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Chapter 4

Enterprise and Supply Chain Architecture

4.1 Enterprise Architecture

Enterprise architecture (EA) has been considered as an IT methodology to translate between business architecture and information architecture. EA is a term that has been broadly defined and used by both academics and practitioners. A number of EA efforts have been made, including the Department of Defense Architecture Framework (DoDAF), the Federal Enterprise Architecture Framework (FEAF), and the Open Group Architecture Framework (TOGAF). DoDAF is an architecture framework developed for the US Department of Defense (DoD) that provides structure for a specific stakeholder concern through viewpoints organized by various views. These views help users understand, assimilate, and visualize the scope and complexities of an architecture. It has been applied to large systems for realizing complex integration and has provided interoperability capability. The FEAF is an initiative of the US Office of Management and Budget and the Office of E-Government and IT for the purpose of representing the EA within the US Federal Government. EA became a recognized strategic and management tool in the US Federal Government with the passage of the Clinger–Cohen Act in 1996. TOGAF is an EA framework used for planning, designing, and implementing an enterprise information architecture. TOGAF® has been the registered trademark of the Open Group in the United States and in other countries since 2011. As a high-level modeling method that is typically modeled at four levels—business, application, data, and technology—TOGAF works to provide an overall as well as a holistic framework for information architecture tasks, which can then be further
built upon. TOGAF is, in general, an approach that considers the entire life cycle of enterprise system architecture: from the planning and design to the implementation stage. It allows an enterprise to incrementally adapt to business changes through continuous iterations. The earlier-mentioned efforts not only pursue an in-depth understanding of business architecture but also support a technological line of interest. EA effort is characterized by both continuity and iteration. Figure 4.1 shows EA as a continuous activity for many organizations as well as the relationship between current and future architecture.

From a systems perspective, EA can be considered as the fundamental design of an organization as a whole, together with all of the relevant components, as well as the principles governing its design and evolution. The word “enterprise” here may refer to the context of extended enterprises. EA promises to help manage the ongoing enterprise processes in a consistent and systematic fashion, both intra- and interorganizationally, achieving and maintaining enterprise integration in the meantime. Some researchers consider that EA has already become an established subject; however, other researchers consider EA itself as a rather new field, since it still lacks a consistent and agreed-upon definition. As mentioned earlier, from a systems perspective, EA can be considered a type of holistic thinking about the architecture of an enterprise. EA is an architectural description of the enterprise, at both system and subsystem levels, to guide its implementation. The architecture consists of the structure of the system, subsystems, and their interrelationships. Meanwhile, EA strives to be a coherent whole of principles, methods, and techniques that can
be used in the design and realization of various architectures. As such, EA’s target is to represent an enterprise holistically at both the system and subsystem levels with sound methodologies. The EA’s key subsystems include business architecture, information architecture, and other architectures. Business architecture addresses both business strategy and business processes. Information architecture addresses infrastructure, applications, and other aspects. Information architecture addresses the ontologies, taxonomies, data, and security associated with the enterprise. Some of these aspects interact across different architectures. EA aims to bring a coherent structure into key architectures for the system, subsystems, and then to align them systematically.

As EA can provide structure for a specific stakeholder concern as well as a larger and holistic perspective, EA can be applied to various specific tasks. In such specific tasks, EA can provide systematic support to map and trace identified tasks to enterprise artifacts modeled within the EA, supporting the overall strategy of an organization. The idea is to use EA descriptions to represent accurate information, allowing a better understanding of the components that can be affected from the manifestation of tasks.

EA can illustrate the systems relationships within an organization and the impact of the changes that an organization intends to make. EA can be described by its levels:

1. **System level:** This level deals with the design of a system and is mainly concerned with a system such as an enterprise, in terms of its structure and behavior. It deals with enterprise tasks such as enterprise development and enterprise integration and aims at structuring concepts and activities related to the system architecture.

2. **Subsystem level:** This level is mainly for sub-EA. Compared with the system architecture, this is more subsystem oriented.

3. **Meta-system level:** This level is mainly used for extended EA, as the design of an EA must be coherent with that of other enterprise systems in an extended enterprise context and must be aligned with SCM strategy.

For the three levels mentioned earlier, EA can be represented in terms of rules, text, graphics, etc., that relate to different levels. EA defines and organizes the generic concepts that are required to enable the creation of enterprise models for industrial organizations. Its main purpose is to provide an organizing mechanism so that concepts and knowledge about an enterprise and its interoperability, intra- and/or interorganizationally, can be represented in a structured way.

As mentioned earlier, EA is considered a framework that represents the interrelations of the whole system and its components. In EA, models are used to depict the overall infrastructure of the enterprise, as well as its main components and layers, thus aiding in the understanding of the enterprise. In this view, EA is able to define the business and technological components of an enterprise. Thus,
EA can be defined as a set of models that represent the structure of the whole enterprise. As such, EA can be employed as a base for designing and implementing enterprise systems. EAs are particularly useful in employing a consistent language to describe an enterprise. Furthermore, EA can be used as a reference model to note how an enterprise can achieve its objective by studying and comparing the architectures of different enterprises, relating to the architectures and their impact on the functionality of the enterprise. In Figure 4.2, each of the layers is a separate one, and the EA is the bridge that integrates each of them in a systematic manner.

EA is usually analyzed starting from the highest level, in order for it to adapt to the changes that are required. The business architecture reflects business strategies, processes, and functions of an enterprise. It is the base of the enterprise for which the business operations will be managed. Aligning the organization’s business and information strategy is an important determinant for any enterprise’s success. The importance of such alignment has been emphasized in the literature. For example, the measures of information management include focusing information on key business drivers and integrating data from across the business units to support business planning. Such measures highlight the roles of alignment, identifying key business drivers, and integration across business units to define information management. The application architecture facilitates the development and/or implementation of applications that fulfill the business requirements and assure that the required functions will be supported. Information architecture concerns the logical and physical aspects. In this architecture, computing services are identified and then planned to support the enterprise information infrastructure. Different architecture frameworks may share similar characteristics; it is beneficial to understand the similarities and differences of each in order to find a framework that fits the required organizational needs. The purpose of conducting an analysis of EA frameworks is to facilitate scientific analysis on the most suitable framework for creating an EA for a particular enterprise. Table 4.1 shows a comparison of different EA frameworks (from existing literature).
In Table 4.1, certain characteristics are evaluated against different frameworks (Lapkin, 2004). Some researchers consider these characteristics to represent those attributes that an EA framework should have. At minimum, a framework should provide a logic structure, should be able to decompose the entire enterprise from its highest level, and should be able to abstract an enterprise business entity and provide artifacts to describe them. Some researchers consider that, relatively speaking, the Zachman framework is more suitable for the implementation purpose in terms of representing the context of EA. The reason is that the Zachman framework is extensive and flexible, in a relative sense, as it does not impose and/or restrict predefined artifact systems. In general, EA is recognized as a good tool for providing sound methods for analyzing the enterprise requirements through which an enterprise operates.

EA can have different layers, as follows (Winter and Fischer, 2006):

- **Business architecture layer**: The business architecture layer represents the fundamental organization of the enterprise from a business strategy viewpoint. Design and evolution principles for the business architecture layer can be derived from approaches, based on different disciplines.

- **Process architecture layer**: The process architecture layer represents the fundamental organization of processes in the relevant enterprise context. Design and evolution principles for this layer focus on effectiveness (creating specified outputs), efficiency (meeting specified performance goals), optimization, and other criteria.

- **Software architecture layer**: The software architecture layer represents the fundamental organization of software artifacts (e.g., software services). A broad range of design and evolution principles is available for this layer. An example is introduced in Section 4.4.

- **Hardware architecture layer**: The hardware architecture layer represents the fundamental organization of computing and telecommunications hardware and networks. A broad range of design and evolution principles is available for this layer.

### Table 4.1 Comparison of EA Frameworks Based on Certain Characteristics

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Structure</th>
<th>Top-Down</th>
<th>Abstraction</th>
<th>Artifact</th>
<th>Adoption</th>
<th>Research Focus</th>
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<td>High</td>
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- **Hardware architecture layer**: The hardware architecture layer represents the fundamental organization of computing and telecommunications hardware and networks. A broad range of design and evolution principles is available for this layer.
Integration architecture layer: The integration architecture layer represents the integration aspects of information architecture components in the relevant enterprise context. The design and evolution principles for this layer focus on agility, cost efficiency, speed, and many other criteria. The main concern is achieving the goal of integration.

Figure 4.3 is an illustration of an EA that comprises the layers mentioned earlier. For each layer, integration is always a key concept and technology.

With the formation of architecture layers within the enterprise, methods and techniques are required for dealing with details and complexity. In a multilayer architecture, methods/techniques can be either layer specific or cross-layer. Layer-specific ones can be those business and/or process-oriented methods for the layers of the business architecture and process architecture. Cross-layer methods and techniques usually involve information integration. Based on the concepts of multilayer and cross-layer view and representation, EA represents all aggregate artifacts and their relationships across all of the layers of an enterprise. The way in which an enterprise system collaborates with other systems will inevitably depend upon its multilayer EA. A better EA is likely to result in a better-achieved goal.

As EA can be considered as a blueprint of the organization, the goals of EA include the following:

- Supporting organizational strategic goals through providing support for consistent and systematic design and evolution of artifacts on different layers
Supporting business transformation, business process reengineering, new business development, etc., through providing a variety of analyses

Supporting information integration efforts not only through documenting structures and relationships but also by allowing analyzing multilayer relationships

EA can bring many benefits to enterprises due to its impact on enterprise competitiveness, from both a business perspective and an IT perspective. Table 4.2 lists some of these benefits. EA can bring architectural alignment, coherence between strategy and operation, and collaboration among planning, operations, and infrastructure. Additional benefits include business IT alignment, consolidation, standardization, cost reduction, regulatory compliance, and agility, among others. EA enables enterprises to meet challenges such as integration, agility, and change. As the blueprint of an organization, an EA comprises most of the important assets of the organization, such as organizational structures and resources that are vital to the effective functioning of the organization. One EA can better satisfy some key goals than another EA. The concept of EA may emerge from the structuring of the organization’s full vision, in all of its complexity and dimensions, in a theoretical fashion. EA can provide the framework to be used in the establishment of the business foundation for the enterprise; can effectively integrate processes, information, and diverse information technologies based upon the business’ goals; and can lead to efficacious decisions pertaining to all of the relevant aspects of the business.

EA approaches have received considerable attention due to their ability to align business and IT in organizations, and they are making way for a business vision that can be reflected in both operations and supporting systems. However, due to the high-level nature of EA approaches, their ability to adapt to specific domains can be challenging and can require efforts both on the EA and on the application

<table>
<thead>
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<th>Table 4.2  EA Benefits</th>
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<tr>
<td><strong>Business-related benefits</strong></td>
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<tr>
<td>• Knowledge management</td>
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<td>• Adaption</td>
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<td>• Improving operations</td>
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<tr>
<td><strong>IT-related benefits</strong></td>
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<tr>
<td>• Complexity management</td>
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<tr>
<td>• Resource management</td>
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<td>• Visibility</td>
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domain. EA approaches still lack formal methods that can sufficiently represent the organizational context or goals in general and specifically require situation-specific assumptions, which can limit their interoperability with other components of the architecture.

In EA research, many existing frameworks, reference architectures, and methodologies are relevant and useful. In recent years, the ArchiMate language and framework has become available for EA design. Some researchers consider this situation similar to that of UML for software design—with its own international open standard. ArchiMate is an EA modeling language that supports the description, analysis, and visualization of architecture both within and across business domains. It is a technical standard from the Open Group and is based on the concepts of the IEEE 1471 standard. ArchiMate distinguishes itself from other languages such as UML by its enterprise modeling characteristics. ArchiMate divides the EA into three layers: the business, application, and technology layers. The “business layer” covers the business processes, services, functions, and events of business units. The “application layer” covers the software applications that support the components in the business with application services. The “technology layer” deals with the hardware and communication to support the “application layer.” This layer offers infrastructural services needed to run applications. Each layer is self-contained, despite being a component of the integrated model.

Design and Engineering Methodology for Organizations (DEMO) is another major stream. In DEMO, an organization is viewed as consisting of three aspects: the B-organization (business) aspect, the I-organization (information) aspect, and the D-organization (data) aspect. A thorough understanding of the B-organization is a good starting point in designing and reengineering an organization, which can ultimately lead to developing software and systems for implementing business processes. DEMO takes a language-action perspective and looks at organizations at the ontological, info-logical, and data-logical levels. Central to DEMO are the basic patterns of a business transaction. DEMO further distinguishes the construction, process, state, and action aspects. Practical applications of DEMO have been reported for organizational composition and decomposition modeling.