Exploring the future of enterprise architecture: A Zachman perspective

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A B S T R A C T

Today, and for the foreseeable future, organizations will face ever-increasing levels of complexity and uncertainty. Many believe that enterprise architecture (EA) will help organizations address such difficult terrain by guiding the design of adaptive and resilient enterprises and their information systems. This paper presents the "Grand Challenges" that we believe will challenge organizations in the future and need to be addressed by enterprise architecture. As a first step in using enterprise architecture as a solution for overcoming identified challenges, the Zachman Enterprise Architecture Framework is used to guide and structure the discussion. The paper presents the "Grand Challenges" and discusses promising theories and models for addressing them. In addition, current advances in the field of enterprise architecture that have begun to address the challenges will be presented. In conclusion, final thoughts on the future of enterprise architecture as a research field and a profession are offered.

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1. Introduction

We live in complex and uncertain times characterized by rapid changes in social structures, operating environments and technology disruptions. At one time, governments were considered to be solid. Today, these once rock-like institutions are recognized as vulnerable because they can be toppled by the winds of social change and market turbulence. Just in the last couple of years countries such as Greece, Italy, Egypt and Tunisia have been profoundly shaken and, as was seen, modern disruptive technologies such as connected social networks have the potential to play key roles in enabling change as well as fostering innovative activities.

The world has become a very challenging place in which to manage organizations. Organizations now face "global markets" that are subject to ongoing social transformation and governmental instabilities. In addition to being affected by turbulence outside of their boundaries, organizations are also faced with the complexities of the changing world within their boundaries.

Modern personnel must cope with challenges such as cultural diversity (e.g. plurality of perspectives and values), globalization and disruptive technologies. Today's organizations must "survive" in the modern world where, in the blink of an eye, allies become foes and foes become allies. Moreover, many disruptive technologies are either almost past the "tipping point" of entering the mainstream or lurking on the horizon. Technologies such as cloud computing, broadband always-on-connectivity, ubiquitous computing, and 3D printing could be potential signs of profound yet-to-come changes in our lives in the same way the television and phone once were [1–4]. In summary, the world has become a complex place within which complex organizations (enterprises) operate.

Faced with these realities, people concerned with the design and functioning of enterprises must struggle with important questions such as: how should enterprises cope with pervasive complexity? How should enterprise information systems be designed for modern realities? If the realities of today are just the proverbial "tip of the iceberg" for what is yet to come, how should we prepare?

Enterprise architecture (EA) is a practice and emerging field intended to improve the management and functioning of complex enterprises and their information systems. Many feel that EA can play a key role in helping to design the enterprises of the future. However, it is difficult not to be inquisitive about how EA will help

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enterprises face the realities of the future or how EA as a technology will itself have to be redefined in order to stay relevant. These are difficult questions to answer since new technologies, and their potential uses, emerge at such staggering rates that it is a difficult process to predict what "Grand Challenges" will emerge.

Enterprise information systems are a key component of an enterprise's architecture. Implementing and changing an enterprise information system entails changes in its architecture. Conversely, any change to an enterprise's architecture will have repercussions on its information systems. Consequently, next generation enterprise information systems should be seen in the context of these new realities.

The reflections of this paper are guided by the Zachman Framework for Enterprise Architecture (ZFEA), a well-recognized EA model that offers an ontology for enterprises [5]. Through the use of the ZFEA, we propose a number of "Grand Challenges" that we foresee to be important for the design of enterprises and their information systems. We also discuss models and theories that we believe could be useful in coping with the identified "Grand Challenges". To exemplify the value of these models and theories, we discuss current advances in the field of EA that are guided by the presented models and theories. It is not the intention of this article to analyse in detail the "Grand Challenges" with various EA tools (e.g. models, frameworks, etc.); rather the goal is to explore how EA is evolving (and should evolve) in order to stay relevant with regards to the "Grand Challenges". Towards this purpose, we found the Zachman Framework for EA valuable to guide the discussion about directing the use of EA to help enterprises of today reflect upon the future and themselves.

The article is organized as follows. In Section 2, we briefly introduce the field and practice of EA as well as discuss its relationship to EE and enterprise information systems (EIS). In Section 3, we present the ZFEA as well as the results of using it to foresee the challenges of the future. Subsequently, these challenges are synthesized into four "Grand Challenges" that serve as the focus for the rest of the paper. In Section 4, for each "Grand Challenge", we present useful models and theories for coping as well as recent advances in the field that are guided either by these theories and models or other closely related literature. Section 5 discusses possible future scenarios for the practice and investigation of EA.

2. Contribution to next generation enterprise information systems

2.1. Enterprises, enterprise frameworks, EA and EE

The initial idea to describe, understand, represent and design different dimensions of the enterprise was developed simultaneously within different disciplines in the early nineties. This lead inevitably to the emergence of several EA frameworks [6]. One of the original frameworks was the Zachman Framework for Enterprise Architecture (ZFEA) [7] that has as its purpose the identification of the basic elements that comprise an enterprise. Many existing EA frameworks were inspired by the ZFEA such as the Extended Enterprise Architecture Framework (E2AF), Enterprise Architecture Planning (EAP), the Federal Enterprise Architecture Framework (FEAF) and the Integrated Architecture Framework (IAF) [6].

Initially the industrial engineering community and the manufacturing sector proposed several EA initiatives and frameworks. One of these initiatives was an international study that raised awareness about the emerging engineering discipline within enterprise integration in 1992 [8]. From 1989–1992, research at the Purdue Laboratory for Applied Industrial Control (PLAIC) led to the development of the Purdue Enterprise Reference Architecture (PERA) to address the complexities of industrial enterprises, emphasising the human involvement within the enterprise system [6,9]. The Computer Integrated Manufacturing Open System Architecture (CIMOSA) Project, which was established in 1985 and closed in 1994, was based on an Enterprise Modelling framework and its aim was to develop an open system architecture to set standards and facilitate the development of future CIM systems [6,10]. During the 1990s, the International Federation of Automatic Control (IFAC) and International Federation for Information Processing (IFIP) created a task force to evaluate the existing frameworks, which led to the development of the Generalised Enterprise Reference Architecture and Methodology (GERAM) [11]. During the same time frame, Doumeingts et al. also developed the GRAI Integrated Methodology (GIM) to design CIM systems, which was later mapped onto GERAM [11,12].

Given this history, there are numerous views on what EA is. For the purpose of the paper, in order to stay neutral, we prefer to use a definition of EA that is broad and inclusive. We thus propose a definition that builds upon the ISO/IEC/IEEE 42010 standard [13], namely that EA should be understood as being constituted of the essential elements of a socio-technical organization, their relationships to each other and to their changing environment as well as the principles of the organization's design and evolution. Enterprise architecture management is the continuous practice of describing and updating the EA in order to understand complexity and manage change. This definition should be understood just as a means to facilitate the understanding of this paper. This is only one definition of EA and at present there are a number of core definitions used, as well as several prominent discussions about the meaning of general terms within the EA domain [14,15]. The reason for the existence of multiple definitions is arguably, as mentioned, the input that the domain receives from several associated domains and disciplines, such as systems engineering, organizational science, industrial engineering and, last but not least, information systems and ICT. Each of these disciplines place a unique perspective on the notion of enterprises and what we need to do to align, design, engineer or change them [16]. A number of other more specific definitions and discussion on the meaning of EA may be found in [13,14],[16–21]. Enterprise engineering (EE) and enterprise ontology (EO) are terms that emerged within the enterprise and EA domains. EE was first introduced in the nineties by CIMOSA and largely discussed in several papers in Computers in Industry (see for example [22]). EO was developed by Mark Fox and colleagues (see for example [23]). EE developed as a sub-discipline of the systems engineering domain, which means that it is largely practice based and aims to study enterprises in a multi-disciplinary and engineering-driven way [24]. EE inherits concepts from systems engineering, including the definition of enterprises as socio-technical systems, but also the notion that within enterprises, it is possible to distinguish between teleological and ontological systems [25]. According to Dietz [25], an EO describes the construction and operation of a system and is therefore needed to design the enterprise [26]. For the purpose of this paper, since consensus on the meaning of terms such as EA and EE does not exist within the community, we will mainly consider the term EA and adopt its meaning to be as comprehensive as possible, and since the focus of this paper is on the design of the enterprise of tomorrow, ambiguity with the meaning of EA and EE is of little concern. We choose to be inclusive and adopt all different perspectives as part of the discussion about enterprises and their future.

2.2. Relationship with and contribution to EIS

Enterprise Information Systems (EIS) are defined as all the information systems (composed of people, technology and data)