

CONTENTS AT A GLANCE

CHAPTER 1 Introduction to Software Engineering 33

PART ONE The Software Process 51

CHAPTER 2 A Generic View of Process 52

CHAPTER 3 Process Models 77

CHAPTER 4 An Agile View of Process 103

PART TWO Software Engineering Practice 127

CHAPTER 5 Software Engineering Practice 128

CHAPTER 6 System Engineering 154

CHAPTER 7 Requirements Engineering 174

CHAPTER 8 Building the Analysis Model 207

CHAPTER 9 Design Engineering 258

CHAPTER 10 Creating an Architectural Design 286

CHAPTER 11 Modeling Component-Level Design 324

CHAPTER 12 Performing User Interface Design 356

CHAPTER 13 Testing Strategies 386

CHAPTER 14 Testing Tactics 420

CHAPTER 15 Product Metrics 461

PART THREE Applying Web Engineering 499

CHAPTER 16 Web Engineering 500

CHAPTER 17 Initiating a WebApp Project 514

CHAPTER 18 Analysis for WebApps 539

CHAPTER 19 Design for WebApps 559

CHAPTER 20 Testing for WebApps 594

PART FOUR Managing Software Projects 627

CHAPTER 21 Project Management 628

CHAPTER 22 Metrics for Process and Project 649

CHAPTER 23 Estimation 674

CHAPTER 24 Project Scheduling 705

CHAPTER 25 Risk Management 726

CONTENTS AT A GLANCE

CHAPTER 26 Quality Management 744

CHAPTER 27 Change Management 771

PART FIVE **Advanced Topics in Software Engineering** 801

CHAPTER 28 Formal Methods 802

CHAPTER 29 Cleanroom Software Engineering 828

CHAPTER 30 Component-Based Development 847

CHAPTER 31 Reengineering 869

CHAPTER 32 The Road Ahead 892

TABLE OF CONTENTS

Preface 25

Walkthrough 29

CHAPTER 1 INTRODUCTION TO SOFTWARE ENGINEERING 33

- ✓ 1.1 The Evolving Role of Software 34
- 1.2 Software 36
- 1.3 The Changing Nature of Software 40
- 1.4 Legacy Software 42
 - 1.4.1 The Quality of Legacy Software 43
 - 1.4.2 Software Evolution 43
- 1.5 Software Myths 45
- 1.6 How It All Starts 47
- 1.7 Summary 48
- REFERENCES 49
- PROBLEMS AND POINTS TO PONDER 49
- FURTHER READINGS AND INFORMATION SOURCES 50

PART ONE—THE SOFTWARE PROCESS 51

CHAPTER 2 A GENERIC VIEW OF PROCESS 52

- 2.1 Software Engineering—A Layered Technology 53 ✓
- 2.2 A Process Framework 54
- 2.3 The Capability Maturity Model Integration (CMMI) 59
- 2.4 Process Patterns 63
- 2.5 Process Assessment 66
- 2.6 Personal and Team Process Models 68
 - 2.6.1 Personal Software Process (PSP) 68
 - 2.6.2 Team Software Process (TSP) 70
- 2.7 Process Technology 71
- 2.8 Product and Process 72
- 2.9 Summary 73
- REFERENCES 74
- PROBLEMS AND POINTS TO PONDER 75
- FURTHER READINGS AND INFORMATION SOURCES 75

CHAPTER 3 PROCESS MODELS 77

- ✓ 3.1 Prescriptive Models 78
- 3.2 The Waterfall Model 79
- 3.3 Incremental Process Models 80
 - 3.3.1 The Incremental Model 80
 - 3.3.2 The RAD Model 81
- 3.4 Evolutionary Process Models 83
 - 3.4.1 Prototyping 83
 - 3.4.2 The Spiral Model 86

TABLE OF CONTENTS

3.4.3	The Concurrent Development Model	88
3.4.4	A Final Comment on Evolutionary Processes	89
3.5	Specialized Process Models	91
3.5.1	Component-Based Development	91
3.5.2	The Formal Methods Model	92
3.5.3	Aspect-Oriented Software Development	93
3.6	The Unified Process	94
3.6.1	A Brief History	95
3.6.2	Phases of the Unified Process	96
3.6.3	Unified Process Work Products	98
3.7	Summary	99
	REFERENCES	100
	PROBLEMS AND POINTS TO PONDER	101
	FURTHER READINGS AND INFORMATION SOURCES	102

CHAPTER 4 AN AGILE VIEW OF PROCESS 103

4.1	What Is Agility?	105
4.2	What Is an Agile Process?	106
4.2.1	The Politics of Agile Development	107
4.2.2	Human Factors	108
4.3	Agile Process Models	109
4.3.1	Extreme Programming (XP)	110
4.3.2	Adaptive Software Development (ASD)	114
4.3.3	Dynamic Systems Development Method (DSDM)	116
4.3.4	Scrum	117
4.3.5	Crystal	119
4.3.6	Feature Driven Development (FDD)	120
4.3.7	Agile Modeling (AM)	121
4.4	Summary	123
	REFERENCES	124
	PROBLEMS AND POINTS TO PONDER	125
	FURTHER READINGS AND INFORMATION SOURCES	126

PART TWO—SOFTWARE ENGINEERING PRACTICE 127

CHAPTER 5 SOFTWARE ENGINEERING PRACTICE 128

5.1	Software Engineering Practice	129
5.1.1	The Essence of Practice	129
5.1.2	Core Principles	131
5.2	Communication Practices	133
5.3	Planning Practices	136
5.4	Modeling Practices	139
5.4.1	Analysis Modeling Principles	140
5.4.2	Design Modeling Principles	141
5.5	Construction Practice	144
5.5.1	Coding Principles and Concepts	145
5.5.2	Testing Principles	146
5.6	Deployment	148
5.7	Summary	150

REFERENCES	151
PROBLEMS AND POINTS TO PONDER	152
FURTHER READINGS AND INFORMATION SOURCES	152

CHAPTER 6 SYSTEM ENGINEERING 154

6.1	Computer-Based Systems	155
6.2	The System Engineering Hierarchy	157
6.2.1	System Modeling	158
6.2.2	System Simulation	160
6.3	Business Process Engineering: An Overview	161
6.4	Product Engineering: An Overview	162
6.5	System Modeling	164
6.5.1	Hatley-Pirbhai Modeling	165
6.5.2	System Modeling with UML	167
6.6	Summary	171
REFERENCES		172
PROBLEMS AND POINTS TO PONDER		172
FURTHER READINGS AND INFORMATION SOURCES		173

CHAPTER 7 REQUIREMENTS ENGINEERING 174

7.1	A Bridge to Design and Construction	175
7.2	Requirements Engineering Tasks	176
7.2.1	Inception	176
7.2.2	Elicitation	177
7.2.3	Elaboration	177
7.2.4	Negotiation	178
7.2.5	Specification	179
7.2.6	Validation	179
7.2.7	Requirements Management	180
7.3	Initiating the Requirements Engineering Process	181
7.3.1	Identifying the Stakeholders	182
7.3.2	Recognizing Multiple Viewpoints	182
7.3.3	Working toward Collaboration	183
7.3.4	Asking the First Questions	183
7.4	Eliciting Requirements	184
7.4.1	Collaborative Requirements Gathering	185
7.4.2	Quality Function Deployment	188
7.4.3	User Scenarios	189
7.4.4	Elicitation Work Products	190
7.5	Developing Use-Cases	191
7.6	Building the Analysis Model	196
7.6.1	Elements of the Analysis Model	196
7.6.2	Analysis Patterns	200
7.7	Negotiating Requirements	201
7.8	Validating Requirements	203
7.9	Summary	204
REFERENCES		204
PROBLEMS AND POINTS TO PONDER		205
FURTHER READINGS AND INFORMATION SOURCES		206

CHAPTER 8 BUILDING THE ANALYSIS MODEL 207

8.1	Requirements Analysis	208
8.1.1	Overall Objective and Philosophy	209
8.1.2	Analysis Rules of Thumb	210
8.1.3	Domain Analysis	210
8.2	Analysis Modeling Approaches	211
8.3	Data Modeling Concepts	213
8.3.1	Data Objects	213
8.3.2	Data Attributes	214
8.3.3	Relationships	214
8.3.4	Cardinality and Modality	215
8.4	Object-Oriented Analysis	217
8.5	Scenario-Based Modeling	218
8.5.1	Writing Use-Cases	218
8.5.2	Developing an Activity Diagram	223
8.5.3	Swimlane Diagrams	224
8.6	Flow-Oriented Modeling	226
8.6.1	Creating a Data Flow Model	226
8.6.2	Creating a Control Flow Model	229
8.6.3	The Control Specification	230
8.6.4	The Process Specification	232
8.7	Class-Based Modeling	233
8.7.1	Identifying Analysis Classes	233
8.7.2	Specifying Attributes	236
8.7.3	Defining Operations	237
8.7.4	Class-Responsibility-Collaborator (CRC) Modeling	240
8.7.5	Associations and Dependencies	246
8.7.6	Analysis Packages	247
8.8	Creating a Behavioral Model	248
8.8.1	Identifying Events with the Use-Case	249
8.8.2	State Representations	250
8.9	Summary	253
	REFERENCES	254
	PROBLEMS AND POINTS TO PONDER	255
	FURTHER READINGS AND INFORMATION SOURCES	256

CHAPTER 9 DESIGN ENGINEERING 258

9.1	Design within the Context of Software Engineering	259
9.2	Design Process and Design Quality	261
9.3	Design Concepts	265
9.3.1	Abstraction	265
9.3.2	Architecture	265
9.3.3	Patterns	266
9.3.4	Modularity	267
9.3.5	Information Hiding	268
9.3.6	Functional Independence	268
9.3.7	Refinement	269
9.3.8	Refactoring	270
9.3.9	Design Classes	271
9.4	The Design Model	274
9.4.1	Data Design Elements	275

9.4.2	Architectural Design Elements	275
9.4.3	Interface Design Elements	276
9.4.4	Component-Level Design Elements	278
9.4.5	Deployment-Level Design Elements	279
9.5	Pattern-Based Software Design	280
9.5.1	Describing a Design Pattern	280
9.5.2	Using Patterns in Design	281
9.5.3	Frameworks	281
9.6	Summary	282
	REFERENCES	283
	PROBLEMS AND POINTS TO PONDER	283
	FURTHER READINGS AND INFORMATION SOURCES	284

CHAPTER 10 CREATING AN ARCHITECTURAL DESIGN 286

10.1	Software Architecture	287
10.1.1	What Is Architecture?	287
10.1.2	Why Is Architecture Important?	288
10.2	Data Design	289
10.2.1	Data Design at the Architectural Level	289
10.2.2	Data Design at the Component Level	290
10.3	Architectural Styles and Patterns	291
10.3.1	A Brief Taxonomy of Architectural Styles	292
10.3.2	Architectural Patterns	296
10.3.3	Organization and Refinement	297
10.4	Architectural Design	298
10.4.1	Representing the System in Context	298
10.4.2	Defining Archetypes	300
10.4.3	Refining the Architecture into Components	301
10.4.4	Describing Instantiations of the System	303
10.5	Assessing Alternative Architectural Designs	304
10.5.1	An Architecture Trade-Off Analysis Method	304
10.5.2	Architectural Complexity	306
10.5.3	Architectural Description Languages	306
10.6	Mapping Data Flow into a Software Architecture	307
10.6.1	Transform Flow	308
10.6.2	Transaction Flow	308
10.6.3	Transform Mapping	309
10.6.4	Transaction Mapping	316
10.6.5	Refining the Architectural Design	320
10.7	Summary	320
	REFERENCES	321
	PROBLEMS AND POINTS TO PONDER	322
	FURTHER READINGS AND INFORMATION SOURCES	323

CHAPTER 11 MODELING COMPONENT-LEVEL DESIGN 324

11.1	What Is a Component?	325
11.1.1	An Object-Oriented View	326
11.1.2	The Conventional View	327
11.1.3	A Process-Related View	330
11.2	Designing Class-Based Components	330
11.2.1	Basic Design Principles	331

TABLE OF CONTENTS

11.2.2	Component-Level Design Guidelines	334
11.2.3	Cohesion	335
11.2.4	Coupling	337
11.3	Conducting Component-Level Design	339
11.4	Object Constraint Language	345
11.5	Designing Conventional Components	347
11.5.1	Graphical Design Notation	348
11.5.2	Tabular Design Notation	349
11.5.3	Program Design Language	350
11.5.4	Comparison of Design Notation	352
11.6	Summary	353
	REFERENCES	354
	PROBLEMS AND POINTS TO PONDER	354
	FURTHER READINGS AND INFORMATION SOURCES	355

CHAPTER 12 PERFORMING USER INTERFACE DESIGN 356

12.1	The Golden Rules	357
12.1.1	Place the User in Control	357
12.1.2	Reduce the User's Memory Load	359
12.1.3	Make the Interface Consistent	360
12.2	User Interface Analysis and Design	361
12.2.1	Interface Analysis and Design Models	362
12.2.2	The Process	363
12.3	Interface Analysis	365
12.3.1	User Analysis	365
12.3.2	Task Analysis and Modeling	367
12.3.3	Analysis of Display Content	372
12.3.4	Analysis of the Work Environment	373
12.4	Interface Design Steps	373
12.4.1	Applying Interface Design Steps	374
12.4.2	User Interface Design Patterns	375
12.4.3	Design Issues	377
12.5	Design Evaluation	381
12.6	Summary	383
	REFERENCES	383
	PROBLEMS AND POINTS TO PONDER	384
	FURTHER READINGS AND INFORMATION SOURCES	385

CHAPTER 13 TESTING STRATEGIES 386

13.1	A Strategic Approach to Software Testing	387
13.1.1	Verification and Validation	388
13.1.2	Organizing for Software Testing	388
13.1.3	A Software Testing Strategy for Conventional Architectures	390
13.1.4	A Software Testing Strategy for Object-Oriented Architectures	391
13.1.5	Criteria for Completion of Testing	392
13.2	Strategic Issues	393
13.3	Test Strategies for Conventional Software	394
13.3.1	Unit Testing	394
13.3.2	Integration Testing	397
13.4	Test Strategies for Object-Oriented Software	404
13.4.1	Unit Testing in the OO Context	404
13.4.2	Integration Testing in the OO Context	405

13.5	Validation Testing	406
13.5.1	Validation Test Criteria	406
13.5.2	Configuration Review	406
13.5.3	Alpha and Beta Testing	406
13.6	System Testing	408
13.6.1	Recovery Testing	409
13.6.2	Security Testing	409
13.6.3	Stress Testing	409
13.6.4	Performance Testing	410
13.7	The Art of Debugging	411
13.7.1	The Debugging Process	411
13.7.2	Psychological Considerations	413
13.7.3	Debugging Strategies	414
13.7.4	Correcting the Error	416
13.8	Summary	416
	REFERENCES	417
	PROBLEMS AND POINTS TO PONDER	417
	FURTHER READINGS AND INFORMATION SOURCES	418

CHAPTER 14 TESTING TACTICS 420

14.1	Software Testing Fundamentals	421
14.2	Black-Box and White-Box Testing	423
14.3	White-Box Testing	424
14.4	Basis Path Testing	425
14.4.1	Flow Graph Notation	425
14.4.2	Independent Program Paths	426
14.4.3	Deriving Test Cases	428
14.4.4	Graph Matrices	431
14.5	Control Structure Testing	432
14.5.1	Condition Testing	432
14.5.2	Data Flow Testing	432
14.5.3	Loop Testing	433
14.6	Black-Box Testing	434
14.6.1	Graph-Based Testing Methods	435
14.6.2	Equivalence Partitioning	437
14.6.3	Boundary Value Analysis	438
14.6.4	Orthogonal Array Testing	439
14.7	Object-Oriented Testing Methods	442
14.7.1	The Test Case Design Implications of OO Concepts	442
14.7.2	Applicability of Conventional Test Case Design Methods	443
14.7.3	Fault-Based Testing	443
14.7.4	Test Cases and Class Hierarchy	444
14.7.5	Scenario-Based Testing	444
14.7.6	Testing Surface Structure and Deep Structure	446
14.8	Testing Methods Applicable at the Class Level	447
14.8.1	Random Testing for OO Classes	447
14.8.2	Partition Testing at the Class Level	448
14.9	InterClass Test Case Design	449
14.9.1	Multiple Class Testing	449
14.9.2	Tests Derived from Behavior Models	450
14.10	Testing for Specialized Environments, Architectures, and Applications	452
14.10.1	Testing GUIs	452

TABLE OF CONTENTS

14.10.2	Testing of Client/Server Architectures	452
14.10.3	Testing Documentation and Help Facilities	453
14.10.4	Testing for Real-Time Systems	454
14.11	Testing Patterns	456
14.12	Summary	457
REFERENCES		458
PROBLEMS AND POINTS TO PONDER		459
FURTHER READINGS AND INFORMATION SOURCES		460

CHAPTER 15 PRODUCT METRICS 461

15.1	Software Quality	462
15.1.1	McCall's Quality Factors	463
15.1.2	ISO 9126 Quality Factors	464
15.1.3	The Transition to a Quantitative View	465
15.2	A Framework for Product Metrics	466
15.2.1	Measures, Metrics, and Indicators	466
15.2.2	The Challenge of Product Metrics	466
15.2.3	Measurement Principles	467
15.2.4	Goal-Oriented Software Measurement	468
15.2.5	The Attributes of Effective Software Metrics	469
15.2.6	The Product Metrics Landscape	470
15.3	Metrics for the Analysis Model	472
15.3.1	Function-Based Metrics	472
15.3.2	Metrics for Specification Quality	476
15.4	Metrics for the Design Model	477
15.4.1	Architectural Design Metrics	477
15.4.2	Metrics for Object-Oriented Design	480
15.4.3	Class-Oriented Metrics—The CK Metrics Suite	481
15.4.4	Class-Oriented Metrics—The MOOD Metrics Suite	484
15.4.5	OO Metrics Proposed by Lorenz and Kidd	485
15.4.6	Component-Level Design Metrics	486
15.4.7	Operation-Oriented Metrics	488
15.4.8	User Interface Design Metrics	489
15.5	Metrics for Source Code	490
15.6	Metrics for Testing	491
15.6.1	Halstead Metrics Applied to Testing	491
15.6.2	Metrics for Object-Oriented Testing	491
15.7	Metrics for Maintenance	492
15.8	Summary	493
REFERENCES		494
PROBLEMS AND POINTS TO PONDER		496
FURTHER READINGS AND INFORMATION SOURCES		497

PART THREE—APPLYING WEB ENGINEERING 499**CHAPTER 16 WEB ENGINEERING 500**

16.1	Attributes of Web-Based Systems and Applications	501
16.2	WebApp Engineering Layers	504
16.2.1	Process	504
16.2.2	Methods	505
16.2.3	Tools and Technology	506

16.3	The Web Engineering Process	506
16.3.1	Defining the Framework	507
16.3.2	Refining the Framework	509
16.4	Web Engineering Best Practices	510
16.5	Summary	511
	REFERENCES	512
	PROBLEMS AND POINTS TO PONDER	512
	FURTHER READINGS AND INFORMATION SOURCES	513

CHAPTER 17 INITIATING A WEBAPP PROJECT 514

17.1	Formulating Web-Based Systems	515
17.1.1	Formulation Questions	515
17.1.2	Requirements Gathering for WebApps	517
17.1.3	The Bridge to Analysis Modeling	521
17.2	Planning for Web Engineering Projects	522
17.3	The Web Engineering Team	523
17.3.1	The Players	523
17.3.2	Building the Team	524
17.4	Project Management Issues for Web Engineering	525
17.4.1	WebApp Planning—Outsourcing	526
17.4.2	WebApp Planning—In-House Web Engineering	530
17.5	Metrics for Web Engineering and WebApps	532
17.5.1	Metrics for Web Engineering Effort	533
17.5.2	Metrics for Assessing Business Value	534
17.6	“Worst Practices” for WebApp Projects	534
17.7	Summary	536
	REFERENCES	536
	PROBLEMS AND POINTS TO PONDER	537
	FURTHER READINGS AND INFORMATION SOURCES	538

CHAPTER 18 ANALYSIS FOR WEBAPPS 539

18.1	Requirements Analysis for WebApps	540
18.1.1	The User Hierarchy	541
18.1.2	Developing Use-Cases	542
18.1.3	Refining the Use-Case Model	544
18.2	The Analysis Model for WebApps	545
18.3	The Content Model	545
18.3.1	Defining Content Objects	546
18.3.2	Content Relationships and Hierarchy	546
18.3.3	Analysis Classes for WebApps	547
18.4	The Interaction Model	548
18.5	The Functional Model	551
18.6	The Configuration Model	553
18.7	Relationship-Navigation Analysis	553
18.7.1	Relationship Analysis—Key Questions	554
18.7.2	Navigation Analysis	555
18.8	Summary	556
	REFERENCES	557
	PROBLEMS AND POINTS TO PONDER	557
	FURTHER READINGS AND INFORMATION SOURCES	558

CHAPTER 19 DESIGN FOR WEBAPPS 559

19.1	Design Issues for Web Engineering	560
19.1.1	Design and WebApp Quality	560
19.1.2	Design Goals	563
19.2	The WebE Design Pyramid	564
19.3	WebApp Interface Design	565
19.3.1	Interface Design Principles and Guidelines	566
19.3.2	Interface Control Mechanisms	571
19.3.3	Interface Design Workflow	571
19.4	Aesthetic Design	573
19.4.1	Layout Issues	574
19.4.2	Graphic Design Issues	574
19.5	Content Design	575
19.5.1	Content Objects	575
19.5.2	Content Design Issues	576
19.6	Architecture Design	577
19.6.1	Content Architecture	577
19.6.2	WebApp Architecture	579
19.7	Navigation Design	581
19.7.1	Navigation Semantics	581
19.7.2	Navigation Syntax	583
19.8	Component Level Design	584
19.9	Hypermedia Design Patterns	584
19.10	Object-Oriented Hypermedia Design Method (OOHDM)	586
19.10.1	Conceptual Design for OOHDM	586
19.10.2	Navigational Design for OOHDM	587
19.10.3	Abstract Interface Design and Implementation	588
19.11	Design Metrics for WebApps	588
19.12	Summary	589
	REFERENCES	590
	PROBLEMS AND POINTS TO PONDER	592
	FURTHER READINGS AND INFORMATION SOURCES	593

CHAPTER 20 TESTING FOR WEBAPPS 594

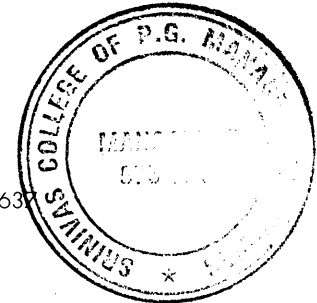
20.1	Testing Concepts for WebApps	595
20.1.1	Dimensions of Quality	595
20.1.2	Errors within a WebApp Environment	596
20.1.3	Testing Strategy	597
20.1.4	Test Planning	598
20.2	The Testing Process—An Overview	598
20.3	Content Testing	601
20.3.1	Content Testing Objectives	601
20.3.2	Database Testing	603
20.4	User Interface Testing	605
20.4.1	Interface Testing Strategy	605
20.4.2	Testing Interface Mechanisms	606
20.4.3	Testing Interface Semantics	608
20.4.4	Usability Tests	608
20.4.5	Compatibility Tests	610
20.5	Component-Level Testing	611

20.6	Navigation Testing	613
20.6.1	Testing Navigation Syntax	613
20.6.2	Testing Navigation Semantics	614
20.7	Configuration Testing	615
20.7.1	Server-Side Issues	616
20.7.2	Client-Side Issues	616
20.8	Security Testing	617
20.9	Performance Testing	619
20.9.1	Performance Testing Objectives	619
20.9.2	Load Testing	620
20.9.3	Stress Testing	620
20.10	Summary	622
	REFERENCES	623
	PROBLEMS AND POINTS TO PONDER	624
	FURTHER READINGS AND INFORMATION SOURCES	625

PART FOUR—MANAGING SOFTWARE PROJECTS 627

CHAPTER 21 PROJECT MANAGEMENT 628

21.1	The Management Spectrum	629
21.1.1	The People	629
21.1.2	The Product	630
21.1.3	The Process	630
21.1.4	The Project	630
21.2	The People	631
21.2.1	The Stakeholders	631
21.2.2	Team Leaders	632
21.2.3	The Software Team	633
21.2.4	Agile Teams	636
21.2.5	Coordination and Communication Issues	637
21.3	The Product	638
21.3.1	Software Scope	638
21.3.2	Problem Decomposition	639
21.4	The Process	640
21.4.1	Melding the Product and the Process	640
21.4.2	Process Decomposition	641
21.5	The Project	642
21.6	The W ⁵ HH Principle	644
21.7	Critical Practices	644
21.8	Summary	645
	REFERENCES	646
	PROBLEMS AND POINTS TO PONDER	646
	FURTHER READINGS AND INFORMATION SOURCES	647



CHAPTER 22 METRICS FOR PROCESS AND PROJECTS 649

22.1	Metrics in the Process and Project Domains	650
22.1.1	Process Metrics and Software Process Improvement	650
22.1.2	Project Metrics	653
22.2	Software Measurement	654
22.2.1	Size-Oriented Metrics	655
22.2.2	Function-Oriented Metrics	656

TABLE OF CONTENTS

22.2.3	Reconciling LOC and FP Metrics	656
22.2.4	Object-Oriented Metrics	658
22.2.5	Use-Case Oriented Metrics	659
22.2.6	Web Engineering Project Metrics	659
22.3	Metrics for Software Quality	661
22.3.1	Measuring Quality	662
22.3.2	Defect Removal Efficiency	663
22.4	Integrating Metrics within the Software Process	664
22.4.1	Arguments for Software Metrics	665
22.4.2	Establishing a Baseline	665
22.4.3	Metrics Collection, Computation, and Evaluation	666
22.5	Metrics for Small Organizations	666
22.6	Establishing a Software Metrics Program	668
22.7	Summary	670
	REFERENCES	670
	PROBLEMS AND POINTS TO PONDER	671
	FURTHER READINGS AND INFORMATION SOURCES	672

CHAPTER 23 ESTIMATION 674

23.1	Observations on Estimation	675
23.2	The Project Planning Process	676
23.3	Software Scope and Feasibility	677
23.4	Resources	677
23.4.1	Human Resources	678
23.4.2	Reusable Software Resources	678
23.4.3	Environmental Resources	679
23.5	Software Project Estimation	680
23.6	Decomposition Techniques	681
23.6.1	Software Sizing	681
23.6.2	Problem-Based Estimation	682
23.6.3	An Example of LOC-Based Estimation	683
23.6.4	An Example of FP-Based Estimation	685
23.6.5	Process-Based Estimation	686
23.6.6	An Example of Process-Based Estimation	687
23.6.7	Estimation with Use-Cases	688
23.6.8	An Example of Use-Case Based Estimation	689
23.6.9	Reconciling Estimates	690
23.7	Empirical Estimation Models	691
23.7.1	The Structure of Estimation Models	692
23.7.2	The COCOMO II Model	692
23.7.3	The Software Equation	694
23.8	Estimation for Object-Oriented Projects	695
23.9	Specialized Estimation Techniques	696
23.9.1	Estimation for Agile Development	696
23.9.2	Estimation for Web Engineering Projects	697
23.10	The Make/Buy Decision	698
23.10.1	Creating a Decision Tree	699
23.10.2	Outsourcing	700
23.11	Summary	701
	REFERENCES	702
	PROBLEMS AND POINTS TO PONDER	703
	FURTHER READINGS AND INFORMATION SOURCES	703

CHAPTER 24 PROJECT SCHEDULING 705

- 24.1 Basic Concepts 706
- 24.2 Project Scheduling 708
 - 24.2.1 Basic Principles 709
 - 24.2.2 The Relationship Between People and Effort 710
 - 24.2.3 Effort Distribution 712
- 24.3 Defining a Task Set for the Software Project 713
 - 24.3.1 A Task Set Example 714
 - 24.3.2 Refinement of Major Tasks 714
- 24.4 Defining a Task Network 715
- 24.5 Scheduling 716
 - 24.5.1 Timeline Charts 717
 - 24.5.2 Tracking the Schedule 718
 - 24.5.3 Tracking Progress for an OO Project 720
- 24.6 Earned Value Analysis 722
- 24.7 Summary 723
- REFERENCES 723
- PROBLEMS AND POINTS TO PONDER 724
- FURTHER READINGS AND INFORMATION SOURCES 725

CHAPTER 25 RISK MANAGEMENT 726

- 25.1 Reactive vs. Proactive Risk Strategies 727
- 25.2 Software Risks 728
- 25.3 Risk Identification 729
 - 25.3.1 Assessing Overall Project Risk 730
 - 25.3.2 Risk Components and Drivers 731
- 25.4 Risk Projection 732
 - 25.4.1 Developing a Risk Table 733
 - 25.4.2 Assessing Risk Impact 735
- 25.5 Risk Refinement 737
- 25.6 Risk Mitigation, Monitoring, and Management 737
- 25.7 The RMMM Plan 740
- 25.8 Summary 741
- REFERENCES 742
- PROBLEMS AND POINTS TO PONDER 742
- FURTHER READINGS AND INFORMATION SOURCES 743

CHAPTER 26 QUALITY MANAGEMENT 744

- 26.1 Quality Concepts 745
 - 26.1.1 Quality 746
 - 26.1.2 Quality Control 746
 - 26.1.3 Quality Assurance 747
 - 26.1.4 Cost of Quality 747
- 26.2 Software Quality Assurance 748
 - 26.2.1 Background Issues 749
 - 26.2.2 SQA Activities 749
- 26.3 Software Reviews 751
 - 26.3.1 Cost Impact of Software Defects 752
 - 26.3.2 Defect Amplification and Removal 752
- 26.4 Formal Technical Reviews 754
 - 26.4.1 The Review Meeting 754
 - 26.4.2 Review Reporting and Record Keeping 755

TABLE OF CONTENTS

26.4.3	Review Guidelines	756
26.4.4	Sample-Driven Reviews	757
26.5	Formal Approaches to SQA	759
26.6	Statistical Software Quality Assurance	759
26.6.1	A Generic Example	760
26.6.2	Six Sigma for Software Engineering	761
26.7	Software Reliability	762
26.7.1	Measures of Reliability and Availability	763
26.7.2	Software Safety	763
26.8	The ISO 9000 Quality Standards	765
26.9	The SQA Plan	766
26.10	Summary	767
	REFERENCES	768
	PROBLEMS AND POINTS TO PONDER	769
	FURTHER READINGS AND INFORMATION SOURCES	769

CHAPTER 27 CHANGE MANAGEMENT 771

27.1	Software Configuration Management	772
27.1.1	A SCM Scenario	773
27.1.2	Elements of a Configuration Management System	774
27.1.3	Baselines	775
27.1.4	Software Configuration Items	775
27.2	The SCM Repository	777
27.2.1	The Role of the Repository	777
27.2.2	General Features and Content	778
27.2.3	SCM Features	779
27.3	The SCM Process	780
27.3.1	Identification of Objects in the Software Configuration	781
27.3.2	Version Control	782
27.3.3	Change Control	784
27.3.4	Configuration Audit	787
27.3.5	Status Reporting	788
27.4	Configuration Management for Web Engineering	788
27.4.1	Configuration Management Issues for WebApps	789
27.4.2	WebApp Configuration Objects	790
27.4.3	Content Management	790
27.4.4	Change Management	793
27.4.5	Version Control	795
27.4.6	Auditing and Reporting	796
27.5	Summary	797
	REFERENCES	798
	PROBLEMS AND POINTS TO PONDER	799
	FURTHER READINGS AND INFORMATION SOURCES	800

PART FIVE—ADVANCED TOPICS IN SOFTWARE ENGINEERING 801

CHAPTER 28 FORMAL METHODS 802

28.1	Basic Concepts	803
28.1.1	Deficiencies of Less Formal Approaches	804
28.1.2	Mathematics in Software Development	805
28.1.3	Formal Methods Concepts	805

28.2	Mathematical Preliminaries	808
28.2.1	Sets and Constructive Specification	808
28.2.2	Set Operators	810
28.2.3	Logic Operators	812
28.2.4	Sequences	812
28.3	Applying Mathematical Notation for Formal Specification	813
28.4	Formal Specification Languages	815
28.5	Object Constraint Language (OCL)	816
28.5.1	A Brief Overview of OCL Syntax and Semantics	816
28.5.2	An Example Using OCL	818
28.6	The Z Specification Language	820
28.6.1	A Brief Overview of Z Syntax and Semantics	820
28.6.2	An Example Using Z	820
28.7	The Ten Commandments of Formal Methods	823
28.8	Formal Methods—The Road Ahead	824
28.9	Summary	825
	REFERENCES	825
	PROBLEMS AND POINTS TO PONDER	826
	FURTHER READINGS AND INFORMATION SOURCES	827

CHAPTER 29 CLEANROOM SOFTWARE ENGINEERING 828

29.1	The Cleanroom Approach	829
29.1.1	The Cleanroom Strategy	830
29.1.2	What Makes Cleanroom Different?	832
29.2	Functional Specification	833
29.2.1	Black-Box Specification	834
29.2.2	State-Box Specification	835
29.2.3	Clear-Box Specification	835
29.3	Cleanroom Design	836
29.3.1	Design Refinement and Verification	836
29.3.2	Advantages of Design Verification	840
29.4	Cleanroom Testing	841
29.4.1	Statistical Use Testing	842
29.4.2	Certification	843
29.5	Summary	844
	REFERENCES	844
	PROBLEMS AND POINTS TO PONDER	845
	FURTHER READINGS AND INFORMATION SOURCES	846

CHAPTER 30 COMPONENT-BASED DEVELOPMENT 847

30.1	Engineering of Component-Based Systems	848
30.2	The CBSE Process	850
30.3	Domain Engineering	851
30.3.1	The Domain Analysis Process	851
30.3.2	Characterization Functions	852
30.3.3	Structural Modeling and Structure Points	853
30.4	Component-Based Development	854
30.4.1	Component Qualification, Adaptation, and Composition	854
30.4.2	Component Engineering	857
30.4.3	Analysis and Design for Reuse	858

TABLE OF CONTENTS

30.5	Classifying and Retrieving Components	859
30.5.1	Describing Reusable Components	859
30.5.2	The Reuse Environment	861
30.6	Economics of CBSE	862
30.6.1	Impact on Quality, Productivity, and Cost	862
30.6.2	Cost Analysis Using Structure Points	863
30.7	Summary	864
	REFERENCES	865
	PROBLEMS AND POINTS TO PONDER	866
	FURTHER READINGS AND INFORMATION SOURCES	867

CHAPTER 31 REENGINEERING 869

31.1	Business Process Reengineering	870
31.1.1	Business Processes	871
31.1.2	A BPR Model	871
31.2	Software Reengineering	873
31.2.1	Software Maintenance	873
31.2.2	A Software Reengineering Process Model	874
31.3	Reverse Engineering	878
31.3.1	Reverse Engineering to Understand Data	880
31.3.2	Reverse Engineering to Understand Processing	880
31.3.3	Reverse Engineering User Interfaces	881
31.4	Restructuring	882
31.4.1	Code Restructuring	882
31.4.2	Data Restructuring	883
31.5	Forward Engineering	884
31.5.1	Forward Engineering for Client/Server Architectures	885
31.5.2	Forward Engineering for Object-Oriented Architectures	886
31.5.3	Forward Engineering User Interfaces	887
31.6	The Economics of Reengineering	887
31.7	Summary	888
	REFERENCES	889
	PROBLEMS AND POINTS TO PONDER	890
	FURTHER READINGS AND INFORMATION SOURCES	891

CHAPTER 32 THE ROAD AHEAD 892

32.1	The Importance of Software—Revisited	893
32.2	The Scope of Change	893
32.3	People and the Way They Build Systems	895
32.4	The “New” Software Engineering Process	896
32.5	New Modes for Representing Information	897
32.6	Technology as a Driver	899
32.7	The Software Engineer’s Responsibility	900
32.8	A Concluding Comment	902
	REFERENCES	903
	PROBLEMS AND POINTS TO PONDER	903
	FURTHER READINGS AND INFORMATION SOURCES	903