

Contents

| | |
|---|-----------|
| Part 1 Introduction | 1 |
| 1 What is Rationale and Why Does It Matter? | 3 |
| 1.1 Introduction | 3 |
| 1.1.1 The Scope and Value of Rationale in Software Engineering | 3 |
| 1.1.2 Objectives of This Chapter | 5 |
| 1.2 A Rough Sketch of Research on Rationale..... | 5 |
| 1.2.1 Argumentative Approaches to Rationale..... | 5 |
| 1.2.2 Rationale Methods That Go Beyond Argumentation | 12 |
| 1.3 Why Rationale Matters | 13 |
| 1.3.1 The Usefulness of Rationale for Artifact Creation | 13 |
| 1.3.2 The Usefulness of Rationale for Software Engineering | 16 |
| 1.4 Summary and Conclusions | 22 |
| 2 What Makes Software Different..... | 25 |
| 2.1 Introduction | 25 |
| 2.1.1 Rationale for Software Artifacts versus Rationale for Physical Artifacts..... | 25 |
| 2.1.2 Objectives of This Chapter | 26 |
| 2.2 The Roles of the Computer..... | 26 |
| 2.2.1 Comparison of the Roles of the Computer in the Lifecycles of Physical and Software Artifacts | 27 |
| 2.2.2 The Significance for Rationale Management in Software Engineering..... | 28 |
| 2.3 Iteration in Development | 32 |
| 2.3.1 The Role of Iteration in Different Types of Development | 32 |
| 2.3.2 Implications of Iteration for Rationale Management in Software Engineering | 33 |
| 2.4 Summary and Conclusion..... | 35 |
| 3 Rationale and Software Engineering | 37 |
| 3.1 Introduction | 37 |
| 3.1.1 Software Engineering | 37 |
| 3.1.2 Software Engineering Rationale..... | 38 |

| | |
|---|-----------|
| 3.1.3 Objectives of This Chapter | 38 |
| 3.2 Rationale and the Software Process | 38 |
| 3.2.1 Software Process Definition and Implementation | 38 |
| 3.2.2 Rationale and SE Process Decision-Making | 39 |
| 3.3 Rationale and Project Management | 41 |
| 3.4 Rationale and Software Development | 43 |
| 3.4.1 Why Capture Software Engineering Rationale? | 43 |
| 3.4.2 What are the Uses of Software Engineering Rationale? | 44 |
| 3.4.3 When can Software Engineering Rationale be Used in Software Development? | 45 |
| 3.4.4 How Can We Support Software Engineering Rationale Use in Software Development? | 47 |
| 3.5 Summary and Conclusions | 47 |
| 4 Learning from Rationale Research in Other Domains..... | 49 |
| 4.1 Introduction | 49 |
| 4.1.1 Research on Rationale in other Domains..... | 49 |
| 4.1.2 Objectives of This Chapter | 50 |
| 4.2 Domain-Oriented Design Environments Using PHI | 50 |
| 4.2.1 PHIDIAS and JANUS | 50 |
| 4.2.2 Discussion..... | 53 |
| 4.3 Automating the Capture of Design Rationale with CAD | 55 |
| 4.3.1 The Rationale Capture Problem | 55 |
| 4.3.2 Solution Approach: Automating the Capture of Rationale..... | 56 |
| 4.3.3 Implementation: The Rationale Construction Framework | 57 |
| 4.3.4 Discussion..... | 58 |
| 4.4 Parameter Dependency Networks as Design Rationale..... | 59 |
| 4.4.1 The DRIVE System and Parameter Dependency Networks.... | 59 |
| 4.4.2 Discussion..... | 60 |
| 4.5 Case-Based Reasoning as Design Rationale..... | 61 |
| 4.5.1. From Automated Case-Based Reasoning to Case-Based Design Aids | 61 |
| 4.5.2 Discussion..... | 64 |
| 4.6 Summary and Conclusions | 66 |
| 5 Decision-Making in Software Engineering | 67 |
| 5.1 Introduction | 67 |
| 5.1.1 General | 67 |
| 5.1.1 Objectives of this Chapter | 67 |
| 5.2 Decision-Making Problems | 68 |
| 5.2.1 Where Decisions Go Wrong..... | 68 |
| 5.2.2 Poor Decisions in Software | 69 |

| | |
|---|------------|
| 5.3 Naturalistic Decision-Making..... | 71 |
| 5.3.1 Background..... | 71 |
| 5.3.2 The Recognition-Primed Decision Model..... | 72 |
| 5.4 Rationale as a Resource for Decision-Making | 73 |
| 5.4.1 Classical Decision-Making..... | 74 |
| 5.4.2 Naturalistic Decision-making | 75 |
| 5.5 Summary and Conclusions | 76 |
| Part 2 Uses for Rationale..... | 77 |
| 6 Presentation of Rationale | 79 |
| 6.1 Introduction | 79 |
| 6.1.1 General | 79 |
| 6.1.2 Objectives of This Chapter | 79 |
| 6.2 Codifying Rationale Semiformally..... | 80 |
| 6.2.1 The rationale for rationale notations..... | 80 |
| 6.2.2 Hypermedia Presentations of Rationale..... | 81 |
| 6.2.3 Using Semiformal Rationales | 82 |
| 6.3 Codifying Rationale Informally..... | 83 |
| 6.4 Directions..... | 85 |
| 6.4.1 Reusable Rationale Databases | 86 |
| 6.4.2 Multi-Scale Presentations of Rationale | 87 |
| 6.4.3 Integrated Presentation | 87 |
| 6.5 Summary and Conclusions | 89 |
| 7 Evaluation..... | 91 |
| 7.1 Introduction | 91 |
| 7.1.1 Argumentation-Based Rationale..... | 91 |
| 7.1.2 Scenario-Based Rationale..... | 93 |
| 7.1.3 Objectives of This Chapter | 93 |
| 7.2 Evaluating the Rationale..... | 94 |
| 7.2.1 Completeness..... | 94 |
| 7.2.2 Correctness | 95 |
| 7.3 Evaluating the Decisions | 96 |
| 7.3.1 Comparing Alternatives..... | 96 |
| 7.3.2 Combining Inputs from Multiple Developers..... | 97 |
| 7.3.3 Handling Uncertainty | 98 |
| 7.4 Scenario-Based Evaluation..... | 100 |
| 7.5 Summary and Conclusions | 101 |
| 8 Support for Collaboration..... | 103 |
| 8.1 Introduction | 103 |

| | |
|---|------------|
| 8.1.1 General | 103 |
| 8.1.2 Objectives of This Chapter | 103 |
| 8.2 Software Development as Collaborative Work | 104 |
| 8.2.1 Collaboration Is Inescapable | 104 |
| 8.2.2 Collaboration Entraines Challenges | 105 |
| 8.3 Collaboration Supports Rationale..... | 106 |
| 8.3.1 Collaboration Externalizes Rationales..... | 107 |
| 8.3.2 Software Development Communities of Practice..... | 108 |
| 8.4 Rationale Supports Collaboration..... | 110 |
| 8.4.1 Awareness..... | 110 |
| 8.4.2 Coordination..... | 111 |
| 8.5 Summary and Conclusions | 112 |
| 9 Change Analysis..... | 113 |
| 9.1 Introduction | 113 |
| 9.1.1 Issues with Change in Software Development | 113 |
| 9.1.2 Objectives of This Chapter | 115 |
| 9.2 Types of Software Changes..... | 115 |
| 9.2.1 Functional Requirement Change | 116 |
| 9.2.2 Nonfunctional Requirement Change | 117 |
| 9.2.3 Changing Assumptions..... | 118 |
| 9.2.4 Structural Changes..... | 119 |
| 9.2.5 Defect Correction | 119 |
| 9.3 Change Impact Assessment..... | 120 |
| 9.4 Consistency Management..... | 121 |
| 9.5 Summary and Conclusions | 122 |
| Part 3 Rationale and Software Engineering..... | 123 |
| 10 Rationale and the Software Lifecycle..... | 125 |
| 10.1 Introduction | 125 |
| 10.1.1 Software Engineering Process | 125 |
| 10.1.2 Objectives of This Chapter | 126 |
| 10.2 Development Activities and Rationale | 126 |
| 10.2.1 Project Planning and Management | 126 |
| 10.2.2 Requirements..... | 127 |
| 10.2.3 Design..... | 127 |
| 10.2.4 Implementation..... | 128 |
| 10.2.5 Verification and Validation | 128 |
| 10.2.6 Maintenance | 129 |
| 10.2.7 Retirement | 129 |
| 10.3 Software Lifecycle Models..... | 129 |

| | |
|--|------------|
| 10.3.1 Sequential Models | 129 |
| 10.3.2 Iterative Models..... | 131 |
| 10.3.3 Other Models..... | 133 |
| 10.4. Software Process Improvement | 136 |
| 10.4.1 CMM | 136 |
| 10.4.2 Personal Software Process..... | 137 |
| 10.5. Summary and Conclusions | 138 |
| 11 Rationale and Requirements Engineering..... | 139 |
| 11.1 Introduction | 139 |
| 11.1.1 Requirements Engineering | 139 |
| 11.1.2 Objectives of This Chapter | 140 |
| 11.2 Obtaining Requirements | 140 |
| 11.2.1 Requirements Elicitation | 140 |
| 11.2.2 Achieving Consensus | 142 |
| 11.2.3 Requirements Inconsistency | 143 |
| 11.2.4 Requirements Prioritization..... | 144 |
| 11.3 Requirements Traceability..... | 144 |
| 11.4 Rationale and Nonfunctional Requirements..... | 146 |
| 11.4.1 Nonfunctional Requirement Categorization..... | 146 |
| 11.4.2 The NFR Framework..... | 147 |
| 11.4.3 SEURAT Argument Ontology and NFR Prioritization..... | 148 |
| 11.4.4 NFRs and Conflict Representation and Detection..... | 148 |
| 11.5 Goal-Based Requirements Engineering..... | 149 |
| 11.5.1 Goal-Based Requirements Analysis | 149 |
| 11.5.2 Goal-Oriented Requirements Engineering | 150 |
| 11.5.3 Relationship to Rationale..... | 151 |
| 11.6 Adapting to Changing Requirements..... | 152 |
| 11.7 Summary and Conclusions | 153 |
| 12 Rationale and Software Design..... | 155 |
| 12.1 Introduction | 155 |
| 12.1.1 The Nature and Importance of Software Design Rationale.. | 156 |
| 12.1.2 Objectives of This Chapter | 156 |
| 12.2 Relating Rationale Approaches to Software Design Processes.. | 157 |
| 12.2.1 Decision-centric and Usage-centric Rationale Approaches.. | 157 |
| 12.2.2 Prescriptive and Descriptive Roles of Rationale Approaches..... | 159 |
| 12.2.3 Rationale for Design Space Analysis and Deeper Reflection | 164 |
| 12.3 Specific Approaches that Integrate Rationale into Software Design..... | 167 |

| | |
|--|------------|
| 12.3.1 Rationale and Software Architecture..... | 167 |
| 12.3.2 Strategies for Fitting Rationale into Architectural Design Processes..... | 172 |
| 12.4 Summary and Conclusions | 173 |
| 13 Rationale and Software Verification, Validation, and Testing..... | 175 |
| 13.1 Introduction | 175 |
| 13.1.1 Verification, Validation, and Testing | 175 |
| 13.1.2 Software Testing Issues | 176 |
| 13.1.3 Objectives of This Chapter | 177 |
| 13.2 Types of Software VV&T | 177 |
| 13.2.1 Inspection | 177 |
| 13.2.2 Unit Testing..... | 178 |
| 13.2.3 Integration Testing..... | 179 |
| 13.2.4 System Testing | 179 |
| 13.3 Rationale Support for Software VV&T | 180 |
| 13.3.1 Rationale and Testability | 180 |
| 13.3.2 Rationale and Test Case Prioritization | 181 |
| 13.3.3 Rationale, Testing, and Component Selection..... | 182 |
| 13.4 Software Testing Rationale..... | 183 |
| 13.4.1 Testing Rationale..... | 183 |
| 13.4.2 Uses for Testing Rationale | 184 |
| 13.5 Summary and Conclusions | 184 |
| 14 Rationale and Software Maintenance | 187 |
| 14.1 Introduction | 187 |
| 14.1.1 Software Maintenance and Evolution..... | 187 |
| 14.1.2 Objectives of This Chapter | 188 |
| 14.2. Types of Software Maintenance | 188 |
| 14.3 Improving Maintainability..... | 190 |
| 14.3.1 Designing for Maintenance | 190 |
| 14.3.2 System Reengineering | 191 |
| 14.4 Software Maintenance Support..... | 193 |
| 14.4.1 Maintenance Prediction | 193 |
| 14.4.2 Impact Assessment | 193 |
| 14.4.3 Program Comprehension | 194 |
| 14.4.4 Maintenance Recovery | 196 |
| 14.4.5 Maintenance Rationale | 197 |
| 14.5 Summary and Conclusions | 198 |
| 15 Rationale and Software Reuse | 199 |
| 15.1 Introduction | 199 |

| | |
|---|------------|
| 15.1.1 Software Reuse | 199 |
| 15.1.2 Objectives of This Chapter | 200 |
| 15.2 Reuse: Concepts and Categories | 200 |
| 15.2.1 Types of Reuse | 200 |
| 15.2.2 Types of Rationale for Reuse | 202 |
| 15.2.3 Reusable Rationale | 203 |
| 15.3 Applying Rationale | 203 |
| 15.3.1 Rationale and Patterns | 203 |
| 15.3.2 Rationale and Component-Based Software Engineering | 205 |
| 15.3.3 Rationale and Software Product Lines | 206 |
| 15.3.4 Rationale and COTS-Based Software Engineering | 208 |
| 15.4. Summary and Conclusions | 209 |
| Part 4 Frameworks for Rationale-Based Software Engineering | 211 |
| 16 A Conceptual Framework | 213 |
| 16.1 Introduction | 213 |
| 16.1.1 What a Conceptual Framework Should Do | 213 |
| 16.1.2 Objectives of This Chapter | 214 |
| 16.2 General Goals of Rationale Usage in Software Engineering | 214 |
| 16.3 Rationale: Types of Approaches, Specific Approaches, and Methods | 215 |
| 16.4 Decision-centric Rationale in Software Engineering | 216 |
| 16.4.1 Decision-Making in Rationale Approaches | 216 |
| 16.4.2 Question Answering in Software Engineering | 218 |
| 16.4.3 Using Decision-centric Rationale in the Full Spectrum of SER | 223 |
| 16.5 Usage-centric Rationale in Software Engineering | 227 |
| 16.6 Rationale and Iterative Software Development | 228 |
| 16.6.1 A Rationale-Based Account of Iterative Development | 229 |
| 16.6.2 Principles for Rationale Approaches to Support Iterative Development | 230 |
| 16.6.3 Supporting Iterative Development by Combining Decision- centric and Usage-centric Rationale | 234 |
| 16.7 Challenges to Rationale Usage | 235 |
| 16.7.1 Solving the Capture Problem | 235 |
| 16.7.2 Solving the Delivery Problem | 238 |
| 16.8 Summary and Conclusions | 239 |
| 17 An Architectural Framework | 241 |
| 17.1 Introduction | 241 |

| | |
|--|------------|
| 17.1.1 An Integrative Architecture for Rationale-Based Software Engineering..... | 241 |
| 17.1.2 Objectives of This Chapter..... | 242 |
| 17.2 The Need for an Integrative Approach to Rationale Management..... | 243 |
| 17.2.1 Representing and Integrating All Types of Software Engineering Rationale..... | 243 |
| 17.2.2 Alleviating the Capture and Delivery Problems..... | 243 |
| 17.3 Framework of an Integrative Architecture for Rationale Management in Software Engineering..... | 248 |
| 17.3.1 An Overview of the Framework..... | 248 |
| 17.3.2 Workings of the Rational Management System..... | 249 |
| 17.3.3 Integration with External Systems..... | 251 |
| 17.4 Summary and Conclusions..... | 254 |
| 18 Rationale-Based Software Engineering: Summary and Prospect..... | 255 |
| 18.1 Introduction..... | 255 |
| 18.1.1. Rationale as an Aid to Software Engineering..... | 255 |
| 18.1.2 Objectives of This Chapter..... | 256 |
| 18.2 Summary of the Book..... | 256 |
| 18.3 The Challenges of Future Software Development..... | 258 |
| 18.3.1 Managing Change..... | 258 |
| 18.3.2 Managing the Increasing Scale, Complexity, and Longevity of Software Projects..... | 258 |
| 18.4 The Promise of Rationale-Based Software Engineering..... | 259 |
| 18.4.1 Rationale and the Management of Change..... | 260 |
| 18.4.2 Using Rationale to Manage the Increasing Scale, Complexity, and Longevity of Software Projects..... | 261 |
| 18.5 Challenges for Rationale-Based Software Engineering..... | 261 |
| 18.5.1 Addressing the Capture Problem..... | 262 |
| 18.5.2 Addressing the Delivery Problem..... | 265 |
| 18.6. Summary and Conclusions..... | 266 |
| Bibliography..... | 269 |
| Glossary..... | 295 |
| Index..... | 311 |