Enterprise architecture is a widely adopted means for coping with organizations’ ever-increasing complexity and for ensuring that organizations appropriately use and optimize their technical resources. Enterprise architecture is an integrated and holistic vision of a system’s fundamental organization, embodied in its elements (people, processes, applications, and so on), their relationships to each other and to the environment, and the principles guiding its design and evolution (IEEE Std 1471-2000 IEEE Recommended Practice for Architectural Description of Software-Intensive Systems, IEEE, 2006).

As the organizing logic for business processes and IT infrastructure, enterprise architecture reflects the integration and standardization requirements of the company’s operating model to achieve business agility and profitable growth (J.W. Ross, P. Weill, and D.C. Robertson, Enterprise Architecture as Strategy: Creating a Foundation for Business Execution, Harvard Business School Press, 2006). Enterprise architecture frameworks identify the architecture’s scope and decompose its elements into structured layers and architectural dimensions. Many private and governmental organizations have adopted such frameworks for operational use.

Enterprise architecture was first embodied in John Zachman’s early enterprise architecture framework (J.A. Zachman, “A Framework for Information Systems Architecture,” IBM Systems J., vol. 26, no. 3, 1987, pp. 276-292). Its reemergence as a way to cope with organizations’ ever-increasing complexity relates to evolving new business trends and IT. Business trends comprise globalization, mergers and acquisitions, e-commerce, and customer-relationship and supply-chain management. IT trends comprise advances in Internet technologies, hardware platforms, and application and workflow servers. With the increasing importance of enterprise architecture, companies such as the Open Group and IBM are offering certification opportunities in an effort to standardize an open method for IT architecture.

An enterprise architecture approach can help align business and IT resources and conform them to fundamental principles and common methodologies governing the entire information systems development process. In that sense, architectural frameworks are a convenient way to support such methodologies and separate roles that facilitate and implement these methodologies as needed. Still, many organizational and technical enterprise architecture challenges remain.

ENTERPRISE ARCHITECTURE BENEFITS

Enterprise architecture provides the fundamental technological and process infrastructure for...
developing an IT strategy and aligning business strategies and implementations. Moreover, enterprise architecture lets an organization view different aspects of the information system from various perspectives. These different aspects provide the guidelines for developing an information system that optimizes the organization’s mission. Enterprise architecture can facilitate business success through the effective use of information-management strategies and IT resources. Competitive advantage relies mainly on customer satisfaction, process life cycles, resource management, task allocation and scheduling, and cost estimations.

A company can use enterprise architecture to organize and structure enterprise-wide information by providing different stakeholders—such as end users and system architects—with the appropriate architectural details. Furthermore, it serves as a baseline for initiating service-oriented architecture and for interconnecting different lines of business. SOA comprises the design practices and architectural principles governing the delivery of IT architecture by maximizing IT reusability. It helps prepare enterprises to consume software as a service by estimating the technical services the organization needs to deliver and enable business processes. From an organizational perspective, enterprise architecture’s benefits are both business and IT related, as Table 1 describes.

**Enterprise Architecture Frameworks**

Enterprise architecture frameworks describe a method for designing information systems in terms of a set of building blocks and how these blocks fit together. Many organizations have adopted enterprise architecture frameworks for operational use—such as the Architecture for Integrated Information Systems (A.-W. Scheer, *Business Process Eng.: Reference Models for Industrial Enterprises*, 2nd ed., Springer, 1999) and the Department of Defense architecture framework. In addition, the US government has adopted the federal enterprise architecture as a business-driven framework to optimize key strategic areas, such as budget allocation, information sharing, performance measurement, and component-based architecture (“Federal Enterprise Architecture,” 2002; http://www.whitehouse.gov/omb/egov/a-1-lea.html).

More specifically, enterprise architecture frameworks contain a list of recommended standards and compliant products for implementing an information system. These frameworks simplify the architecture’s development and ensure complete coverage of the architectural dimensions of the designed solutions through a common terminology. Enterprise architecture frameworks are language independent in that they provide generic concepts and common terminology, letting stakeholders communicate without making any assumptions about each others’ language.

Pragmatically, enterprise architecture frameworks play dual roles. As Figure 1 illustrates, they

- serve as documentation and component-specification tools, and
- facilitate enterprise planning and problem solving.

**Component-specification tools**

By representing an information system as a set of building blocks, enterprise architecture frameworks relate the

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<th>Table 1. Benefits of enterprise architecture.</th>
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<td><strong>Benefit</strong></td>
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<tr>
<td><strong>IT-related</strong></td>
</tr>
<tr>
<td>Complexity management</td>
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<tr>
<td>Technical resource oversight</td>
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<tr>
<td>Knowledge management</td>
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<tr>
<td>IT visibility</td>
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<tr>
<td><strong>Business-related</strong></td>
</tr>
<tr>
<td>Reduction in impact of staff turnover</td>
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<td>Faster adaptability</td>
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<td>Operating procedures improvement</td>
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<td>Decision making</td>
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required information system dimensions—such as business processes, data, and organization units—to different perspectives at certain levels of abstraction. These perspectives rely mainly on differences in stakeholders’ views of the architecture at different levels of detail. As component-specification tools, enterprise architecture frameworks document the architectural layers, domains, models, and artifacts.


- The business layer describes the business entities (such as business processes and relevant business information) and how they interact with each other to achieve enterprise-wide objectives.
- The application layer determines the data elements and software applications that support the business layer.
- The technology infrastructure layer comprises the hardware platforms and communication infrastructure that supports the applications.

Informational, behavioral, and structural aspects naturally characterize such layers. Because organizations consist of several units, the structural aspects determine these units’ static decomposition into subunits. The behavioral aspects show behavior manifested in the sequence of activities and business processes performed to produce the needed services. These units eventually could exchange information to perform business tasks.

Each layer naturally consists of several domains reflecting organizations’ information, behavioral, and structural aspects. These domains specify the architectural aspects, such as process, product, information, technical, and application architectures. Indeed, these domains separate the architectural concerns and reflect different enterprise architecture stakeholders’ views of the architecture. For example, the process domain, which is a part of the business layer, describes business processes or functions offering the products or services to an organization. Different architectural models—such as business process models, value chain diagrams, and organization charts—typically describe and document the architectural domains. Architectural models serve as a basis for documenting the different architectures by annotating the artifacts and their interrelationships. Architectural artifacts represent the necessary constructs and architectural elements (data, business processes, resources, events, and so on) that represent the real-world objects needed to design distinct model types.

Planning tools

Enterprise architecture frameworks provide a holistic view of enterprise architecture through hierarchical layering. This approach implies alignment of the business, application, and technology infrastructure layers. In addition, such frameworks let organizations make business decisions and plan the architecture in the context of the whole rather than stand-alone parts. In other words, enterprise architecture frameworks use abstractions to simplify and isolate simple information system aspects or dimensions without losing sense of the enterprise’s complexity as a whole.

As planning tools, enterprise architecture frameworks entail baseline and target architectures, architectural roadmaps, and transition plans. The baseline architecture (the “as-is” view) encompasses the different layers and existing components (models, diagrams, documents, and so on). This architecture serves as a starting point for identifying relationships between different components as well as gaps that should be filled to improve organizational performance. The target architecture (the “to be” view) specifies the new enterprise architecture components and the strategic initiatives that the organization should perform to bridge the gaps and ensure competitive advantage. This architecture should also identify the IT resources and technological infrastructure needed to support the new components in integrating the organization structure, business processes, data, and technical resources.

Architectural roadmaps represent the baseline architecture’s intermediary alternatives while mitigating the
Enterprise business architects strive to analyze and document business processes, scenarios, and information flow by identifying key solutions for aligning IT-related components with the business (CIO Council, 2001). Their main activities include creating business process models to envision and establish boundaries for processes and other architectural elements, and overseeing the allocated resources. They accomplish this by assuring the integration of all business standards, models, and methodologies.

Enterprise IT architects analyze and document systems, internal and external interfaces, and data flow (CIO Council, 2001). They support enterprise architecture documentation by ensuring that technical standards and technologies will enable system-related qualities such as availability, scalability, and recoverability. In addition to application selection and implementation activities, they're responsible for developing, designing, and evaluating architectural models of current and proposed systems with the collaboration of enterprise business architects.

Data architects analyze and design database-related enterprise architecture components and set data policies such as data management, storage, and access. As such, providing opportunities for data reuse and balancing data centralization and data replication is the data architect's central role.

Infrastructure architects, on the other hand, document and analyze system environments, including network communications, operating systems, and middleware components. System architects mainly collaborate with enterprise IT architects in selecting suitable application frameworks and adopting appropriate standards for systems quality assurance. They also prepare a migration plan when their organization intends to replace existing systems with new systems.
The exact titles of these roles vary from organization to organization. The roles depend on organization size because they rely on the level of detail in the enterprise architecture to be addressed during the development of information system projects. More specifically, these roles aren’t deterministic because they rely mainly on the organization type and how the organization governs the separation of enterprise architecture concerns. In large multinational organizations, these roles are often embodied in committees or groups. This maximizes knowledge sharing and strengthens cross-organizational interaction between parties, thus enhancing the decision-making strategy.

**CHALLENGES**

Although enterprise architecture is recognized as affording the necessary infrastructure for building information systems, several challenges remain. These challenges stem from the fact that enterprise architecture hasn’t reached maturity (A. Wegmann, “On the Systemic Enterprise Architecture Methodology [SEAM],” *Proc. Int’l Conf. Enterprise Information Systems*, ICEIS, 2003, pp. 483-490). We highlight enterprise architecture challenges from two perspectives: enterprise architecture frameworks and organization structure.

Most existing enterprise architecture frameworks aren’t reactive to business strategy changes because they can’t perceive changes in their environment (D. Judge, “Agent Enhanced Workflow,” *BT Technical J.*, vol. 16, no. 3, 1998, pp. 79-83). In addition, the absence of traceability in enterprise architecture frameworks yields an unbalanced architecture focused on one view (Wegmann, 2003). Consequently, putting these frameworks into operation can be tedious. Some enterprise architecture stakeholders might also be uncomfortable with the existing frameworks because they aren’t object-oriented, so are difficult to relate to Unified Modeling Language (UML). Moreover, the heterogeneous theories and notations of enterprise architecture models yield an unclear picture of how an organization can meet business requirements across multiple information systems.

Because enterprise architecture is strategically driven, models describing the current and target architectures should be concise and well documented to facilitate understanding of data flows in enterprise architecture (S. Kaisler, F. Armour, and M. Valivullah, “Enterprise Architecting: Critical Problems,” *Proc. 38th Hawaii Int’l Conf. System Sciences*, IEEE CS Press, 2005, p. 224b). Many of these methodologies also lack evaluation or assessment metrics of enterprise architecture elements such as reliability and integrity. Finally, the existing frameworks don’t sufficiently consider the strategic needs of cutting-edge enterprises such as Novartis, Amazon.com, Google, and Shell. Many of these organizations have their own ongoing initiatives for building and implementing enterprise architecture to meet their current and future business needs.

More formally, in large commercial organizations, the layer model doesn’t efficiently advocate the cross-organizational interactions between business entities. Consequently, an ecosystems-oriented architecture has emerged to tackle problems such as responsiveness to changes in business requirements. Indeed, the ecosystem enterprise architecture model aims to create dynamic and interactive enterprises that evolve over time by filling the gaps between internal and external environments, such as customers, suppliers, and business partners. However, this approach is still under development and hasn’t been put in operational use.

From an organizational perspective, project teams aren’t always aware that an enterprise architecture program exists. Moreover, when one does exist, not everyone follows it, because people often resist changing their norms and working standards (J. McGovern et al., *A Practical Guide to Enterprise Architecture*, Prentice Hall, 2003).

Despite the fact that business modelers and IT people need to work together and look at the big picture, stakeholders’ models can be narrow in their outlook and focus on specific information system aspects, regardless of other stakeholders’ realities and perspectives. Because different enterprise architecture stakeholders need perspectives reflecting their view of an information system, an organization should use multiple views to separate the key concerns. Furthermore, people use different tools to produce different models, resulting in an ambiguous documentation of the architecture.

Making enterprise architecture usable, applicable, and practical for a particular organization requires significant effort in terms of defining the formal steps for implementing the architecture and complying with different stakeholders’ requirements in the information system’s development. For usability, no explicit separation of concerns and roles within existing enterprise architecture frameworks reflect the distinct perspectives of enterprise architecture stakeholders. As far as enterprise architecture practicality is concerned, there is no rigid approach to manage and develop information systems in the context of enterprise architecture because no formal steps exist for defining, maintaining, and implementing enterprise archi-
As enterprise architecture has proven valuable for organizing and structuring enterprise-wide information, organizations have recognized knowledge management’s use in monitoring and planning this information. Our ongoing work in this area focuses on developing a conceptual knowledge management model to facilitate an enterprise architectural approach, with an emphasis on strategic knowledge support. Such a model would support knowledge discovery and facilitate the exploitation of information captured through the application of enterprise architecture frameworks.

Hanifa Shah is a professor of information systems, head of the Informatics and Knowledge Management Group, and a strategic IT consultant to Britvic Soft Drinks. Contact her at h.shah@staffs.ac.uk.

Mohamed El Kourdi is a doctoral student in the Faculty of Computing, Engineering, and Technology at Staffordshire University and a member of the Informatics and Knowledge Management Group. Contact him at m.elkourdi@staffs.ac.uk.