

Contents

| | |
|--|-------------|
| <i>About the Author</i> | <i>xiii</i> |
| <i>About the Technical Reviewer</i> | <i>xiv</i> |
| <i>Acknowledgments</i> | <i>xv</i> |
| <i>Introduction</i> | <i>xvii</i> |
| Chapter 1 Language Interoperability | 1 |
| <i>Language Interoperability in Action</i> | <i>1</i> |
| <i>Language Interoperability in Theory</i> | <i>8</i> |
| <i>Language Interoperability in Practice</i> | <i>12</i> |
| <i>Conclusion</i> | <i>21</i> |
| Chapter 2 ilasm Directives and Attributes | 23 |
| <i>General Assembly ilasm</i> | <i>23</i> |
| Defining the Assembly | <i>23</i> |
| Defining the Modules | <i>30</i> |
| Defining the UI | <i>30</i> |
| Concurrent Assembly Execution | <i>31</i> |
| Defining Data Segments | <i>31</i> |
| <i>Type-Specific Directives</i> | <i>32</i> |
| Defining the Type | <i>32</i> |
| <i>Adding Fields to a Type</i> | <i>41</i> |
| Field Scope | <i>42</i> |
| Field Initialization | <i>43</i> |
| serializable Redux | <i>44</i> |
| <i>Adding Methods to Types</i> | <i>45</i> |
| Type and Instance Methods | <i>45</i> |
| Method Implementation Details | <i>46</i> |
| Calling Conventions | <i>46</i> |
| Passing Arguments | <i>48</i> |
| Unmanaged Calls | <i>48</i> |
| Type and Instance Initializers | <i>49</i> |
| beforefieldinit Redux | <i>50</i> |
| Exporting Methods | <i>51</i> |
| Method Body Directives | <i>53</i> |
| <i>Defining Properties in Types</i> | <i>62</i> |
| <i>Adding Events to Types</i> | <i>64</i> |
| <i>Conclusion</i> | <i>67</i> |

| | |
|--|---------|
| Chapter 3 CIL Opcodes | 69 |
| <i>Basic Stack Information</i> | 69 |
| <i>Opcode Essentials</i> | 70 |
| <i>Basic Opcodes</i> | 71 |
| Using Local Variables | 71 |
| Conversions | 74 |
| Using Method Arguments | 77 |
| Using Type Fields | 79 |
| <i>Basic Operations</i> | 80 |
| Arithmetic Operations | 80 |
| Binary Operations | 83 |
| Comparison Operations | 85 |
| <i>Object Instructions</i> | 86 |
| Creating Type Instances | 86 |
| Calling Methods | 88 |
| Constructors | 91 |
| Unmanaged Method Calls | 91 |
| Method Pointers | 93 |
| Boxing, Unboxing, and Value Type Indirection | 94 |
| Type Casting | 96 |
| Array Manipulation | 97 |
| Memory Manipulation | 99 |
| String Manipulation | 101 |
| <i>Controlling Code Flow</i> | 102 |
| <i>Handling Exceptions</i> | 106 |
| <i>Opcode Miscellanea</i> | 114 |
| Variable Argument Lists | 114 |
| .maxstack Calculations | 116 |
| Pointer Prefixes | 117 |
| Method Jumps | 117 |
| <i>Conclusion</i> | 119 |
| Chapter 4 ilasm and CIL in Practice | 121 |
| <i>Generating Random Numbers</i> | 121 |
| <i>Designing the Essentials</i> | 122 |
| <i>Implementing the Essentials</i> | 123 |
| Stubbing Out the Delegate | 123 |
| Field Definitions | 125 |
| Event Methods | 125 |

| | |
|--|-----|
| Constructors | 127 |
| Creating the Properties | 128 |
| Implementing Generate() | 129 |
| Implementing GenerateViaDelegate() | 131 |
| Implementing GenerateViaEvent() | 132 |
| Generating the RIG Assembly | 133 |
| <i>Designing the Test Harness</i> | 133 |
| <i>Implementing the Test Harness</i> | 134 |
| Referencing Assemblies for UI Design | 134 |
| Defining UI Components | 135 |
| Initializing the Form | 136 |
| Calling Generate() | 138 |
| Calling GenerateViaDelegate() | 141 |
| Calling GenerateViaEvent() | 143 |
| Generating the RIGTestClient Assembly | 144 |
| <i>Conclusion</i> | 147 |
| <i>Chapter 5 Debugging CIL</i> | 149 |
| <i>Debug Builds</i> | 149 |
| <i>The Command-Line Tool: cordbg.exe</i> | 151 |
| cordbg Basics | 151 |
| Watching Register Values and Native Instructions | 156 |
| Setting Breakpoints | 159 |
| Modes | 160 |
| Recording and Using cordbg Scripts | 161 |
| <i>The GUI Tool: dbgclr.exe</i> | 163 |
| Debugging Windows | 165 |
| Saving the Solution | 170 |
| Debugger Differences | 171 |
| <i>Debugging In-Process Assemblies</i> | 171 |
| DLLs in dbgclr | 171 |
| DLLs in cordbg | 176 |
| <i>Registry Control</i> | 176 |
| <i>Verifying Assemblies</i> | 178 |
| <i>Debugging Compiled Programs</i> | 182 |
| Preventing Recompilation | 186 |
| <i>Conclusion</i> | 192 |

| | |
|---|-----|
| Chapter 6 .NET Languages and CIL | 193 |
| <i>Debug and Release Builds</i> | 193 |
| The C# Implementation | 194 |
| The VB .NET Implementation | 198 |
| The Component Pascal Implementation | 202 |
| Commentary | 204 |
| <i>Language Constructs</i> | 205 |
| VB .NET's With Statement | 205 |
| Implementing Interface Methods | 208 |
| On Error Resume Next, or How to Create a Lot of CIL | 214 |
| Active Objects | 221 |
| <i>Language Interoperability: The Real Story</i> | 224 |
| Inheritance with Oberon .NET Types | 224 |
| Overloaded and Overridden Methods | 226 |
| The Other Property | 230 |
| Overloading Methods in CIL | 234 |
| <i>Conclusion</i> | 237 |
| Chapter 7 Emitting Types | 239 |
| <i>Applying CIL</i> | 239 |
| <i>Emitter Basics</i> | 240 |
| Defining the Essentials | 240 |
| Creating Assemblies | 241 |
| Building Types | 243 |
| Adding Fields | 244 |
| <i>Emitting Methods</i> | 244 |
| Adding Methods | 244 |
| Implementing Methods | 246 |
| Exception Handling | 250 |
| <i>Persisting the Results</i> | 251 |
| Baking Types | 251 |
| Transient-Only Assemblies | 252 |
| Persistent-Only Assemblies | 252 |
| Transient, Persistent Assemblies | 254 |
| <i>Beyond the Basics</i> | 254 |
| Setting Entry Points | 254 |
| Adding Attributes | 255 |
| Modifying Method Parameter Information | 256 |

| | |
|---|-----|
| <i>Debugging Dynamic Assemblies</i> | 258 |
| Emitting Debug Information | 258 |
| Adding to the Symbol Writer | 258 |
| Reloading the Assembly | 260 |
| Where's the Target IL File? | 262 |
| Creating the DebugFile Class | 263 |
| Debugging Transient Modules | 269 |
| <i>Conclusion</i> | 270 |

Chapter 8 Dynamic Proxies in .NET271

| | |
|---|-----|
| <i>Separating Concerns</i> | 271 |
| <i>Functional Specifications</i> | 274 |
| <i>Class Design and Method Call Conditions</i> | 275 |
| Receiving a Notification before Method Invocation | 276 |
| Receiving a Notification after Method Invocation | 277 |
| When Method Invocations Go Bad | 278 |
| Proxy Call Flow | 278 |
| <i>Implementing Proxy Creation</i> | 279 |
| Preconditional Checks | 279 |
| Caching Types, Modules, and Assemblies | 282 |
| Defining the Constructors | 285 |
| Implementing the Interfaces | 287 |
| Invoking Target Methods | 287 |
| Setting Up the Method Hooks | 294 |
| <i>Testing the Solution</i> | 301 |
| Loading the Form | 302 |
| Creating Proxies | 302 |
| Type Inspection | 305 |
| <i>Contexts and .NET</i> | 309 |
| Dynamic Proxies and Contexts | 314 |
| <i>Conclusion</i> | 315 |

Chapter 9 CIL Tips317

| | |
|---|-----|
| <i>Be CLS-Compliant Aware</i> | 317 |
| <i>Use Verification Tools</i> | 317 |
| <i>Comments and Code Regions</i> | 318 |
| <i>Stay Location Savvy When Emitting Assemblies</i> | 318 |
| <i>Final Thoughts</i> | 318 |

| | |
|--|---------|
| <i>Appendix A The Future of CIL</i> | 319 |
| <i>Generics in CIL</i> | 319 |
| <i>Extended IL</i> | 322 |
| <i>Inline CIL</i> | 324 |
| <i>Appendix B .NET Languages</i> | 327 |
| <i>Index</i> | 329 |