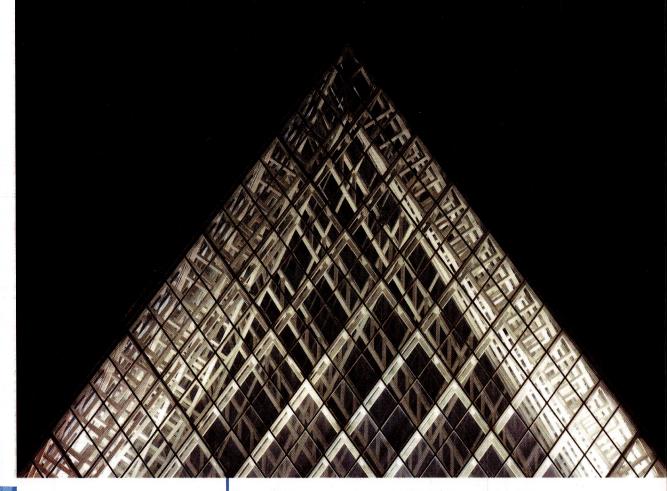
HASSAN GOMAA

SOFTWARE MODELING & DESIGN



UML, USE CASES, PATTERNS, & SOFTWARE ARCHITECTURES

Contents

Prej	ace		page xv
Ann	otate	ed Table of Contents	xix
Ack	now	ledgments	xxv
PAR	RT I	Overview	
1	Int	roduction	3
	1.1	Software Modeling	3
	1.2	Object-Oriented Methods and the Unified Modeling	
		Language	3
	1.3	Software Architectural Design	5
	1.4	Method and Notation	5
	1.5	COMET: A UML-Based Software Modeling and Design	
		Method for Software Applications	6
	1.6	UML as a Standard	6
	1.7	Multiple Views of Software Architecture	7
	1.8	Evolution of Software Modeling and Design Methods	8
	1.9	Evolution of Object-Oriented Analysis and Design Methods	9
	1.10	Survey of Concurrent, Distributed, and Real-Time	
		Design Methods	11
	1.1	1 Summary	12
		Exercises	12
2	Ove	erview of the UML Notation	14
	2.1	UML Diagrams	14
	2.2	Use Case Diagrams	15
	2.3	Classes and Objects	15
	2.4	Class Diagrams	16
	2.5	Interaction Diagrams	18
	2.6	State Machine Diagrams	19
	2.7	Packages	21

/iii	Cont	ents		
		2.8	Concurrent Communication Diagrams	21
		2.9	Deployment Diagrams	23
		2.10	UML Extension Mechanisms	23
		2.11	Conventions Used in This Book	25
		2.12	Summary	27
			Exercises	28
	3	Softw	vare Life Cycle Models and Processes	29
		3.1	Software Life Cycle Models	29
		3.2	Design Verification and Validation	40
		3.3	Software Life Cycle Activities	41
		3.4	Software Testing	42
		3.5	Summary	43
			Exercises	43
	4	Softw	vare Design and Architecture Concepts	45
		4.1	Object-Oriented Concepts	45
		4.2	Information Hiding	48
		4.3	Inheritance and Generalization/Specialization	51
		4.4	Concurrent Processing	53
		4.5	Design Patterns	57
		4.6	Software Architecture and Components	58
		4.7	Software Quality Attributes	59
		4.8	Summary Exercises	59 60
	5	Overs	view of Software Modeling and Design Method	61
	•	5.1	COMET Use Case–Based Software Life Cycle	61
		5.2	Comparison of the COMET Life Cycle with Other	O1
		J.2	Software Processes	64
		5.3	Requirements, Analysis, and Design Modeling	65
		5.4	Designing Software Architectures	67
		5.5	Summary	68
			Exercises	68
	PAR	RT II S	Software Modeling	
	6	Use (Case Modeling	71
		6.1	Requirements Modeling	72
		6.2	Use Cases	74
		6.3	Actors	76
		6.4	Identifying Use Cases	78
		6.5	Documenting Use Cases in the Use Case Model	80
		6.6	Example of Use Case Description	80
		6.7	Use Case Relationships	82
		6.8	The Include Relationship	82
		6.9	The Extend Relationship	85
		6.10	Use Case Structuring Guidelines	88

85

			Contents
	6.11	Specifying Nonfunctional Requirements	89
	6.12	Use Case Packages	89
	6.13	Activity Diagrams	89
	6.14	Summary	92
		Exercises	92
7	Static	: Modeling	94
	7.1	Associations between Classes	95
	7.2	Composition and Aggregation Hierarchies	100
	7.3	Generalization/Specialization Hierarchy	102
	7.4	Constraints	103
	7.5	Static Modeling and the UML	103
	7.6	Static Modeling of the System Context	104
	7.7	Categorization of Classes Using UML Stereotypes	106
	7.8	Modeling External Classes	107
	7.9	Static Modeling of Entity Classes	111
	7.10	Summary	113
		Exercises	114
8	Objec	t and Class Structuring	115
_	8.1	Object and Class Structuring Criteria	116
	8.2	Modeling Application Classes and Objects	116
	8.3	Object and Class Structuring Categories	117
	8.4	External Classes and Software Boundary Classes	118
	8.5	Boundary Classes and Objects	119
	8.6	Entity Classes and Objects	123
	8.7	Control Classes and Objects	124
	8.8	Application Logic Classes and Objects	127
	8.9	Summary	130
		Exercises	130
9	Dvnar	nic Interaction Modeling	132
_	9.1	Object Interaction Modeling	133
	9.2	Message Sequence Numbering on Interaction	100
		Diagrams	136
	9.3	Dynamic Interaction Modeling	139
	9.4	Stateless Dynamic Interaction Modeling	139
	9.5	Examples of Stateless Dynamic Interaction Modeling	140
	9.6	Summary	148
		Exercises	148
10	Finite	State Machines	151
-	10.1	Finite State Machines and State Transitions	151
	10.2	Examples of Statecharts	153
	10.3	Events and Guard Conditions	157
	10.4	Actions	158
	10.5	Hierarchical Statecharts	163
	10.6	Guidelines for Developing Statecharts	167

ix

Contents

X

	10.7	Developing Statecharts from Use Cases	168
	10.8	Example of Developing a Statechart from a Use Case	169
	10.9	Summary	175
		Exercises	175
11	State	Dependent Dynamic Interaction Modeling	177
	11.1	Steps in State-Dependent Dynamic Interaction Modeling	177
	11.2	Modeling Interaction Scenarios Using Interaction Diagrams	
		and Statecharts	178
	11.3	Example of State-Dependent Dynamic Interaction Modeling:	
		Banking System	179
	11.4	Summary	187
		Exercises	188
PAF	RT III 🔏	Architectural Design	
12	Overv	iew of Software Architecture	193
	12.1	Software Architecture and Component-Based	
		Software Architecture	193
	12.2	Multiple Views of a Software Architecture	194
	12.3	Software Architectural Patterns	198
	12.4	Documenting Software Architectural Patterns	205
	12.5	Interface Design	206
	12.6	Designing Software Architectures	207
	12.7	Summary	209
		Exercises	210
13		are Subsystem Architectural Design	212
	13.1	Issues in Software Architectural Design	212
	13.2	Integrated Communication Diagrams	213
	13.3	Separation of Concerns in Subsystem Design	216
	13.4	Subsystem Structuring Criteria	220
	13.5	Decisions about Message Communication between	22.5
	12.6	Subsystems	226
	13.6	Summary	228
		Exercises	228
14	_	ning Object-Oriented Software Architectures	230
	14.1	Concepts, Architectures, and Patterns	231
	14.2	Designing Information Hiding Classes	231
	14.3	Designing Class Interface and Operations	232
	14.4	Data Abstraction Classes	234
	14.5	State-Machine Classes	236
	14.6	Graphical User Interaction Classes	237
	14.7	Business Logic Classes	239
	14.8	Inheritance in Design	239
	14.9	Class Interface Specifications Detailed Design of Information Hiding Classes	245
	14.10	Detailed Design of Information Hiding Classes	246

			Contents
	14.11	Polymorphism and Dynamic Binding	248
	14.11	Implementation of Classes in Java	249
	14.12	Summary	250
	14.13	Exercises	251
15	Desig	ning Client/Server Software Architectures	253
	15.1	Concepts, Architectures, and Patterns for Client/Server	
		Architectures	254
	15.2	Client/Service Software Architectural Structure Patterns	254
	15.3	Architectural Communication Patterns for Client/Server	
		Architectures	258
	15.4	Middleware in Client/Server Systems	260
	15.5	Design of Service Subsystems	261
	15.6	Design of Wrapper Classes	266
	15.7	From Static Models to Relational Database Design	268
	15.8	Summary	275
		Exercises	276
16	Desig	ning Service-Oriented Architectures	278
	16.1	Concepts, Architectures, and Patterns for Service-Oriented	
		Architecture	279
	16.2	Software Architectural Broker Patterns	280
	16.3	Technology Support for Service-Oriented Architecture	283
	16.4	Software Architectural Transaction Patterns	285
	16.5	Negotiation Pattern	289
	16.6	Service Interface Design in Service-Oriented Architecture	292
	16.7	Service Coordination in Service-Oriented Architecture	294
	16.8	Designing Service-Oriented Architectures	295
	16.9	Service Reuse	297
	16.10	Summary	298
		Exercises	298
17	Desig	ning Component-Based Software Architectures	300
	17.1	Concepts, Architectures, and Patterns for Component-Based	
		Software Architectures	300
	17.2	Designing Distributed Component-Based Software	
		Architectures	301
	17.3	Composite Subsystems and Components	302
	17.4	Modeling Components with UML	303
	17.5	Component Structuring Criteria	307
	17.6	Group Message Communication Patterns	310
	17.7	Application Deployment	314
	17.8	Summary	316
		Exercises	316
18		ning Concurrent and Real-Time Software Architectures	318
	18.1	Concepts, Architectures, and Patterns for Concurrent	
		and Real-Time Software Architectures	318

χi

	18.2	Characteristics of Real-Time Systems	319
	18.3	Control Patterns for Real-Time Software Architectures	320
	18.4	Concurrent Task Structuring	322
	18.5	I/O Task Structuring Criteria	323
	18.6	Internal Task Structuring Criteria	327
	18.7	Developing the Concurrent Task Architecture	331
	18.8	Task Communication and Synchronization	332
	18.9	Task Interface and Task Behavior Specifications	338
	18.10	Implementation of Concurrent Tasks in Java	342
	18.11	Summary	342
		Exercises	343
19	Desig	ning Software Product Line Architectures	344
	19.1	Evolutionary Software Product Line Engineering	344
	19.2	Requirements Modeling for Software Product Lines	345
	19.3	Analysis Modeling for Software Product Lines	349
	19.4	Dynamic State Machine Modeling	
		for Software Product Lines	352
	19.5	Design Modeling for Software Product Lines	353
	19.6	Summary	355
		Exercises	355
20		are Quality Attributes	357
	20.1	Maintainability	357
	20.2	Modifiability	358
	20.3	Testability	360
	20.4	Traceability	360
	20.5	Scalability	361
	20.6	Reusability	363
	20.7	Performance	364
	20.8	Security	365
	20.9	Availability	366
	20.10	Summary	367
		Exercises	367
PAF	RT IV	Case Studies	
21	Client	t/Server Software Architecture Case Study	371
	21.1	Problem Description	371
	21.2	Use Case Model	372
	21.3	Static Modeling	376
	21.4	Object Structuring	381
	21.5	Dynamic Modeling	384
	21.6	ATM Statechart	396
	21.7	Design of Banking System	401
	21.8	Integrating the Communication Model	401
	21.9	Structuring the System into Subsystems	403
	21.10	Design of ATM Client Subsystem	404