

Table of Contents

| | |
|---|----|
| Part I Foundations of Object-Process Methodology | 1 |
| Chapter 1 A Taste of OPM | 3 |
| 1.1 The Wedding Example: A Sneak Preview of OPM | 5 |
| 1.2 OPM Building Blocks: Objects, Processes, and States | 5 |
| 1.3 Specialization and Inheritance | 7 |
| 1.4 Aggregation and the Result Link | 8 |
| Summary | 10 |
| Problems | 11 |
| Chapter 2 Object-Process Diagrams | 13 |
| 2.1 Objects and Aggregation | 13 |
| 2.2 Structural Relations and Structural Links | 15 |
| 2.3 Processes and Procedural Links | 16 |
| 2.4 System Diagram: The Top-Level OPD | 18 |
| 2.5 Zooming into the Transaction Executing Process | 20 |
| 2.6 The OPD Set | 21 |
| 2.7 How to Read an OPD | 22 |
| 2.7.1 Flow of Control | 22 |
| 2.7.2 The Timeline in OPDs | 23 |
| 2.7.3 Object States and Conditions | 23 |
| 2.8 Completing the In-Zoomed Transaction Executing OPD | 24 |
| 2.8.1 Logical XOR, AND, and OR Operators | 25 |
| 2.8.2 The System Map | 26 |
| 2.8.3 The Ultimate OPD | 27 |
| 2.8.4 Zooming Out of Transaction Executing | 28 |
| Summary | 29 |
| Problems | 30 |

| | | |
|------------------|--|-----------|
| Chapter 3 | Object-Process Language | 33 |
| 3.1 | Motivation for a Language | 33 |
| 3.1.1 | Real-Time Textual Feedback | 34 |
| 3.1.2 | Closing the Requirements-Implementation Gap | 35 |
| 3.2 | Structural Links and Structure Sentences | 35 |
| 3.2.1 | The First OPL Sentence | 36 |
| 3.2.2 | The First OPL Aggregation Sentence | 37 |
| 3.3 | The OPL Paragraph and the Graphics-Text Principle | 38 |
| 3.3.1 | Extending the OPL Paragraph | 40 |
| 3.3.2 | Enabling Sentences | 40 |
| 3.3.3 | Transformation Sentences | 41 |
| 3.3.4 | The SD Paragraph | 43 |
| 3.4 | More OPL Sentence Types | 43 |
| 3.4.1 | State Enumeration and Condition Sentences | 44 |
| 3.4.2 | AND, XOR, and OR Logical Operators | 46 |
| 3.4.3 | The SD1 Paragraph | 47 |
| 3.4.4 | In-Zooming and Out-Zooming Sentences | 48 |
| 3.5 | Boolean Objects and Determination Sentence | 49 |
| 3.5.1 | Boolean Condition Sentences | 50 |
| 3.5.2 | Compound Condition Sentences | 50 |
| 3.5.3 | State-Specified Generation Sentence | 50 |
| 3.5.4 | Converting a Dual-State Object into a Boolean Object | 50 |
| 3.6 | OPD-OPL Item Pairs and Synergy | 52 |
| | Summary | 52 |
| | Problems | 53 |
| Chapter 4 | Objects and Processes | 55 |
| 4.1 | Existence, Things, and Transformations | 55 |
| 4.1.1 | Objects | 56 |
| 4.1.2 | Transformation and Processes | 57 |
| 4.2 | Processes and Time | 59 |
| 4.2.1 | Cause and Effect | 59 |
| 4.2.2 | Syntactic vs. Semantic Sentence Analysis | 60 |
| 4.2.3 | The Process Test | 61 |
| 4.3 | Things | 62 |
| 4.3.1 | Things and Entities | 63 |
| 4.3.2 | The Perseverance of Things | 64 |
| 4.3.3 | The Essence of Things | 66 |
| 4.3.4 | Symbolizing Physical Things | 68 |
| 4.3.5 | The Origin of Things | 70 |
| 4.3.6 | The Complexity of Things | 70 |

| | |
|---|--------|
| 4.3.7 Thing Types | 70 |
| 4.3.8 The Relativity of Object and Process Importance | 71 |
| 4.3.9 Object and Process Naming | 71 |
| 4.4 Informational Objects | 72 |
| 4.4.1 Telling Informational and Physical Objects Apart | 72 |
| 4.4.2 Systems and Information Systems | 73 |
| 4.4.3 Translation of Informational Objects | 74 |
| 4.4.4 Toward “Pure” Informational Objects | 74 |
| 4.5 Object Identity | 75 |
| 4.5.1 Change of State or Change of Identity? | 76 |
| 4.5.2 Classes and Instances of Objects and Processes | 77 |
| Summary | 78 |
| Problems | 78 |
| Part II Concepts of OPM Systems Modeling | 81 |
| Chapter 5 Dynamics | 83 |
| 5.1 States | 83 |
| 5.1.1 Object States and Status | 83 |
| 5.1.2 Change and Effect | 84 |
| 5.1.3 Explicit and Implicit Status Representations | 85 |
| 5.1.4 The Input, Output, and Effect Links | 87 |
| 5.1.5 State Suppression and the Effect Link | 88 |
| 5.1.6 State Expression | 89 |
| 5.2 Existence and Transformation | 90 |
| 5.2.1 Result and Consumption Links | 92 |
| 5.2.2 Procedural Links, Enablers, and Transformees | 93 |
| 5.2.3 Enablers | 93 |
| 5.2.4 Agents | 94 |
| 5.2.5 Instruments | 94 |
| 5.2.6 Enabling Links | 95 |
| 5.2.7 Transformees | 96 |
| 5.2.8 Odd Man Out: The Invocation Link | 97 |
| 5.3 Object Roles with Respect to a Process | 98 |
| 5.3.1 Enablers and Affectees | 99 |
| 5.3.2 The Involved, Preprocess, and Postprocess Object Sets | 99 |
| 5.3.3 Condition and Agent Condition Links | 100 |
| 5.3.4 Operator, Operand, and Transform? | 101 |
| Summary | 102 |
| Problems | 102 |

| | | |
|------------------|---|------------|
| Chapter 6 | Structure | 105 |
| 6.1 | Structural Relations | 105 |
| 6.1.1 | Structural Links | 106 |
| 6.1.2 | Structural Relation Directions | 108 |
| 6.1.3 | Unidirectional Structural Link | 109 |
| 6.1.4 | OPD Sentences | 109 |
| 6.1.5 | The Reciprocity of a Structural Relation | 110 |
| 6.1.6 | Null Tags and Their Default OPL Reserved Phrases | 111 |
| 6.1.7 | Structural Relations as Static Verbs | 112 |
| 6.2 | Participation Constraints and Cardinality | 113 |
| 6.2.1 | Participation Constraints | 113 |
| 6.2.2 | Parameterized Participation Constraints | 114 |
| 6.2.3 | Range Participation Constraints | 115 |
| 6.2.4 | Shorthand Notations and Reserved Phrases | 116 |
| 6.2.5 | Cardinality | 117 |
| 6.2.6 | Participation Constraints in Procedural Relations | 119 |
| 6.3 | The Distributive Law and Forks | 120 |
| 6.3.1 | Forks | 121 |
| 6.3.2 | Fork Degree | 123 |
| 6.3.3 | Fork Comprehensiveness | 124 |
| 6.4 | The Transitivity of Structural Relations | 125 |
| 6.5 | The Four Fundamental Structural Relations | 126 |
| | Summary | 129 |
| | Problems | 130 |
| Chapter 7 | Aggregation and Exhibition | 133 |
| 7.1 | Aggregation-Participation: Underlying Concepts | 133 |
| 7.1.1 | Aggregation-Participation as a Tagged Structural Relation | 135 |
| 7.1.2 | The Aggregation-Participation Symbol | 136 |
| 7.1.3 | Sets and Order | 137 |
| 7.1.4 | Aggregate Naming | 138 |
| 7.1.5 | Aggregating Processes | 139 |
| 7.2 | Aggregation Hierarchy and Comprehensiveness | 141 |
| 7.2.1 | Aggregation Hierarchy | 141 |
| 7.2.2 | Aggregation Comprehensiveness | 142 |
| 7.2.3 | Parameterized Participation Constraints | 142 |
| 7.2.4 | Participation Level and Aggregational Complexity | 143 |
| 7.3 | Exhibition-Characterization: Underlying Concepts | 144 |
| 7.3.1 | The Name Exhibition-Characterization | 145 |
| 7.3.2 | The Exhibition-Characterization Symbol | 145 |
| 7.3.3 | Attribute and Operation Are Features | 146 |
| 7.3.4 | Exhibition Complexity | 147 |

| | |
|---|------------|
| 7.4 Features in OO vs. OPM | 148 |
| 7.5 The Four Thing-Feature Combinations | 151 |
| 7.5.1 The Object-Attribute Combination | 152 |
| 7.5.2 The Object-Operation Combination | 152 |
| 7.5.3 The Process-Attribute Combination | 154 |
| 7.5.4 Process-Operation Combination | 155 |
| 7.6 The Feature Hierarchy | 156 |
| 7.7 Feature-Related Natural Language Issues | 157 |
| 7.7.1 Attribute Naming Dilemmas | 157 |
| 7.7.2 Reserved Objects and the Measurement Unit Reserved Object | 159 |
| 7.7.3 Continuous Values and Multi-Valued Attributes | 160 |
| 7.7.4 Mathematical Inequalities in OPM | 162 |
| 7.8 Reflective Metamodeling of an Attribute | 162 |
| 7.8.1 The Size of an Attribute | 162 |
| 7.8.2 The Mode of an Attribute | 163 |
| 7.8.3 The Touch of an Attribute | 164 |
| 7.8.4 The Source of a Feature | 165 |
| 7.8.5 The Operation a Feature Carries | 166 |
| Summary | 166 |
| Problems | 167 |
| Chapter 8 Generalization and Instantiation | 171 |
| 8.1 Generalization-Specialization: Introduction | 171 |
| 8.1.1 Specialization Symbol and Sentence | 172 |
| 8.1.2 Process Specialization | 173 |
| 8.2 Inheritance | 175 |
| 8.2.1 Feature Inheritance | 175 |
| 8.2.2 Structural Relations Inheritance | 177 |
| 8.2.3 Procedural Link Inheritance | 178 |
| 8.2.4 State Inheritance | 180 |
| 8.2.5 State Specialization | 181 |
| 8.2.6 Process Specialization | 183 |
| 8.2.7 Generalization Complexity | 187 |
| 8.3 Qualification | 187 |
| 8.3.1 Qualification Inheritance | 188 |
| 8.3.2 Multiple Qualification Inheritance | 189 |
| 8.4 Classification-Instantiation | 191 |
| 8.4.1 Classes and Instances | 193 |
| 8.4.2 The Relation Between Instantiation and Specialization | 194 |
| 8.4.3 The Relativity of Instance | 194 |
| 8.4.4 Instance Qualification | 196 |
| 8.4.5 Process Instances | 197 |
| 8.4.6 Classification Complexity | 198 |

| | |
|---|---------|
| 8.5 Modifiers and Instances | 198 |
| 8.5.1 Natural Language Modifiers and Shortcuts | 198 |
| 8.5.2 Adjectives and Attributes | 199 |
| 8.5.3 Adverbs and Operations | 201 |
| 8.6 Specializations of the Involved Object Set Members | 202 |
| 8.7 Non-Comprehensiveness | 203 |
| 8.7.1 Non-Comprehensiveness of Fundamental Structural Relations | 203 |
| 8.7.2 Non-Comprehensiveness of States and Values | 204 |
| Summary | 205 |
| Problems | 205 |
| Chapter 9 Managing Systems' Complexity | 207 |
| 9.1 The Need for Complexity Management | 207 |
| 9.1.1 Middle-Out as the De-Facto Architecting Practice | 208 |
| 9.1.2 Determining the Extent of Refinement | 210 |
| 9.1.3 Towards Quantifying Complexity | 211 |
| 9.2 Divide and Conquer: By Aspects or by Details? | 212 |
| 9.2.1 Why is Detail Decomposition Good? | 215 |
| 9.2.2 When Should a New OPD Be Created? | 217 |
| 9.3 The Attributes of Scaling | 217 |
| 9.3.1 The Purpose of Scaling | 217 |
| 9.3.2 The Mode of Scaling | 218 |
| 9.3.3 Controlling Visibility by In- and Out-Zooming | 221 |
| 9.3.4 The Distributivity of Procedural Links | 223 |
| 9.3.5 Unfolding and Folding | 224 |
| 9.3.6 State Expressing and Suppressing | 227 |
| 9.3.7 Primary and Secondary Operands | 230 |
| 9.4 Abstracting | 230 |
| 9.4.1 Consolidating | 230 |
| 9.4.2 Zoom consolidating | 231 |
| 9.4.3 Paths and Path Labels | 231 |
| 9.4.4 Zoom Consolidating Pitfalls | 233 |
| 9.4.5 Zoom Consolidating Conditions | 234 |
| 9.4.6 Fold Consolidating | 235 |
| 9.5 What Happens to Procedural Links During Abstracting? | 235 |
| 9.5.1 Procedural Link Precedence | 236 |
| 9.5.2 Semi-Folding and Semi-Unfolding | 238 |
| 9.5.3 Selective Semi-Folding and Semi-Unfolding | 240 |
| 9.6 Looking at the Big Picture: The System Map and the OPM Construct Pairs | 241 |
| Summary | 244 |
| Problems | 245 |

| | |
|---|-----|
| Part III Building Systems with OPM | 247 |
| Chapter 10 Systems and Modeling | 249 |
| 10.1 Defining Systems | 249 |
| 10.1.1 Some Existing Definitions | 249 |
| 10.1.2 Function | 251 |
| 10.1.3 The Various Functions of Stone | 251 |
| 10.2 System Defined | 252 |
| 10.2.1 System as a Relative Term | 254 |
| 10.2.2 System as a Subjective Term | 254 |
| 10.2.3 The Function of Natural and Artificial Systems | 255 |
| 10.3 Goal, Concept, and Function | 255 |
| 10.3.1 The Intent and Goal of Artificial Systems | 256 |
| 10.3.2 Telling System Function and Dynamics Apart | 256 |
| 10.3.3 Function, Structure, and Behavior | 260 |
| 10.4 System Architecture | 260 |
| 10.4.1 Function vs. Dynamics | 260 |
| 10.4.2 The Concept Behind a System | 261 |
| 10.4.3 The Origin and Essence of Systems | 262 |
| 10.5 Objects, Systems, and Products | 263 |
| 10.5.1 Product Defined | 263 |
| 10.5.2 The Object-System-Product Hierarchy | 264 |
| 10.5.3 Goods, Services, and Projects | 266 |
| 10.6 Documenting Functions of the System Architecture | 267 |
| 10.6.1 The Function Hierarchy | 267 |
| 10.6.2 Function Boxes and Function Sentences | 268 |
| 10.6.3 Functionality | 271 |
| 10.7 From Systems to Models | 271 |
| 10.7.1 Some Model Definitions | 272 |
| 10.7.2 Model Defined | 272 |
| 10.8 Modeling Paradigms | 272 |
| 10.8.1 Natural Language as a Modeling Tool | 273 |
| 10.8.2 Mathematical and Symbolic Modeling | 276 |
| 10.8.3 Graphic Modeling and Knowledge Representation | 281 |
| 10.9 Reflective Metamodeling | 283 |
| Summary | 285 |
| Problems | 286 |
| Chapter 11 System Lifecycle and Evolution | 289 |
| 11.1 System Lifecycle | 289 |
| 11.1.1 Lifecycle of Artificial Systems | 290 |
| 11.1.2 Software and Product Development Processes | 290 |

| | |
|--|------------|
| 11.2 Systems Analysis and the Scientific Method | 291 |
| 11.3 Categorization vs. Interdisciplinarity | 293 |
| 11.4 System Engineering and the Role of the System Architect | 293 |
| 11.5 An OPM Model of System Lifecycle Phases | 294 |
| 11.5.1 Top-Level Description of System Evolution | 295 |
| 11.5.2 Initiating the System | 297 |
| 11.5.3 Developing the System | 297 |
| 11.5.4 Analyzing | 298 |
| 11.5.5 The Refining-Abstracting Cycles | 299 |
| 11.5.6 Designing | 300 |
| 11.5.7 The Waterfall Model vs. Iterative and Incremental Development | 301 |
| 11.5.8 Deploying the System | 302 |
| 11.6 Zooming into Analyzing | 304 |
| 11.7 Zooming into Designing and Implementing | 306 |
| 11.8 From Design to Implementation | 308 |
| Summary | 308 |
| Problems | 309 |
| Chapter 12 States and Values | 311 |
| 12.1 State-specified Objects and Links | 311 |
| 12.1.1 Initial, Ultimate and Default States | 313 |
| 12.1.2 The Transformation Attribute of a Process | 314 |
| 12.1.3 Object as a Role Player for State | 315 |
| 12.1.4 State Maintaining Processes | 316 |
| 12.1.5 Sentences and Phrases of States and Values | 317 |
| 12.1.6 Single Value Sentence | 322 |
| 12.2 Telling States Apart from Values | 322 |
| 12.3 Metamodeling the Attributes of Value and Their States | 324 |
| 12.3.1 Numeric and Symbolic Values | 326 |
| 12.3.2 Mapping Object States onto Attribute Values | 326 |
| 12.4 Compound States and State Space | 328 |
| 12.4.1 The Attribute Feasibility Matrix | 332 |
| 12.4.2 Logical Compound States | 332 |
| Summary | 335 |
| Problems | 337 |
| Chapter 13 Advanced OPM Concepts | 339 |
| 13.1 Real-Time Issues | 339 |
| 13.1.1 Sequential vs. Parallel Process Execution | 339 |
| 13.1.2 Process Synchronization | 340 |
| 13.1.3 Events | 341 |

| | |
|---|------------|
| 13.1.4 Chronon and Event | 342 |
| 13.1.5 Basic Triggering Event Types | 342 |
| 13.2 Process and State Duration | 344 |
| 13.3 Processing states | 346 |
| 13.4 Probability in Procedural Relations | 348 |
| 13.5 Scope and Name Disambiguation | 349 |
| 13.5.1 The Fundamental DAG | 350 |
| 13.5.2 Scope of an Object | 351 |
| 13.6 The Reserved Words “of” and “which” | 352 |
| 13.6.1 The Reserved Word “of” and the Dot Operator | 356 |
| 13.6.2 Using “of” with Tagged Structural Relations | 357 |
| 13.6.3 The Reserved Word “which” | 357 |
| 13.6.4 Operation: A Process Without Side Effect | 360 |
| 13.7 Structure-Related Issues | 360 |
| 13.7.1 Transitivity Strength | 361 |
| 13.7.2 Hamiltonian Distance | 362 |
| 13.7.3 The Fractal Relation | 362 |
| 13.7.4 Covariance and Contravariance | 364 |
| 13.8 OPM Metamodeling Issues | 365 |
| 13.8.1 A Metamodel of Thing | 366 |
| 13.8.2 The Specialization-Specification Hierarchy | 368 |
| 13.8.3 A Refined Generic Processing Model | 369 |
| 13.8.4 Time Exception Handling | 371 |
| 13.9 The OPM Construct Hierarchy | 372 |
| Summary | 374 |
| Problems | 376 |
| Chapter 14 Systems Theory | 379 |
| 14.1 The Informatics Hierarchy | 379 |
| 14.1.1 Computers Are Climbing the Informatics Hierarchy | 380 |
| 14.1.2 Knowledge and Understanding | 381 |
| 14.2 Ontology | 382 |
| 14.3 General Systems Theory | 383 |
| 14.3.1 A Brief History of General Systems Theory | 383 |
| 14.3.2 The Hierarchy of System Levels | 385 |
| 14.4 Autopoietic vs. Allopoietic Systems | 387 |
| 14.5 Systems and Humans | 387 |
| 14.6 Systems Theory Characteristics | 388 |
| 14.6.1 Previously Defined Characteristics | 389 |
| 14.6.2 System, Environment and Beneficiaries | 389 |
| 14.6.3 Control and Feedback | 390 |

| | |
|--|---------|
| 14.7 Classical Physics vs. Quantum Theory | 393 |
| 14.7.1 Visualization | 394 |
| 14.7.2 Causality | 395 |
| 14.7.3 Locality | 395 |
| 14.7.4 Self-Identity | 395 |
| 14.7.5 Objectivity | 396 |
| 14.8 Objectifying: Converting a Process into an Object | 397 |
| Summary | 399 |
| Problems | 400 |
| Chapter 15 Object-Oriented Modeling | 401 |
| 15.1 The Evolution of System Analysis Methods | 401 |
| 15.1.1 Data Flow Diagrams | 402 |
| 15.1.2 Entity-Relationship Diagrams and Their Combination with DFD | 402 |
| 15.1.3 The Object-Oriented Paradigm | 403 |
| 15.2 Pre-UML Object-Oriented Methods | 403 |
| 15.2.1 Object Modeling Technique | 404 |
| 15.2.2 Object-Oriented Software Engineering | 404 |
| 15.2.3 Object-Oriented Analysis and Object-Oriented Design | 405 |
| 15.2.4 Object-Oriented Systems Analysis | 405 |
| 15.2.5 Object-Oriented Analysis & Design | 406 |
| 15.2.6 Object Life-Cycles | 406 |
| 15.2.7 The Booch Method | 407 |
| 15.2.8 MOSES | 407 |
| 15.2.9 The Fusion Method | 407 |
| 15.2.10 OPEN Modeling Language | 408 |
| 15.3 Unified Modeling Language – UML | 408 |
| 15.4 Metamodeling in OO Methods | 410 |
| 15.5 OO Methods – A Summary | 410 |
| 15.6 Software Development Approaches and Trends | 412 |
| 15.6.1 Aspect-Oriented Programming | 412 |
| 15.6.2 The Rational Unified Process | 412 |
| 15.6.3 Extreme Programming | 413 |
| 15.6.4 Agile Modeling | 413 |
| 15.7 Challenges for OO Methods | 413 |
| 15.7.1 A Historic Perspective | 414 |
| 15.7.2 The Encapsulation Challenge | 415 |
| 15.7.3 The Model Multiplicity Challenge | 415 |
| 15.7.4 Empirical Evidence of the Model Multiplicity Problem | 417 |
| 15.7.5 The Complexity Management Challenge | 417 |

| | |
|--|-----|
| 15.8 OPM and OO | 418 |
| 15.8.1 The UML 2.0 Initiative | 419 |
| 15.8.2 Systemantica: an OPM Supporting Tool | 420 |
| 15.8.3 OPM Applications and Research: Present and Future | 421 |
| Summary | 423 |
| Problems | 424 |
| Appendix A: The ATM System | 425 |
| References | 435 |
| Index | 443 |



<http://www.springer.com/978-3-540-65471-1>

Object-Process Methodology

A Holistic Systems Paradigm

Dori, D.

2002, XXV, 455 p., Hardcover

ISBN: 978-3-540-65471-1