Design of Enterprise Systems

Theory, Architecture, and Methods
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Theory, Architecture, and Methods

Ronald E. Giachetti
Contents

Preface xiii

I Enterprise Engineering 1

1 Enterprise Engineering 3

1.1 Definition of Enterprise Engineering 3

1.1.1 Enterprise Systems 4

1.1.2 Enterprise Engineer 5

1.1.3 Enterprise Life-Cycle 7

1.1.4 Enterprise Design Method 8

1.1.5 Enterprise Architecture 9

1.1.6 Enterprise Engineering Projects 10

1.2 Need for Enterprise Engineering 11

1.2.1 Enterprise Engineering Compared to Systems Engineering 13

1.2.2 Skills and Knowledge of Enterprise Engineers 13

1.3 The Enterprise Environment 14

1.4 History of Enterprise Engineering 18

1.4.1 Scientific Management 19

1.4.2 Humanist School 22

1.4.3 General Systems Theory Movement 23

1.5 Summary 24

Bibliography 25

2 Systems Theory 29

2.1 Definition of a System 29

2.1.1 Enterprise Boundaries 30

2.1.2 Enterprise Subsystems 30

2.1.3 Holism 31

2.1.4 Open versus Closed 31

2.1.5 Purposefulness 32

2.1.6 Feedback and Control 32

2.1.7 Complexity 34

2.1.8 Dynamic 36

2.1.9 Equifinality 37

2.2 System Dynamics 37

2.2.1 Causal Loop Diagrams 37

2.2.2 Stock and Flow Diagrams 39

2.2.3 Critique of System Dynamics 42

2.3 Systems Thinking 43

2.3.1 Reductionist Perspective 43

2.3.2 Systems Perspective 44

2.4 How To Think Like a Systems Thinker 48
2.4.1 Implications for Enterprise System Design ........................................ 48
2.5 Summary .................................................................................. 49

Bibliography .................................................................................. 51

3 Modeling Concepts ..................................................................... 53
3.1 Model Definition ........................................................................ 53
3.2 Features of Models ..................................................................... 54
3.3 Model Viewpoint ......................................................................... 57
3.4 Modeling Language ...................................................................... 58
3.4.1 Types of Models ...................................................................... 60
3.5 Model Verification and Validation .................................................. 63
3.5.1 Model Verification and Validation Procedure .............................. 64
3.5.2 Obstacles to Validation .............................................................. 65
3.6 Modeling Process .......................................................................... 67
3.6.1 Modeling Project Initiation ......................................................... 67
3.6.2 Model Construction ................................................................... 68
3.6.3 Model Solving ........................................................................... 70
3.6.4 Reporting ................................................................................ 70
3.6.5 Model Implementation ............................................................... 70
3.7 Model Reuse ................................................................................. 71
3.8 Summary .................................................................................. 72

Bibliography .................................................................................. 74

4 Enterprise Design Methodology ....................................................... 75
4.1 Design Theory ............................................................................. 75
4.1.1 Design as Problem Solving ....................................................... 78
4.1.2 The Design Problem ................................................................. 80
4.1.3 Design Thinking ..................................................................... 83
4.1.4 Design for Change ................................................................. 84
4.2 Design Methodologies ................................................................. 86
4.2.1 Waterfall Design Model ........................................................... 88
4.2.2 Spiral Design Model ................................................................. 89
4.2.3 Controlled Iteration Design Model ........................................... 90
4.2.4 Methods in Practice ............................................................... 92
4.3 Methodology Principles ............................................................. 92
4.4 Capability Maturity Model Integration ......................................... 95
4.5 Summary .................................................................................. 97

Bibliography .................................................................................. 99

5 Enterprise Architecture ................................................................. 101
5.1 Introduction ............................................................................... 101
5.2 Enterprise Architecture Frameworks ........................................... 105
5.2.1 Zachman’s Framework ............................................................ 107
5.2.2 TOGAF .................................................................................... 110
5.2.3 Other Enterprise Architectures ............................................ 112
5.2.4 Summary Enterprise Reference Architectures ......................... 113
5.3 Developing the Enterprise Architecture ....................................... 113
5.4 Enterprise Reference Architecture ............................................. 114
5.5 Summary ................................................................................ 115
Bibliography

6  Enterprise Analysis and Design Methodology  119
   6.1  Enterprise Design Methodology .......................... 119
   6.2  Cross Life-Cycle Activities ............................. 120
       6.2.1  Project Management ................................. 120
       6.2.2  Requirements Management ............................. 121
       6.2.3  Quality Assurance ................................. 121
       6.2.4  Configuration Management and Control ............... 122
       6.2.5  Risk Management ................................. 122
   6.3  Project Initiation ....................................... 125
       6.3.1  Project Definition ................................. 127
       6.3.2  Define Project Scope, Schedule and Budget ......... 128
       6.3.3  Project Scope Definition ........................... 129
       6.3.4  Project Budget ..................................... 130
       6.3.5  Project Schedule ................................... 130
       6.3.6  Project Approval ................................... 130
       6.3.7  Business Case ...................................... 131
   6.4  Project Planning ....................................... 131
       6.4.1  Work Breakdown Structure ......................... 132
       6.4.2  Estimation ......................................... 133
       6.4.3  Scheduling ......................................... 135
       6.4.4  Budgeting ......................................... 136
       6.4.5  Other Project Plans ............................... 137
   6.5  Analysis ............................................... 137
   6.6  Generate and Evaluate Alternatives ..................... 139
   6.7  Design ................................................ 139
   6.8  Construction ......................................... 140
   6.9  Implementation .................................. 142
   6.10  Project Tools ...................................... 144
   6.11  Summary .......................................... 144

Bibliography  146

II  Enterprise Project  147

7  Strategy  149
   7.1  Strategy Definition .................................. 149
       7.1.1  Strategy Hierarchy ............................... 151
   7.2  Strategy Theory ..................................... 152
       7.2.1  Resource-Based Theory of Strategy ............... 152
       7.2.2  Market-Based Theory of Strategy ................ 154
   7.3  Strategy Formulation ................................ 155
       7.3.1  Strategy in Highly Dynamic Environments ....... 158
   7.4  Summary .......................................... 159

Bibliography  161
8 Problem Formulation and Requirements

8.1 Data Gathering .................................................. 163
8.1.1 Document Collection and Analysis ....................... 164
8.1.2 Observation ................................................. 164
8.1.3 Interview .................................................. 167
8.1.4 Questionnaire .............................................. 170
8.1.5 Requirements Workshops .................................. 172
8.1.6 Putting It Together ........................................ 173

8.2 Issue and Problem Analysis .................................. 174
8.2.1 Fishbone Diagram of Cause and Effect .................. 177
8.2.2 Causal Loop Analysis ..................................... 177
8.2.3 Document Problem Analysis ................................. 180
8.2.4 Stakeholder Analysis ...................................... 180

8.3 Goals and Objectives .......................................... 182
8.4 Requirements Engineering ..................................... 183
8.4.1 Requirements Definition ................................... 186
8.4.2 Good Requirement Statements ............................. 186
8.4.3 Requirements Best Practices ............................... 190

8.5 Linking Problem Analysis and Requirements ................ 191
8.6 Problem Analysis and Requirements Documentation ........ 192
8.7 Summary ....................................................... 193

Bibliography ................................................................ 196

9 Generate and Evaluate Alternatives ............................. 197

9.1 Generate Alternatives ............................................ 197
9.1.1 Brainstorming ............................................... 200
9.1.2 Delphi Method ................................................ 201
9.1.3 Literature Search ............................................ 201
9.1.4 Request for Proposals ....................................... 201
9.1.5 Benchmarking ............................................... 201
9.1.6 Morphological Analysis ................................... 202
9.2 Document Alternatives ......................................... 202
9.3 Evaluate Alternatives .......................................... 203
9.4 Selection of Best Alternative .................................. 206
9.5 Summary ....................................................... 207

Bibliography ................................................................ 208

III Process View ....................................................... 209

10 Process Modeling ................................................... 211

10.1 Definition of Business Process ............................... 211
10.2 Process Decomposition ......................................... 215
10.3 Classification of Business Processes ......................... 219
10.4 Flowchart ....................................................... 220
10.5 Data Flow Diagram ............................................ 223
10.5.1 Data Structure .............................................. 227
10.5.2 How To Construct a Data Flow Diagram ................. 227
10.6 IDEF0 Function Model ......................................... 229
10.6.1 IDEF0 Model Constructs .................................. 230
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.6.2 IDEF0 Decomposition Hierarchy</td>
<td>231</td>
</tr>
<tr>
<td>10.6.3 IDEF0 Syntax and Semantics</td>
<td>234</td>
</tr>
<tr>
<td>10.7 Other Process Modeling Techniques</td>
<td>236</td>
</tr>
<tr>
<td>10.8 Summary</td>
<td>237</td>
</tr>
<tr>
<td><strong>Bibliography</strong></td>
<td>242</td>
</tr>
<tr>
<td><strong>11 Queueing Theory</strong></td>
<td>245</td>
</tr>
<tr>
<td>11.1 The Queueing System</td>
<td>245</td>
</tr>
<tr>
<td>11.1.1 Understanding Variability</td>
<td>247</td>
</tr>
<tr>
<td>11.1.2 Arrival Process</td>
<td>248</td>
</tr>
<tr>
<td>11.1.3 The Queue</td>
<td>250</td>
</tr>
<tr>
<td>11.1.4 The Server</td>
<td>251</td>
</tr>
<tr>
<td>11.1.5 Queueing System Performance</td>
<td>252</td>
</tr>
<tr>
<td>11.1.6 Queueing Model Assumptions</td>
<td>252</td>
</tr>
<tr>
<td>11.1.7 Queueing System Notation</td>
<td>253</td>
</tr>
<tr>
<td>11.2 Little’s Law</td>
<td>253</td>
</tr>
<tr>
<td>11.3 Queueing System Performance</td>
<td>254</td>
</tr>
<tr>
<td>11.3.1 M/M/1 Queue</td>
<td>254</td>
</tr>
<tr>
<td>11.3.2 M/M/m Queue</td>
<td>256</td>
</tr>
<tr>
<td>11.3.3 GI/G/1 Queue</td>
<td>257</td>
</tr>
<tr>
<td>11.3.4 GI/G/m Queue</td>
<td>257</td>
</tr>
<tr>
<td>11.3.5 Fork/Join Queue</td>
<td>257</td>
</tr>
<tr>
<td>11.3.6 Transient Behavior of Queues</td>
<td>263</td>
</tr>
<tr>
<td>11.4 Queueing Networks</td>
<td>264</td>
</tr>
<tr>
<td>11.5 Psychology of Waiting</td>
<td>265</td>
</tr>
<tr>
<td>11.6 Queueing Costs</td>
<td>267</td>
</tr>
<tr>
<td>11.7 What Queueing Theory Tells Us about Business Processes</td>
<td>267</td>
</tr>
<tr>
<td>11.7.1 Service Time Variation</td>
<td>268</td>
</tr>
<tr>
<td>11.7.2 Capacity Utilization</td>
<td>268</td>
</tr>
<tr>
<td>11.8 Summary</td>
<td>269</td>
</tr>
<tr>
<td><strong>Bibliography</strong></td>
<td>272</td>
</tr>
<tr>
<td><strong>12 Process Design</strong></td>
<td>275</td>
</tr>
<tr>
<td>12.1 Process Analysis Method</td>
<td>275</td>
</tr>
<tr>
<td>12.1.1 Process Goals</td>
<td>277</td>
</tr>
<tr>
<td>12.2 Cycle Time and Throughput Rate</td>
<td>279</td>
</tr>
<tr>
<td>12.2.1 Activity Components</td>
<td>279</td>
</tr>
<tr>
<td>12.2.2 Bounding Process Performance</td>
<td>282</td>
</tr>
<tr>
<td>12.2.3 Parallel Processes</td>
<td>287</td>
</tr>
<tr>
<td>12.3 Capacity</td>
<td>289</td>
</tr>
<tr>
<td>12.3.1 Pooling Capacity</td>
<td>291</td>
</tr>
<tr>
<td>12.4 Cost</td>
<td>293</td>
</tr>
<tr>
<td>12.5 Quality</td>
<td>296</td>
</tr>
<tr>
<td>12.5.1 Process Improvement</td>
<td>299</td>
</tr>
<tr>
<td>12.6 Summary</td>
<td>301</td>
</tr>
</tbody>
</table>
Preface

Design is the defining characteristic of engineering. Each engineering discipline is strongly associated with the artifact it designs. In mechanical, electrical, and civil engineering the artifact is a physical, technological system. This is not so for engineers who design enterprise systems. What distinguishes the design of enterprise systems from other designed systems is twofold: first the design artifact – the enterprise system – is not tangible, and second, enterprise systems include humans as part of the artifact, not as users of the artifact.

The term “enterprise system” has taken on a narrow meaning of only the information system an organization uses. Research and project experience has taught us that to design a good enterprise system, we need to adopt a much broader understanding of enterprise systems. The greater view of enterprise systems is inclusive of the processes the system supports, the people who work in the system, and the information content of the system. Hereafter, I shall use the term enterprise systems to refer to not just the information system, but to the enterprise itself. This use of the term encompasses companies (both manufacturing and service), not-for-profits, and government organizations. Adopting this view encourages us to analyze the integrated system and focus on the relationships between the components that can lead to better system designs, and consequently, project success.

In many ways, the abstract characteristics of enterprises make their design much more challenging than the design of physical objects. First, the fact that enterprises have both physical and abstract aspects makes the representation of the system difficult. There are countless ways to model a process, which is only a single part of an enterprise. In fact, there are countless ways to even define what a process is, highlighting the abstract nature of dealing with enterprise systems. Second, enterprises include a human element, and we have as yet found equations that model humans as accurately as we can model stress/strain, mechanical loads, or the flow of electrons. While civil, mechanical, and electrical engineers can base design decisions on analysis that draws from physics, chemistry, and other basic sciences, the enterprise engineer must also include sociology and psychology to understand the human element. Moreover, enterprise design does not occur at a single point in time like the design of most systems. Instead, enterprises evolve over time and are constantly changing, or are constantly being designed.

In practice, many different people with backgrounds in many different disciplines contribute to the design of an enterprise. It is not only engineers but people from management, organizational theory, accounting, finance, business process design, psychology, and sociology that all study, analyze, or design parts of the enterprise system. Anybody that makes decisions to change the current enterprise to achieve some preferred structure or performance is a designer. What is problematic is that the knowledge of enterprise design is fragmented. Each specialty is important for the design of enterprises, but what is lacking is the holistic and systems-wide perspective to integrate the specialized knowledge of separate aspects of the enterprise to achieve a globally optimized enterprise. What is really needed is a new term, enterprise engineering to describe the discipline that focuses on the design of enterprise systems. Enterprise engineers need to have knowledge in a broad area of enterprise systems. Enterprise engineers will not have the same depth of knowledge in each

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1The word “organization” also fits this criteria, but we reserve this word to later specify the organizational structure of an enterprise.
sub-specialty as their counterparts in each contributing field. What enterprise engineers specialize in is integration: the process of making subsystems work together harmoniously in a way that optimizes the performance of the entire enterprise. The integration of many disparate systems, processes, people, and resources is specialist knowledge – the knowledge of the enterprise engineer.

The purpose of this book is to describe an enterprise engineering methodology. Because enterprise systems are exceedingly complex, encompassing many independent domains of study, students must first be taught how to think about enterprise systems. This book takes a system-theoretical perspective of the enterprise, and describes a systematic approach, called an enterprise design method to design the enterprise. The design method demonstrates the principles, models, methods, and tools needed to design enterprise systems. The book details the enterprise engineering process from initial conceptualization of an enterprise to its final design.

---

**Intended Audience**

The book is aimed at three groups: engineering students, business students, and working professionals. My intention is that this book fills a need for greater design content in engineering curricula by describing how to design enterprise systems. Inclusion of design is also critical for business students, since they should realize the importance their decisions may have on the long-term design of the enterprises they work with. Forrester\(^2\) uses the analogy of an airplane to explain the difference between enterprise design and enterprise operation. There are two groups of people: those who design the airplane and those, the pilots, who fly the airplane. The pilot’s success depends on the airplane designer to create a good airplane. Most all textbooks in related areas such as operations management, manufacturing systems, etc. are aimed toward the operator or manager of the enterprise, not the designer. Somebody must design an enterprise system; so there is a need to collect the theory, models, tools, and methods to design enterprise systems in a single book.

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**Organization**

To present all the topics needed to analyze and design an enterprise is a tremendous undertaking; what I have decided to focus on is the life cycle of an enterprise from initial conceptualization to final design. This includes the design models, tools, and methodology to design an enterprise. The book uses an enterprise reference architecture that contains three views: process, organization, and information. The enterprise architecture is used to provide a model to understand how the parts of the enterprise fit together. The enterprise architecture is also used to organize the last four parts of the book.

The book is organized into six parts as follows:

- Part I establishes the foundation for enterprise engineering and the remainder of the book. Chapter 1 describes the history of thought leading up to enterprise engineering. It describes the knowledge required to do enterprise engineering, a classification of enterprises, and the types of enterprise engineering projects. Chapter 2 describes systems

theory and how it can be used to understand, analyze, and design enterprises. Chapter 3 describes modeling concepts because building models is required for the analysis and design of enterprises. Chapter 4 reviews engineering design theory and the enterprise design methodologies. Chapter 5 reviews enterprise architectures. Chapter 6 presents the enterprise design methodology that is used in this book.

- Part II contains three chapters describing the preliminaries and initiation of an enterprise project. Chapter 7 describes strategy as a guide for defining how the enterprise should be designed. Chapter 8 discusses problem formulation and requirements engineering. Chapter 9 describes how to generate and evaluate alternatives.

- Part III focuses on the process view of the enterprise. Chapter 10 describes how to model processes. Chapter 11 reviews queueing theory, which is used to analyze processes. Chapter 12 describes approaches to analyze and design processes.

- Part IV focuses on the information view. Chapter 13 describes how to model the information structure of the enterprise. Chapter 14 describes a design methodology, SQL, and normalization.

- Part V focuses on the organization view. Chapter 15 discusses organizational theory and describes an approach to organizational design.

- Part VI describes the integration of the three views of process, organization, and information. Chapter 16 defines five types of enterprise integration, the technical architecture of systems, and integration technologies. Chapter 17 describes techniques for integrating the three enterprise views. It summarizes the design methodology by showing how all the independent subsystems come together.

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**Website**

The author maintains a Website at http://web.eng.fiu.edu/Ronald/ that contains:

- Powerpoint slides for each chapter.


- Project case studies that can be assigned to students as semester-long projects to accompany the text.

- Quiz questions for each chapter.

- Business Process Analyzer software for download.

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**Book Features**

The book has the following special features:
• Focus on doing enterprise engineering – The book encourages the reader to apply the enterprise system design concepts and techniques. For each major technique, the book provides examples and explains best practices. The review questions and exercises, and accompanying projects all emphasize the practice of enterprise engineering.

• Business Process Analyzer – A spreadsheet and VBA implementation of multi-class queueing networks using the parameter-decomposition method for GI/G/n queues that allows students to model a business process and estimate the performance measures of cycle time, waiting time, and resource utilization.

• Coverage of information modeling – The book using entity-relationship models and shows how to create the models, normalize them, and write SQL.

• A project-based approach – The book uses the enterprise system design method that consists of seven phases. An accompanying project lets the reader understand the inputs, activities, and outputs of each life-cycle phase.

• Coverage of architecture – The enterprise architecture provides a high-level design of the enterprise and guides all other system projects.

• Chapter on integration – A chapter describes how to integrate the three architectural views with each other and with enterprise technologies.

• Instructor resources – Available to instructors on the Website are an accompanying project book, PowerPoint files for each chapter, quizzes, and exam questions.

• Student resources – Available to students on the Website are accompanying templates, checklists, forms, and models to support the enterprise engineering process.

Acknowledgments

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Ronald E. Giachetti, Ph.D., is an Associate Professor of Engineering Management at Florida International University (FIU) in Miami, Florida. Prior to joining FIU in 1998, he worked at the National Institute of Standards and Technology in Gaithersburg, Maryland. He conducts research in enterprise systems, operations research, and information systems. He has completed projects for government agencies including the National Science Foundation (NSF), U.S. Air Force, and National Aeronautics and Space Administration (NASA). For the U.S. Air Force at Wright Patterson he and a colleague developed a short course on Enterprise Resource Planning (ERP) Project Management. At NASA he worked with the Ames Research Laboratory and developed an enterprise integration methodology to help them address their information integration challenges. He has also completed projects with industry including Carnival Cruise Lines, Royal Caribbean Cruise Lines, Americatel, Baptist Healthcare and KoolSmiles Dentistry. These industry projects focused on business process improvement. He has published over 50 journal articles, book chapters, and conference papers on this work. At FIU he teaches courses in enterprise systems and operations research to both undergraduate and graduate students. He has received the IIE Teacher of the Year award three times at FIU. He teaches in the graduate Engineering Management program on campus and through FIU’s Global Programs Office. He has taught graduate students in Mexico, Jamaica, Peru, and Colombia. He has a Ph.D. in Industrial Engineering from North Carolina State University, an MS in Manufacturing Engineering from Polytechnic University, and a BS in Mechanical Engineering from Rensselaer Polytechnic Institute.