

Table of Contents

Part I Classes	1
Chapter 1 Total Programming	5
1.1 Class Interface	6
1.1.1 Class heading	7
1.1.2 Methods	10
1.1.2.1 Getters and setters	13
1.1.2.2 Mutators and inspectors	15
1.1.2.3 Instance methods versus class methods	18
1.1.2.4 Explicit arguments	23
1.1.2.5 Overloading	24
1.1.2.6 Constructors	25
1.1.3 Documentation	27
1.1.3.1 Method summary	32
1.1.3.2 Parameters	33
1.1.3.3 Postconditions	34
1.1.4 Class usage	47
1.1.4.1 Construction of new objects	48
1.1.4.2 Invocation of instance methods	50
1.1.4.3 Invocation of class methods	53
1.1.4.4 Application Program Interface (API)	53
1.1.4.5 Main method	58
1.2 Class Representation	60
1.2.1 Instance variables and class variables	62
1.2.1.1 Instance variables	63
1.2.1.2 Class variables	69
1.2.1.3 Final qualifications	70
1.2.2 Value semantics and reference semantics	73
1.2.2.1 Value semantics	74
1.2.2.2 Reference semantics	75
1.2.2.3 Boxing and unboxing	78
1.2.2.4 Call by value	79
1.2.3 Primitive types	82
1.2.3.1 Integral types	82
1.2.3.2 Floating point types	86
1.2.3.3 Characters	89
1.2.3.4 Booleans	90
1.3 Class Implementation	91
1.3.1 Instance methods	98
1.3.2 Class methods	105

1.3.3 Constructors	106
1.4 Class Verification	109
1.4.1 Principles of black box testing	110
1.4.2 Black box testing with JUnit	113
1.4.2.1 Test fixture	114
1.4.2.2 Individual tests	116
Chapter 2 Nominal Programming	121
2.1 Class Invariants	122
2.1.1 Encapsulation	125
2.1.2 Formal specification	126
2.1.3 Semantics	129
2.1.3.1 Class properties	129
2.1.3.2 Object properties	131
2.2 Preconditions	139
2.2.1 Semantics	146
2.2.2 Verification	149
2.2.2.1 Static verification	149
2.2.2.2 Dynamic verification	151
2.3 Postconditions Revisited	153
2.3.1 New qualification	153
2.3.2 Effect clauses	155
2.3.3 Inspectors	156
2.3.4 Verification	157
2.3.5 Model methods	163
2.4 Multi-Valued Properties	164
2.4.1 Representation	169
2.4.1.1 Declaration of arrays	170
2.4.1.2 Construction of arrays	172
2.4.2 Getters and setters	174
2.4.2.1 Number of elements	174
2.4.2.2 Accessing individual elements	175
2.4.2.3 Restrictions on individual elements	177
2.4.2.4 Initialization	178
2.4.2.5 Additional methods	180
2.5 Structured Programming	182
2.5.1 Iterative statements	183
2.5.1.1 While statement	183
2.5.1.2 Do-while statement	185
2.5.1.3 For statement	186
2.5.1.4 Enhanced for statement	190
2.5.2 Loop invariants	192
2.5.3 Correctness of iterative algorithms	194
2.5.4 Termination of iterative constructs	198
2.5.5 Alternative implementations of algorithms	200
2.6 A Word on Formal Specifications	205

Chapter 3 Defensive Programming	209
3.1 Definition of Exceptions	210
3.1.1 Predefined exception classes	211
3.1.2 Self-defined exception classes	213
3.1.2.1 The root class of throwables	213
3.1.2.2 The class of illegal amount exceptions	215
3.2 Extended Method Specifications	219
3.2.1 Structure of method specifications	220
3.2.2 Extended method signature	227
3.2.3 Defensive specification of bank accounts	230
3.2.4 Semantics of throws clauses	235
3.3 Throwing Exceptions	237
3.4 Catching Exceptions	247
3.4.1 General structure of try-catch statements	247
3.4.2 Semantics of try-catch statements	249
3.4.3 Order of catchers	251
3.4.4 Nesting of try-catch statements	252
3.4.4.1 Statically nested try-catch statements	252
3.4.4.2 Dynamically nested try-catch statements	255
3.4.5 The class of bank accounts: Catching exceptions	258
3.5 The Finally Clause	261
3.5.1 Semantics	262
3.5.2 Application	265
3.6 Verification	266
3.7 Dependencies between Properties	270
3.7.1 Checkers	271
3.7.2 Initialization	272
Chapter 4 Value Classes	279
4.1 Objects versus Values	280
4.1.1 Objects	280
4.1.1.1 State of objects	280
4.1.1.2 Behavior of objects	281
4.1.1.3 Identity of objects	282
4.1.1.4 Lifetime of objects	283
4.1.2 Values	283
4.2 Definition of Value Classes	284
4.2.1 Algebras	284
4.2.2 Money amounts	285
4.2.3 Basic inspectors	286
4.2.4 Constructors	286
4.2.5 Operators	287
4.2.6 Methods inherited from the root class of objects	288
4.2.7 Definition of the class of money amounts	291
4.3 Enumerations	300
4.4 Bank Accounts	305

Part II Associations	317
Chapter 5 Associations with Restricted Multiplicity	321
5.1 Class Diagrams	323
5.1.1 Classes	323
5.1.1.1 Graphical representation of classes	324
5.1.1.2 Static classification	325
5.1.1.3 Disjoint classification	328
5.1.2 Associations	329
5.1.3 Object diagrams	333
5.2 Unidirectional Associations	334
5.2.1 Representation	334
5.2.2 Manipulation	336
5.3 Bidirectional Associations	339
5.3.1 Representation	340
5.3.2 Manipulation	341
5.3.2.1 Definition of the class of bank cards	342
5.3.2.2 Definition of the class of bank accounts	354
5.4 Memory Management	359
5.4.1 Run-time stack	360
5.4.2 Object memory	363
5.4.3 Recovery of object memory	364
5.4.4 Finalization	368
5.5 Destructors	369
5.6 Packages	371
5.6.1 Packages	371
5.6.2 Nested packages	372
5.6.3 Packages and directories	374
5.6.4 Package statement	375
5.6.5 Import statement	376
5.6.6 Access rights	380
5.7 The Banking System Revisited	383
Chapter 6 Associations with Unrestricted Multiplicity	387
6.1 Detailed Design	388
6.1.1 Classification	389
6.1.2 Relations	389
6.1.3 Attributes	391
6.1.4 Methods	391
6.2 Specification	392
6.2.1 Introduction to interfaces	392
6.2.1.1 Non-generic interfaces	393
6.2.1.2 Generic classes and interfaces	394
6.2.2 Lists	397
6.2.2.1 Number of elements	397
6.2.2.2 Accessors	398
6.2.2.3 Adders and removers	398

6.2.2.4 Inspectors	400
6.2.2.5 Constructors	401
6.2.2.6 Destructor	401
6.2.3 Sets	401
6.2.3.1 Basic inspector	402
6.2.3.2 Checker	402
6.2.3.3 Adders and removers	403
6.2.3.4 Inspectors	404
6.2.3.5 Constructors and destructor	404
6.3 Representation	411
6.3.1 Data structures	412
6.3.1.1 Lists	412
6.3.1.2 Sets	414
6.3.1.3 Maps	415
6.3.1.4 Representation of bank accounts	416
6.3.2 Representation invariants	418
6.3.2.1 Semantics of representation invariants	419
6.3.2.2 Specification of representation invariants	420
6.4 Implementation	422
6.4.1 Constructor	422
6.4.2 Savings accounts: Basic methods	423
6.4.3 Grantees: Basic methods	427
6.4.4 Additional methods	434
6.4.5 Destructor	437
6.4.6 The class of savings accounts	437
6.5 Verification	441
6.5.1 Basics of white box testing	441
6.5.1.1 Program graphs	441
6.5.1.2 Decision-to-decision paths	443
6.5.1.3 Path testing	444
6.5.1.4 Data flow testing	445
6.5.2 Practice of white box testing	447
6.5.3 Black & white testing	450
Part III Inheritance	453
Chapter 7 Extension Inheritance	457
7.1 Taxonomies	458
7.1.1 Semantics of inheritance	458
7.1.2 Design notation	459
7.2 Subclass Definition	461
7.2.1 Inheritance of instance features	462
7.2.2 Inheritance of static features	463
7.2.3 Access rights	465
7.2.4 Constructors of subclasses	467
7.2.5 Extending subclasses	471
7.2.6 Overloading revisited	474
7.2.7 Open-closed principle	475

7.3 Abstract Classes	477
7.3.1 Definition of abstract classes	478
7.3.2 Testing	480
7.4 Polymorphism	482
7.4.1 Variables with reference semantics	482
7.4.2 Variables with value semantics	487
7.5 Run-Time Type Information	488
7.5.1 The operator "instanceof"	489
7.5.2 Type casts	490
7.5.3 Reflection	491
7.5.4 Generalization	493
Chapter 8 Specialization Inheritance	497
8.1 Overriding Instance Methods	498
8.1.1 Comprehensive method definitions	499
8.1.2 Overriding abstract methods	501
8.1.3 Dynamic binding	504
8.1.4 Overriding concrete methods	505
8.1.5 Final qualifications	508
8.1.6 White box testing	510
8.1.7 Dynamic binding versus RTTI	513
8.2 Static Binding and Class Methods	518
8.2.1 Hiding class methods	519
8.2.2 Semantics of static binding	522
8.2.3 Class methods versus instance methods	524
Chapter 9 Liskov Substitution Principle	529
9.1 Basic Semantics	530
9.2 Class Invariants	533
9.2.1 Additional class invariants	534
9.2.2 Strengthening class invariants	535
9.2.3 Strengthening restrictions on class properties	537
9.3 Postconditions	539
9.3.1 Additional postconditions	540
9.3.2 Inertia axiom	542
9.3.3 Strengthening postconditions	543
9.3.4 Effect clauses	547
9.4 Preconditions	549
9.5 Return Clauses	555
9.6 Exceptions	567
9.6.1 List of exceptions	568
9.6.2 Conditions for throwing exceptions	570
9.7 Return Types	579
9.8 Formal Arguments	582
9.9 Access Rights	587
9.10 Annotations	589

