

# Contents

---

<b>Preface</b>	<b>v</b>
<b>Foreword to the second edition</b>	<b>xiii</b>
<b>About the accompanying CD-ROM</b>	<b>xiv</b>
<b>On the bibliography, Internet sources and exercises</b>	<b>xv</b>
<b>Contents</b>	<b>xvii</b>
<b>PART A: THE ISSUES</b>	<b>1</b>
<b>Chapter 1: Software quality</b>	<b>3</b>
1.1 EXTERNAL AND INTERNAL FACTORS	3
1.2 A REVIEW OF EXTERNAL FACTORS	4
1.3 ABOUT SOFTWARE MAINTENANCE	17
1.4 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	19
1.5 BIBLIOGRAPHICAL NOTES	19
<b>Chapter 2: Criteria of object orientation</b>	<b>21</b>
2.1 ON THE CRITERIA	21
2.2 METHOD AND LANGUAGE	22
2.3 IMPLEMENTATION AND ENVIRONMENT	31
2.4 LIBRARIES	33
2.5 FOR MORE SNEAK PREVIEW	34
2.6 BIBLIOGRAPHICAL NOTES AND OBJECT RESOURCES	34
<b>PART B: THE ROAD TO OBJECT ORIENTATION</b>	<b>37</b>
<b>Chapter 3: Modularity</b>	<b>39</b>
3.1 FIVE CRITERIA	40
3.2 FIVE RULES	46
3.3 FIVE PRINCIPLES	53
3.4 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	64
3.5 BIBLIOGRAPHICAL NOTES	64
EXERCISES	65

<b>Chapter 4: Approaches to reusability</b>	<b>67</b>
4.1 THE GOALS OF REUSABILITY	68
4.2 WHAT SHOULD WE REUSE?	70
4.3 REPETITION IN SOFTWARE DEVELOPMENT	74
4.4 NON-TECHNICAL OBSTACLES	74
4.5 THE TECHNICAL PROBLEM	81
4.6 FIVE REQUIREMENTS ON MODULE STRUCTURES	83
4.7 TRADITIONAL MODULAR STRUCTURES	89
4.8 OVERLOADING AND GENERICITY	93
4.9 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	98
4.10 BIBLIOGRAPHICAL NOTES	99
<b>Chapter 5: Towards object technology</b>	<b>101</b>
5.1 THE INGREDIENTS OF COMPUTATION	101
5.2 FUNCTIONAL DECOMPOSITION	103
5.3 OBJECT-BASED DECOMPOSITION	114
5.4 OBJECT-ORIENTED SOFTWARE CONSTRUCTION	116
5.5 ISSUES	117
5.6 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	119
5.7 BIBLIOGRAPHICAL NOTES	119
<b>Chapter 6: Abstract data types</b>	<b>121</b>
6.1 CRITERIA	122
6.2 IMPLEMENTATION VARIATIONS	122
6.3 TOWARDS AN ABSTRACT VIEW OF OBJECTS	126
6.4 FORMALIZING THE SPECIFICATION	129
6.5 FROM ABSTRACT DATA TYPES TO CLASSES	142
6.6 BEYOND SOFTWARE	147
6.7 SUPPLEMENTARY TOPICS	148
6.8 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	159
6.9 BIBLIOGRAPHICAL NOTES	160
EXERCISES	161
<b>PART C: OBJECT-ORIENTED TECHNIQUES</b>	<b>163</b>
<b>Chapter 7: The static structure: classes</b>	<b>165</b>
7.1 OBJECTS ARE NOT THE SUBJECT	165
7.2 AVOIDING THE STANDARD CONFUSION	166
7.3 THE ROLE OF CLASSES	169
7.4 A UNIFORM TYPE SYSTEM	171
7.5 A SIMPLE CLASS	172
7.6 BASIC CONVENTIONS	177

---

---

7.7 THE OBJECT-ORIENTED STYLE OF COMPUTATION	181
7.8 SELECTIVE EXPORTS AND INFORMATION HIDING	191
7.9 PUTTING EVERYTHING TOGETHER	194
7.10 DISCUSSION	203
7.11 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	213
7.12 BIBLIOGRAPHICAL NOTES	215
EXERCISES	216
<b>Chapter 8: The run-time structure: objects</b>	<b>217</b>
8.1 OBJECTS	218
8.2 OBJECTS AS A MODELING TOOL	228
8.3 MANIPULATING OBJECTS AND REFERENCES	231
8.4 CREATION PROCEDURES	236
8.5 MORE ON REFERENCES	240
8.6 OPERATIONS ON REFERENCES	242
8.7 COMPOSITE OBJECTS AND EXPANDED TYPES	254
8.8 ATTACHMENT: REFERENCE AND VALUE SEMANTICS	261
8.9 DEALING WITH REFERENCES: BENEFITS AND DANGERS	265
8.10 DISCUSSION	270
8.11 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	276
8.12 BIBLIOGRAPHICAL NOTES	277
EXERCISES	277
<b>Chapter 9: Memory management</b>	<b>279</b>
9.1 WHAT HAPPENS TO OBJECTS	279
9.2 THE CASUAL APPROACH	291
9.3 RECLAIMING MEMORY: THE ISSUES	293
9.4 PROGRAMMER-CONTROLLED DEALLOCATION	294
9.5 THE COMPONENT-LEVEL APPROACH	297
9.6 AUTOMATIC MEMORY MANAGEMENT	301
9.7 REFERENCE COUNTING	302
9.8 GARBAGE COLLECTION	304
9.9 PRACTICAL ISSUES OF GARBAGE COLLECTION	309
9.10 AN ENVIRONMENT WITH MEMORY MANAGEMENT	312
9.11 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	315
9.12 BIBLIOGRAPHICAL NOTES	315
EXERCISES	316
<b>Chapter 10: Genericity</b>	<b>317</b>
10.1 HORIZONTAL AND VERTICAL TYPE GENERALIZATION	317
10.2 THE NEED FOR TYPE PARAMETERIZATION	318
10.3 GENERIC CLASSES	320

10.4 ARRAYS	325
10.5 THE COST OF GENERICITY	328
10.6 DISCUSSION: NOT DONE YET	329
10.7 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	329
10.8 BIBLIOGRAPHICAL NOTES	330
EXERCISES	330
<b>Chapter 11: Design by Contract: building reliable software</b>	<b>331</b>
11.1 BASIC RELIABILITY MECHANISMS	332
11.2 ABOUT SOFTWARE CORRECTNESS	333
11.3 EXPRESSING A SPECIFICATION	334
11.4 INTRODUCING ASSERTIONS INTO SOFTWARE TEXTS	337
11.5 PRECONDITIONS AND POSTCONDITIONS	338
11.6 CONTRACTING FOR SOFTWARE RELIABILITY	341
11.7 WORKING WITH ASSERTIONS	348
11.8 CLASS INVARIANTS	363
11.9 WHEN IS A CLASS CORRECT?	369
11.10 THE ADT CONNECTION	373
11.11 AN ASSERTION INSTRUCTION	378
11.12 LOOP INVARIANTS AND VARIANTS	380
11.13 USING ASSERTIONS	389
11.14 DISCUSSION	398
11.15 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	406
11.16 BIBLIOGRAPHICAL NOTES	407
EXERCISES	408
POSTSCRIPT: THE ARIANE 5 FAILURE	410
<b>Chapter 12: When the contract is broken: exception handling</b>	<b>411</b>
12.1 BASIC CONCEPTS OF EXCEPTION HANDLING	411
12.2 HANDLING EXCEPTIONS	414
12.3 AN EXCEPTION MECHANISM	419
12.4 EXCEPTION HANDLING EXAMPLES	422
12.5 THE TASK OF A RESCUE CLAUSE	427
12.6 ADVANCED EXCEPTION HANDLING	431
12.7 DISCUSSION	435
12.8 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	437
12.9 BIBLIOGRAPHICAL NOTES	438
EXERCISES	438
<b>Chapter 13: Supporting mechanisms</b>	<b>439</b>
13.1 INTERFACING WITH NON-O-O SOFTWARE	439
13.2 ARGUMENT PASSING	444

---

---

13.3 INSTRUCTIONS	447
13.4 EXPRESSIONS	452
13.5 STRINGS	456
13.6 INPUT AND OUTPUT	457
13.7 LEXICAL CONVENTIONS	457
13.8 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	458
EXERCISES	458
<b>Chapter 14: Introduction to inheritance</b>	<b>459</b>
14.1 POLYGONS AND RECTANGLES	460
14.2 POLYMORPHISM	467
14.3 TYPING FOR INHERITANCE	472
14.4 DYNAMIC BINDING	480
14.5 DEFERRED FEATURES AND CLASSES	482
14.6 REDECLARATION TECHNIQUES	491
14.7 THE MEANING OF INHERITANCE	494
14.8 THE ROLE OF DEFERRED CLASSES	500
14.9 DISCUSSION	507
14.10 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	516
14.11 BIBLIOGRAPHICAL NOTES	517
EXERCISES	517
<b>Chapter 15: Multiple inheritance</b>	<b>519</b>
15.1 EXAMPLES OF MULTIPLE INHERITANCE	519
15.2 FEATURE RENAMING	535
15.3 FLATTENING THE STRUCTURE	541
15.4 REPEATED INHERITANCE	543
15.5 DISCUSSION	563
15.6 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	566
15.7 BIBLIOGRAPHICAL NOTES	567
EXERCISES	567
<b>Chapter 16: Inheritance techniques</b>	<b>569</b>
16.1 INHERITANCE AND ASSERTIONS	569
16.2 THE GLOBAL INHERITANCE STRUCTURE	580
16.3 FROZEN FEATURES	583
16.4 CONSTRAINED GENERICITY	585
16.5 ASSIGNMENT ATTEMPT	591
16.6 TYPING AND REDECLARATION	595
16.7 ANCHORED DECLARATION	598
16.8 INHERITANCE AND INFORMATION HIDING	605
16.9 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	609

16.10 BIBLIOGRAPHICAL NOTE	610
EXERCISES	610
<b>Chapter 17: Typing</b>	<b>611</b>
17.1 THE TYPING PROBLEM	611
17.2 STATIC TYPING: WHY AND HOW	615
17.3 COVARIANCE AND DESCENDANT HIDING	621
17.4 FIRST APPROACHES TO SYSTEM VALIDITY	628
17.5 RELYING ON ANCHORED TYPES	630
17.6 GLOBAL ANALYSIS	633
17.7 BEWARE OF POLYMORPHIC CATCALLS!	636
17.8 AN ASSESSMENT	639
17.9 THE PERFECT FIT	640
17.10 KEY CONCEPTS STUDIED IN THIS CHAPTER	641
17.11 BIBLIOGRAPHICAL NOTES	641
<b>Chapter 18: Global objects and constants</b>	<b>643</b>
18.1 CONSTANTS OF BASIC TYPES	643
18.2 USE OF CONSTANTS	645
18.3 CONSTANTS OF CLASS TYPES	646
18.4 APPLICATIONS OF ONCE ROUTINES	648
18.5 CONSTANTS OF STRING TYPE	653
18.6 UNIQUE VALUES	654
18.7 DISCUSSION	656
18.8 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	659
18.9 BIBLIOGRAPHICAL NOTES	660
EXERCISES	660
<b>PART D: OBJECT-ORIENTED METHODOLOGY:</b>	
<b>APPLYING THE METHOD WELL</b>	661
<b>Chapter 19: On methodology</b>	<b>663</b>
19.1 SOFTWARE METHODOLOGY: WHY AND WHAT	663
19.2 DEVISING GOOD RULES: ADVICE TO THE ADVISORS	664
19.3 ON USING METAPHORS	671
19.4 THE IMPORTANCE OF BEING HUMBLE	673
19.5 BIBLIOGRAPHICAL NOTES	674
EXERCISES	674
<b>Chapter 20: Design pattern: multi-panel interactive systems</b>	<b>675</b>
20.1 MULTI-PANEL SYSTEMS	675
20.2 A SIMPLE-MINDED ATTEMPT	677

---

---

20.3 A FUNCTIONAL, TOP-DOWN SOLUTION	678
20.4 A CRITIQUE OF THE SOLUTION	682
20.5 AN OBJECT-ORIENTED ARCHITECTURE	684
20.6 DISCUSSION	693
20.7 BIBLIOGRAPHICAL NOTE	694
<b>Chapter 21: Inheritance case study: “undo” in an interactive system</b>	<b>695</b>
21.1 PERSEVERARE DIABOLICUM	695
21.2 FINDING THE ABSTRACTIONS	699
21.3 MULTI-LEVEL UNDO-REDO	704
21.4 IMPLEMENTATION ASPECTS	707
21.5 A USER INTERFACE FOR UNDOING AND REDOING	711
21.6 DISCUSSION	712
21.7 BIBLIOGRAPHICAL NOTES	715
EXERCISES	715
<b>Chapter 22: How to find the classes</b>	<b>719</b>
22.1 STUDYING A REQUIREMENTS DOCUMENT	720
22.2 DANGER SIGNALS	726
22.3 GENERAL HEURISTICS FOR FINDING CLASSES	731
22.4 OTHER SOURCES OF CLASSES	735
22.5 REUSE	740
22.6 THE METHOD FOR OBTAINING CLASSES	741
22.7 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	743
22.8 BIBLIOGRAPHICAL NOTES	744
<b>Chapter 23: Principles of class design</b>	<b>747</b>
23.1 SIDE EFFECTS IN FUNCTIONS	748
23.2 HOW MANY ARGUMENTS FOR A FEATURE?	764
23.3 CLASS SIZE: THE SHOPPING LIST APPROACH	770
23.4 ACTIVE DATA STRUCTURES	774
23.5 SELECTIVE EXPORTS	796
23.6 DEALING WITH ABNORMAL CASES	797
23.7 CLASS EVOLUTION: THE OBSOLETE CLAUSE	802
23.8 DOCUMENTING A CLASS AND A SYSTEM	803
23.9 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	806
23.10 BIBLIOGRAPHICAL NOTES	806
EXERCISES	807

---

---

<b>Chapter 24: Using inheritance well</b>	<b>809</b>
24.1 HOW NOT TO USE INHERITANCE	809
24.2 WOULD YOU RATHER BUY OR INHERIT?	812
24.3 AN APPLICATION: THE HANDLE TECHNIQUE	817
24.4 TAXOMANIA	820
24.5 USING INHERITANCE: A TAXONOMY OF TAXONOMY	822
24.6 ONE MECHANISM, OR MORE?	833
24.7 SUBTYPE INHERITANCE AND DESCENDANT HIDING	835
24.8 IMPLEMENTATION INHERITANCE	844
24.9 FACILITY INHERITANCE	847
24.10 MULTIPLE CRITERIA AND VIEW INHERITANCE	851
24.11 HOW TO DEVELOP INHERITANCE STRUCTURES	858
24.12 A SUMMARY VIEW: USING INHERITANCE WELL	862
24.13 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	863
24.14 BIBLIOGRAPHICAL NOTES	863
24.15 APPENDIX: A HISTORY OF TAXONOMY	864
EXERCISES	869
<b>Chapter 25: Useful techniques</b>	<b>871</b>
25.1 DESIGN PHILOSOPHY	871
25.2 CLASSES	872
25.3 INHERITANCE TECHNIQUES	873
<b>Chapter 26: A sense of style</b>	<b>875</b>
26.1 COSMETICS MATTERS!	875
26.2 CHOOSING THE RIGHT NAMES	879
26.3 USING CONSTANTS	884
26.4 HEADER COMMENTS AND INDEXING CLAUSES	886
26.5 TEXT LAYOUT AND PRESENTATION	891
26.6 FONTS	900
26.7 BIBLIOGRAPHICAL NOTES	901
EXERCISES	902
<b>Chapter 27: Object-oriented analysis</b>	<b>903</b>
27.1 THE GOALS OF ANALYSIS	903
27.2 THE CHANGING NATURE OF ANALYSIS	906
27.3 THE CONTRIBUTION OF OBJECT TECHNOLOGY	907
27.4 PROGRAMMING A TV STATION	907
27.5 EXPRESSING THE ANALYSIS: MULTIPLE VIEWS	914
27.6 ANALYSIS METHODS	917
27.7 THE BUSINESS OBJECT NOTATION	919
27.8 BIBLIOGRAPHY	922



---

<b>Chapter 28: The software construction process</b>	<b>923</b>
28.1 CLUSTERS	923
28.2 CONCURRENT ENGINEERING	924
28.3 STEPS AND TASKS	926
28.4 THE CLUSTER MODEL OF THE SOFTWARE LIFECYCLE	926
28.5 GENERALIZATION	928
28.6 SEAMLESSNESS AND REVERSIBILITY	930
28.7 WITH US, EVERYTHING IS THE FACE	933
28.8 KEY CONCEPTS COVERED IN THIS CHAPTER	934
28.9 BIBLIOGRAPHICAL NOTES	934
<b>Chapter 29: Teaching the method</b>	<b>935</b>
29.1 INDUSTRIAL TRAINING	935
29.2 INTRODUCTORY COURSES	937
29.3 OTHER COURSES	941
29.4 TOWARDS A NEW SOFTWARE PEDAGOGY	942
29.5 AN OBJECT-ORIENTED PLAN	946
29.6 KEY CONCEPTS STUDIED IN THIS CHAPTER	948
29.7 BIBLIOGRAPHICAL NOTES	948
<b>PART E: ADVANCED TOPICS</b>	<b>949</b>
<b>Chapter 30: Concurrency, distribution, client-server and the Internet</b>	<b>951</b>
30.1 A SNEAK PREVIEW	951
30.2 THE RISE OF CONCURRENCY	953
30.3 FROM PROCESSES TO OBJECTS	956
30.4 INTRODUCING CONCURRENT EXECUTION	964
30.5 SYNCHRONIZATION ISSUES	977
30.6 ACCESSING SEPARATE OBJECTS	982
30.7 WAIT CONDITIONS	990
30.8 REQUESTING SPECIAL SERVICE	998
30.9 EXAMPLES	1003
30.10 TOWARDS A PROOF RULE	1022
30.11 A SUMMARY OF THE MECHANISM	1025
30.12 DISCUSSION	1028
30.13 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	1032
30.14 BIBLIOGRAPHICAL NOTES	1033
EXERCISES	1035

<b>Chapter 31: Object persistence and databases</b>	<b>1037</b>
31.1 PERSISTENCE FROM THE LANGUAGE	1037
31.2 BEYOND PERSISTENCE CLOSURE	1039
31.3 SCHEMA EVOLUTION	1041
31.4 FROM PERSISTENCE TO DATABASES	1047
31.5 OBJECT-RELATIONAL INTEROPERABILITY	1048
31.6 OBJECT-ORIENTED DATABASE FUNDAMENTALS	1050
31.7 O-O DATABASE SYSTEMS: EXAMPLES	1055
31.8 DISCUSSION: BEYOND O-O DATABASES	1058
31.9 KEY CONCEPTS STUDIED IN THIS CHAPTER	1060
31.10 BIBLIOGRAPHICAL NOTES	1061
EXERCISES	1062
<b>Chapter 32: Some O-O techniques for graphical interactive applications</b>	<b>1063</b>
32.1 NEEDED TOOLS	1064
32.2 PORTABILITY AND PLATFORM ADAPTATION	1066
32.3 GRAPHICAL ABSTRACTIONS	1068
32.4 INTERACTION MECHANISMS	1071
32.5 HANDLING THE EVENTS	1072
32.6 A MATHEMATICAL MODEL	1076
32.7 BIBLIOGRAPHICAL NOTES	1076
<b>PART F: APPLYING THE METHOD IN VARIOUS LANGUAGES AND ENVIRONMENTS</b>	<b>1077</b>
<b>Chapter 33: O-O programming and Ada</b>	<b>1079</b>
33.1 A BIT OF CONTEXT	1079
33.2 PACKAGES	1081
33.3 A STACK IMPLEMENTATION	1081
33.4 HIDING THE REPRESENTATION: THE PRIVATE STORY	1085
33.5 EXCEPTIONS	1088
33.6 TASKS	1091
33.7 FROM ADA TO ADA 95	1092
33.8 KEY CONCEPTS INTRODUCED IN THIS CHAPTER	1097
33.9 BIBLIOGRAPHICAL NOTES	1097
EXERCISES	1098

---

---

<b>Chapter 34: Emulating object technology in non-O-O environments</b>	<b>1099</b>
34.1 LEVELS OF LANGUAGE SUPPORT	1099
34.2 OBJECT-ORIENTED PROGRAMMING IN PASCAL?	1100
34.3 FORTRAN	1102
34.4 OBJECT-ORIENTED PROGRAMMING AND C	1106
34.5 BIBLIOGRAPHICAL NOTES	1112
EXERCISES	1112
<b>Chapter 35: Simula to Java and beyond: major O-O languages and environments</b>	<b>1113</b>
35.1 SIMULA	1113
35.2 SMALLTALK	1126
35.3 LISP EXTENSIONS	1130
35.4 C EXTENSIONS	1131
35.5 JAVA	1136
35.6 OTHER O-O LANGUAGES	1137
35.7 BIBLIOGRAPHICAL NOTES	1138
EXERCISES	1139
<b>PART G: DOING IT RIGHT</b>	<b>1141</b>
<b>Chapter 36: An object-oriented environment</b>	<b>1143</b>
36.1 COMPONENTS	1143
36.2 THE LANGUAGE	1144
36.3 THE COMPILATION TECHNOLOGY	1144
36.4 TOOLS	1148
36.5 LIBRARIES	1150
36.6 INTERFACE MECHANISMS	1152
36.7 BIBLIOGRAPHICAL NOTES	1160
<b>Epilogue, In Full Frankness Exposing the Language</b>	<b>1161</b>

<b>PART H: APPENDICES</b>	<b>1163</b>
<b>Appendix A: Extracts from the Base libraries</b>	<b>1165</b>
<b>Appendix B: Genericity versus inheritance</b>	<b>1167</b>
B.1 GENERICITY	1168
B.2 INHERITANCE	1173
B.3 EMULATING INHERITANCE WITH GENERICITY	1175
B.4 EMULATING GENERICITY WITH INHERITANCE	1176
B.5 COMBINING GENERICITY AND INHERITANCE	1184
B.6 KEY CONCEPTS INTRODUCED IN THIS APPENDIX	1187
B.7 BIBLIOGRAPHICAL NOTES	1188
EXERCISES	1188
<b>Appendix C: Principles, rules, precepts and definitions</b>	<b>1189</b>
<b>Appendix D: A glossary of object technology</b>	<b>1193</b>
<b>Appendix E: Bibliography</b>	<b>1203</b>
E.1 WORKS BY OTHER AUTHORS	1203
E.2 WORKS BY THE AUTHOR OF THE PRESENT BOOK	1221
<b>Index</b>	<b>1225</b>