Integrating SOA into an Enterprise Architecture – A Comparative Analysis of Alternative Approaches

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Abstract. Enterprise Architectures have emerged as comprehensive corporate artifacts that provide structure to the plethora of conceptual views on an enterprise. The recent popularity of a service-oriented design of organizations has added 'service' and related constructs as a new element that requires consideration within an Enterprise Architecture. This paper analyzes and compares the existing proposals for how to best integrate services into Enterprise Architectures. It uses the popular Zachman Framework as an example and differentiates the existing integration alternatives. This research can be generalized beyond service integration into an investigation onto how to possibly extend Enterprise Architectures with emerging constructs.

Keywords: *Service Orientation, Service-Oriented Architecture, Enterprise Architecture, Zachman Framework*

l. MOTIVATION

Enterprise Architecture (EA) has become an essential means to obtain, conceptualize, store and maintain knowledge about the enterprise, its structure and its behavior. As a central repository reflecting organizational elements and relationships it has become essential input for the development of required information systems (Khoshnevis, Aliee & Jamshidi, 2009). The increased scope and level of complexity of information systems design are demanding the use of a logical construct, or architecture, to define, integrate and control the system components and its complexities (Zachman, 1987). The static Enterprise Architecture is complemented by an Enterprise Architecture Lifecycle methodology that guides the process of developing and maintaining such an Architecture. After an initial focus on the more IT-centered constructs (such as data, applications or infrastructure), there is a noticeable trend to embed more business-centered constructs into Enterprise Architectures. In particular, Enterprise Architectures need to be open regarding the integration of emerging phenomena such as the increased pressure on compliance and risk management, security concerns or the increased priority on services (Jung, 2009).

The *aim of this paper* is to analyze the current status of one of the most established and still widely used (Varnus & Panaich, 2009). Enterprise Architectures, the Zachman Framework, in terms of how it can accommodate the emerging service-oriented view of the firm.

The Service-Oriented Architecture (SOA) is one of the most widespread architectural styles today. It considers each business or system a service provider offering one or more services. Services are increasingly considered as one of the enterprise's essential assets. Therefore, they need to be considered and integrated in an Enterprise Architecture (Khoshnevis et al., 2009). Services capture and encapsulate a valuable capability and abstract the details of their functionality through well-defined interfaces that facilitate the exchange of structured messages. This concept comprehensively covers the high level understanding of business capabilities as services (e.g. payment, fraud detection) down to the technical implementation of encapsulated software capabilities in terms of Web Services. As a consequence, the wide use of services confirms the rising importance of the service concept for Enterprise Architecture (Correia & Silva, 2007). This demands the integration of SOA artifacts with the current EA frameworks in order to contribute to the overall goal of an Enterprise Architecture as an integrated conceptualization of the key corporate assets and as a decision support tool facilitating organization agility (Jung, 2009).

This paper is driven by the following three *research questions*:

- What are alternative proposals for the integration of SOA into the Zachman Enterprise Architecture Framework?
- What criteria could be used to evaluate these alternative types of integration?
- How do these proposed types of integration rank in light of these criteria?

This paper is structured as follows. In the next section, we will briefly introduce the Zachman Framework as an established example for an Enterprise Architecture. Then, we will discuss the core concepts behind services and Service-oriented Architectures. In the core part, we discuss five alternative forms for how to integrate SOA into the Zachman Framework. These alternatives will be compared in light of a number of criteria. Conclusions and an outlook on future research are presented in the final chapter.

2. THE ZACHMAN FRAMEWORK

The Zachman Framework initially covered the information systems architecture of an enterprise (Zachman, 1987). Later, the framework has been extended to address those aspects that were only loosely covered in the previous version (Sowa & Zachman, 1992). The Zachman Framework is the first and the probably best-known EA framework. It has been widely used and incorporated into various other frameworks (Riempp & Gieffers-Ankel, 2007; Tang, Han & Chen, 2004; Traverson, 2008; Urbaczewski & Mrdalj, 2006).

The Zachman Framework is arranged in a matrix-like structure. It is a logical structure for organizing and classifying the components of an enterprise that are important to the stakeholders and the enterprise systems development. Its rows represent six different perspectives on the enterprise. These perspectives are scope (Planner), enterprise model (Owner), system model (Designer), technology model (Builder), detailed representation (Sub-contractor), and functioning systems. The columns (ab-

stractions) of the framework represent different ways to describe the real world. The columns are data, function, network, people, time and motivation (Sowa & Zachman, 1992; Zachman, 1987).

The purpose of the framework is to show how the different constructs fit together. In other words, it is a means of viewing a system from many different viewpoints and illustrating how they are connected (Sowa & Zachman, 1992).

3. SERVICE-ORIENTED ARCHITECTURE

3.1 SOA Definitions

There are many definitions of SOA and they do not usually characterize SOA in the same way. As Erl (2005) argues, service orientation and SOA appear to be confusing terms. Examples of such definitions are shown below:

- The Open Group (2006) defines SOA as "an architectural style that supports service orientation, and service orientation is a way of thinking in terms of services and service-based development and the outcomes of services".
- IBM defines SOA as "a business-centric IT architectural approach that supports integrating business as a linked, repeatable business task, or service" (Ren & Lyytinen, 2008).
- The OASIS (2006) defines SOA as "a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains".
- Noran and Bernus (2009) consider SOA as an architectural style that emphasizes service concept and service consumers as a foundation to structure the functionality of an entire business.
- Finally, SOA is a way to reorganize a collection of formerly siloed software applications into an interlinked set of services. Each service can be accessed through a standard interface using messaging protocols (Papazoglou, 2003).

These definitions are by no means a complete list of SOA definitions. However, they are chosen to illustrate the diversity of understandings that might have influence on the way SOA is perceived, and consequently the way SOA is integrated with EA frameworks. Viering, Legner and Ahlemann (2009) raise the issue by asserting the need for a clear, generic SOA definition accompanied by typologies and taxonomies that distinguish SOA and Service designs.

Additionally, SOA provides a framework to assist the communication and interaction between services. Services are advertised by providers with related service level agreements in service registries to be accessed and utilized by consumers (Luthria & Rabhi, 2009). Thus, there are three key players in SOA: service provider, service consumers and the agencies that help consumers find services (Erl, 2005; Luthria & Rabhi, 2009; Papazoglou, 2003).

3.2 Service Taxonomy

A service is a business function implemented in software that has a formal, advertised interface. Services embody full business functions. They are designed to be reused and involved in transactions at the application, enterprise and across enterprise levels (Papazoglou, 2003).

Jung (2009) presents a service taxonomy (see Figure 1) that includes process services, business services, application services and infrastructure services. A business service represents business logic (Jung, 2009) and is a self-contained, independent unit (Banerjee & Aziz, 2007) that supports business processes (Nurcan & Schmidt, 2009). On the other hand, an application service represents a specific technical functionality and provides reusable technical functions. It encapsulates a unit of software and has a published interface (Nurcan & Schmidt, 2009). An infrastructure service provides non-business functionality (Jung, 2009). It is a more hardware related service (Nurcan & Schmidt, 2009). Further, a process service is a coarse-grained service composed of other services (Jung, 2009). Although business processes are not services in their own, it might be sometimes justifiable to provide a service interface for a business process, for example, to make a process available to other business units inside the organization (Schulte, Kadner, Repp & Steinmetz, 2009).

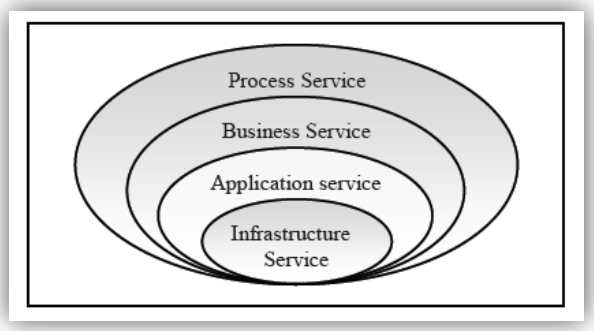

Figure 1. Service Taxonomy (Jung, 2009)

3.3 Different Perspectives

Business participants may perceive a service as a transaction described and regulated by a contract delivered from a provider to a consumer in accordance to defined service level agreements. The semantics and the presumptions of the service are expressed from business experience that determines the perspective. On the other hand, technical users may perceive a service as a unit of functionality that has an interface facilitating the exchange of messages. However, these perspectives complement each other. A business-centric SOA maps the business functions to the technical applications and infrastructure to facilitate the automation of business rules and align business and IT (Luthria & Rabhi, 2009; Perrey & Lycett, 2003).

3.4 SOA Reference Architecture

An SOA reference architecture, shown in Figure 2, is used as an enabler to achieve the value propositions of SOA. The objective of an SOA reference architecture is to offer a guideline for establishing and evaluating the architecture. In addition, it provides insights for integrating the fundamental components of SOA in SOA layers (Arsanjani, Zhang, Ellis, Allam & Channabasavaiah, 2007; The Open Group, 2009).

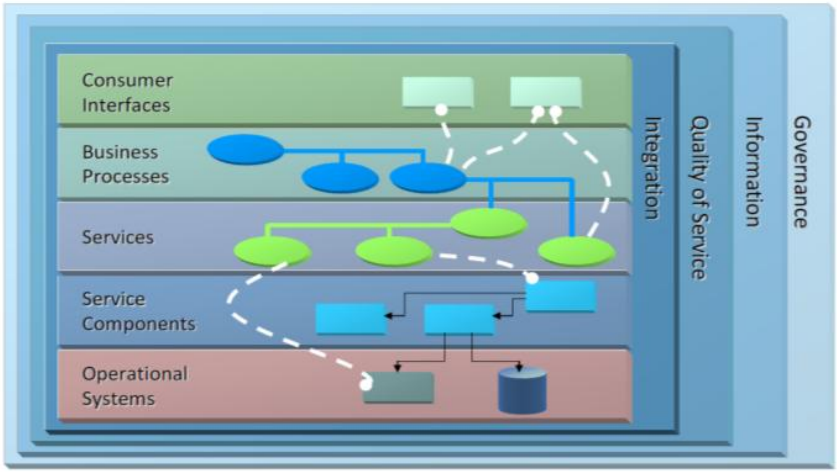

Figure 2. Layers of the SOA Reference Architecture (The Open Group, 2009)

First, the operational systems layer captures existing and new infrastructure needed to support SOA. It includes the required infrastructure to run SOA, physical and operational systems components, application assets, infrastructure services, and other composed or orchestrated services. Second, the service component layer contains software components providing implementation or realization for services. It links the service contract to its implementation in the first layer. Third, the service layer, which contains all SOA services, includes the service description, runtime contract description and service dependencies. Figure 3 is a further elaboration on the service layer. It represents a middleware view and classification of services on the SOA reference architecture. Fourth, the business process layer is dedicated to service composition and orchestration. Finally, the consumer layer is responsible for the provision of the capabilities, through channels and portals, to end users (Arsanjani et al., 2007; The Open Group, 2009).

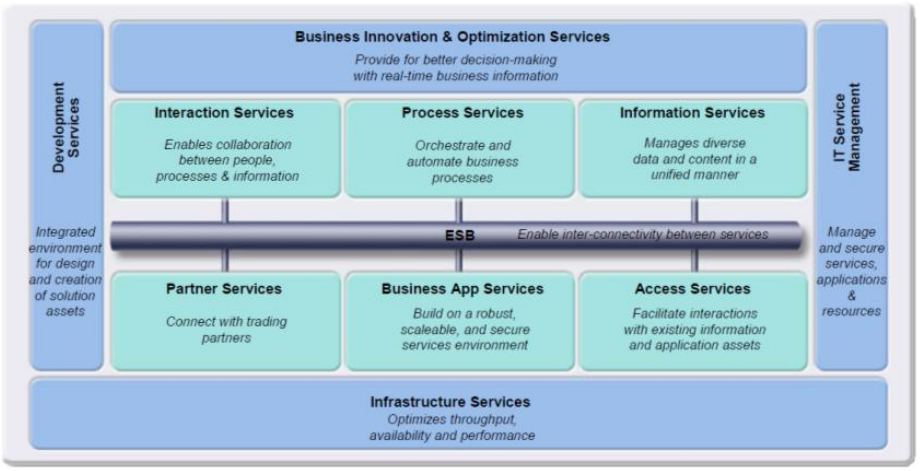

Figure 3. The Middleware View of the SOA Reference Architecture (The Open Group, 2009)

4. INTEGRATION OF SOA IN THE ZACHMAN FRAMEWORK

4.1 Possible Integration Scenarios

To integrate SOA with the Zachman Framework, different approaches are possible including the addition of a new column, a new row as well as integrating SOA in multiple cells, or in a particular cell.

In our endeavor to study the proposed forms of integrating SOA and Zachman, we have searched Google scholar, IEEE Xplore, ScienceDirect, ACM digital library and SpringerLink databases using different search terms and strategies. Based on this, we have identified five related publications that propose different ways of integrating SOA with the Zachman Framework. Three studies integrate SOA/services in the Zachman Framework as a new column. One study integrates SOA on multiple neighboring squares, while the last one integrates SOA on an existing column of the Zachman Framework. The next section will discuss each approach in detail.

4.1.1 First Approach

Correia and Silva (2007) introduce the service concept to Enterprise Architecture. They argue that service is a key concept similar to the other core concepts in Enterprise Architecture such as data, function, and location. They claim that an integrated and cohesive vision of services in the Enterprise Architecture is required in order to enhance an organization's agility.

The authors argue that the service concept is still ambiguous and has multiple semantic meanings and different levels of abstractions, such as business services, technical services and web services. They perceive a service as "a unit of work done by a service provider to achieve desired end results for a service consumer". Additionally,

they see services as a means of linking architectural elements to achieve coherence and a means to achieve flexibility in the operation of these elements.

Due to the lack of service representation on existing EA frameworks, Correia and Silva (2007) proposed the addition of a new column to the Zachman Framework to incorporate the service view. The new column is entitled "Whence" and is used to provide information about the source of the service, the service requester and how it is represented in different views (Table 1). The representation of the service changes on each perspective and the models become increasingly fine-grained as we navigate from top to lower rows. For example, at the top level, the planner perspective is concerned with strategic planning and the mission of the organization. At the level of the owner's perspective, the major concerns are services provided to customers and services requested from partners. The designer perspective is concerned with services customization to stakeholders through market segmentation. The builder perspective focuses on the technical conditions of service availability and systems integration. Finally, the subcontractor perspective focuses on service availability guarantees for the technological components.

Table 1. First Approach

	What	How	Where	Who	When	Why	Whence		
							Cell Example	Provider/ Consumer	Service
Scope (Planner)							Strategic definition of core business	Industry	Business Model
Business Model (Owner)							Definition of core services	Major suppliers, partners and customers	Business outsourcing, Partnership contracts with SLA
System Model (Designer)							Market Segmentation	B2B, B2C, B2E	Customization
Technology Model (Builder)							Systems Integration	CRM, ERP, SRM	SOAP, web services, XML
Detailed Representations (Subcontractor)							Pay as you go , IT Outsourcing	Software and Hardware constructors	Support and maintenance
Functioning Enterprise									

4.1.2 Second Approach

Khoshnevis, Aliee and Jamshidi (2009) point out that SOA artifacts are not explicitly included in the Zachman Framework. Thus, in order to provide the Zachman Framework with the needed capabilities to represent SOA artifacts, they proposed a model driven approach to extend the Zachman Framework. The authors argue that the service artifacts have to be presented at all five perspectives (planner to subcontractor) in the Zachman Framework (Table 2). Khoshnevis, Aliee and Jamshidi (2009) also proposed a method for modeling the service column except for the first and the sixth rows. They argue that the first perspective is not a model, but rather a list of things described in a natural language. The sixth row is not a perspective and represents the actual deployed components of the enterprise. To model the other perspectives, a Computation Independent Model is chosen for the second perspective, a Platform Independent Model for the third perspective, a Platform Specific Model for the fourth perspective, and code for the fifth perspective.

Table 2. Second Approach

	Data (What)	Function (How)	Network (Where)	People (Who)	Time (When)	Motivation (Why)	What Services
Scope (Planner)							List of business Services
Business Model (Owner)							Business Service Model
System Model (Designer)							Logical System Service Model
Technology Model (Builder)							Physical System Service Model
Detailed Representations (Subcontractor)							Service Implementation
Functioning Enterprise							Functioning Service Oriented Enterprise

4.1.3 Third Approach

Scheithauer, Augustin and Wirtz (2009) use the Zachman Framework to classify service description notations in a service ecosystems context on the different perspectives. As a result, such an approach will facilitate the identification of service description notations for each perspective. In their approach, they also added a new column to the Zachman Framework (Table 3). From the planner's perspective, service properties have a strategic semantic, a service purpose, and a list of important properties. From the owner's perspective, the service value proposition and the owner's requirements in regard to the service are represented. From the designer's perspective, a complete service model, which is formal and technology-independent, is represented. From the builder's perspective, concrete technology properties, such as web services and a modeling ontology are adapted. From the subcontractor's perspective, functionality properties such as WSDL and quality of service properties are represented. On the last row, the implemented service description, i.e. the actual service, is represented.

Table 3. Third Approach

	Data (What)	Function (How)	Network (Where)	People (Who)	Time (When)	Motivation (Why)	Service
Scope (Planner)							List of important properties
Business Model (Owner)							Value proposition
System Model (Designer)							Service Model
Technology Model (Builder)							Service Profile
Detailed Representations (Subcontractor)							Service component
Functioning Enterprise							Service

4.1.4 Discussion of these three approaches

In all three approaches, SOA/service is associated with the Zachman Framework by *the addition of a new column.* Moreover, in all of the three approaches, SOA or particularly services are considered an essential part of the Framework and as impor-

tant as the other aspects such as data and network. SOA or services are viewed as a concern for all the stakeholders in these approaches. SOA or service elements are aggregated into the original perspectives (views) of the Zachman Framework by the addition of a new square (model) to the end of each perspective. However, none of these approaches discusses how the elements of the new column (SOA/service) are associated with the original elements of the Zachman Framework. Further, in contrast to the second approach, the first and the third approaches do not even have a meta-model that explains the relationships between their new column elements.

4.2 Type 2: SOA on nine squares

Schmelzer (2006) agrees that there are different views of SOA. For example, SOA may be perceived as a form of application architecture, while in other occasions SOA may be seen as representing an area of concern as broad as enterprise architecture. He believes the disagreement is caused by unawareness that there are multiple viewpoints for SOA. Therefore, in order to understand the relationships between different viewpoints of SOA and to make sense of them, Schmelzer (2006) proposes the use of the Zachman Framework and attempts to tailor the Zachman Framework to accommodate SOA. He suggests the initial logical position for SOA is the application architecture square at the intersection of the "System Model" row and the "Function" column. However, SOA is not just an approach dealing with applications and functions of the system. Processes are composed of services and business processes are exposed as services in SOA. In addition, SOA also influences information sharing and representation, and the way a network deals with applications (Schmelzer, 2006; Seppänen, 2008). Therefore, SOA goes beyond the application architecture square and affects all the eight neighboring squares on the Zachman Framework (see Table 4). As a result of mapping SOA to the Zachman Framework, architects have a clear understanding of the relationships between the various components of a SOA (Schmelzer, 2006).

Table 4. SOA on multiple squares approach

	Data (What)	Function (How)	Network (Where)	People (Who)	Time (When)	Motivation (Why)
Scope (Planner)						
Business Model (Owner)	SOA					
System Model (Designer)						
Technology Model (Builder)						
Detailed Representations (Subcontractor)						
Functioning Enterprise						

In this integration type, SOA is positioned on nine squares on the Zachman Framework. SOA and the elements of the nine squares share the same position. Further, no meta-model is given as to how SOA elements and the original elements of the cells are supposed to be integrated or modeled. However, Schmelzer (2006) states that IT assets are represented as services on the application architecture square. He also

states how processes and services are associated. He generally argues that SOA affects all eight neighboring squares of the Application Architecture square.

Further, in regard to the perspectives, SOA is only considered a concern for three perspectives, namely that of the owner, the designer and the builder. It is not a concern for the planner and the sub-contractor. In other words, SOA does not have any strategies, goals, or objectives that are important to the planner. Regarding the affected aspects, SOA is considered part of only the data, function, and network aspects.

4.3 Type 3: SOA on the Network column

Laplante, Zhang and Voas (2008) utilize the Zachman Framework to clarify the differences between SOA and Software as a Service (SaaS). SOA is defined as an architectural strategy intended to change the way internal systems are built and the way systems interact. In SOA, re-usable services are the essential elements of the software system. SOA is used to enable the publishing, discovery and use of the services. These services interact through well-defined interfaces and protocols and can be further used to build new software components which can be published as a new service (Laplante et al., 2008).

Laplante, Zhang and Voas (2008) argue that SOA belongs to the Network (Where) column in the Zachman Framework, as shown in Table 5, because SOA focuses on connections among its elements in the bigger picture. From the planner's perspective, the SOA network model is a list of possible services to be used in a software system under development. From the owner's perspective, SOA constitutes a collection of existing business services to be utilized in the system. At the designer level, SOA represents an architectural model specifying interaction patterns between service components. The builder's perspective depicts the identification and selection of necessary technology, e.g. web services, to realize the interaction model. At the subcontractor level, the concern is about the list of languages, protocols and services used. Finally, at the functioning system level, the main concerns are the management and monitoring of all collaboration and communication among services and service components.

Table 5. SOA on Existing Column Approach

	Data (What)	Function (How)	Network (Where)	People (Who)	Time (When)	Motivation (Why)
Scope (Planner)			SOA			
Business Model (Owner)						
System Model (Designer)						
Technology Model (Builder)						
Detailed Representations (Subcontractor)						
Functioning Enterprise						

In this integration type, SOA is positioned on the Network column in the Zachman Framework. SOA elements and the elements of the Network column occupy the same position. However, neither details nor a meta-model are given to explain the relationships between those elements. With regard to the perspectives, SOA is considered part of all them. SOA is represented on existing squares on the network column.

5. COMPARISON

In order to provide an overview and a comparison of the commonalities and differences of the five approaches discussed in this paper, we had to select a set of comparison criteria. To this end, we draw from Jamshidi et al. (2008) who adopt some essential factors that are designed to characterize information development processes and utilize them to evaluate a service-oriented analysis and design method and reuse applicable factors related to SOA and services for our comparison of the EA/SOA integration types. In addition, we also adopt some metrics from Franke et al. (2009) who compare different enterprise architecture frameworks in terms of architecture governance and modeling concepts. However, the limited amount of conceptual background information provided by some of the studies discussed in this paper restricted the comprehensiveness of the comparison.

Table 6. Comparison between the different approaches

Approaches	Perspectives (viewpoints) affected by SOA					Aspects (abstraction) affected							Perspective		Focus On		Type Of integration			Metamodel	
	Planner	Owner	Designer	Builder	Sub-Contractor	Data	Function	Network	People	Time	Motivation	Service	Business	Technical	SOA	Services	New Column	Multiple cells	On Network Column	Relationship with ZF cells	SOA/Service
1	+	+	+	+	+	-	-	-	-	-	-	+	+	+		+	+			-	-
2	+	+	+	+	+	-	-	-	-	-	-	+	+	+	+	+	+			-	+
3	+	+	+	+	+	-	-	-	-	-	-	+	+	+		+	+			-	-
4	-	+	+	+	-	+	+	+	-	-	-	_	+	+	+			+		-	_
5	+	+	+	+	+	-	-	+	-	-	-	_		+	+				+	-	-

Table 6 refers to the five approaches presented earlier in this paper in the sequence of their appearance as rows 1 to 5. The first column shows which perspectives in the Zachman Framework are affected by the respective SOA integration approach. It can be seen from this column that in all five approaches SOA is a concern for the three perspectives owner, designer and builder, while four of them consider SOA as a concern for all the perspectives. Column two depicts which aspects of the Zachman Framework are affected by the different integration types. Since the first three approaches are examples of the integration type that adds a new column to the existing framework, they only affect the added aspect "service". As described in section 4.2, the fourth approach is based on an integration type that superimposes SOA on nine models (squares) in the Zachman Framework and thereby affects three aspects, name-

ly Data, Function and Network, whereas the last approach is restricted to the Network aspect. The third column reflects whether the respective approach takes on a rather business-oriented or technical view or both. Only the last approach seems to neglect the business perspective completely. The fourth column makes a distinction between the concepts of SOA on the one hand and service on the other. Some approaches target both concepts, while others focus on either the former or the latter. The second to last column shows the classification of the integration type chosen in the respective approach, which has been discussed in detail before. The last column finally informs about the fact whether the approach comes with a meta-model that defines the SOA/service concepts and their relationships and whether it offers information about the relationships with the original Zachman Framework elements.

Unfortunately, based on the available information it was not clear whether a SOA understanding as technical or business paradigm is a major contributor to the differences in SOA's integration with the Zachman Enterprise Architecture Framework.

6. CONCLUSION AND FUTURE WORK

One of the key benefits to be gained from Enterprise Architecture is the ability to support decision making in changing businesses. To be able to deliver that benefit, we believe that Enterprise Architecture Frameworks themselves need to embrace change in a way that they adequately consider emerging new paradigms and requirements affecting Enterprise Architecture, such as the paradigm of service orientation. In this paper, we have focused on the prime father of Enterprise Architecture frameworks, the Zachman Framework, and discussed different attempts in the literature to extend this framework in a way that it accommodates SOA and services. We were able to identify substantially different types of integration, which points to the fact that there is a lack of agreement of where and how to position SOA and services in the Zachman Framework. This finding indicates the need for a precise and detailed approach explicating the relationships between SOA elements and the Zachman Framework elements. Our future work will extend the scope of our analysis by also taking into consideration more current Enterprise Architecture frameworks, e.g. TOGAF, and conducting exploratory case studies in organizations and a survey with Chief Enterprise Architects to include the state of practice as well. We aim at understanding why EA and SOA are integrated in different ways, if and how this may be related to the different understandings of SOA, and ultimately strive to derive normative guidelines from these insights, that will assist organizations to adopt an integrated EA and SOA framework that is tailored for their specific business goals.

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