The Journal of Systems and Software 84 (2011) 1480–1506

Contents lists available at ScienceDirect

The Journal of Systems and Software

journal homepage: www.elsevier.com/locate/jss

# Enterprise architecture patterns for business process support analysis

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ARTICLE INFO

*Article history:*
Received 30 August 2010
Received in revised form 17 February 2011
Accepted 24 February 2011
Available online 17 March 2011

*Keywords:*
Enterprise architecture
Enterprise architecture pattern
Business process support analysis
Business process
Business object

ABSTRACT

The field of enterprise architectures lacks architecture patterns that would support analysis of a given enterprise architecture, comparison of different enterprise architecture solutions and provide guidelines for development of a target enterprise architecture based on the analysis of existing enterprise architecture. In this paper, we focus on business process support analysis using information derived from enterprise architecture description. We give a systematic overview of important aspects. We establish and formally define foundational enterprise architecture patterns for business process support analysis. They are implementation independent and enable more efficient qualitative architecture analysis of business process support, which is the basis for achieving more optimal business operation. We have defined the patterns using the standard enterprise architecture language – ArchiMate. They are formalized in a way that enables their implementation in enterprise architecture tools. This is an important characteristic that allows for efficient work by automatic detection of different, more or less suitable, architecture structures. We have derived the patterns based on real-world enterprise architecture descriptions and have used and verified them in enterprise architecture analysis and planning projects for four large organizations. The enterprise architecture analysis patterns address an important research issue in the field of enterprise architectures that has so far not been systematically researched.



## 1. Introduction

Enterprise architecture represents a knowledge base that comprises elements of internal and external business environment and relations between them (Šaša and Krisper, 2010). With increasing requirements for business system agility and business-IT alignment, enterprise architectures have become an important field (Wilkinson, 2006) and have drawn attention of many researchers and experts from IT and business domains (Jonkers et al., 2006; Johnson et al., 2007). Enterprise architectures represent a means for achieving coherency and consistency of a business system, for relating strategic elements with business processes, for relating the business mission and goals with IT mission and goals, and for ensuring more informed decisions about important topics, such as integration with internal and external information systems and business process optimization (Doucet et al., 2009; Lankhorst, 2009; Ross et al., 2006; The Open Group, 2009b).

Enterprise architecture analysis represents the basis for achieving the potential enterprise architecture benefits. It is important especially for decision support, for planning and for enterprise architecture optimization. Whenever a change is required in an enterprise architecture, architecture analysis should play the central role. It enables evaluation of different variants of the target architecture, study of the impact of change in the existing enterprise architecture, and more informed decisions, for example when making compromises between costs, quality, and efficiency (Lankhorst, 2009). Without enterprise architecture analysis, the enterprise architecture can be used mainly for representation and communication purposes, whereas other potential applications and benefits are not realized or realized with difficulty.

Study of related work has shown that existing enterprise architecture analysis approaches lack architecture patterns for qualitative evaluation of architecture solutions. Our vision is to develop enterprise architecture patterns that would represent a foundation for analysis of enterprise architectures, for comparison of different enterprise architectures and for development of guidelines and blueprints. The goal of such patterns is to enable examination of an enterprise architecture in terms of a sound architecture, detection of typical architecture structures which indicate a more or less optimal solution based on different perspectives, to enable examination of possible improvements, and to allow for evaluation and comparison of different target architectures. In this paper we focus on the aspects of business process support analysis with regard to business process execution support and support for business objects that are used in a business process. We have derived the patterns based on real world enterprise architecture descriptions and have used and improved them

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doi:10.1016/j.jss.2011.02.043

throughout projects for four large Slovenian organizations. Our work is based on the ArchiMate enterprise architecture language due to its ability to provide a common base for concepts of different architecture domains and cross-domain relationships, which are important characteristics for business process support analysis. However, since only a subset of the ArchiMate language constructs is used, the patterns can be applied to other enterprise architecture descriptions that do not use ArchiMate, provided that the metamodel they are based on comprises the constructs used in pattern definitions.

The paper is organized as follows. In the next section, we introduce and explain the basic concepts in the field of enterprise architectures. In Section 3, we present the related work and the motivation of our research. In Section 4, we present our approach and how the concept of patterns plays the central role in our work. In Section 5, we introduce the ArchiMate metamodel and concepts that we use in pattern definitions. In Section 6, we discuss and define the enterprise architecture analysis patterns for business process support: we define different business process support analysis perspectives, present relations between different perspectives, define the enterprise architecture patterns for each of the perspectives and compare them. In the seventh section, the proof of concept is presented. Section 8 discusses implications and further work. The last section contains the concluding remarks.

## 2. Preliminaries

Conceptual foundation in the field of architectures was established with the IEEE 1471-2000 standard in the year 2000 (*IEEE Recommended Practice for Architectural Description of Software-Intensive Systems*) (IEEE Computer Society, 2000). The standard represents a theoretical foundation for creation, analysis, and sustainment of architectures of software-intensive systems and comprises definitions, conceptual framework and architectural description practices (Krisper and Rožanec, 2005). The conceptual model that the standard defines is given in Fig. 1. The standard was accepted by the organization ISO as the ISO/IEC 42010:2007 (ISO – International Organization for Standardization, 2007).

In the field of enterprise architectures a consensus about different elements and definitions regarding enterprise architectures still has not been achieved. Therefore, the ISO/IEC 42010:2007 represents an important foundation also for enterprise architectures. It defines an enterprise architecture (EA) as the fundamental conception of a system [the enterprise] in its environment embodied in its elements, their relationships to each other and to its environment, and the principles guiding its design and evolution (ISO – International Organization for Standardization, 2007). Another commonly referenced definition of the term *enterprise architecture* was given by The Open Group, which considers enterprise architecture as having two meanings depending upon the context (The Open Group, 2009b):

- EA is a formal description of a system, or a detailed plan of the system at component level to guide its implementation.
- EA is the structure of components, their inter-relationships, and the principles and guidelines governing their design and evolution over time.

An enterprise architecture description is usually very complex, because it comprises a large set of components and relationships between them. Based on stakeholders' concerns, different parts of an enterprise architecture are relevant for different stakeholders (Lankhorst, 2004; van der Raadt et al., 2008). It is important that enterprise architecture can be represented with relevant information and at the appropriate level of detail for individual stakeholders. For this purpose, most of enterprise architecture approaches define viewpoints and views related with different stakeholders. Based on the viewpoint definition and a given enterprise architecture, a view for the target stakeholder can be derived (Fig. 1).

## 3. Related work and motivation

Numerous approaches, methods and frameworks have been developed in the field of enterprise architectures. We distinguish between domain specific and generic approaches. One of the earliest origins of domain specific approaches can be found in the field of production and manufacturing systems, where reference architectures and methods have been developed since 1980s. Examples are the Integration Definition method (IDEF) (Mayer et al., 1995), GRAI Integrated Methodology (GRAI-GIM) (Zanettin and Doumeingts, 1992), Open System Architecture for CIM (CIMOSA) (ESPIRIT Consortium AMICE, 1993; Zelm et al., 1995), Purdue enterprise reference architecture (PERA) (Williams, 1992), and TOronto Virtual Enterprise (TOVE) project (Fox, 1992). Williams et al. (1994) present a summary of the IFAC/IFIP Task Force on Architectures for Integrating Manufacturing Activities and Enterprises technical report. They discuss recommendations for achieving a complete and a sound architecture by selecting and combining the best available architectural features. A study of these approaches can be found in Chalmeta et al. (2001). Mertins and Jochem (2005) present one of the latest contributions related to enterprise architectures in manufacturing. They provide an overview of architectures, methods and tools for enterprise engineering, propose the integrated enterprise modelling (IEM) method, and a software tool that supports the method. Another important area of domain specific enterprise architecture frameworks is government. Examples are: Federal Enterprise Architecture Framework (FEAF) (The Chief Information Officers Council, 1999), Enterprise Architecture framework of the Federal Deposit Insurance Corporation (FDIC EA) (The Chief Information Officers Council, 2008), Treasury Enterprise Architecture Framework (TEAF) (Department of the Treasury Chief Information Officer Council, 2000) in the USA; the cross-Government Enterprise Architecture (xGEA) (Cabinet Office Chief Information Officer Council, 2010) in UK; NORA (ICTU, 2007) in the Netherlands; and the Danish cross governmental enterprise architecture framework (OIO EA) (National IT and Telecom Agency, 2009) in Denmark. Several EA frameworks can also be found in the defence industry, such as AGATE (Délégation Générale pour l'Armement, 2007) in France, NATO Architecture Framework (NATO Consultation, Command and Control Board, 2007) and Department of Defence Architecture Framework (DoDAF) (Department of Defense, 2009) in the USA, and Ministry of Defence Architecture Framework (MoDAF) (Ministry of Defence, 2008) in UK. We do not try to develop a reference architecture, a complete enterprise architecture framework or a methodology; we focus on systematic examination of different aspects of business process support that can enhance existing achievements in the field of enterprise architectures. Our work is applicable to arbitrary domains.

There are several domain independent enterprise architecture approaches; the most recognized among them are the Zachman framework (Zachman, 2010), Generic Enterprise Reference Architecture and Methodology (GERAM) (Bernus and Nemes, 1996), The Open Group Architecture Framework (TOGAF), Model Driven Architecture (MDA), Gartner Enterprise Architecture Method (GEAM) (Bittles and Kreizman, 2005; James et al., 2005), and ArchiMate (Lankhorst, 2009; The Open Group, 2009a). The Zachman framework originated in 1987 and is one of the oldest enterprise architecture frameworks. It is a widely recognized schema for classification of enterprise architecture artefacts. It defines different