Tailoring Enterprise Architecture Frameworks: Resource Structuring for Service-oriented Enterprises

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Abstract: Enterprise Architecture (EA) is a discipline concerned primarily with enterprise Business-IT alignment. The Open Group Architecture Framework (TOGAF) is one of the leading EA frameworks that describes methodology to carry out architecture work. TOGAF prescribes tailoring of the architecture frameworks for enterprise architecture initiatives. However, there are no real-world examples of how these frameworks would look like, nor there exist a clear process describing how to construct such frameworks. In this paper, we show how to tailor an enterprise architecture framework for service-oriented enterprises.

1 INTRODUCTION

Human-made systems are becoming inherently complex (ISO, 2011). Enterprise Architecture (EA) discipline is aiming at addressing complexity issues of enterprises, and is primarily concerned with enterprise Business-IT alignment (Ross et al., 2006). The Open Group Architecture Framework (TOGAF) (The Open Group, 2011) is one of the leading EA frameworks that describes methodology to carry out architecture work. TOGAF prescribes tailoring of the architecture frameworks for enterprise architecture initiatives. However, there are no real-world examples of how these frameworks would look like, nor there exist a clear process describing how to construct such frameworks. Smart Cities can be viewed as enterprises that are strategically using Information and Communication Technology (ICT) to improve quality of citizens life (Mamkaitis et al., 2016). The application of ICT requires alignment between system requirements and citizens needs (Bastidas et al., 2017, Bastidas and Helfert, 2018). From our conversations with Smart City leaders, one of the themes that was became evident in the process of discussing EA work was the fact that city councils have no preference towards the “business” language in the EA initiatives. More precisely, while reasoning in terms of the business architecture, business services, business functions, business roles, etc. the main comments were that city government is not aiming at doing business, but rather at providing a service. However, Enterprise Architecture work revolves around the concepts of business. In particular, the requirement that all architecture decisions made during the architecting process must be grounded in the need to support business agenda of the enterprise (Lankhorst, 2009).

Today, services constitute a major part of developed economies (National Academy of Engineering, 2003). To formalize service research, academic and research community proposed the notion of Service Science Management and Engineering (SSME) (Chesbrough and Spohrer, 2006), or Service Science (SS) for short (Maglio et al., 2006, Spohrer et al., 2007). Service science defines a set of concepts that are intended to constitute a service system (Spohrer et al., 2008). Researchers have identified connections between these concepts to construct service system ontologies (Mora et al., 2011, Ferrario et al., 2011, Blaschke, 2018). Effectively, an ontology could be utilized to describe and model service system architecture. However, to-date there is no research explaining what approach can be taken for service system architecture description and modeling. In this paper, we construct and demonstrate a practical Tailored Enterprise Architecture Framewrok (TFEA). This framework is based on the service science theoretical foundations of service-dominant logic (S-D) (Vargo and Lusch, 2004; 2006), and best practice in the Enterprise Architecture (EA) discipline. This work shows how to tailor

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architecture framework to the requirements of the EA initiatives.

2 METHODOLOGY

Our approach to this research is guided by Ostrowski and Helfert (2012) who list three techniques that are important for execution of the Design Science phases. These are a) literature review, b) collaboration with practitioners, and c) modelling. We complement our approach with systems research thinking (Ackoff, 1971, Checkland, 1981, Gelman and Garcia, 1989). First, we modeled the water provisioning service in a city setting with established Enterprise Architecture modeling methods and tools. Following this, we discussed the resulting model with four experts in the water provision industry to make corrections to the model where was necessary. From conversations with water experts, we found that our model does capture the structure of reality and therefore provided a useful representation (March et al., 1995). All experts were from different countries, companies, and different employment positions in their associated companies. After confirming the validity of the model, we analyse it from theoretical and conceptual view of service science (SS) (Spohrer et al., 2008) and service-dominant (S-D) logic perspective (Vargo and Lusch, 2006) to construct a service-oriented enterprise architecture framework. We then present results of this analysis.

3 SERVICE ARCHITECTURE SIMULATED MODEL EXAMPLE

Report by ABI Research (2017), referring to Institute of Public Utilities at Michigan State University, reveals that water had a tremendous increase in price over the last thirty years. Water is the basic utility in every city and is often taken for granted by the city residents (Postel, 2014; Shiva, 2016). However, water supply service system is not a trivial system (Salzman, 2006), and we chose to simulate a water supply service as a case for this paper analysis.

We chose to simulate the water supply service as it very well exhibits the third Foundational Premise (FP3) of service-dominant logic – "goods are a distribution mechanism for service provision", meaning that "goods.. derive their value through use – the service they provide" (Vargo and Lusch, 2008). Goods aid in addressing and solving specific problems of persons and businesses, who acquire those goods. The resolution of the problem is manifested in value acquisition of which there might be numerous (Sheth et al., 1991). However, the functional value in this case is not straight-forward clear. For example, water can be used for recreational, health, domestic, food, industrial, and so on, purposes (Rijsberman, 2006, Kenny et al., 2009, Hoekstra 2006). The simulated use case was modelled from the Enterprise Architecture practice perspective (The Open Group, 2011) using ArchiMate modelling language (The Open Group, 2016, Lankhorst et al., 2009). The Water Supply Service architecture model included four layers, top-down, as elaborated in Table 1.

Table 1: Enterprise Architecture layers and their contents.

Business Layer	Stakeholders, Business Processes, Business Objects (contracts), Business Services.
Application Layer	Application systems that support business layer activities – e.g. software systems, applications and data.
Technology Layer	Shows hardware elements and equipment, such as computer devices, to run and support components in the application layer.
Physical Layer	Enables to model water as the material component of service.

The model did not include neither the strategy layer nor the motivation layer, which enable to model elements of e.g. value, meaning, requirement (and constraints), principles, goals and outcomes, etc. (Quartel et al., 2010, Greefhorst and Proper, 2011, The Open Group, 2011). The reason for this is that we were aiming to show how to construct tailored enterprise architecture frameworks, not to give an example of a complete or comprehensive one.

4 SERVICE SCIENCE

Where one perceives goods, they should think what processes, skills, human effort and intent went into creating those goods. In fact, any non-automated processes are proveded as human service, and any automated processes are provided by the systems that are created, deployed, and maintained by the means of human labour – in effect, facilitated by the human service (Sheridan, 2002, Cichocki et al., 2012). To this day, the established goods-dominant (G-D) worldview (Vargo and Lusch, 2004; 2008) makes many to perceive that the basis for the economic system is the notion of goods as a measurable units of tangible. However, no product has existential significance without, or outside of, the human social system (Hollnagel and Woods, 1999; 2006). Service science on the other hand, is studying the universal service approach by viewing service as a driving force for human cooperation and survival (Vargo and Lusch, 2008, Leonard et al., 2012, Bowles, 2003, Deutsch, 1949,). In this context, even goods are considered as being indirect service provision (Vargo and Lusch, 2008). This approach to view service at the core of all human activity is supported by service-dominant (S-D) logic (Vargo and Lusch, 2004; 2008). Recent study of manufacturing companies applying service science and service innovation concepts shows positive results while transforming their operations according to service science approach (Gao and Paton, 2018, Victorino et al., 2018). In this section, we provide information about the service science conepts used in this research. We primarily focus on the basic resource types that are specified by the service science, and in the next section we use this knowledge to construct the Tailored Enterprise Architecture Framework (TFEA).

4.1 Service System Architecture

The unit of analysis for service science is the service system. Service system is a dyadic service interaction between two atomic service systems. Atomic service system is defined as “one that uses no other service systems as resources” (Maglio et al., 2009). Service systems exist to interact with other service systems in the quest for value co-creation (Maglio, 2008). A service system that is composed of atomic service systems, forms a composite service system (Maglio et al., 2009). Examples of types of service systems range from individuals, family, organization, business, hospitals, universities, cities, departments, nations and global economy (Jaakkola et al., 2014, Maglio and Spohrer, 2008).

Service systems are the configurations of resources, skills, and knowledge to co-create value (Maglio et al., 2006, Spohrer et al., 2007). The complexity of resource configurations is presented by Madhavaram and Hunt (2008), where authors describe the framework of basic, composite, and interconnected operant resources. It is known that “every system has an architecture” (Software Engineering Standards Committee, 2000), therefore service systems being classified as complex systems (Chae, 2012, Barile and Saviano, 2010) inherently require scientific methods to study and design service systems architecture. That said, service science is lacking methods to describe and model service system architectures, and early research on formalising the service concept propose that beyond the definition of *what* and *how*, service goes further to integrate the two (Goldstein et al., 2002). Integration involves the standardisation process of the same. In line with architecture best-practice (Software Engineering Standards Committee, 2000, The Open Group 2011, Force, 1999), such architectures must be descriptions of interactions and relations between actors, and their use of various configurations of resources. To facilitate description and modeling of service systems architectures, the methods for service system architecture practice must accommodate at the very least the following artifacts a) service system architecture framework, b) a service system architecture meta-model, and c) a service system architecture description and modeling techniques and processes. In this paper, we show how Enterprise Architecture can facilitate the use and application of service science concepts. As a result, we construct and demonstrate Tailored Enterprise Architecture Framework (TFEA) for service oriented architecture initiatives.

4.2 Service System Resource Types

A first challenge for service science is “understanding of the type of resources.. and methods to formally model their role” (Maglio, 2008). The purpose of this sections is to elaborate on the types of resources that compose the service system. Table 2. shows the types of resources specified by service science (Maglio, 2008) which we use as a base for the further analysis in this paper. We also supplement the types of resources with the set of resource types that are necessary for service system architecture description – *applications, data, materials*.

Examining the model described in Section 3, it became clear that service science specifies a set of resources which are not sufficient for a comprehensive architecture description. For example, it was not possible to assign water to any one of the four currently defined resource types (person, business, technology, information) Table 2. To articulate the need for “Materials” type of resources we should bring attention to the fact that any produced goods, potentially can be classified as technology. The composition of any such technology, physically, is essentially a configuration of resources of nature whose properties are mended, altered, and eventually combined with other resources to constitute goods. Such goods constitute an end product whose purpose is to serve and aid a goods-operating party in their endeavours. Therefore, the life of any goods starts from the resources that are provided by nature (Bridge, 2009) and are of physical or "material" type. In our simulated water provisioning service case, water was the naturally occurring and renewable, component.

Table 2: Resources attributes, classes, and types. Adapted from Maglio (2008).

	With-Rights (WR)	Without-Rights (NR)
Non-Physical (NP)	Business	Information, *Applications*, *Data*
Physical (P)	Person	Technology, *Materials*

Note: resource types in italics are the resources introduced in this research.

Service science specifies four classes of resources based on four attributes as they pertain to physical constitution and assignment of rights – person, business, information, technology. Physical constitution in this regard means the tangibility of the resource, and "rights" referred to herein are natural rights (Finnis, 2012) and legal righst (Stone, 1972). In addition to the resource types defined by service science, we include three types of resources that are necessary for the service system description in the context of architecture – *application*, *data*, and *materials*, - Table 2. Further we elaborate on the resource classes, and their types.

a) **Physical-With-Rights (PWR)** – is a class of physical resources with natural and/or legal rights. Service science specifies one type of resource pertaining to this class – a person.

b) **Non-Physical-With-Rights (NPWR)** – is a class of resources that are of conceptual, rather than physical. The types of resources in this class are legal entities, or otherwise legaly recognised congregated body of persons. Service science specifies one type of resource pertaining to this class – e.g. business, a corporation, or other type of organization with legal status.

c) **Physical-Without-Rights (PNR)** – is a class of physical resources that are the human-made artifacts. Service science specifies one type of resource related to this class – technology. As part of this paper, we propose additional type of resources pertaining to this class – *Materials*, which are resources of nature that are harvested, processed, and used by persons and businesses with, or without, the aid of technology.

d) **Non-Physical-Without-Rights (NPNR)** – is a class of non-physical resources the artifacts in this class include information such as laws, processes, traditions, skills, contracts. We add two types of resource to this category, namely – *Applications*, and *Data*.

Applications is a type of resource which include software products, that are the instructions to be executed by the computer hardware (Mahoney, 2004). We found it important for this type of resource to be represented as a type of resource in it's own right, primarily due to the reason that it is not possible to assign it to neither Technology, nor Information type of resource. In fact, Applications use technology (tangible resources, e.g. computers) to produce information.

Data is a type of resource that is distinct from either type of resources in the Non-Physical-Without-Rights (NPNR) class. Applications operate on data, to produce information (Bellinger et al., 2004). In fact, data, information, knowledge and wisdom, stack up in a pyramid of dependency on one another (Rowley, 2007).

Materials is the resource type that includes raw materials, as well as materials facilitated by nature – this is necessary to provide inclusion of resources that are not addressed by any of the resource types currently specified by service science. Materials are the type of resource that come from nature and have their own mechanisms of formation and, or, reproduction – such as water, wind, solar energy, oxygen, etc. (Liu et al., 2007). Materials type belong to the class Physical-Without-Righst (Table 2). The aim of material resources type is to include renewable, non-renewable, as well as mineral resources. Wind, water, fauna, flora, crude oil, petrol, gold, silver, ore, are all examples of material resources. Some of these resources have the capacity to self-sustain and regenerate over the life-time of a human being, and some take much longer time. However, the purpose of this type of resource is to communicate the fact that resources of nature are used as components for the creation of artifacts in the technology layer.

Service science research revolves around understanding of service system actors, the context in which they operate, their interactions, interaction outcomes, co-creation, measures, value, stakeholders, entities, and resource configurations (Spohrer et al., 2008, Patricio and Fisk, 2011). However the area of constructing and architecting service systems has not yet been explored. In the next section, we present and analyse a layers for service-oriented architecture framework that serves as a basis for our explanation of resource structuring within the service system architectures.

5 TAILORED ENTERPRISE ARCHITECTURE FRAMEWORK

Service science objective is to study service systems. In the previous sections we discussed the types of EA resources and how they align to the layers in an EA practice. In this section, we show how layering of types of resources align within the service science resource classification, Table 3 and Table 4. Further we discuss layers of the tailored service-oriented architecture framework top-down.

Table 3: Architecture elements to types comparison: Service Science (SS) and Enterprise Architecture (EA).

Resource Name	SS Type	EA Type
Environ.Regulator	Business	Actor
Home Owner	Person	Actor
Household	Technology	Facility
Cust.Mgmgt.Process	Information	Business Process
Account Manager	Person	Actor
Env. Regulator	Business	Actor
Consumer Protection Agency	Business	Actor
Water Ops. Manager	Person	Actor
Contract	Information	Business Contract
Customer Profile	Data	Data Object
Financial Transaction	Data	Data Object
Water Customer Support	Person	Actor
Issue Management Process	Information	Business Process
Water Daily Ops. Process	Information	Business Process
Monitoring Application	Application	Application
Ticketing Application	Application	Application
Customer Mgmt.Application	Application	Application
Issue Resolution System	Technology	Node
Database System	Technology	Node
Internet 4G	Technology	Comm.Network
Water Supply Control	Technology	Device
Water	Material	Material

5.1 Service Layer

The aim of the Enterprise Architecture is the Business-IT alignment (Ross et al., 2006), the principal idea behind which is that all architectural decisions should be grounded in the need to support business agenda of the enterprise (Lankhorst, 2009). Business layer of the enterprise architecture includes persons and organizations. In contrast to the EA, service science research revolves around agenda of service, in the context of which business is a type of resource rather than a conceptual layer (Table 2, Table 3). Interaction between persons and businesses happen in a service setting, e.g. Home Owner to Account Manager interaction, Water Operations Manager to Environmental Regulator interaction, or

Table 4: Architecture elements to architecture layers comparison: Service Science (SS) and Enterprise Architecture (EA).

Resource Name	SS Layer	EA layer
Environ.Regulator	Service	Business
Home Owner	Service	Business
Household	Technology	Technology
Cust.Mgmgt.Process	Information	Business
Account Manager	Service	Business
Env. Regulator	Service	Business
Consumer Protection Agency	Service	Business
Water Ops. Manager	Service	Business
Contract	Information	Business
Customer Profile	Information	Application
Financial Transaction	Application	Application
Water Customer Support	Service	Business
Issue Mgmt. Process	Information	Business
Water Daily Ops. Process	Information	Business
Monitoring Application	Application	Application
Ticketing Application	Application	Application
Customer Mgmt. Application	Application	Application
Issue Resolution System	Technology	Technology
Database System	Technology	Technology
Internet 4G	Technology	Technology
Water Supply Control	Technology	Technology
Water	Materials	Physical

Consumer Protection Agency to Water Customer Suport interaction. All of these actors engage in service interactions. They make up, and belong to, the logical strata of service (Table 4).

5.2 Information Layer

The next resource type is information. Enterprise Architecture specify business contract, as well as business processes as types within the business layer, Table 4. In the context of service science, contracts and processes fall within the Information resource type – as these resources are considered to be conceptual rather than physical, Table 2. Technology and Applications can be used to construct and present these resources – e.g. make visual presentation with pen and paper, or digitally). Artifacts in the Information Layer are the resources that are in the state of “ready-to-be-acted-upon”. Actors in a service system are constantly engaging with other actors in the quest of value co-creation and value extraction. Any interactions between actors are based on the value propositions (Frow and Payne, 2011). These propositions are delivered in a form of information. In fact, information is a first-order operand in the context of any actor activities (McFadyen and Cannella, 2004). An example is a person-to-person communication, where information is passed between persons without the use of technology – e.g. by the means of spoken language (Premack, 2004). Humans use information to make decisions, directing them in the universal space of entities and contextual space of actors (a scoped service system). Information Layer includes, but is not limited to, written knowledge, processes, procedures, written law, traditions, agreements, contracts, instructions, spoken language, etc. This makes logical information strata to exist independently from other service architecture layers.

5.3 Application Layer

Further, humans exchange information in two broadly accepted ways. First is with the use of technology. One of the most primitive example of information exchange with the aid of technology is the use of writing, and print. In the modern society, Information Technology (IT) has advanced beyond writing and print to include information science and information systems (Campbell-Kelly, 2018, Janich et al. 2018). In this context, technology facilitates the functions of data and information collection, storing, transmission, processing and display, etc. Therefore, much of the life-time, information resides within the context of technology (applications) in the form of data.

5.4 Technology Layer

According to the basic types of resources, Table 2., Technological resources are of a Physical-Without-Rights (PNR). These resources are the human-made artifacts (March, 2008, Arthur, 2009, Franssen et al., 2013) such as, but not limited to, buildings, factories, computer equipment, network communications infrastructure including devices and networks, etc. Technology resources are utilised by humans to more effectively and efficiently accomplish tasks at hand.

5.5 Materials Layer

Humans harvest and consume resources of nature. In the context of this research, these are the resources of mineral (Kesler and Simon, 2015, Ross, 2015) and natural origin (Gylfason, 2001, Lederman et al., 2006). In general, the Materials Layer is aimed to include all the nature resources, inclusive of renewable and non-renewable, mineral, and natural resources. These resources are then used by humans to produce composite resources (Madhavaram, 2008), higher order constructs, such as food, tools, circuit boards, alloy compounds, etc.

6 CONCLUSIONS

To solve the complexity of enterprises, practitioners embrace the Enterprise Architecture discipline (Ross, 2006). EA is both a product and a process (Lankhorst, 2009) in terms that it provides methods to record and plan, as well as produces artifacts that help to implement, analyse and change the architectures of enterprises. However, due to the expressiveness of TOGAF, architecture frameworks need to be tailored for specific enterprise architecture initiatives. In this paper, we showed how it is possible to construct a Tailored Enterprise Architecture Framework for the service-oriented enterprises. Our approach shows, that by grounding architecture work in the theoretical foundations of the subject of interest, service science in our case, it is possible to tailor TOGAF framework to a specific project needs. In this particular case, the framework enables architecture approach to service systems and shows where exactly in the context of architecture service related theories and methods should be applied – the service layer, between actors, stakeholders and entities. Future research should focus on service-specific architecture processes, to extract elements pertaining to service systems and facilitate the service system description methods.

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