Systematic change control
- Technical reviews
- Quality assurance planning
- Implementation planning
- Automated source code control
- Estimation updates at major milestones

Projects that use no process often suffer from:

- Application redesigns and rewrites during testing
- Integration problems
- Defect corrections late in the development life cycle at great cost
- Expansion of requirements—a malady often called "thrashing"

Projects that use a well-managed process display a high degree of certainty about the status of the project in relation to its plan. Process also improves development team morale. In one 50-company survey, 60% of developers who rated morale as good or excellent worked for firms that emphasized process, as compared to 20% whose firms were the least process oriented.

DevPartner Studio EE adapts to a company's existing software development process, and provides tools to help teams enhance that process if they so choose. It provides a way to formalize a team's work flow, to make people answerable to that work flow, and to audit the entire process. Combining customizable work flow with automatic error detection improves software quality and streamlines the development process.

The DevPartner Studio EE Solution

DevPartner Studio EE provides solutions to problems commonly facing software development teams:

- Improved project control
- Higher software quality through enhanced code reliability
- Improved productivity

Improved Project Control

Keeping projects under control involves the ability to determine easily:

- What tasks has the team completed?
- What tasks remain uncompleted?
- How volatile is the application's code?
- How thoroughly tested is the application?
- How reliable is the application?

Dynamic Tracking of Project Information

DevPartner Studio EE excels at tracking dynamic project information using TrackRecord.

Numerous tools exist to plan software projects. These tools help determine resource allocation, schedules, critical-path tasks, and other vital information. Before DevPartner Studio EE, approved project plans became static data points. During real projects, schedules slip, programmers get pulled off projects to deal with escalated problems in other projects, and delivery conditions change. Project planning tools alone cannot easily help to deal with changing conditions, but the DevPartner Studio EE connection between Microsoft Project and TrackRecord allows dynamic recalculation of schedules.

Higher Software Quality

Developers and testing engineers will use DevPartner throughout the software development cycle.

Finding Problems Before Your Users Do

DevPartner Studio EE differs from other software project enhancement tools by encouraging a proactive and systematic approach to finding and fixing program anomalies, from outright bugs to code bottlenecks. The early location of a program's problems contributes to high quality in the final product. DevPartner Studio EE's debugging features assist developers, individually and collectively, throughout the development

cycle. DevPartner saves time for programmers by making errors easier to find and repair, and easy report creation increases the likelihood that developers will enter defect and feature reports.

Finding errors is just the start of a process. Errors need to be discovered, recorded, reproduced, and assigned a priority for repair. TrackRecord streamlines much of this process, which frees developers to be more productive while guaranteeing that problems do not get lost or forgotten in a hectic schedule.

Improved Productivity

As project milestones—crucial dates such as code freeze and deployment dates—approach, dynamic displays of project data, such as number of defects outstanding, code volatility, and team-wide code coverage statistics, help everyone on the team assess their progress toward goals.

Every DevPartner Studio EE user can create a unique *view* of the information in a project database.

- Managers can get a big-picture view of a project, can track whether crucial tests are being run, and can control quality more tightly
- Developers can create lists of tasks needing immediate attention, rank tasks according to priority, perform error checks and performance tests on their code, and focus their daily activities
- Testers can track bugs and the status of known problems, merge data generated by coverage runs, execute test plans, and organize daily activity
- Writers can track when specifications get published, when features get implemented, and when user interface changes get made
- Support coordinators can quickly locate information, such as known defects and configurations tested, to help customers resolve problems

In this way, individual users will be more productive by quickly retrieving just the information they need. Views such as the Milestone Summary provide a context for the display of this information.

Every software development project is different, and every company has different needs. Different parts of a single company need different information about ongoing projects. DevPartner Studio EE satisfies these requirements by offering flexibility in the design of projects, particularly in the types of information that get tracked.

Although DevPartner Studio EE provides numerous pre-built views of database information, every DevPartner Studio EE user will have unique requirements for the storage and display of project information. DevPartner Studio EE provides the flexibility to allow companies to customize reports, forms, workflow, projects, and information types to fit their needs.

Feature Overview

DevPartner Studio EE provides the tools for accumulating and sharing software development project information. DevPartner Studio EE provides a rich set of features to facilitate the process of keeping track of a project under development.

Requirements Management

The crucial first step in any application development project is capturing the right set of end-user requirements. Next, those requirements must be effectively communicated to the development and testing teams. Reconcile provides a way to capture, organize, and distribute project requirements.

Using the familiar Microsoft Word as its editor, Reconcile provides a way to gather and refine requirements. Then, development teams can use the Reconcile Project Explorer to navigate requirement relationships. Reconcile requirements can be synchronized with QADirector to automatically create test procedures, and to correlate test results with test plans.

Reconcile integration with TrackRecord makes possible the association of defects and issues with project requirements. In this way, Reconcile and TrackRecord allow every development team member to stay up-to-date on project objectives.

Merging Coverage Data

The DevPartner Studio EE coverage feature generates information about the amount of a component's code that has been exercised or tested. Since different developers will likely work on different components, this individual coverage data will not tell a complete story about an application project. Each developer's local coverage report may need to be merged with other coverage results to obtain a complete picture of how much of the total project's code has been exercised.

DevPartner Studio EE allows the merging of sets of coverage data based on builds, configurations, users, or other criteria.

Project Activity Tracking

Tracking the various tasks and components of a software project helps to deal with the problem of complexity. As team members work on a specific task, new tasks needing attention at a future date often emerge. DevPartner Studio EE provides a way to record and track those tasks so that they will not get lost. Combining the work of individual developers requires attention to detail, coordination, and accurate recording of problems that will require consideration at a later date.

Tracking the level of testing being done, the number of faults being discovered, and the amount of coverage activity taking place can help a project manager anticipate and avoid problems. Two-way communication between DevPartner Studio EE and Microsoft Project can even automate schedule changes.

Automatic Notification of Changes

Timeliness promotes productivity. For example, prompt notification of:

- Newly-found high priority bugs helps managers reallocate resources to deal with shifting task priorities
- Newly-assigned tasks helps developers schedule their time more efficiently

While dynamic Outline reports provide the primary method for notifying users about changes to project data, the DevPartner Studio EE AutoAlert feature provides another way to notify one or more individuals when a tracked event occurs. AutoAlert lets you define flexible criteria for notifying remote or infrequent users of changes that might be of interest to them.

Each user who receives automatic mail notification sets up the notification criteria by creating special DevPartner Studio EE mail queries. AutoAlert monitors the DevPartner Studio EE database, periodically checking to see if any new items match the mail queries.

Whenever an item is entered or changed so that it matches one of the mail queries, DevPartner Studio EE automatically sends an e-mail message to the owner of the e-mail query. By using the TrackRecord software's flexible query engine, AutoAlert makes it possible for you to receive mail notification based on almost any criteria.

Customizable Workflow

Every software development team needs a way to make sure that certain tasks get completed, often in a specific order. Quality Assurance cannot test a repaired defect, for example, until the fix gets logged as integrated with the rest of the application under development. DevPartner Studio EE allows, but does not require, setting up a workflow that works in this manner.

DevPartner Studio EE provides a mechanism to implement an ordered workflow. Teams can design this workflow to restrict who can move an item of project data from one stage in the workflow life cycle to another. The workflow and its enforcement policies can require certain information under specified conditions. These policies provide a way to make team members accountable to the process the project uses.

Remote Access via the Web

When members of a development team work at remote locations, they can still have access to project data. The DevPartner Studio EE WebServer provides remote access via standard Web connections to allow users to view, enter, and change crucial project data.

Central Store of Shared Information

DevPartner Studio EE provides a robust client-server-based repository for sharing information. This repository uses an object-oriented database that is programmatically accessible through ActiveX (formerly OLE automation) interfaces. The repository provides the underlying infrastructure to enable groups to work together while each member works separately.

An extensible and flexible database structure, based on information types, forms the core of DevPartner Studio EE's repository, and provides its power.

About TrackRecord and DevPartner Studio

TrackRecord is part of the DevPartner Studio Enterprise Edition suite of software development tools. These applications automatically generate and store information about the detection, diagnosis, and resolution of software problems.

Developers can use TrackRecord to capture this information, along with other project information, such as milestone dates, to help resolve problems quickly and consistently.

Note: Integration of TrackRecord and DevPartner Studio is version dependent. You might need to upgrade your DevPartner Studio or TrackRecord software if you purchased the tools at separate times.

DevPartner Studio Interaction with TrackRecord

DevPartner Studio provides toolbar buttons and menu selections that allow the submission of defects to TrackRecord databases.

DevPartner Toolbar Buttons

The DevPartner toolbar buttons let you enter DevPartner Defects. Clicking these buttons opens a defect form, allowing you to key information into the DevPartner Studio database.

Defect Submissions

Submitting a DevPartner Studio Defect starts with highlighting an item from a DevPartner Studio debug display.

Entering a Defect from DevPartner

Complete the following steps to enter a defect from DevPartner:

1. Choose **Submit Defect** from a DevPartner menu or toolbar.

   Alternatively, choose a **Submit Defect** button from a DevPartner feature toolbar.

   TrackRecord opens either a blank **Defect** form, or a form with some fields prefilled with relevant data.

2. Enter other needed information into the defect report.

3. Click **Save** and **Close**.

TrackRecord and DevPartner Studio Coverage Analysis

DevPartner coverage users can merge session files that accumulate within their private work space. These merged sessions indicate how much testing that developer's code has received over time.

With DevPartner Studio and TrackRecord, coverage sessions can be merged and filtered across users and environments. Merging coverage sessions from *all* the developers working on an application lets a manager or test coordinator determine how much of an application's total code base has been exercised by test programs.

Refer to the coverage documentation and online help for information about how to use DevPartner coverage.

Merging coverage sessions entails two steps: creating a coverage merge set, and merging the sessions. A developer typically chooses what coverage sessions should be merged and what sessions should be excluded. Criteria for identifying sessions to merge can include the following.

- Application component
- Date
- Memory
- Milestone
- Operating System
- Person
- Project

You can match one of these selections to a specific value, to any value, or to any value except one you specify.

Creating Criteria for Merge Coverage Operation

To create criteria for a merge coverage operation, complete the following steps:

1. In TrackRecord, select **Merge Coverage Sessions** from the **Tools** menu.
2. Select a target from the left-most list box.
3. Select a match criteria from the right-most list box.
4. If you selected "is equal to" in Step 2, select a value from the bottom list box.

   For example, if you selected "Operating System is equal to" in the two top lists, you would select a value, such as "Windows 98," from the lower list.
5. Click **Add**.
6. Click **Next** to view the sessions that met your criteria.

Merging Coverage Sessions

To merge coverage sessions, complete the following procedure:

1. Click the check box next to a session to toggle it on or off.

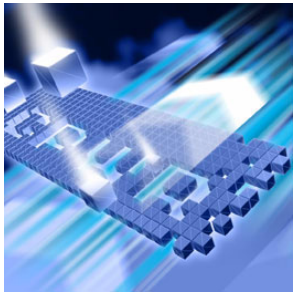
   When checked, that session will be merged with the other files selected. If unchecked, that session will not be merged with the other selected files.

2. Click **Merge**.

   The DevPartner coverage main dialog box opens and displays a bar graph and statistics about the amount of lines and functions exercised by your unit tests.

Appendix B

DevPartner Studio Supported Project Types



- Supported Project Types
- Error Detection Supported Project Types
- Code Review Supported Project Types
- Coverage Analysis, Performance Analysis, Memory Analysis, and Performance Expert Supported Project Types

This chapter contains tables listing project types supported by each DevPartner Studio feature listed above.

Supported Project Types

DevPartner Studio works in many software development environments which include Visual Studio integrated development environments, managed and unmanaged project types, and programming languages.

Table B-1 Supported Visual Studio Version and Language Reference

Integrated Development Environment	Managed or Unmanaged	Language
Visual Studio 2008 (VS2008)	Managed	Visual Basic Visual C++ Visual C#
	Unmanaged	Visual C++
Visual Studio 2005 (VS2005)	Managed	Visual Basic Visual C++ Visual C# Visual J#
	Unmanaged	Visual C++

The following pages describe supported IDEs, project types, and languages for each respective DevPartner Studio feature.

Error Detection Supported Project Types

Application projects build into an x86 executable. DevPartner error detection supports the following project types:

Table B-2 Error Detection Support for Managed Project Types

Visual Studio Version(s)	Application Project Types	Supported Languages
VS2008	MFC Application MFC DLL Win32 Console Application Win32 Project Win32 Smart Device Project (see note)	C++
	Crystal Reports Application Test Project Windows Control Library Windows Application Windows Forms Application Windows Forms Control Library WPF Application[1] WPF User Control Library[1] WPF Custom Control Library[1] WPF Browser Application[1]	C#, VB
	Console Application Windows Service	C++, C#, VB
[1] XAML generated code; .NET Framework 3.0 or later		

Table B-2 Error Detection Support for Managed Project Types

Visual Studio Version(s)	Application Project Types	Supported Languages
VS2005	MFC Application MFC DLL MFC Active X Control MFC ISAPI Extension DLL Win32 Console Application Win32 Project Win32 Smart Device Project (see note) Windows Forms Control Library	C++
	Calculator Starter Kit	J#
	Crystal Reports Application Windows Control Library Windows Application	C#, J#, VB
	Console Application Windows Service	C++, C#, J#, VB
MFC - Microsoft Foundation Class		

Note: Win32 Smart Device project types (Smart Device project types where the Solution Platform is set to Win32) must be running on the development machine, not an emulator, for DevPartner error detection to support them.

Hosted projects are built into an x86 DLL, and need to be hosted in an application if you want to test them. DevPartner error detection supports the following project types only when hosted within another executable:

Table B-3 Supported When the Project is Hosted Within Another Executable

Visual Studio Version(s)	Supported Project Types When Hosted Within Another Executable	Supported Languages
VS2008	ATL Project ATL Server Project ATL Smart Device Project Extended Stored Procedure DLL MFC Active X Control MFC DLL MFC ISAPI Extension DLL MFC Smart Device ActiveX Control MFC Smart Device Application MFC Smart Device DLL Windows Forms Control Library	C++
	Web Control Library	C#, VB
	Class Library Windows Control Library	C++, C#, VB
VS2005	ATL Project ATL Server Project ATL Smart Device Project Extended Stored Procedure DLL MFC Active X Control MFC DLL MFC ISAPI Extension DLL MFC Smart Device ActiveX Control MFC Smart Device Application MFC Smart Device DLL Windows Forms Control Library	C++
	Web Control Library	C#, J#, VB
	Class Library Windows Control Library	C++, C#, J#, VB
ATL - Active Template Library MFC - Microsoft Foundation Class		

Code Review Supported Project Types

The following table lists project types supported by DevPartner Studio code review.

Table B-4 Code Review Support for Managed Project Types

Visual Studio Version(s)	Managed Project Type	Supported Languages
VS2008	ASP.NET Web Application ASP.NET Web Service ASP.NET Web Site ASP.NET AJAX Server Control[1] ASP.NET AJAX Server Control Extender[1] ASP.NET Server Control[1] Class Library Console Application Crystal Reports Application Mobile Web Application Test Project[2] Empty Workflow Project[2] Sequential Workflow Console Application[2] Sequential Workflow Library[2] State Machine Workflow Console Application[2] State Machine Workflow Library[2] Workflow Activity Library[2] Web Control Library Windows Application Windows Control Library Windows Service WPF Application[3] WPF User Control Library[3] WPF Custom Control Library[3] WPF Browser Application[3] WCF Service Application	C#, VB

[1] As an ASP .NET Web Application

[2] As a standard VB or C# application

[3] XAML generated code; .NET Framework 3.0 or later

Table B-4 Code Review Support for Managed Project Types

Visual Studio Version(s)	Managed Project Type	Supported Languages
VS2005	ASP.NET Web Application ASP.NET Web Service ASP.NET Web Site Class Library Console Application Crystal Reports Application Mobile Web Application Web Control Library Windows Application Windows Control Library Windows Service	C#, VB

Coverage Analysis, Performance Analysis, Memory Analysis, and Performance Expert Supported Project Types

The following table lists DevPartner Studio analysis supported projects.

Table B-5 Coverage Analysis, Performance Analysis, Memory Analysis, and Performance Expert Supported Project Types

Visual Studio Version(s)	Project Type	Supported Languages
VS2008	ATL Project ATL Server Project ATL Server Web Service ASP.NET Web Service CLR Console Application CLR Empty Project Shared Add-in MFC ActiveX Control MFC Application MFC DLL Win32 Console Application Win32 Project	C++
	ASP.NET Web Site ASP.NET AJAX Server Control[1, 4] ASP.NET AJAX Server Control Extender[1] ASP.NET Server Control[1] ASP.NET Web Application ASP.NET Web Service Application Console Application Crystal Reports Application Reports Application SQL Server Project WPF Application[2] WPF Browser Application[2] WPF Custom Control Library[2] WPF User Control Library[2] WCF Service Application[3] Test Project[3]	C#, VB

Table B-5 Coverage Analysis, Performance Analysis, Memory Analysis, and Performance Expert Supported Project Types

Visual Studio Version(s)	Project Type	Supported Languages
VS2008 (cont.)	Empty Workflow Project[3] Sequential Workflow Console Application[3] Sequential Workflow Library[3] State Machine Workflow Console Application[3] State Machine Workflow Library[3] Workflow Activity Library[3] Visual Studio Add-in Visual Studio Integration Package Web Control Library Windows Application Windows Control Library	C#, VB
	Class Library Windows Forms Application Windows Forms Control Library Windows Service	C++, C#, VB

[1] JavaScript, Asynchronous XML

[2] XAML generated code; .NET Framework 3.0 or later

[3] As a standard VB or C# application

[4] Coverage Analysis and Performance Analysis only

MFC - Microsoft Foundation Class

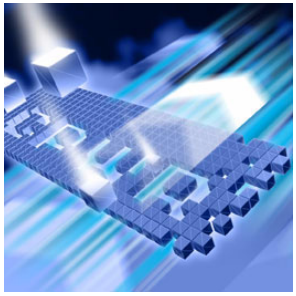
Table B-5 Coverage Analysis, Performance Analysis, Memory Analysis, and Performance Expert Supported Project Types

Visual Studio Version(s)	Project Type	Supported Languages
VS2005	ATL Project ATL Server Project ATL Server Web Service ASP.NET Web Service CLR Console Application CLR Empty Project Shared Add-in MFC ActiveX Control MFC Application MFC DLL Win32 Console Application Win32 Project	C++
	ASP.NET Web Application ASP.NET Web Service Application SQL Server Project	C#, VB
	ASP.NET Web Site Console Application Crystal Reports Application Visual Studio Add-in Visual Studio Integration Package Web Control Library Windows Application Windows Control Library	C#, J#, VB
	Class Library Windows Forms Application Windows Forms Control Library Windows Service	C++, C#, J#, VB
ATL - Active Template Library MFC - Microsoft Foundation Class		

Note: DevPartner Studio coverage analysis and performance analysis support VBScript and JScript in both classic ASP and client-side Web script.

Appendix C

Starting Analysis from the Command Line



- Introducing DPAnalysis.exe
- Running DPAnalysis.exe from the Command Line
- Using DPAnalysis.exe with an XML Configuration File
- Collecting Analysis Data from a Remote Machine

This appendix contains information about the `DPAnalysis.exe` command line tool which works for: coverage analysis, memory analysis, performance analysis, and Performance Expert.

Introducing DPAnalysis.exe

In addition to collecting analysis data while running your program in Visual Studio, you can use `DPAnalysis.exe` to collect profiling information without launching Visual Studio. `DPAnalysis.exe` collects application data in conjunction with option switches or by pointing to an XML configuration file.

Running DPAnalysis.exe from the Command Line

You can use `DPAnalysis.exe` from the command line, using switches or an XML configuration file to direct the analysis session. The following command line example launches a performance analysis session for the application `target.exe` and saves the session file (`.dpprf`) to the `c:\output` directory:

```
DPAnalysis.exe /perf /output c:\output\target.dpprf /p target.exe
```

Using `DPAnalysis.exe` from the command line, you can enable data collection and spawn a single process or service. To spawn more than one process with `DPAnalysis.exe`, see "Using DPAnalysis.exe with an XML Configuration File" on page 349.

`DPAnalysis.exe` does not instrument unmanaged code. To collect performance or coverage analysis data for an unmanaged application, you must first instrument the application. See "Collecting Data for Unmanaged Code" on page 139 for coverage analysis and "Collecting Data from Unmanaged Code" on page 233 for performance analysis.

Use the following syntax and switches to run the four DevPartner Studio analysis tools from the command line.

```
DPAnalysis.exe [/Perf|/Cov|/Mem|/Exp] [/E|/D|/R]
[/O outputfilename] [/W workingdirectory] [/PROJ_DIR]
[/H hostmachine] [/NOWAIT] [/NO_UI_MSG] [/N] [/F]
[/NO_MACH5 /NM_METHOD_GRANULARITY /EXCLUDE_SYSTEM_DLLS
/NM_ALLOW_INLINING /NO_OLEHOOKS
/NM_TRACK_SYSTEM_OBJECTS] {/P|/S} target.exe [target arguments]
```

Analysis Type Switches

Sets the run-time analysis type. The default is performance analysis.

`/Cov[erage]`	Sets analysis type to DevPartner coverage analysis
`/Exp[ert]`	Sets analysis type to DevPartner Performance Expert
`/Mem[ory]`	Sets analysis type to DevPartner memory analysis
`/Perf[ormance]`	Sets analysis type to DevPartner performance analysis

Data Collection Switches

Enables or disables data collection for a given target, but does not launch the target. These switches are optional.

`/E[nable]`	Enables data collection for the specified process or service.
`/D[isable]`	Disables data collection for the specified process or service.
`/R[epeat]`	Profiling occurs any time you run the specified process until you use the `/D` switch to disable profiling.

Other Switches

These switches are optional.

`/O[utput]`	Specify the session file output directory or directory and name.
`/W[orkingDir]`	Specify the working directory for the target process or service.
`/PROJ_DIR`	Specify the directory of DevPartner Studio project, used to locate playlists, etc.
`/H[ost]`	Specify target's host machine.

`/NOWAIT`	If you use `/NOWAIT` with multiple targets in a batch file, `DPAnalysis.exe` launches `process2` immediately after `process1` starts.
	For example:
	`DPAnalysis.exe /Exp /NOWAIT /P c:\temp\process1.exe`
	`DPAnalysis.exe /Exp /NOWAIT /P c:\temp\process2.exe`
	If you omit the optional `/NOWAIT` switch, `DPAnalysis.exe` waits until `process1` exits to start `process2` (default behavior).

`/NO_UI_MSG`	Set this switch to "true" to suppress UI error messages. The default is “false”.
`/N[ewconsole]`	Run the process in its own command window. If using `DPAnalysis.exe` to analyze a console application requiring keyboard input, you must use the `/NewConsole` switch to open a console window to accept the input.
`/F[orce]`	Forces coverage analysis or performance analysis profiling of unmanaged code applications that have not been instrumented with DevPartner Native C/C++ Instrumentation.

Quoted Paths and the /O[utput] Switch

If you use a quoted path as the parameter for the output (`/o`) switch and you do not include the file name, you must end the path in one of the following ways:

`/o "c:\test directory"`	End with a quote.
`/o "c:\test directory\."`	End with a back slash followed by a period.
`/o "c:\test directory/"`	End with a forward slash.

Analysis Options

These switches are optional.

`/NO_MACH5`	Disables excluding time spent on other threads.
`/NM_METHOD_GRANULARITY`	Sets data collection granularity to method-level. Line-level is default (performance analysis only).
`/EXCLUDE_SYSTEM_DLLS`	Excludes data collection for system dlls (performance analysis only).
`/NM_ALLOW_INLINING`	Enable run-time instrumentation of inline methods.
`/NO_OLEHOOKS`	Disable collection of COM.
`/NM_TRACK_SYSTEM_OBJECTS`	Track system object allocation (memory analysis only).

Target Switch

Required. Pick only one. Identifies target to follow as either a process or service. All arguments that follow the target name or path will be arguments to the target.

`/P[rocess]`	Specify a target process (followed by arguments to process).
`/S[ervice]`	Specify a target service (followed by arguments to service).
`/C[onfig]`	Specify the configuration file and path.

Using DPAnalysis.exe with an XML Configuration File

To manage analysis sessions with an XML configuration file, run `DPAnalysis.exe` from the command line with the `/config` switch and a properly structured XML configuration file as its target. For example:

```
DPAnalysis.exe /config c:\temp\configuration_file.xml
```

By using a configuration file, you can profile and manage multiple processes or services. The ability to profile multiple processes can be especially useful for analyzing Web applications.

Starting a session with `DPAnalysis.exe` launches a Session Control toolbar for each profiled process on the system where you invoked `DPAnalysis.exe`. Use the appropriate instance of the toolbar to execute session control actions for each process.

The following is a sample configuration file:

```
<?xml version="1.0" ?>
<ProductConfiguration xmlns="http://www.compuware.com/products">
  <RuntimeAnalysis Type="Performance"
   MaximumSessionDuration="1000" NoUIMsg="true" />
  <Targets RunInParallel="true">
    <Process CollectData="true" Spawn="true"
     NoWaitForCompletion="true">
      <AnalysisOptions NO_MACH5="1" NM_METHOD_GRANULARITY="1"
       SESSION_DIR="c:\temp" />
      <Path>ClientApp.exe</Path>
      <Arguments>/arg1 /agr2 /arg3</Arguments>
      <WorkingDirectory>c:\temp</WorkingDirectory>
      <ExcludeImages>
        <Image>ClassLibrary1.dll</Image>
        <Image>ClassLibrary2.dll</Image>
      </ExcludeImages>
    </Process>
    <Service CollectData="true" Start="true"
     RestartIfRunning="true"
     RestartAtEndOfRun="true">
      <AnalysisOptions NM_METHOD_GRANULARITY="0"
       EXCLUDE_SYSTEM_DLLS="1" />
      <Name>IISadmin</Name>
```

```
      <Host>remotemachine</Host>
    </Service>
  </Targets>
</ProductConfiguration>
```

XML Configuration File Element Reference

The following information describes the elements of an XML Configuration file.

Runtime Analysis Element

```
<RuntimeAnalysis Type = “type of analysis”
         MaximumSessionDuration = “number of seconds”
         NoUIMsg = "allow or suppress UI error messages" />
```

Attributes None.

Type Required. Possible choices are: `Performance`, `Coverage`, `Memory`, or `Expert`. These choices specify the analysis types for all targets listed.

MaximumSessionDuration Optional. If omitted, no default used. If specified, `DPAnalysis.exe` limits a session run to this number of seconds. For example, if you specify: `MaximiumSessionDuration=”60”` and then begin profiling a service (with `RestartAtEndOfRun=”true”` for the service), after 60 seconds, `DPAnalysis.exe` stops the service and then restarts the service.

NoUIMsg Optional. If omitted, “false” is used by default. If set to “true”, `DPAnalysis.exe` suppresses all UI error messages that may appear during the duration of the session. Setting this to “true” is useful when sessions are run unattended or when running a large number of consecutive tests.

Element Information

Number of occurrences	One
Parent elements	ProductConfiguration
Contents	None

Remarks Defines the type of analysis and maximum session time.

Example The following example shows a construction using `RuntimeAnalysis` following a `ProductConfiguration` tag. In this example, the `Type` attribute specifies a performance analysis with a maximum duration of 1000 seconds and suppression of UI error messages.

```
<?xml version=”1.0” ?>
<ProductConfiguration xmlns=”http://www.compuware.com/products”>
<RuntimeAnalysis Type=”Performance” MaximumSessionDuration=”1000”
NoUIMsg="true" />
```

Targets Element

```
<Targets RunInParallel="true or false">
    ...
  </Targets>
```

Attributes

RunInParallel

Optional. Specify `true` or `false`. Defaults to `true` if omitted. If you specify more than one target, defines how the targets are run. When `RunInParallel` is `true`, `DPAnalysis.exe` starts the target processes and services one right after the other; multiple targets will run at the same time (parallel). Otherwise, `DPAnalysis.exe` starts target N + 1 only after process N has launched and exited; targets run one at a time (serial).

Element Information

Number of occurrences	One
Parent elements	RuntimeAnalysis
Contents	Process, Service

Remarks

Required. Begins a block of one or more `<Process>` or `<Service>` entries. Target processes and services are started in the order they are listed in the configuration file.

Example

The following example shows a construction using `Targets` to specify analysis of one `<Service>` and two `<Process>` elements. Note that `RunInParallel` is `true` so that, for this example, the targets would run in parallel.

```
<Targets RunInParallel="true">
   <Service CollectData="true" Start="true">
      <AnalysisOptions NM_METHOD_GRANULARITY="0"
         EXCLUDE_SYSTEM_DLLS="1" />
      <Name>ServiceApp</Name>
      <Host>remotemachine</Host>
   </Service>
   <Process CollectData="true" Spawn="true"
         NoWaitForCompletion="true">
      <AnalysisOptions NO_MACH5="1"
         NM_METHOD_GRANULARITY="1"
         SESSION_DIR="c:\MyDir" />
      <Path>ClientApp.exe</Path>
      <WorkingDirectory>c:\temp</WorkingDirectory>
```

```
   </Process>
   <Process CollectData="true" Spawn="true"
         NoWaitForCompletion="true">
      <AnalysisOptions NO_MACH5="1"
         NM_METHOD_GRANULARITY="1"
         SESSION_DIR="c:\MyDir" />
      <Path>TestApp02.exe</Path>
      <WorkingDirectory>c:\temp</WorkingDirectory>
   </Process>
</Targets>
```

Process Element

```
<Process
CollectData = "true or false"
Spawn = "true or false"
NoWaitForCompletion = "true or false"
NewConsole = "true or false"
RepeatInjection = "true or false"
         >
         ...
</Process>
```

Attributes

Profiling occurs any time you run the specified process until you use the `/D` switch to disable profiling.

CollectData

Optional. Specify `true` or `false`. Defaults to `true` if omitted. Specifies whether profiling will be enabled for the target process.

Spawn

Optional. Specify `true` or `false`. Defaults to `true` if omitted. Specifies if `DPAnalysis.exe` will spawn the specified target. Do not set to `true` for `aspnet_wp.exe` or `w3wp.exe`. DevPartner cannot spawn the ASP.NET worker process directly. Launch the ASP.NET worker process by opening the target Web page.

NoWaitForCompletion

Optional. Specify `true` or `false`. Defaults to `false` if omitted. The default is to wait until the process has completed. If set to `true`, causes `DPAnalysis.exe` to wait only until the target has started executing. `DPAnalysis.exe` will not wait for processes on remote machines (using the `Host` element). The `MaximumSessionDuration` attribute in the `RuntimeAnalysis` element overrides `NoWaitForCompletion`.

NewConsole

Optional. Specify `true` or `false`. Defaults to `false` if omitted. Causes `DPAnalysis.exe` to run the target in its own console window. The default is to use the same console that you typed the `DPAnalysis.exe` command line in. If you use `DPAnalysis.exe` to analyze a console application that requires keyboard input, you must use the `/NewConsole` switch to open a console window to accept the input.

RepeatInjection

Optional. Specify `true` or `false`. Defaults to `false` if omitted. Causes `DPAnalysis.exe` to profile the target in every time it runs until you explicitly specify `false`.

Element Information

Number of occurrences	One or more
Parent elements	Target
Contents	AnalysisOptions, Path, Arguments, WorkingDirectory, ExcludeImages

Remarks

Specifies a target executable.

Example

The following example shows a construction using `Process` and includes `AnalysisOptions`, `Path`, `Arguments`, and `WorkingDirectory` tags.

```
<Targets RunInParallel=”true”>
<Process CollectData=”true” Spawn=”true”
 NoWaitForCompletion=”true” NewConsole=”true”>
  <AnalysisOptions NO_MACH5=”1” NM_METHOD_GRANULARITY=”1”
   SESSION_DIR=”c:\MyDir” />
  <Path>ClientApp.exe</Path>
  <Arguments>/arg1 /agr2 /arg3</Arguments>
  <WorkingDirectory>c:\temp</WorkingDirectory>
</Process>
</Targets>
```

Analysis Options Element

Attributes that work with `AnalysisOptions` vary depending on the type of analysis session you run. Refer to the table at the end of this description. `DPAnalysis.exe` ignores attributes mismatched with the type of analysis.

```
<AnalysisOptions
        SESSION_DIR = "c:\MyDir"
        SESSION_FILENAME = "myfile.dpcov"
        NM_METHOD_GRANULARITY = "1"
        EXCLUDE_SYSTEM_DLLS = "1"
        NM_ALLOW_INLINING = "1"
        NO_OLEHOOKS = "1"
        NM_TRACK_SYSTEM_OBJECTS = "1"
        NO_MACH5 = "1"
        FORCE_PROFILING = "1"
/>
```

Attributes

SESSION_DIR

Optional. Use with coverage analysis, memory analysis, performance analysis, and Performance Expert. Specify a directory for saving the session file generated by the profiled target. Without this attribute, the resulting session file will be placed in the user's **My Documents** or **Documents** directory. If both `SESSION_DIR` and `SESSION_FILENAME` are absent, `DPAnalysis.exe` prompts you for the save location at the end of the session.

SESSION_FILENAME

Optional. Use with coverage analysis, memory analysis, performance analysis, and Performance Expert. Specify a session name for the session file generated for this target. Without this attribute, `DPAnalysis.exe` creates a unique name by combining the target's image name with a number (for example, `iexplore1.dpprf`). If you specify a name but no directory, the file will be placed in user's `My Documents` directory. If both `SESSION_FILENAME` and `SESSION_DIR` are absent, `DPAnalysis.exe` prompts you for the save location at the end of the session.

NM_METHOD_GRANULARITY

Optional. Use with performance analysis to set data collection granularity to method-level (line-level is default). Specify a value of `1` to set the attribute. Omitting the attribute disables it.

EXCLUDE_SYSTEM_DLLS

Optional. Use with performance analysis to exclude system images. Specify a value of 1 to set the attribute. Omitting the attribute disables it.

NM_ALLOW_INLINING

Optional. Use with coverage analysis and performance analysis to specify level of analysis detail. Enables run-time instrumentation of inline methods. Equivalent to the **Instrument Inline Functions** property. Specify a value of 1 to instrument inline functions. Omit the attribute to disable it.

NO_OLEHOOKS

Optional. Use with performance analysis to activate tracking of system objects. Specify a value of 1 to set the attribute. Omitting the attribute disables it.

NM_TRACK_SYSTEM_OBJECTS

Optional. Use with memory analysis to ignore system or third-party object allocations when tracking allocated objects. Specify a value of 1 to set the attribute. Omitting the attribute disables it. The default state (disabled) enables you to see memory allocations made when your application uses system or other non-profiled resources.

NO_MACH5

Optional. Use with performance analysis and Performance Expert to exclude time spent in threads of other running applications. Specify a value of 1 to set the attribute. Omitting the attribute disables it.

FORCE_PROFILING

Optional. Use with coverage analysis and performance analysis to force profiling of applications written without managed code or DevPartner Native C/C++ Instrumentation. Specify a value of 1 to set the attribute. Omitting the attribute disables it.

Attribute	Coverage	Memory	Performance	Performance Expert
NM_METHOD_GRANULARITY			X	
EXCLUDE_SYSTEM_DLLS			X	
NM_ALLOW_INLINING	X		X	
NO_OLEHOOKS			X	
NM_TRACK_SYSTEM_OBJECTS		X		
NO_MACH5			X	X
FORCE_PROFILING	X		X	

Element Information

Number of occurrences	One or none per Process or Service
Parent elements	Process, Service
Contents	None

Remarks

Optional. Defines runtime attributes for the specified target process or service. Attributes correspond to coverage analysis, memory analysis, and performance analysis properties accessible from the **Properties Window** in Visual Studio.

Example

The following example shows a construction using `AnalysisOptions` within a Service.

```
<Service CollectData="true">
  <AnalysisOptions NM_METHOD_GRANULARITY="1"
   EXCLUDE_SYSTEM_DLLS="1" NM_ALLOW_INLINING="1"
   NO_OLEHOOKS="1">
</Service>
```

Path Element

```
<Path> c:\MyDir\target.exe </Path>
```

Attributes

None.

Element Information

Number of occurrences	One
Parent elements	Process
Contents	Path to the executable

Remarks Required. Specify a fully qualified or relative path to the executable. You can specify the executable name without the path if the executable exists in the current directory.

Example The following example shows a construction using `Path` within a `Process` element.

```
<Process CollectData="true">
  <Path>ClientApp.exe</Path>
</Process>
```

Arguments Element

```
<Arguments>/arg1 /arg2 /arg3</Arguments>
```

Attributes None.

Element Information

Number of occurrences	Zero or one per Process or Service
Parent elements	Process, Service
Contents	None

Remarks Optional. No default if omitted. Arguments to be passed to the target `process` or `service`.

Example The following example shows a construction using `Arguments` within a `Process` element.

```
<Process CollectData="true">
  <Arguments>/arg1 /agr2 /arg3</Arguments>
</Process>
```

Working Directory Element

```
<WorkingDirectory> c:\MyWorkingDir </WorkingDirectory>
```

Attributes None.

Element Information

Number of occurrences	One per Process or Service element
Parent elements	Process, Service
Contents	Path to the target directory

Remarks Optional. No default if omitted. Set the working directory of the target process or service.

Example The following example shows a construction using `WorkingDirectory` nested within a parent `Process` element.

```
<Process CollectData="true">
  <WorkingDirectory>c:\temp</WorkingDirectory>
</Process>
```

Exclude Images Element

```
<ExcludeImages>
         <Image>ClassLibrary1.dll</Image>
         <Image>ClassLibrary2.dll</Image>
</ExcludeImages>
```

Attributes None

Element Information

Number of occurrences	Zero or one per process or service
Parent elements	Process, Service
Contents	Image

Remarks Optional. No default if omitted. Provide a list of at least one image (no maximum) which, if loaded by the target process or service, will not be profiled.

Example The following example shows a construction using `ExcludeImages`. within a `Process` element. Note the `Image` elements contained within `ExcludeImages`.

```
<Process CollectData="true">
  <ExcludeImages>
    <Image>ClassLibrary1.dll</Image>
    <Image>ClassLibrary2.dll</Image>
  </ExcludeImages>
</Process>
```

Service Element

```
<Service
        CollectData = “true or false”
        Start = “true or false”
        RestartIfRunning = “true or false”
        RestartAtEndOfRun = “true or false”
        RepeatInjection = “true or false”
        >
        ...
</Service>
```

Attributes

None.

CollectData

Optional. Specify `true` or `false`. Defaults to `true` if omitted. Specifies whether profiling will be enabled for the target service.

Start

Optional. Specify `true` or `false`. Defaults to `true` if omitted. Specifies if `DPAnalysis.exe` will start the specified target. If set to `false`, profiling is enabled for this target but it will not be started; profiling begins the next time the service is started (by whatever means).

RestartIfRunning

Optional. Specify `true` or `false`. Defaults to `false` if omitted. When you set `RestartIfRunning` to `true`, `DPAnalysis.exe` attempts to restart the specified service if it is running on the host machine.

RestartAtEndOfRun

Optional. Specify `true` or `false`. Defaults to `false` if omitted. When you specify `true`, `DPAnalysis.exe` attempts to restart the service (generating a session file) at the end of the run.

RepeatInjection

Optional. Specify `true` or `false`. Defaults to `false` if omitted. Causes `DPAnalysis.exe` to profile the target every time it runs until you explicitly specify `false`.

Element Information

Number of occurrences	The configuration file must contain at least one Process or one Service element.
Parent elements	Targets
Contents	AnalysisOptions, Path, Arguments, Working Directory, ExcludeImages, Name, Host

Remarks — Specifies a target service.

Example — The following example shows a construction using `Service` within a `Targets` element.

```
<Targets RunInParallel="true">
  <Service CollectData="true" Start="true"
   RestartIfRunning="true" RestartAtEndOfRun="true">
   <Name>ServiceApp</Name>
  </Service>
</Targets>
```

Name Element

```
<Name>MyServiceName</Name>
```

Attributes — None

Element Information

Number of occurrences	One
Parent elements	Service
Contents	Service name

Remarks — Required. The name of the service as registered with the service control manager. This is the same name you would use with a NET START command.

Example — The following example shows a construction using `Name` within a `Service`.

```
<Service CollectData="true">
  <Name>ServiceApp</Name>
</Service>
```

Host Element

```
<Host>hostmachine</Host>
```

Attributes

None.

Element Information

Number of occurrences	For each Process or Service, zero or one
Parent elements	Process, Service
Contents	Name of the host machine

Remarks

Optional. No default if omitted. Set the host machine of the target process or service.

Example

The following example shows a construction using `Host` within a `Service`. Note that the example includes the required `Name` element.

```
<Service CollectData="true">
  <Name>ServiceApp</Name>
  <Host>remotemachine</Host>
</Service>
```

Profiling Web Applications with the XML Config File

In general, there are three processes of interest for Web profiling: the browser; the Web server; and the ASP.NET worker process. All three entries can be contained in a single configuration file. Specify the browser and the ASP.NET worker process within `<Process>` elements; specify the Web server within a `<Service>` element where a `<Name>` element identifies the service name. For IIS, this is `iisadmin`.

For example:

```
<?xml version="1.0" ?>
<ProductConfiguration xmlns="http://www.compuware.com/products">
  <RuntimeAnalysis Type="Expert"/>
  <Targets>
     <Process CollectData="true">
       <AnalysisOptions
         SESSION_DIR="z:\SessionFiles"/>
       <Path>aspnet_wp.exe</Path>
       <Host>remotemachine</Host>
     </Process>
     <Service CollectData="true" Start="true"
```

```
        RestartIfRunning="true"
        RestartAtEndOfRun="true">
        <AnalysisOptions
          SESSION_DIR="z:\SessionFiles"/>
        <Name>iisadmin</Name>
        <Host>remotemachine</Host>
      </Service>
      <Process CollectData="true" Spawn="true">
        <AnalysisOptions
          SESSION_DIR="c:\SessionFiles"/>
        <Path>iexplore.exe</Path>
        <Arguments>
          http://remotemachine/WebApplication/
          StartPage.aspx
        </Arguments>
       </Process>
  </Targets>
</ProductConfiguration>
```

The configuration file above:

- Enables data collection for the ASP.NET worker process on `remotemachine`.
- Enables data collection for `inetinfo.exe` (`iisadmin`) on the remote machine and restarts it so profiling can begin.
- Opens a local browser to the local machine directed at a Web page on the remote machine. This causes `aspnet_wp.exe` to be spawned on the remote machine and profiling for it begins.

When the browser is closed on the local machine, IIS on the remote machine will be restarted on the remote machine (killing `aspnet_wp`) and session files will be automatically be saved to the respective save directories. If you wish, you can use an existing mapped drive on the remote machine to save the session files to the machine where profiling was initiated, as shown by the `z:\` drive in the `<Process>` and `<Service>` elements in the example.

Sample Configuration Files

The DevPartner Studio installation includes these sample, read-only configuration files. Use them as models to construct custom configuration files.

```
Sample.Process.Config.xml
Sample.Service.Config.xml
Sample.WebApp.Config.xml
Sample.DCOM.Config.xml
Sample.ClassicASP_IIS_High_Isolation.Config.xml
Sample.ClassicASP_IIS_Low_Isolation.Config.xml
Sample.Multi_Process.Config.xml
```

The default installation places the files in this directory:

```
<install drive>:\Program Files\Compuware\DevPartner
Studio\Analysis\SampleConfigs\
```

Note: For installs on 64-bit versions of Windows, the default directory is located at: `\Program Files (x86)\Compuware\DevPartner Studio\Analysis\SampleConfigs\`

`DPAnalysis.exe` does not instrument unmanaged code. To collect performance or coverage analysis data for an unmanaged application, you must first instrument the application. See "Collecting Data for Unmanaged Code" on page 139 for coverage analysis and "Collecting Data from Unmanaged Code" on page 233 for performance analysis.

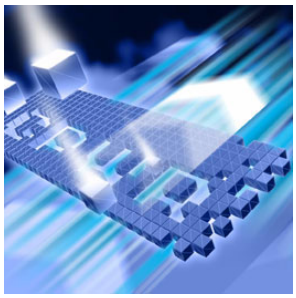
Collecting Analysis Data from a Remote Machine

If you use `DPAnalysis.exe` to collect data for an application that executes on a remote machine, be aware of the following considerations:

- When using `DPAnalysis.exe` to run an application on a remote system, use the command line or XML configuration file to specify a directory and file name in order to save the session file.
- You can specify any directory to which you have write permission, including an existing mapped directory to the local (client) machine on which profiling was initiated.
- If you do not specify the directory and file name, DevPartner presents a File Save dialog on the remote machine. You must have physical access, a Terminal Services connection, or a Remote Desktop connection to the machine in order to use the dialog. The File Save dialog's default directory is the `My Documents` or `Documents` directory of the active user account.

Appendix D

Analysis Session Controls



- Introducing Session Control Files
- Creating a Session Control File Within Visual Studio
- Using the Session Control API
- Using the Session Control API

This appendix contains information about session control files and the Session Control API, which can be used with DevPartner coverage analysis, memory analysis, performance analysis, and Performance Expert.

Introducing Session Control Files

Use the **Session Control File** options to create a set of rules and actions to control the data DevPartner collects as your application runs. DevPartner stores these rules and actions in a session control file (`SessionControl.txt`) in your application's solution directory.

A session control file includes data collection actions for selected methods so you can:

- Specify data collection actions at the entry to or exit from methods.
- Retain the session control file from session to session.
- Create entries in the session control file that affect coverage analysis, memory analysis, performance analysis, and Performance Expert sessions.

Creating a Session Control File Within Visual Studio

From Visual Studio 2005 or 2008, you can create the file through the **DevPartner > Options** menu, as described below. Refer to "Using the Session Control API" on page 367 for information on creating a session control file with a text editor.

To create a session control file:

1. Choose **DevPartner > Options**.
2. In **Options**, choose **DevPartner > Analysis > Session Control File**. The first time you set session control file options, you access an empty session control (`SessionControl.txt`) file.
3. Click **Add**.
4. In the Module text box, choose or browse to locate the module for which you want to collect data. The module instrumentation status appears.

Note: All managed code modules display a "not instrumented" status. Only unmanaged (native) C++ modules that have been built with native C/C++ instrumentation show an "instrumented" status.

5. From the Methods list, choose a method for which you want to record data.

Note: If you are choosing methods from a .NET module (`.netmodule`), the Method List displays methods in `namespace.classname.method` format. DevPartner Studio supports a maximum of 512 characters for the qualified method name in the session control file. Names longer than 512 characters are ignored and no session control action occurs for that method.

6. Choose when you want the session control action to start.
7. Choose one of the following actions that you want to apply:
   - **Stop recording (take final snapshot)**
   - **Take snapshot**
   - **Clear all recorded data**
   - **Start tracking (Memory leak analysis)**
   - **Stop tracking (Memory leak analysis)**
   - **Run GC (Memory analysis)**
8. Click **OK**.
9. Repeat steps 3 through 8 until you have chosen all the methods you want to include.
10. Click **OK** to close and save the session control file.

If you have a solution open in Visual Studio, DevPartner saves the session control file in the solution directory.

Note: DevPartner searches for the `SessionControl.txt` file in the solution directory that contains the application executable you are profiling. If DevPartner does not find the file in the solution directory, it looks in the output directory where your application executable is built. If you place your `SessionControl.txt` file in another location, DevPartner will not be able to recognize the session control commands.

Entries in the session control file affect analysis sessions in coverage analysis, memory analysis, performance analysis, and Performance Expert.

Using the Session Control API

Call the Session Control API from anywhere in your source code to control data collection for any Visual Studio application. Using the session control text file allows DevPartner session control actions only on entry to and exit from methods.

DevPartner Session Control API functions

`Clear`	Clears the data collected up to this point. Data collection continues. Returns `NMStatusSuccess` if data was successfully cleared or `NMStatusFailure` if data was not cleared.
`Snap`	Takes a snapshot of the data being recorded. Returns `NMStatusSuccess` if the snapshot was successfully saved or `NMStatusFailure` if snapshot was not saved.
`SaveNow`	Takes a snapshot and stops data collection. Takes the filename for the method, if provided. Returns `NMStatusSuccess` or `NMStatusFailure`.
`StartTrackingForLeakAnalysis`	Starts tracking allocated objects. (Memory Leak analysis only)
`StopTrackingForLeakAnalysis`	Stops tracking allocated objects. (Memory Leak analysis only)
`RunGC`	Runs the system garbage collector. (Memory analysis)

Note: Make sure `SaveNow` is the last API function call used in your code. It stops data collection for the process, therefore all subsequent API calls are ignored.

Note: The `Snap Session Control` API call produces a temporary objects session file in memory analysis sessions. In order to capture memory size data for objects allocated since the last garbage collection, insert the `RunGC` API call before the `Snap` API call.

Location of API

The files below contain the session control API functions for use with managed and unmanaged code, respectively. All are installed in the `\DevPartner Studio\Analysis` directory of your DevPartner Studio installation.

Managed code Visual Studio applications	`DevPartner.Analysis.SessionControl.dll`
Unmanaged (native) code C/C++ or C++ applications	`NmTxApi.h`

Using the Session Control APIs with Managed Applications

To use the session control API functions in managed code Visual Studio applications, you must reference `DevPartner.Analysis.SessionControl.dll` in your project.

This gives you access to the session control APIs in the DevPartner namespace. You can insert calls to the API at appropriate points in your code using the syntax shown below.

`Clear`

```
DevPartner.Analysis.SessionControl.Clear()
```

`Snap`

```
DevPartner.Analysis.SessionControl.Snap(<your session file
name>.dpxxx)
```

Where dpxxx is the extension for your analysis type: dpcov, dpmem, dpprf, or dppxp.

`SaveNow`

```
DevPartner.Analysis.SessionControl.SaveNow(<your session file
name>.dpxxx)
```

Where dpxxx is the extension for your analysis type: dpcov, dpmem, dpprf, or dppxp.

`StartTrackingForLeakAnalysis`

```
DevPartner.Analysis.SessionControl.StartTrackingForLeakAnalysis()
```

`StopTrackingForLeakAnalysis`

```
DevPartner.Analysis.SessionControl.StopTrackingForLeakAnalysis()
```

`RunGC`

```
DevPartner.Analysis.SessionControl.RunGC()
```

Valid input for the `Snap` and `SaveNow` API functions includes:

- A file name
- A fully qualified path to a directory, terminated with a "\" (backslash)

- A fully qualified path including a file name
- Nothing (Null)

For information on how DevPartner treats the file and path information, see "Saving Files through the Session Control API" on page 371.

If You Get a Security Exception

If you get a security exception when using the session control APIs to profile a managed code application, it means that your security policy is preventing normal DevPartner instrumentation of your code at runtime. To remedy this, you must enable secure profiling.

Set the following global environment variable:

```
NM_NO_FAST_INSTR=1
```

Retry profiling the application.

Note: By default, assemblies need to have the `SkipVerification` permission in order to be profiled. If you remove this permission from the permission set of the policy under which the code executes, or add imperative security declarations to the assembly that cause this permission to be revoked, you will not be able to profile it. The solution described above allows you to work around this issue, although it does exact a slight performance penalty. If you choose not to implement the solution described above, you can also enable profiling of such assemblies with DevPartner Studio by either changing the policy for the assembly using the .NET Framework Configuration tool MMC snap-in, or by temporarily removing any imperative security declarations in the assembly.

See the *.NET Framework Developers Guide* in the Visual Studio on-line help for more information on security policy in Visual Studio.

Using the Session Control APIs with Unmanaged Applications

You can use the Session Control API to control coverage analysis and performance analysis sessions for unmanaged C/C++.

Unmanaged (Native) C/C++ Projects

Before you can collect coverage data for your native C/C++ application, you must rebuild your solution (or native C/C++ projects) with Native C/C++ Instrumentation.

To use the Session Control API functions in native C/C++:

1. Include `NmTxApi.h` in a file to which you want to add Session Control API calls. Add `TxInterf.lib` to the link library list.
2. Insert calls to the Session Control API functions at appropriate points in your code. See "Session Control API Syntax for Unmanaged Projects" on page 371.
3. Rebuild the solution or individual native C/C++ projects with Native C/C++ Instrumentation.

Unmanaged (Native) C++ Projects

Before you can collect coverage data for your native C++ application, you must rebuild your project with instrumentation in Visual Studio.

Session Control API Syntax for Unmanaged Projects

Refer to the information below for Session Control API syntax for unmanaged projects.

`Clear`	`Clear()`
`Snap`	`Snap("<your session file name>.dpxxx")` Where dpxxx is the extension for your analysis type: dpcov, or dpprf.
`SaveNow`	`SaveNow("<your session file name>.dpxxx")` Where dpxxx is the extension for your analysis type: dpcov, or dpprf.

Saving Files through the Session Control API

When you use the Session Control API to take data snapshots or create final session files, you can specify the session file name and directory in the API call.

File names and directories specified in Session Control API calls override file names and directories specified by other means, for example, the `/output` switch on the command line or the `SESSION_FILENAME` or `SESSION_DIR` attributes in the XML configuration file.

- If you specify a file name and directory in the session control `Snap` or `SaveNow` API call, DevPartner saves the file accordingly. If a file with the same name exists in the directory, it will be overwritten.
- If you specify only a directory, DevPartner saves the session under a unique file name based on the name of the target process. DevPartner automatically increments the file name to avoid overwriting existing files.

- If you specify only a file name, DevPartner saves the session under the specified name and determines the destination directory by the means you used to start the application. If you started the application from Visual Studio, the file is saved to the current project's solution directory. If you started the application from the command line with `DPAnalysis.exe`, the file is saved to the **My Documents** or **Documents** directory of the active user account. If a file with the same name exists in the directory, it will be overwritten.
- If you specify neither a file name nor a directory, DevPartner saves the session with a unique file name and determines the destination directory by the means you used to start the application, as above. DevPartner automatically increments the file name to avoid overwriting files.

Note: If your project does not have an output directory, for example, a Visual Studio 2005 Web site project, DevPartner physically saves the files to the project directory.

Note the following when specifying paths:

- DevPartner evaluates the path information relative to the current working directory of the process being profiled. Be aware that in some cases, the working directory can change as the application executes.
- To ensure that you can easily locate your session files, it is a good practice to specify the complete path.
- On the local machine, DevPartner creates the complete path if it does not already exist. If you are collecting data on a remote machine, you must specify an existing directory.
- If you intend to specify a path, but no file name, be sure to terminate the path with a "\" (backslash). DevPartner treats characters following the final backslash as a file name.
- If the path contains invalid data, DevPartner saves the file as though no directory was specified.

Interactions and Precedence

File names and directories specified in Session Control API calls override file names and directories specified by any other means.

Recommendation: Set the file name and directory in either the API call or the command line, but not both.

For example: If you specify only a directory (or a file name) in the Session Control API, but specify a file name (or a directory) in the

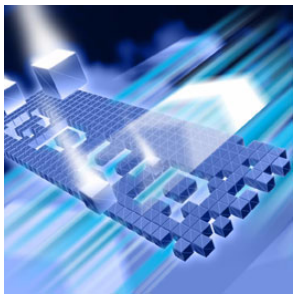
`DPAnalysis.exe` command line or in the XML configuration file, DevPartner combines the information to name and save the file. In this example, if you intended to let DevPartner create unique file names, you would have defeated your purpose.

Recommendation: To simplify file management, specify both snapshots and the final session file with API calls.

For example: If you do not specify a final snapshot (`SaveNow`) through the Session Control API, DevPartner takes a final snapshot when the process terminates. If you started the application with `DPAnalysis.exe`, DevPartner saves the final session file according to the options specified on the command line or in the XML configuration file. If you started the application from Visual Studio, DevPartner displays the unsaved session data.

Appendix E

Exporting Analysis Data to XML



- Introducing DevPartner Data Export
- Exporting Analysis Data to XML
- Exporting Analysis Data to XML from the Command Line

This appendix contains information about exporting analysis data to XML, which can be used with DevPartner coverage analysis, performance analysis, and Performance Expert.

Introducing DevPartner Data Export

DevPartner allows you to export saved session files from coverage analysis, performance analysis, and Performance Expert data to XML. You can export the XML data from Visual Studio or from the command line.

You can analyze the exported XML data using your own or third-party software. For example:

- Use **Export DevPartner Data** on a development build server or QA server where unit tests, functional tests, or regression tests are staged. Analyze the exported XML data to monitor daily progress.
- Use **Export DevPartner Data** to collect data for longer-term analysis. You can accumulate the XML data in a database or data warehouse in order to:
  - Integrate the data with development and QA methodologies, tools and infrastructure
  - Run custom analytics on the data
  - Archive the data for historical or auditing purposes

Exporting Analysis Data to XML

From within Visual Studio, you can export saved DevPartner coverage analysis (`*.dpcov`), coverage analysis merge (`*.dpmrg`), performance analysis (`*.dpprf`), and Performance Expert (`*.dppxp`) data to XML format.

To export to XML in Visual Studio:

1. Open a saved session file (see above).
2. Choose **File > Export DevPartner Data.**

By default, DevPartner saves the XML file in the folder where the session file is saved and appends an `.xml` extension to the saved session file name. For example, `Chart1.dpcov.xml`.

The file `DevPartnerPerformanceCoverage`*xx*`.xsd` defines the XML Schema that DevPartner uses to export coverage analysis and performance analysis data. The file `DevPartnerPerformanceExpert`*xx*`.xsd` defines the XML Schema that DevPartner uses to export Performance Expert data. Both schemas are located in `C:\Program Files\Compuware\DevPartner Studio\Analysis`.

Note: For installs on 64-bit versions of Windows, DevPartner Studio is located at: `\Program Files (x86)\Compuware\DevPartner Studio\Analysis\`.

Exporting Analysis Data to XML from the Command Line

As an alternative to using Visual Studio, you can use `DevPartner.Analysis.DataExport.exe` from a command line to export coverage analysis, coverage analysis merge, performance analysis, and Performance Expert data to XML.

The utility is located in `C:\Program Files\Compuware\DevPartner Studio\Analysis`.

Note: For installs on 64-bit versions of Windows, DevPartner Studio is located at: `\Program Files (x86)\Compuware\DevPartner Studio\Analysis`.

Usage

```
DevPartner.Analysis.DataExport.exe [ sessionfilename |
pathtodirectory ] { options }
```

Options

`/out[put]=<String>`	Specify the local or remote output directory for exported XML files. Creates the directory if the directory does not exist.

`/r[ecurse]`	Search subdirectories for DevPartner session files.
`/f[ilename]=<String>`	Specify the name of the XML output file. Appends .xml to the name specified.
`/showAll`	Shows all performance and coverage session file data available in a performance or coverage session file. For example, if you export a performance session file with this option, the resulting XML file contains both performance and coverage data fields. This option is not available for Performance Expert session files.
`/w[ait]`	Wait for input before closing console window.
`/nologo`	Do not display the logo or copyright notice.
`/help or /?`	Display help in the console window.
`/summary`	Export Performance Expert summary data which includes a default maximum of the top ten callpaths and the top ten methods that use the most CPU resources. Use the `/maxpaths` and `/maxmethods` options to override the maximums. The summary data displays by default.
`/method`	Export Performance Expert method data.
`/calltree`	Export Performance Expert call tree data.
`/maxpaths=<integer>`	Used only with Performance Expert. Exports the specified number of the top call paths that use the most CPU resources.
`/maxmethods=<integer>`	Used only with Performance Expert. Exports the specified number of the top methods that use the most CPU resources.

You can use an equal sign, a colon, or a space to separate an option from the value or values you specify.

Devpartner.Analysis.Export.exe Usage Examples

The following examples show some of the ways you can use `DevPartner.Analysis.DataExport.exe`.

Example 1: Export a coverage analysis session file to an XML file in the same directory.

```
DevPartner.Analysis.DataExport.exe
“c:\WindowsApplication1\WindowsApplication1.dpcov”
```

Output will be saved to:

```
c:\windowsApplication1\WindowsApplication1.dpcov.xml
```

Example 2: Export a performance analysis session file saved in one location to another directory.

```
DevPartner.Analysis.DataExport.exe
“c:\WindowsApplication1\WindowsApplication1.dpprf”
/output=”c:\temp”
```

Output will be saved to: `c:\temp\WindowsApplication1.dpprf.xml`

Example 3: Export multiple Performance Expert session files saved in the same directory.

This example assumes two Performance Expert session files saved in the same directory: `WindowsApplication1.dppxp` and `WindowsApplication2.dppxp`.

```
DevPartner.Analysis.DataExport.exe
“c:\WindowsApplication1\*.dppxp”
```

Output will be saved to:

```
c:\WindowsApplication1\WindowsApplication1.dppxp.xml
c:\WindowsApplication1\WindowsApplication2.dppxp.xml
```

Example 4: Export multiple Coverage Analysis, Performance Analysis, and Performance Expert session files saved in the same directory.

This example assumes three session files saved in the same directory: `WindowsApplication1.dpprf; WindowsApplication2.dpcov; and WindowsApplication3.dppxp`

```
DevPartner.Analysis.DataExport.exe “c:\WindowsApplication1”
```

Output will be saved to these three files:

```
c:\WindowsApplication1\WindowsApplication1.dpprf.xml
c:\WindowsApplication1\WindowsApplication2.dpcov.xml
c:\WindowsApplication1\WindowsApplication3.dppxp.xml
```

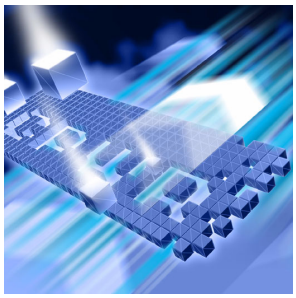
Example 5: Export a Performance Expert summary and change the default output from the top ten methods to the top twenty methods that use the most CPU resources.

```
DevPartner.Analysis.DataExport.exe
“c:WindowsApplication1WindowsApplication1.dppxp”
/summary /maxmethods=20
```

Output will be saved to:

```
c:WindowsApplication1WindowsApplication1.dppxp.xml
```

Index



Symbols

.dpmem file extension
    memory analysis 179
.NET Framework analysis
    error detection 48
.NET Framework call reporting
    error detection 49
.NET Framework methods
    coverage analysis 134, 227
    performance analysis 230
    Performance Expert 262

A

allocating memory
    leaks from methods 196
allocation trace graph
    memory analysis 166, 182, 195
analysis option element
    XML configuration file 354
analysis session controls 365
analysis sessions
    using the session control API 367
analyzing memory leaks
    memory analysis 164
API
    session control 368
    system comparison 314
API call reporting, error detection 40
arguments element
    XML configuration file 357
ASP.NET application
    coverage analysis 142
    memory profiling 212
    performance analysis 236
ASP.NET modules in merge files 151
AutoAlert 330
automating data collection
    Performance Expert 284

B

batch mode 346
    bc.com 56
    bc.exe 56
    code review 93
    DevPartner.Analysis.DataExport.exe 376
    DPAnalysis.exe 345
    error detection 56
    Performance Expert 285

C

C++ 6.0
    session control API 371
C/C++ project
    session control API 370
calculation
    Performance Expert data 261
Call Graph
    code review 89
    memory analysis 181, 201, 203
    performance analysis 243
    Performance Expert 261, 280
Call Stacks tab, Performance Expert 278, 282
Call Tree, Performance Expert 261, 281
call validation
    error detection 36, 41
child methods
    performance analysis 245
    Performance Expert 261
Choose Columns dialog, Performance Expert 278
class list
    memory analysis 171
classes profiled 171
code complexity

code review 85
code review
analyzing results 64
bad fix probability 86
batch mode 93
Call Graph 89
code complexity 85
code violations 80
collecting call graph data 61, 63
collecting metrics 85
collecting metrics data 61, 63
command line 93
excluding projects 61, 63
exporting data 96
filtering results 66
general options 70
getting started 60
Hungarian naming 101
metrics analysis 86
naming analysis 74, 98
naming guidelines, summary 79
naming violations 82
project types, supported 340
quick start 60
ready, set, go procedure 60
repairing violations 64
results window 65
Rule Manager 103
rules database 103
saving session files 68
selecting a rule set 62
selecting naming guidelines 61, 63
starting the session 64
summary of naming guidelines 79
summary of problems 79
collecting data
analysis, remote machines 363
coverage analysis 138
memory analysis 160
multiple processes, memory 212
Performance Expert 258
COM and DCOM
collecting coverage data 147
collecting performance data 242
COM call reporting
error detection 42
COM object tracking
error detection 43
combining coverage session files 142
command line
code review 93
DPAnalysis.exe 345
error detection 56
Performance Expert 279, 284
system comparison 313
XML export, analysis data 376
comparing sessions, performance 246
configuring IIS
coverage analysis 146
controlling analysis sessions
session control file 365
correlating data
coverage analysis 142
performance 235
coverage analysis
and Visual Studio Team System 155
classic Web script application 145
collecting from COM and DCOM 147
COM information property 135
configuring IE 147
correlated data 142
deleting temporary files 146
excluding images 136
exporting a CSV file 153
getting started 126
instrument unmanaged code 139
Instrumentation Manager 139
integration with error detection 154
managed project types, supported 342
merge property 134
merging session data 148
mixed code 140, 234
multiple processes 141
NMSource 146
overview 126
project types, supported 342
properties and options 134
quick start 126
ready, set, go procedure 126
remote systems 141
saving session files 133
security exception 138
session file names 133
session summary tab 131
source tab 131
startup project 134
unexpected file save dialog 143
viewer 153
volatility 148
Web applications 142
Web service 145
XML export 375
CPU/thread use 274
CRBatch.exe 94

CRExport.exe 96
critical path
in performance analysis 244
memory analysis 182, 201
Performance Expert 263, 282
CSV file
exporting from coverage 153
exporting performance data 248

D

data
collecting coverage analysis 138
collecting memory analysis 160
collecting performance analysis 231
collecting Performance Expert 258
combining performance 235
data calculation
Performance Expert 261
data collection
automating Performance Expert 284
data columns
adding to Performance Expert views 278
data export (XML)
code review 96
coverage, performance, Performance Expert 375
error detection 54
deadlock analysis
error detection 43
debugger
memory analysis 174
Performance Expert 259
deleting temporary files
performance analysis 240
development cycle
memory analysis 215
Performance Expert 292
DevPartner
and terminal services 9
and Visual Studio 5
and Visual Studio Team System 8
installed features 6
instrumentation model 231
overview 1
software development cycle 10
toolbar 7
Visual C++ BoundsChecker Suite xiii
DevPartner Enterprise Edition 325
features 329
DevPartner.Analysis.DataExport.exe 376
differ service 303
differences found by system comparison 304
disk I/O 274
displaying data, options for 229
distributed applications
memory analysis 211
Performance Expert 287
DPAnalysis.exe 346
analysis switches 346
command line 346
command line, analysis 345
sample XML configuration file 363
XML configuration file 349
dynamic class list
memory analysis 177

E

E-mail notification 330
error detection
.NET Framework analysis 48
.NET Framework call reporting 49
ActiveCheck 24
API call reporting 40
batch mode 56
call validation 36, 41
COM call reporting 42
COM object tracking 43
command line 56
configuration file management 53
data collection properties 39
deadlock analysis 43
deciding analysis scope 15
deciding error types 16
event logging 54
filter file 34
filtering errors 34
FinalCheck 25
fonts and colors 52
getting started 14
hiding filtered errors 36
leak errors 26
Locate in Transcript 21
managed project types 337
memory and resource viewer 29
memory block checking 37
memory errors 26
memory leak 29
memory overwrite detection 42
memory tracking 45
modules and files 50
pointer errors 26
program error detected 27
project types, supported 337
properties and options 37
quick start 14

ready, set, go procedure 14
resource leaks 29
resource tracking 49
results, interpreting 19
running 17
saving session files 23
settings 37
suppressing errors 31
suppression files 31
suppression libraries 31
system directories 51
viewing filtered errors 36
Visual Studio Team System 58
windows messages 54
event logging
error detection 54
example
exporting session files to XML 377
exclude images element
XML configuration file 358
excluding images
coverage 136
excluding time, performance property 228
exporting data
code review 96
coverage, performance, Performance Expert 375
CSV file from coverage 153
error detection 54
exporting to XML
examples 377

F

file element reference
XML configuration file 350
file I/O 274
file save dialog, unexpected 143
file save dialog, unexpected 237
filter file
error detection 34
filtering errors
error detection 34
FinalCheck 25
Framework methods
coverage analysis 134, 227
performance analysis 230
Performance Expert 262

G

garbage collection
managed code 190
memory analysis 163
object life span 198
getting started
code review 60
coverage analysis 126
error detection 14
memory analysis 159
performance analysis 218
Performance Expert 255
system comparison 297

H

host element
XML configuration file 361
Hungarian naming, code review 101

I

identify execution paths 181
identifying
memory problems 186
IE
configuring for coverage analysis 147
configuring for performance analysis 242
IIS
configuring for coverage analysis 146
configuring for performance analysis 241
installing the system comparison utility 312
instrument inline functions, performance property 228
instrument unmanaged code
coverage analysis 139
instrumentation
coverage analysis 137
performance analysis 231
instrumentation level property, performance 229
Instrumentation Manager
coverage analysis 139
performance analysis 233
instrumenting code
performance analysis 233

L

language reference
Visual Studio 336
launch model
Visual Studio 275
live view
memory analysis 171
long-lived object 198

M

machine.config file, editing 144
managed code
  garbage collection 190
  memory problems 170
managed project
  language reference 336
  using the session control API 369
managed project, supported
  code review 340
  coverage, performance analysis 342
  error detection 337
McCabe metrics, collecting 85
measuring code changes 148
measuring RAM footprint 204
medium-lived objects 198
memory analysis
  .dpmem file extension 179
  allocation trace graph 166, 182, 195
  analyzing collected data 164
  ASP.NET application 212
  Call Graph 181, 201, 203
  class list 171
  collecting data 160
  critical path 182
  defining memory leaks 190
  development cycle 215
  distributed applications 211
  dynamic class list 177
  features, benefits 171
  force garbage collection 163
  garbage collection 160, 188, 190
  getting started 159
  identifying scalability problems 199
  interpreting real-time graph 200
  interpreting results 191
  introduction 158
  leak analysis results 190
  leaked memory graph 196
  locating memory leaks 188
  managing object references 167
  memory leak definition 159
  memory problems 159
  memory related symptoms 170
  multiple process data collection 212
  navigating source tab 184
  navigation frame 181
  object distribution 205
  object leaked memory graph 193
  object life span 198
  object reference 188, 207
  object reference graph 166, 179
  optimizing memory use 210
  potential problem areas 187
  project types, supported 344
  properties and options 171
  quick start 159
  RAM footprint 204
  ready, set, go procedure 159
  real-time graph 171, 199
  real-time graph patterns 176, 187
  running a session 187
  saving session files 169
  scalability problem results 203
  session control window 161, 175
  session file 171
  session file integration 179
  source code view 166
  source view 202
  starting a session 174
  temporary objects 197, 201
  tools, symptoms 187
  track system object 171
  tracking leaks 161
  viewing managed heap 171
  viewing source code 184
  Web applications 211
  what is memory analysis? 158
memory and resource viewer
  error detection 29
memory block checking
  error detection 37
memory errors
  error detection 26
memory leak
  objects, methods 191
  results summary 195
memory leaks
  error detection 29
memory overwrite detection
  error detection 42
memory problems
  alternate approach 195
  identifying 186
  managed code, Visual Studio 170
  symptoms 170
memory tracking
  error detection 45
merge property, coverage analysis 134
merging session data with ASP.NET 151
merging session data, coverage 148
method
  allocate most leaked memory 196
  most leaked memory 191

mixed code
coverage analysis 140, 234
multiple processes
coverage analysis 141
memory analysis 212
performance analysis 234
Performance Expert 283, 287

N

name element
XML configuration file 360
naming analysis, code review 98
navigation frame
memory analysis 181
network I/O 274, 276
nmexclud.txt 137
NMSource 146, 240

O

object reference
memory analysis 160, 188
most allocated memory 207
most leaked memory 193
object reference graph
memory analysis 166, 179
object reference management
memory analysis 167
object sequencing for performance 167
options and properties 70
code review 69
coverage analysis 134
error detection 37
memory analysis 171
performance analysis 227
Performance Expert 271

P

parent methods
performance analysis 245
Performance Expert 261
path element
XML configuration file 356
performance
optimizing memory use 210
performance analysis 226
and Visual Studio Team System 252
call graph 243
collecting COM data 242
COM project property 228
comparing sessions 246
configuring IE 242
correlating data 235
critical path in call graph 244
display options 229
exclude others property 228
excluding images 230
exporting in CSV format 248
getting started 218
IIS, configuring 241
instrument inline functions 228
instrumentation level property 229
instrumenting code 233
managed project types, supported 342
multiple processes 234
NMSource 240
overview 218
project types, supported 342
quick start 218
ready, set, go procedure 218
recursive functions 242
remote systems 235
results 221
saving session files 226
security exception 232
session data 221
session summary tab 225
unexpected file save dialog 237
viewer 250
Web applications 236
Web script applications 238
XML export 375
Performance Expert
.NET Framework methods 262
automating data collection 284
batch mode 285
Call Graph 261, 280
Call Stacks tab 278, 282
Call Tree 261
collecting data 258
command line 279, 284
data calculation 261
debugger 259
development cycle 292
distributed applications 287
DPAnalysis.exe 279, 284
exporting data to XML 290
multiple processes 283, 287
options and properties 271
path analysis vs. method analysis 261
project types, supported 344
properties and options 271
quick start 255

ready, set, go procedure 255
real-time graph 258
results summary 259
session controls 258
session files 270
session window 258
settings 271
solution properties 271
source code 278
source code on remote systems 284
startup project 272
system methods 262
troubleshooting 282, 288
usage scenarios 276
Web applications 282
XML configuration file 285
XML export 375
XML schema 291
plug-in, system comparison 317
process element
XML configuration file 352
profiled classes
memory analysis 171
program error detected, error detection 27
project types, supported
code review 340
coverage, performance analysis 342
error detection 337
memory analysis 344
Performance Expert 344
properties and options
code review 70
coverage analysis 134
error detection 37
memory analysis 171
performance analysis 227
Performance Expert 271

Q

quick start
code review 60
coverage analysis 126
error detection 14
performance analysis 218
Performance Expert 255
system comparison 297

R

RAM footprint
allocation trace graph 182
interpreting data 204
ready, set, go procedure
coverage analysis 126
performance analysis 218
Performance Expert 255
ready, set, go procedure
memory analysis 159
real-time graph
interpreting memory 187
Performance Expert 258
real-time graph patterns
memory analysis 176
Reconcile 329
recursive functions in performance analysis 242
registry keys, finding with system comparison 308
remote desktop 9
remote machines
collecting analysis data 363
remote systems
coverage analysis 141
memory analysis 211
performance analysis 235
Performance Expert 287
resource leaks
error detection 29
resource tracking
error detection 49
results
code review 64
coverage analysis 129
error detection 19
memory analysis, memory leak 190
memory analysis, real-time graph 200
memory analysis, scalability 203
performance analysis 221
Performance Expert 259
system comparison 301
Rule Manager, code review 103
runtime analysis element
XML configuration file 350

S

SamplePlugin.cs 318
saving session files
code review 68
coverage analysis 133
error detection 23
memory analysis 169
performance analysis 226
Performance Expert 270
scalability problem
interpreting results, fixing 203
memory analysis 199

solving memory issues 197
SDK
system comparison 314
security exception
coverage analysis 138
memory analysis 215
performance analysis 232
Performance Expert 275
service element
XML configuration file 359
session control API
analysis sessions 367
interactions and precedence 372
managed applications 369
saving session files 371
unmanaged applications 370
session control file
introducing 365
user interface, creating 366
session controls
coverage analysis 128
memory analysis 175
performance analysis 220
Performance Expert 258
session data
merging 148
performance analysis 221
session file integration
memory analysis 179
session files
comparing performance 246
memory analysis 171
naming, performance analysis 226
Performance Expert 270
saving, memory analysis 169
session control API 371
viewing outside Visual Studio 153
sessioncontrol.txt 365
settings
coverage analysis 134
error detection 37
memory analysis 171
performance analysis 227
Performance Expert 271
short-lived object 198
skipverification
security exception solution 215
snapshot API 314
snapshots
changing number kept 303
changing time 304
solution properties
coverage analysis 134
memory analysis 171
performance analysis 227
Performance Expert 271
solving memory problems
alternate approach 195
source code, viewing
code review 66
coverage analysis 131
memory analysis 184
on remote systems, Performance Expert 284
performance analysis 224
Performance Expert 278
source file
coverage analysis, changing 150
memory analysis, changing 186
source tab
memory analysis 184
source view
memory analysis 202
startup project
coverage analysis 134
memory analysis 159
performance analysis 227
Performance Expert 272
summary tab
coverage analysis 131
supported project types 335
suppressing errors
error detection 31
switches
DPAnalysis.exe 346
synchronization wait time 274
syntax
session control API 371
system comparison
analyzing results 301
categories of differences 304
changing settings 303
command line 313
finding files 309
gathering different data 317
getting started 297
installing 312
overview 296
plug-in 317
quick start 297
ready, set, go procedure 297
registry keys 308
SamplePlugin.cs 318
SDK 314
service 303

snapshot API 314
system methods
coverage analysis 134, 227
performance analysis 230
Performance Expert 262

T

target element
XML configuration file 351
temporary files
deleting, performance 240
temporary objects
analysis summary 203
memory analysis 197, 198, 201
terminal services 9
toolbar, DevPartner 7
track system object
memory analysis 171
tracking memory leaks
memory analysis 161
TrackRecord
integration with DevPartner 332
merging coverage sessions 332
submitting sessions 332
toolbar buttons 332

U

unmanaged applications
session control API 370
unmanaged project
language reference 336
using XML exported analysis data 375
utilities, command line
bc.com 56
bc.exe 56
CRBatch.exe 94
CRExport.exe 96
DPanalysis.exe 346
DPAnalysis.exe, options 346
XML export, analysis data 376

V

violations, code
code review 80
violations, naming
code review 82
Visual Studio
language reference 336
launch model 275
managing memory problems 170
Visual Studio integration 5
Visual Studio Team System
overview of support 8
submitting coverage data 155
submitting performance data 252
volatility, shown with coverage analysis 148

W

wait time 274
weak references 167
Web applications
coverage analysis 142
memory analysis 211
performance analysis 236
Performance Expert 282
project types, supported 335
Web script applications
coverage analysis 145
performance analysis 238
Web service
coverage analysis 145
performance analysis 240
web.config
coverage analysis requirements 143
performance analysis requirements 236
Performance Expert requirements 283
windows messages
error detection 54
working directory element
XML configuration file 357

X

XML
exporting code review data 96
XML configuration file
DPAnalysis.exe 349
file element reference 350
Performance Expert 285
sample files, location 363
XML schema
coverage, performance location 376
Performance Expert 291
XML schema file 376