

Contents

<i>Foreword</i>	xv
<i>Introduction</i>	xvii
Who Should Read This Book	xviii
Assumptions	xviii
Organization of This Book	xviii
Conventions in This Book	xix
System Requirements	xx
Code Samples	xxi
Installing the Code Samples	xxi
Running the Code Samples	xxii
Acknowledgments	xxvi
Errata & Book Support	xxvii
We Want to Hear from You	xxvii
Stay in Touch	xxviii

PART I A BIT OF BACKGROUND

Chapter 1 Software Development in Windows	3
Windows Evolution	3
Windows Release History	3
Supported CPU Architectures	4
Windows Build Flavors	5
Windows Servicing Terminology	6
Windows Architecture	7
Kernel Mode vs. User Mode	8
User-Mode System Processes	9
User-Mode Application Processes	10
Low-Level Windows Communication Mechanisms	13
Windows Developer Interface	16

Diagnosing Host/Target Communication Issues	76
Understanding the KD Break-in Sequence	77
Controlling the Target in the Kernel Debugger	78
Setting Code Breakpoints in the Kernel Debugger	81
Getting Help for WinDbg Kernel Debugging Commands	83
Summary	83

Chapter 3 How Windows Debuggers Work 85

User-Mode Debugging	85
Architecture Overview	86
Win32 Debugging APIs	87
Debug Events and Exceptions	88
The Break-in Sequence	91
Setting Code Breakpoints	93
Observing Code Breakpoint Insertion in WinDbg	93
Kernel-Mode Debugging	98
Architecture Overview	98
Setting Code Breakpoints	100
Single-Stepping the Target	100
Switching the Current Process Context	101
Managed-Code Debugging	103
Architecture Overview	103
The SOS Windows Debuggers Extension	106
Script Debugging	112
Architecture Overview	112
Debugging Scripts in Visual Studio	114
Remote Debugging	116
Architecture Overview	116
Remote Debugging in WinDbg	117
Remote Debugging in Visual Studio	121
Summary	123

Chapter 4	Postmortem Debugging	125
	Just-in-Time Debugging	125
	Your First JIT Debugging Experiment	126
	How Just-in-Time Debugging Works	128
	Using Visual Studio as Your JIT Debugger	132
	Run-Time Assertions and JIT Debugging	138
	JIT Debugging in Session 0.	139
	Dump Debugging	139
	Automatic User-Mode, Crash-Dump Generation	139
	Analyzing Crash Dumps Using the WinDbg Debugger	143
	Analyzing Crash Dumps in Visual Studio	150
	Manual Dump-File Generation	151
	“Time Travel” Debugging	153
	Kernel-Mode Postmortem Debugging	153
	Summary	157
Chapter 5	Beyond the Basics	159
	Noninvasive Debugging	159
	Data Breakpoints	162
	Deep Inside User-Mode and Kernel-Mode Data Breakpoints	163
	Clearing Kernel-Mode Data Breakpoints	165
	Execution Data Breakpoints vs. Code Breakpoints	166
	User-Mode Debugger Data Breakpoints in Action: C++	
	Global Objects and the C Runtime Library	168
	Kernel-Mode Debugger Data Breakpoints in Action:	
	Waiting for a Process to Exit	170
	Advanced Example: Who Is Changing a Registry Value?	172
	Scripting the Debugger	176
	Replaying Commands Using Debugger Scripts	176
	Debugger Pseudo-Registers	178
	Resolving C++ Template Names in Debugger Scripts	180
	Scripts in Action: Listing Windows Service Processes in the	
	Kernel Debugger	181

WOW64 Debugging	183
The WOW64 Environment	183
Debugging of WOW64 Processes	184
Windows Debugging Hooks (GFLAGS)	187
Systemwide vs. Process-Specific NT Global Flags	187
The GFLAGS Tool	188
The <i>!gflag</i> Debugger Extension Command	191
Impact of User-Mode Debuggers on the Value of the NT Global Flag	193
The Image File Execution Options Hooks	193
Summary	194

Chapter 6 Code Analysis Tools 195

Static Code Analysis	195
Catching Your First Crashing Bug Using VC++ Static Code Analysis	196
SAL Annotations	199
Other Static Analysis Tools	202
Runtime Code Analysis	206
Catching Your First Bug Using the Application Verifier Tool	206
A Behind-the-Scenes Look: Verifier Support in the Operating System	209
The <i>!avrf</i> Debugger Extension Command	214
The Application Verifier as a Quality Assurance Tool	217
Summary	217

Chapter 7 Expert Debugging Tricks 219

Essential Tricks	220
Waiting for a Debugger to Attach to the Target	220
Breaking on DLL Load Events	222
Debugging Process Startup	227
Debugging Child Processes	234

More Useful Tricks	245
Debugging Error-Code Failures.....	245
Breaking on First-Chance Exception Notifications.....	252
Freezing Threads	253
Kernel-Mode Debugging Tricks.....	255
Breaking on User-Mode Process Creation.....	255
Debugging the Startup of User-Mode Processes.....	259
Breaking on DLL Load Events.....	260
Breaking on Unhandled SEH Exceptions	262
Freezing Threads	262
Summary.....	265

Chapter 8 Common Debugging Scenarios, Part 1 267

Debugging Access Violations	267
Understanding Memory Access Violations	268
The <i>!analyze</i> Debugger Extension Command	269
Debugging Heap Corruptions	271
Debugging Native Heap Corruptions.....	271
Debugging Managed (GC) Heap Corruptions	281
Debugging Stack Corruptions	291
Stack-Based Buffer Overruns	291
Using Data Breakpoints in Stack Corruption Investigations.....	294
Reconstructing Call Frames from Corrupted Stacks	295
Debugging Stack Overflows	297
Understanding Stack Overflows	297
The <i>!kf</i> Debugger Command	299
Debugging Handle Leaks	300
A Handle Leak Example	300
The <i>!htrace</i> Debugger Extension Command.....	302
Debugging User-Mode Memory Leaks	307
Detecting Resource Leaks Using the Application Verifier Tool ..	307
Investigating Memory Leaks Using the UMDH Tool	310
Extending the Strategy:	
A Custom Reference Stack-Trace Database.....	314

Debugging Kernel-Mode Memory Leaks	316
Kernel Memory Basics	316
Investigating Kernel-Mode Leaks Using Pool Tagging	318
Summary	322
Chapter 9 Common Debugging Scenarios, Part 2	323
Debugging Race Conditions	323
Shared-State Consistency Bugs	324
Shared-State Lifetime Management Bugs	330
DLL Module Lifetime-Management Bugs	340
Debugging Deadlocks	343
Lock-Ordering Deadlocks	344
Logical Deadlocks	348
Debugging Access-Check Problems	352
The Basic NT Security Model	353
Windows Vista Improvements	358
Wrapping Up	362
Summary	363
Chapter 10 Debugging System Internals	365
The Windows Console Subsystem	365
The Magic Behind <i>printf</i>	366
Handling of Windows UI Events	373
Handling of the Ctrl+C Signal	374
Anatomy of System Calls	380
The User-Mode Side of System Calls	381
The Transition into Kernel Mode	383
The Kernel-Mode Side of System Calls	385
Summary	387

PART III OBSERVING AND ANALYZING SOFTWARE BEHAVIOR

Chapter 11 Introducing Xperf 391

- Acquiring Xperf 391
- Your First Xperf Investigation 396
 - Devising an Investigation Strategy 397
 - Collecting an ETW Trace for the Scenario 397
 - Analyzing the Collected ETW Trace 399
- Xperf's Strengths and Limitations 411
- Summary 412

Chapter 12 Inside ETW 415

- ETW Architecture 416
 - ETW Design Principles 416
 - ETW Components 417
 - The Special NT Kernel Logger Session 418
 - Configuring ETW Sessions Using Xperf 419
- Existing ETW Instrumentation in Windows 422
 - Instrumentation in the Windows Kernel 422
 - Instrumentation in Other Windows Components 426
- Understanding ETW Stack-Walk Events 431
 - Enabling and Viewing Stack Traces for Kernel Provider Events . . . 432
 - Enabling and Viewing Stack Traces for User Provider Events . . . 434
 - Diagnosing ETW Stack-Trace Issues 436
- Adding ETW Logging to Your Code 441
 - Anatomy of ETW Events 441
 - Logging Events Using the ETW Win32 APIs 445
- Boot Tracing in ETW 449
 - Logging Kernel Provider Events During Boot 450
 - Logging User Provider Events During Boot 452
- Summary 455

Chapter 13 Common Tracing Scenarios 457

Analyzing Blocked Time. 458
 The *CSwitch* and *ReadyThread* ETW Events. 459
 Wait Analysis Using Visual Studio 2010 461
 Wait Analysis Using Xperf. 467
Analyzing Memory Usage. 473
 Analyzing High-Level Memory Usage in a Target Process. 474
 Analyzing NT Heap Memory Usage 475
 Analyzing GC Heap (.NET) Memory Usage. 481
Tracing as a Debugging Aid 490
 Tracing Error Code Failures. 490
 Tracing System Internals 494
Summary. 502

Chapter 14 WinDbg User-Mode Debugging Quick Start 505

Starting a User-Mode Debugging Session. 505
Fixing the Symbols Path. 505
Fixing the Sources Path 506
Displaying the Command Line of the Target Process. 507
Control Flow Commands 507
Listing Loaded Modules and Their Version 508
Resolving Function Addresses 509
Setting Code (Software) Breakpoints 509
Setting Data (Hardware) Breakpoints 510
Switching Between Threads 511
Displaying Call Stacks. 511
Displaying Function Parameters. 512
Displaying Local Variables. 513
Displaying Data Members of Native Types 513

Navigating Between Call Frames	514
Listing Function Disassembly	515
Displaying and Modifying Memory and Register Values	516
Ending a User-Mode Debugging Session.	518
Chapter 15 WinDbg Kernel-Mode Debugging Quick Start	519
Starting a Kernel-Mode Debugging Session	519
Switching Between CPU Contexts	519
Displaying Process Information	520
Displaying Thread Information.	521
Switching Process and Thread Contexts	522
Listing Loaded Modules and Their Version	523
Setting Code (Software) Breakpoints Inside Kernel-Mode Code	524
Setting Code (Software) Breakpoints Inside User-Mode Code.	525
Setting Data (Hardware) Breakpoints	525
Ending a Kernel-Mode Debugging Session	526
 <i>Index</i>	 527
 <i>About the Author</i>	 561

What do you think of this book? We want to hear from you!

Microsoft is interested in hearing your feedback so we can continually improve our books and learning resources for you. To participate in a brief online survey, please visit:

microsoft.com/learning/booksurvey