

contents

preface xix
acknowledgments xxi
about this book xxiii
about the authors xxviii
about the cover illustration xxx

PART 1 FUNDAMENTALS1

I *Java 8, 9, 10, and 11: what's happening?* 3

1.1 So, what's the big story? 3

1.2 Why is Java still changing? 6

Java's place in the programming language ecosystem 6

Stream processing 8 ▪ *Passing code to methods with behavior*

parameterization 9 ▪ *Parallelism and shared mutable data* 10

Java needs to evolve 11

1.3 Functions in Java 12

Methods and lambdas as first-class citizens 12 ▪ *Passing code: an*

example 14 ▪ *From passing methods to lambdas* 16

1.4 Streams 17

Multithreading is difficult 19

- 1.5 Default methods and Java modules 21
- 1.6 Other good ideas from functional programming 23

2 *Passing code with behavior parameterization* 26

- 2.1 Coping with changing requirements 27
 - First attempt: filtering green apples* 28 ▪ *Second attempt: parameterizing the color* 28 ▪ *Third attempt: filtering with every attribute you can think of* 29
- 2.2 Behavior parameterization 30
 - Fourth attempt: filtering by abstract criteria* 31
- 2.3 Tackling verbosity 35
 - Anonymous classes* 36 ▪ *Fifth attempt: using an anonymous class* 36 ▪ *Sixth attempt: using a lambda expression* 37 ▪ *Seventh attempt: abstracting over List type* 38
- 2.4 Real-world examples 39
 - Sorting with a Comparator* 39 ▪ *Executing a block of code with Runnable* 40 ▪ *Returning a result using Callable* 40 ▪ *GUI event handling* 41

3 *Lambda expressions* 42

- 3.1 Lambdas in a nutshell 43
- 3.2 Where and how to use lambdas 46
 - Functional interface* 46 ▪ *Function descriptor* 48
- 3.3 Putting lambdas into practice: the execute-around pattern 50
 - Step 1: Remember behavior parameterization* 51 ▪ *Step 2: Use a functional interface to pass behaviors* 51 ▪ *Step 3: Execute a behavior!* 52 ▪ *Step 4: Pass lambdas* 52
- 3.4 Using functional interfaces 53
 - Predicate* 54 ▪ *Consumer* 54 ▪ *Function* 55
- 3.5 Type checking, type inference, and restrictions 59
 - Type checking* 59 ▪ *Same lambda, different functional interfaces* 61 ▪ *Type inference* 63 ▪ *Using local variables* 63
- 3.6 Method references 64
 - In a nutshell* 65 ▪ *Constructor references* 68
- 3.7 Putting lambdas and method references into practice 70
 - Step 1: Pass code* 71 ▪ *Step 2: Use an anonymous class* 71 ▪ *Step 3: Use lambda expressions* 71 ▪ *Step 4: Use method references* 72

- 3.8 Useful methods to compose lambda expressions 72
 - Composing Comparators* 73 ▪ *Composing Predicates* 73
 - Composing Functions* 74
- 3.9 Similar ideas from mathematics 76
 - Integration* 76 ▪ *Connecting to Java 8 lambdas* 77

PART 2 FUNCTIONAL-STYLE DATA PROCESSING WITH STREAMS79

- 4** *Introducing streams* 81
 - 4.1 What are streams? 82
 - 4.2 Getting started with streams 86
 - 4.3 Streams vs. collections 88
 - Traversable only once* 90 ▪ *External vs. internal iteration* 91
 - 4.4 Stream operations 93
 - Intermediate operations* 94 ▪ *Terminal operations* 95
 - Working with streams* 95
 - 4.5 Road map 96
- 5** *Working with streams* 98
 - 5.1 Filtering 99
 - Filtering with a predicate* 99 ▪ *Filtering unique elements* 100
 - 5.2 Slicing a stream 100
 - Slicing using a predicate* 101 ▪ *Truncating a stream* 102
 - Skipping elements* 103
 - 5.3 Mapping 104
 - Applying a function to each element of a stream* 104
 - Flattening streams* 105
 - 5.4 Finding and matching 108
 - Checking to see if a predicate matches at least one element* 108
 - Checking to see if a predicate matches all elements* 109
 - Finding an element* 109 ▪ *Finding the first element* 110
 - 5.5 Reducing 111
 - Summing the elements* 111 ▪ *Maximum and minimum* 113
 - 5.6 Putting it all into practice 117
 - The domain: Traders and Transactions* 117 ▪ *Solutions* 118

- 5.7 Numeric streams 121
 - Primitive stream specializations* 121
 - *Numeric ranges* 123
 - Putting numerical streams into practice: Pythagorean triples* 123
- 5.8 Building streams 126
 - Streams from values* 126
 - *Stream from nullable* 126
 - Streams from arrays* 127
 - *Streams from files* 127
 - Streams from functions: creating infinite streams!* 128
- 5.9 Overview 132

6 Collecting data with streams 134

- 6.1 Collectors in a nutshell 136
 - Collectors as advanced reductions* 136
 - *Predefined collectors* 137
- 6.2 Reducing and summarizing 138
 - Finding maximum and minimum in a stream of values* 138
 - Summarization* 139
 - *Joining Strings* 140
 - *Generalized summarization with reduction* 141
- 6.3 Grouping 146
 - Manipulating grouped elements* 147
 - *Multilevel grouping* 149
 - Collecting data in subgroups* 150
- 6.4 Partitioning 154
 - Advantages of partitioning* 155
 - *Partitioning numbers into prime and nonprime* 156
- 6.5 The Collector interface 159
 - Making sense of the methods declared by Collector interface* 160
 - Putting them all together* 163
- 6.6 Developing your own collector for better performance 165
 - Divide only by prime numbers* 166
 - *Comparing collectors' performances* 170

7 Parallel data processing and performance 172

- 7.1 Parallel streams 173
 - Turning a sequential stream into a parallel one* 174
 - Measuring stream performance* 176
 - *Using parallel streams correctly* 180
 - *Using parallel streams effectively* 182

- 7.2 The fork/join framework 184
 - Working with RecursiveTask* 184
 - *Best practices for using the fork/join framework* 188
 - *Work stealing* 189
- 7.3 Spliterator 190
 - The splitting process* 191
 - *Implementing your own Spliterator* 192

PART 3 EFFECTIVE PROGRAMMING WITH STREAMS AND LAMBIDAS..... 199

8 *Collection API enhancements* 201

- 8.1 Collection factories 202
 - List factory* 203
 - *Set factory* 204
 - *Map factories* 204
- 8.2 Working with List and Set 205
 - removeIf* 205
 - *replaceAll* 206
- 8.3 Working with Map 207
 - forEach* 207
 - *Sorting* 208
 - *getOrDefault* 208
 - Compute patterns* 209
 - *Remove patterns* 210
 - Replacement patterns* 211
 - *Merge* 211
- 8.4 Improved ConcurrentHashMap 213
 - Reduce and Search* 213
 - *Counting* 214
 - *Set views* 214

9 *Refactoring, testing, and debugging* 216

- 9.1 Refactoring for improved readability and flexibility 217
 - Improving code readability* 217
 - *From anonymous classes to lambda expressions* 217
 - *From lambda expressions to method references* 219
 - *From imperative data processing to Streams* 220
 - Improving code flexibility* 221
- 9.2 Refactoring object-oriented design patterns with lambdas 223
 - Strategy* 224
 - *Template method* 225
 - *Observer* 226
 - Chain of responsibility* 229
 - *Factory* 230
- 9.3 Testing lambdas 232
 - Testing the behavior of a visible lambda* 232
 - *Focusing on the behavior of the method using a lambda* 233
 - *Pulling complex lambdas into separate methods* 234
 - *Testing high-order functions* 234

- 9.4 Debugging 234
 - Examining the stack trace* 235
 - Logging information* 236

10 *Domain-specific languages using lambdas* 239

- 10.1 A specific language for your domain 241
 - Pros and cons of DSLs* 242
 - Different DSL solutions available on the JVM* 244
- 10.2 Small DSLs in modern Java APIs 248
 - The Stream API seen as a DSL to manipulate collections* 249
 - Collectors as a DSL to aggregate data* 250
- 10.3 Patterns and techniques to create DSLs in Java 252
 - Method chaining* 255
 - Using nested functions* 257
 - Function sequencing with lambda expressions* 259
 - Putting it all together* 261
 - Using method references in a DSL* 263
- 10.4 Real World Java 8 DSL 266
 - jOOQ* 266
 - Cucumber* 267
 - Spring Integration* 269

PART 4 EVERYDAY JAVA273

11 *Using Optional as a better alternative to null* 275

- 11.1 How do you model the absence of a value? 276
 - Reducing NullPointerExceptions with defensive checking* 277
 - Problems with null* 278
 - What are the alternatives to null in other languages?* 279
- 11.2 Introducing the Optional class 280
- 11.3 Patterns for adopting Optionals 281
 - Creating Optional objects* 281
 - Extracting and transforming values from Optionals with map* 282
 - Chaining Optional objects with flatMap* 283
 - Manipulating a stream of optionals* 287
 - Default actions and unwrapping an Optional* 288
 - Combining two Optionals* 289
 - Rejecting certain values with filter* 290
- 11.4 Practical examples of using Optional 292
 - Wrapping a potentially null value in an Optional* 292
 - Exceptions vs. Optional* 293
 - Primitive optionals and why you shouldn't use them* 294
 - Putting it all together* 294

12 *New Date and Time API* 297

- 12.1 *LocalDate, LocalTime, LocalDateTime, Instant, Duration, and Period* 298

Working with LocalDate and LocalTime 299 ▪ *Combining a date and a time* 300 ▪ *Instant: a date and time for machines* 301
Defining a Duration or a Period 301

- 12.2 *Manipulating, parsing, and formatting dates* 303

Working with TemporalAdjusters 305 ▪ *Printing and parsing date-time objects* 308

- 12.3 *Working with different time zones and calendars* 310

Using time zones 310 ▪ *Fixed offset from UTC/Greenwich* 311
Using alternative calendar systems 311

13 *Default methods* 314

- 13.1 *Evolving APIs* 317

API version 1 317 ▪ *API version 2* 318

- 13.2 *Default methods in a nutshell* 320

- 13.3 *Usage patterns for default methods* 322

Optional methods 322 ▪ *Multiple inheritance of behavior* 323

- 13.4 *Resolution rules* 326

Three resolution rules to know 327 ▪ *Most specific default-providing interface wins* 327 ▪ *Conflicts and explicit disambiguation* 329 ▪ *Diamond problem* 330

14 *The Java Module System* 333

- 14.1 *The driving force: reasoning about software* 334

Separation of concerns 334 ▪ *Information hiding* 334
Java software 335

- 14.2 *Why the Java Module System was designed* 336

Modularity limitations 336 ▪ *Monolithic JDK* 337
Comparison with OSGi 338

- 14.3 *Java modules: the big picture* 339

- 14.4 *Developing an application with the Java Module System* 340

Setting up an application 340 ▪ *Fine-grained and coarse-grained modularization* 342 ▪ *Java Module System basics* 342

- 14.5 Working with several modules 343
 - The exports clause* 344 ▪ *The requires clause* 344
 - Naming* 345
- 14.6 Compiling and packaging 345
- 14.7 Automatic modules 349
- 14.8 Module declaration and clauses 350
 - requires* 350 ▪ *exports* 350 ▪ *requires transitive* 351
 - exports to* 351 ▪ *open and opens* 351 ▪ *uses and provides* 352
- 14.9 A bigger example and where to learn more 352

PART 5 ENHANCED JAVA CONCURRENCY 355

15 *Concepts behind CompletableFuture and reactive programming* 357

- 15.1 Evolving Java support for expressing concurrency 360
 - Threads and higher-level abstractions* 361 ▪ *Executors and thread pools* 362 ▪ *Other abstractions of threads: non-nested with method calls* 364 ▪ *What do you want from threads?* 366
- 15.2 Synchronous and asynchronous APIs 366
 - Future-style API* 368 ▪ *Reactive-style API* 369 ▪ *Sleeping (and other blocking operations) considered harmful* 370
 - Reality check* 372 ▪ *How do exceptions work with asynchronous APIs?* 372
- 15.3 The box-and-channel model 373
- 15.4 CompletableFuture and combinators for concurrency 375
- 15.5 Publish-subscribe and reactive programming 378
 - Example use for summing two flows* 380 ▪ *Backpressure* 384
 - A simple form of real backpressure* 384
- 15.6 Reactive systems vs. reactive programming 385
- 15.7 Road map 386

16 *CompletableFuture: composable asynchronous programming* 387

- 16.1 Simple use of Futures 388
 - Understanding Futures and their limitations* 389 ▪ *Using CompletableFutures to build an asynchronous application* 390

- 16.2 Implementing an asynchronous API 391
 - Converting a synchronous method into an asynchronous one* 392
 - Dealing with errors* 394
- 16.3 Making your code nonblocking 396
 - Parallelizing requests using a parallel Stream* 397
 - Making asynchronous requests with CompletableFuture* 397
 - Looking for the solution that scales better* 399 ▪ *Using a custom Executor* 400
- 16.4 Pipelining asynchronous tasks 402
 - Implementing a discount service* 403 ▪ *Using the Discount service* 404 ▪ *Composing synchronous and asynchronous operations* 405 ▪ *Combining two CompletableFuture: dependent and independent* 408 ▪ *Reflecting on Future vs. CompletableFuture* 409 ▪ *Using timeouts effectively* 410
- 16.5 Reacting to a CompletableFuture completion 411
 - Refactoring the best-price-finder application* 412
 - Putting it all together* 414
- 16.6 Road map 414

17 *Reactive programming* 416

- 17.1 The Reactive Manifesto 417
 - Reactive at application level* 418 ▪ *Reactive at system level* 420
- 17.2 Reactive streams and the Flow API 421
 - Introducing the Flow class* 421 ▪ *Creating your first reactive application* 424 ▪ *Transforming data with a Processor* 429
 - Why doesn't Java provide an implementation of the Flow API?* 431
- 17.3 Using the reactive library RxJava 431
 - Creating and using an Observable* 433 ▪ *Transforming and combining Observables* 437

PART 6 FUNCTIONAL PROGRAMMING AND FUTURE JAVA EVOLUTION..... 443

18 *Thinking functionally* 445

- 18.1 Implementing and maintaining systems 446
 - Shared mutable data* 446 ▪ *Declarative programming* 447
 - Why functional programming?* 448

- 18.2 What's functional programming? 449
 - Functional-style Java* 450
 - *Referential transparency* 452
 - Object-oriented vs. functional-style programming* 452
 - Functional style in practice* 453
- 18.3 Recursion vs. iteration 455

19 **Functional programming techniques** 460

- 19.1 Functions everywhere 461
 - Higher-order functions* 461
 - *Currying* 463
- 19.2 Persistent data structures 464
 - Destructive updates vs. functional* 464
 - *Another example with Trees* 467
 - *Using a functional approach* 468
- 19.3 Lazy evaluation with streams 469
 - Self-defining stream* 470
 - *Your own lazy list* 472
- 19.4 Pattern matching 476
 - Visitor design pattern* 477
 - *Pattern matching to the rescue* 478
- 19.5 Miscellany 481
 - Caching or memoization* 481
 - *What does "Return the same object" mean?* 482
 - *Combinators* 483

20 **Blending OOP and FP: Comparing Java and Scala** 485

- 20.1 Introduction to Scala 486
 - Hello beer* 486
 - *Basic data structures: List, Set, Map, Tuple, Stream, Option* 488
- 20.2 Functions 493
 - First-class functions in Scala* 493
 - *Anonymous functions and closures* 494
 - *Currying* 496
- 20.3 Classes and traits 497
 - Less verbosity with Scala classes* 497
 - *Scala traits vs. Java interfaces* 498

21 **Conclusions and where next for Java** 500

- 21.1 Review of Java 8 features 501
 - Behavior parameterization (lambdas and method references)* 501
 - Streams* 502
 - *CompletableFuture* 502
 - *Optional* 503
 - Flow API* 503
 - *Default methods* 504
- 21.2 The Java 9 module system 504
- 21.3 Java 10 local variable type inference 505

21.4	What's ahead for Java?	507
	<i>Declaration-site variance</i>	507
	<i>Pattern matching</i>	507
	<i>Richer forms of generics</i>	508
	<i>Deeper support for immutability</i>	510
	<i>Value types</i>	511
21.5	Moving Java forward faster	514
21.6	The final word	515
<i>appendix A</i>	<i>Miscellaneous language updates</i>	517
<i>appendix B</i>	<i>Miscellaneous library updates</i>	521
<i>appendix C</i>	<i>Performing multiple operations in parallel on a stream</i>	529
<i>appendix D</i>	<i>Lambdas and JVM bytecode</i>	538
	<i>index</i>	543