

Covers C# 4



C# IN DEPTH

SECOND EDITION

Jon Skeet

FOREWORD BY ERIC LIPPERT

MANNING

contents

foreword xix
preface xxi
acknowledgments xxiii
about this book xxv

PART 1 PREPARING FOR THE JOURNEY 1

I *The changing face of C# development* 3

1.1 Starting with a simple data type 4

The Product type in C# 1 4 ■ *Strongly typed collections in C# 2* 6 ■ *Automatically implemented properties in C# 3* 7
Named arguments in C# 4 7

1.2 Sorting and filtering 9

Sorting products by name 9 ■ *Querying collections* 12

1.3 Handling an absence of data 14

Representing an unknown price 14 ■ *Optional parameters and default values* 15

1.4 Introducing LINQ 16

Query expressions and in-process queries 16 ■ *Querying XML* 17 ■ *LINQ to SQL* 18

1.5	COM and dynamic typing	19
	<i>Simplifying COM interoperability</i>	19
	<i>Interoperating with a dynamic language</i>	20
1.6	Dissecting the .NET platform	21
	<i>C#, the language</i>	22
	<i>Runtime</i>	22
	<i>Framework libraries</i>	22
1.7	Making your code super awesome	23
	<i>Presenting full programs as snippets</i>	23
	<i>Didactic code isn't production code</i>	24
	<i>Your new best friend: the language specification</i>	25
1.8	Summary	26

2 Core foundations: building on C# 1 27

2.1	Delegates	28
	<i>A recipe for simple delegates</i>	28
	<i>Combining and removing delegates</i>	33
	<i>A brief diversion into events</i>	34
	<i>Summary of delegates</i>	35
2.2	Type system characteristics	36
	<i>C#'s place in the world of type systems</i>	36
	<i>When is C# 1's type system not rich enough?</i>	39
	<i>Summary of type system characteristics</i>	42
2.3	Value types and reference types	42
	<i>Values and references in the real world</i>	43
	<i>Value and reference type fundamentals</i>	43
	<i>Dispelling myths</i>	45
	<i>Boxing and unboxing</i>	47
	<i>Summary of value types and reference types</i>	48
2.4	Beyond C# 1: new features on a solid base	48
	<i>Features related to delegates</i>	49
	<i>Features related to the type system</i>	51
	<i>Features related to value types</i>	53
2.5	Summary	54

PART 2 C# 2: SOLVING THE ISSUES OF C# 155

3 Parameterized typing with generics 57

3.1	Why generics are necessary	58
3.2	Simple generics for everyday use	60
	<i>Learning by example: a generic dictionary</i>	60
	<i>Generic types and type parameters</i>	62
	<i>Generic methods and reading generic declarations</i>	65

3.3	Beyond the basics	68
	<i>Type constraints</i>	69
	<i>Type inference for type arguments of generic methods</i>	74
	<i>Implementing generics</i>	75
3.4	Advanced generics	81
	<i>Static fields and static constructors</i>	81
	<i>How the JIT compiler handles generics</i>	83
	<i>Generic iteration</i>	85
	<i>Reflection and generics</i>	88
3.5	Limitations of generics in C# and other languages	91
	<i>Lack of generic variance</i>	92
	<i>Lack of operator constraints or a “numeric” constraint</i>	97
	<i>Lack of generic properties, indexers, and other member types</i>	98
	<i>Comparison with C++ templates</i>	99
	<i>Comparison with Java generics</i>	100
3.6	Summary	101

4

Saying nothing with nullable types 103

4.1	What do you do when you just don't have a value?	104
	<i>Why value type variables can't be null</i>	104
	<i>Patterns for representing null values in C# 1</i>	105
4.2	System.Nullable<T>and System.Nullable	107
	<i>Introducing Nullable<T></i>	107
	<i>Boxing Nullable<T>and unboxing</i>	110
	<i>Equality of Nullable<T> instances</i>	111
	<i>Support from the nongeneric Nullable class</i>	111
4.3	C# 2's syntactic sugar for nullable types	112
	<i>The ? modifier</i>	113
	<i>Assigning and comparing with null</i>	114
	<i>Nullable conversions and operators</i>	116
	<i>Nullable logic</i>	119
	<i>Using the as operator with nullable types</i>	120
	<i>The null coalescing operator</i>	121
4.4	Novel uses of nullable types	124
	<i>Trying an operation without using output parameters</i>	124
	<i>Painless comparisons with the null coalescing operator</i>	126
4.5	Summary	129

5

Fast-tracked delegates 130

5.1	Saying goodbye to awkward delegate syntax	131
5.2	Method group conversions	133
5.3	Covariance and contravariance	134
	<i>Contravariance for delegate parameters</i>	135
	<i>Covariance of delegate return types</i>	136
	<i>A small risk of incompatibility</i>	138

5.4	Inline delegate actions with anonymous methods	138
	<i>Starting simply: acting on a parameter</i>	139
	<i>Returning values from anonymous methods</i>	141
	<i>Ignoring delegate parameters</i>	143
5.5	Capturing variables in anonymous methods	144
	<i>Defining closures and different types of variables</i>	145
	<i>Examining the behavior of captured variables</i>	146
	<i>What's the point of captured variables?</i>	147
	<i>The extended lifetime of captured variables</i>	148
	<i>Local variable instantiations</i>	149
	<i>Mixtures of shared and distinct variables</i>	151
	<i>Captured variable guidelines and summary</i>	153
5.6	Summary	154

6 *Implementing iterators the easy way* 156

6.1	C# 1: the pain of handwritten iterators	157
6.2	C# 2: simple iterators with yield statements	160
	<i>Introducing iterator blocks and yield return</i>	160
	<i>Visualizing an iterator's workflow</i>	162
	<i>Advanced iterator execution flow</i>	164
	<i>Quirks in the implementation</i>	167
6.3	Real-life iterator examples	169
	<i>Iterating over the dates in a timetable</i>	169
	<i>Iterating over lines in a file</i>	170
	<i>Filtering items lazily using an iterator block and a predicate</i>	173
6.4	Pseudo-synchronous code with the Concurrency and Coordination Runtime	175
6.5	Summary	177

7 *Concluding C# 2: the final features* 179

7.1	Partial types	180
	<i>Creating a type with multiple files</i>	181
	<i>Uses of partial types</i>	183
	<i>Partial methods—C# 3 only!</i>	184
7.2	Static classes	186
7.3	Separate getter/setter property access	189
7.4	Namespace aliases	190
	<i>Qualifying namespace aliases</i>	191
	<i>The global namespace alias</i>	192
	<i>Extern aliases</i>	192
7.5	Pragma directives	194
	<i>Warning pragmas</i>	194
	<i>Checksum pragmas</i>	195
7.6	Fixed-size buffers in unsafe code	196

7.7	Exposing internal members to selected assemblies	198
	<i>Friend assemblies in the simple case</i>	198
	<i>Why use InternalsVisibleTo?</i>	199
	<i>InternalsVisibleTo and signed assemblies</i>	199
7.8	Summary	200

PART 3 C# 3: REVOLUTIONIZING HOW WE CODE..... 201

8	Cutting fluff with a smart compiler	203
8.1	Automatically implemented properties	204
8.2	Implicit typing of local variables	207
	<i>Using var to declare a local variable</i>	207
	<i>Restrictions on implicit typing</i>	208
	<i>Pros and cons of implicit typing</i>	209
	<i>Recommendations</i>	211
8.3	Simplified initialization	211
	<i>Defining our sample types</i>	212
	<i>Setting simple properties</i>	213
	<i>Setting properties on embedded objects</i>	214
	<i>Collection initializers</i>	215
	<i>Uses of initialization features</i>	218
8.4	Implicitly typed arrays	219
8.5	Anonymous types	220
	<i>First encounters of the anonymous kind</i>	220
	<i>Members of anonymous types</i>	222
	<i>Projection initializers</i>	223
	<i>What's the point?</i>	225
8.6	Summary	226

9	Lambda expressions and expression trees	227
9.1	Lambda expressions as delegates	229
	<i>Preliminaries: introducing the Func<...> delegate type</i>	229
	<i>First transformation to a lambda expression</i>	230
	<i>Using a single expression as the body</i>	231
	<i>Implicitly typed parameter lists</i>	231
	<i>Shortcut for a single parameter</i>	232
9.2	Simple examples using List<T> and events	233
	<i>Filtering, sorting, and actions on lists</i>	233
	<i>Logging in an event handler</i>	235
9.3	Expression trees	236
	<i>Building expression trees programmatically</i>	236
	<i>Compiling expression trees into delegates</i>	238
	<i>Converting C# lambda expressions to expression trees</i>	239
	<i>Expression trees at the heart of LINQ</i>	242
	<i>Expression trees beyond LINQ</i>	244

9.4 Changes to type inference and overload resolution 246

Reasons for change: streamlining generic method calls 246

Inferred return types of anonymous functions 247 ■ *Two-phase type inference* 248 ■ *Picking the right overloaded method* 252
Wrapping up type inference and overload resolution 254

9.5 Summary 254

10 Extension methods 256

10.1 Life before extension methods 257

10.2 Extension method syntax 259

Declaring extension methods 259 ■ *Calling extension methods* 261 ■ *Extension method discovery* 262
Calling a method on a null reference 263

10.3 Extension methods in .NET 3.5 265

First steps with Enumerable 265 ■ *Filtering with Where and chaining method calls together* 267 ■ *Interlude: haven't we seen the Where method before?* 269 ■ *Projections using the Select method and anonymous types* 269 ■ *Sorting using the OrderBy method* 270 ■ *Business examples involving chaining* 272

10.4 Usage ideas and guidelines 273

"Extending the world" and making interfaces richer 274
Fluent interfaces 274 ■ *Using extension methods sensibly* 276

10.5 Summary 277

11 Query expressions and LINQ to Objects 279

11.1 Introducing LINQ 280

Fundamental concepts in LINQ 280 ■ *Defining the sample data model* 285

11.2 Simple beginnings: selecting elements 285

Starting with a source and ending with a selection 286 ■ *Compiler translations as the basis of query expressions* 287 ■ *Range variables and nontrivial projections* 290 ■ *Cast, OfType, and explicitly typed range variables* 292

11.3 Filtering and ordering a sequence 294

Filtering using a where clause 294 ■ *Degenerate query expressions* 295 ■ *Ordering using an orderby clause* 296

11.4 Let clauses and transparent identifiers 298

Introducing an intermediate computation with let 298
Transparent identifiers 299

11.5 Joins 301

Inner joins using join clauses 301 ▪ Group joins with join ... into clauses 305 ▪ Cross joins and flattening sequences using multiple from clauses 308

11.6 Groupings and continuations 311

Grouping with the group ... by clause 311 ▪ Query continuations 314

11.7 Choosing between query expressions and dot notation 317

Operations that require dot notation 317 ▪ Query expressions where dot notation may be simpler 318 ▪ Where query expressions shine 319

11.8 Summary 320

12 LINQ beyond collections 321

12.1 Querying a database with LINQ to SQL 322

Getting started: the database and model 323 ▪ Initial queries 325 ▪ Queries involving joins 327

12.2 Translations using IQueryable and IQueryProvider 329

Introducing IQueryable<T> and related interfaces 330 ▪ Faking it: interface implementations to log calls 331 ▪ Gluing expressions together: the Queryable extension methods 334 ▪ The fake query provider in action 335 ▪ Wrapping up IQueryable 337

12.3 LINQ-friendly APIs and LINQ to XML 337

Core types in LINQ to XML 338 ▪ Declarative construction 340 ▪ Queries on single nodes 342 ▪ Flattened query operators 344 ▪ Working in harmony with LINQ 345

12.4 Replacing LINQ to Objects with Parallel LINQ 346

Plotting the Mandelbrot set with a single thread 346 ▪ Introducing ParallelEnumerable, ParallelQuery, and AsParallel 347 ▪ Tweaking parallel queries 349

12.5 Inverting the query model with LINQ to Rx 350

IObservable<T> and IObserver<T> 351 ▪ Starting simply (again) 353 ▪ Querying observables 354 ▪ What's the point? 356

12.6 Extending LINQ to Objects 357

Design and implementation guidelines 357 ▪ Sample extension: selecting a random element 359

12.7 Summary 360

13 Minor changes to simplify code 365

- 13.1 Optional parameters and named arguments 366
 - Optional parameters* 366 • *Named arguments* 372
 - Putting the two together* 376
- 13.2 Improvements for COM interoperability 380
 - The horrors of automating Word before C# 4* 380 • *The revenge of optional parameters and named arguments* 381 • *When is a ref parameter not a ref parameter?* 382 • *Calling named indexers* 383 • *Linking primary interop assemblies* 385
- 13.3 Generic variance for interfaces and delegates 387
 - Types of variance: covariance and contravariance* 387 • *Using variance in interfaces* 389 • *Using variance in delegates* 392
 - Complex situations* 392 • *Restrictions and notes* 394
- 13.4 Teeny tiny changes to locking and field-like events 398
 - Robust locking* 398 • *Changes to field-like events* 399
- 13.5 Summary 400

14 Dynamic binding in a static language 401

- 14.1 What? When? Why? How? 403
 - What is dynamic typing?* 403 • *When is dynamic typing useful, and why?* 404 • *How does C# 4 provide dynamic typing?* 405
- 14.2 The five-minute guide to dynamic 406
- 14.3 Examples of dynamic typing 408
 - COM in general, and Microsoft Office in particular* 408
 - Dynamic languages such as IronPython* 410 • *Dynamic typing in purely managed code* 415
- 14.4 Looking behind the scenes 421
 - Introducing the Dynamic Language Runtime* 421 • *DLR core concepts* 422 • *How the C# compiler handles dynamic* 426
 - The C# compiler gets even smarter* 430 • *Restrictions on dynamic code* 432
- 14.5 Implementing dynamic behavior 435
 - Using ExpandoObject* 435 • *Using DynamicObject* 440
 - Implementing IDynamicMetaObjectProvider* 446
- 14.6 Summary 450

15 *Letting your code speak more clearly with Code Contracts* 452

- 15.1 Life before Code Contracts 454
- 15.2 Introducing Code Contracts 455
 - Preconditions* 456 • *Postconditions* 458 • *Invariants* 459
 - Assertions and assumptions* 461 • *Legacy contracts* 462
- 15.3 Rewriting binaries with ccrewrite and ccrefgen 464
 - Simple rewriting* 464 • *Contract inheritance* 466
 - Contract reference assemblies* 469 • *Failure behavior* 470
- 15.4 Static checking 472
 - Getting started with static checking* 473 • *Implicit obligations* 475 • *Selective checking* 478
- 15.5 Documenting contracts with ccdocgen 480
- 15.6 Practical contracts 482
 - Philosophy: what's in a contract?* 483 • *How do I get started?* 484 • *Options, options everywhere* 485
- 15.7 Summary 488

16 *Whither now?* 490

- 16.1 C#—mixing tradition and modernity 490
 - 16.2 Computer science and .NET 491
 - 16.3 The world of computing 492
 - 16.4 Farewell 493
- appendix A LINQ standard query operators* 495
appendix B Generic collections in .NET 508
appendix C Version summaries 521
index 529