Clean Architecture

A Craftsman's Guide to Software Structure and Design

Robert C. Martin

PRENTICE
HALL

Boston • Columbus • Indianapolis • New York • San Francisco • Amsterdam • Cape Town
Dubai • London • Madrid • Milan • Munich • Paris • Montreal • Toronto • Delhi • Mexico City
São Paulo • Sydney • Hong Kong • Seoul • Singapore • Taipei • Tokyo

CONTENTS

Foreword		xv
Preface		xix
Acknowledgments		xxiii
About the Author		xxv
PART I	Introduction	1
Chapter 1	What Is Design and Architecture?	3
	The Goal?	4
	Case Study	5
	Conclusion	12
Chapter 2	A Tale of Two Values	13
	Behavior	14
	Architecture	14
	The Greater Value	15
	Eisenhower's Matrix	16
	Fight for the Architecture	18

PART II	Starting with the Bricks: Programming Paradigms	19
Chapter 3	Paradigm Overview	21
	Structured Programming	22
	Object-Oriented Programming	22
	Functional Programming	22
	Food for Thought	23
	Conclusion	24
Chapter 4	Structured Programming	25
	Proof	27
	A Harmful Proclamation	28
	Functional Decomposition	29
	No Formal Proofs	30
	Science to the Rescue	30
	Tests	31
	Conclusion	31
Chapter 5	Object-Oriented Programming	33
	Encapsulation?	34
	Inheritance?	37
	Polymorphism?	40
	Conclusion	47
Chapter 6	Functional Programming	49
	Squares of Integers	50
	Immutability and Architecture	52
	Segregation of Mutability	52
	Event Sourcing	54
	Conclusion	56
PART III	Design Principles	57
Chapter 7	SRP: The Single Responsibility Principle	61
	Symptom 1: Accidental Duplication	63
	Symptom 2: Merges	65
	Solutions	66
	Conclusion	67

Chapter 8	OCP: The Open-Closed Principle	69
	A Thought Experiment	70
	Directional Control	74
	Information Hiding	74
	Conclusion	75
Chapter 9	LSP: The Liskov Substitution Principle	77
	Guiding the Use of Inheritance	78
	The Square/Rectangle Problem	79
	LSP and Architecture	80
	Example LSP Violation	80
	Conclusion	82
Chapter 10	ISP: The Interface Segregation Principle	83
	ISP and Language	85
	ISP and Architecture	86
	Conclusion	86
Chapter 11	DIP: The Dependency Inversion Principle	87
	Stable Abstractions	88
	Factories	89
	Concrete Components	91
	Conclusion	91
PART IV	Component Principles	93
Chapter 12	Components	95
	A Brief History of Components	96
	Relocatability	99
	Linkers	100
	Conclusion	102
Chapter 13	Component Cohesion	103
	The Reuse/Release Equivalence Principle	104
	The Common Closure Principle	105
	The Common Reuse Principle	107
	The Tension Diagram for Component Cohesion	108
	Conclusion	110

Chapter 14	Component Coupling	111
	The Acyclic Dependencies Principle	112
	Top-Down Design	118
	The Stable Dependencies Principle	120
	The Stable Abstractions Principle	126
	Conclusion	132
PART V	Architecture	133
Chapter 15	What Is Architecture?	135
	Development	137
	Deployment	138
	Operation	138
	Maintenance	139
	Keeping Options Open	140
	Device Independence	142
	Junk Mail	144
	Physical Addressing	145
	Conclusion	146
Chapter 16	Independence	147
	Use Cases	148
	Operation	149
	Development	149
	Deployment	150
	Leaving Options Open	150
	Decoupling Layers	151
	Decoupling Use Cases	152
	Decoupling Mode	153
	Independent Develop-ability	153
	Independent Deployability	154
	Duplication	154
	Decoupling Modes (Again)	155
	Conclusion	158

Chapter 17	**Boundaries: Drawing Lines**	**159**
	A Couple of Sad Stories	160
	FitNesse	163
	Which Lines Do You Draw, and When Do You Draw Them?	165
	What About Input and Output?	169
	Plugin Architecture	170
	The Plugin Argument	172
	Conclusion	173
Chapter 18	**Boundary Anatomy**	**175**
	Boundary Crossing	176
	The Dreaded Monolith	176
	Deployment Components	178
	Threads	179
	Local Processes	179
	Services	180
	Conclusion	181
Chapter 19	**Policy and Level**	**183**
	Level	184
	Conclusion	187
Chapter 20	**Business Rules**	**189**
	Entities	190
	Use Cases	191
	Request and Response Models	193
	Conclusion	194
Chapter 21	**Screaming Architecture**	**195**
	The Theme of an Architecture	196
	The Purpose of an Architecture	197
	But What About the Web?	197
	Frameworks Are Tools, Not Ways of Life	198
	Testable Architectures	198
	Conclusion	199

Chapter 22	**The Clean Architecture**	**201**
	The Dependency Rule	203
	A Typical Scenario	207
	Conclusion	209
Chapter 23	**Presenters and Humble Objects**	**211**
	The Humble Object Pattern	212
	Presenters and Views	212
	Testing and Architecture	213
	Database Gateways	214
	Data Mappers	214
	Service Listeners	215
	Conclusion	215
Chapter 24	**Partial Boundaries**	**217**
	Skip the Last Step	218
	One-Dimensional Boundaries	219
	Facades	220
	Conclusion	220
Chapter 25	**Layers and Boundaries**	**221**
	Hunt the Wumpus	222
	Clean Architecture?	223
	Crossing the Streams	226
	Splitting the Streams	227
	Conclusion	228
Chapter 26	**The Main Component**	**231**
	The Ultimate Detail	232
	Conclusion	237
Chapter 27	**Services: Great and Small**	**239**
	Service Architecture?	240
	Service Benefits?	240
	The Kitty Problem	242
	Objects to the Rescue	244

	Component-Based Services	245
	Cross-Cutting Concerns	246
	Conclusion	247
Chapter 28	**The Test Boundary**	**249**
	Tests as System Components	250
	Design for Testability	251
	The Testing API	252
	Conclusion	253
Chapter 29	**Clean Embedded Architecture**	**255**
	App-titude Test	258
	The Target-Hardware Bottleneck	261
	Conclusion	273
PART VI	**Details**	**275**
Chapter 30	**The Database Is a Detail**	**277**
	Relational Databases	278
	Why Are Database Systems So Prevalent?	279
	What If There Were No Disk?	280
	Details	281
	But What about Performance?	281
	Anecdote	281
	Conclusion	283
Chapter 31	**The Web Is a Detail**	**285**
	The Endless Pendulum	286
	The Upshot	288
	Conclusion	289
Chapter 32	**Frameworks Are Details**	**291**
	Framework Authors	292
	Asymmetric Marriage	292
	The Risks	293
	The Solution	294

	I Now Pronounce You ...	295
	Conclusion	295
Chapter 33	**Case Study: Video Sales**	**297**
	The Product	298
	Use Case Analysis	298
	Component Architecture	300
	Dependency Management	302
	Conclusion	302
Chapter 34	**The Missing Chapter**	**303**
	Package by Layer	304
	Package by Feature	306
	Ports and Adapters	308
	Package by Component	310
	The Devil Is in the Implementation Details	315
	Organization versus Encapsulation	316
	Other Decoupling Modes	319
	Conclusion: The Missing Advice	321
PART VII	**Appendix**	**323**
Appendix A	**Architecture Archaeology**	**325**
Index		**375**