# *Empirical Insights into the Development of a Service-oriented Enterprise Architecture*


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**Paper Title: Empirical Insights into the Development of a Service-oriented Enterprise Architecture**

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## Abstract

Organisations use Enterprise Architecture (EA) to reduce organisational complexity, improve communication, align business and information technology (IT), and drive organisational change. Due to the dynamic nature of environmental and organisational factors, EA descriptions need to change over time to keep providing value for its stakeholders. Emerging business and IT trends, such as Service-Oriented Architecture (SOA), may impact EA frameworks, methodologies, governance and tools. However, the phenomenon of EA evolution is still poorly understood. Using Archer's morphogenetic theory as a foundation, this research conceptualises three analytical phases of EA evolution in organisations, namely conditioning, interaction and elaboration. Based on a case study with a government agency, this paper provides new empirically and theoretically grounded insights into EA evolution, in particular in relation to the introduction of SOA, and describes relevant generative mechanisms affecting EA evolution. By doing so, it builds a foundation to further examine the impact of other IT trends such as mobile or cloud-based solutions on EA evolution. At a practical level, the research delivers a model that can be used to guide professionals to manage EA and continually evolve it.

## Keywords

Enterprise Architecture, EA, Service-oriented Architecture, SOA, critical realism, morphogenetic theory

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## Abstract

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## 1 Introduction

Enterprise Architecture (EA) has been successfully employed to reduce organisational complexity, improve communication, align business and information technology (IT) and drive organisational change (Lankhorst, 2005; Schekkerman, 2005). The importance EA has gained is reflected by a recent Gartner survey, which stated that EA practitioners strongly influence organisations' IT budgets and globally are either the final decision maker or greatly influence more than $1.1 trillion in enterprise IT spending (Gartner, 2012a). There are various perspectives of what is meant by the term EA, and as yet no common definition has emerged. As a working definition, we follow Lankhorst (2005, p. 3) who defines EA as: "… *a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organisational structure, business processes, information systems, and infrastructure*" (Lankhorst, 2005, p.3). Given the dynamic nature of organisations and the continual emergence of new technological and business paradigms, however, it is essential that EA must not be static. As a prerequisite to successful benefits realisation, it is crucial that EA is continually developed, maintained and kept up to date. Frameworks, methodologies and terminology used in developing EA need to take into account that organisations are dynamic, adaptive systems of systems (Sampaio, 2010; Sousa, Lima, Sampaio, & Pereira, 2009) and it is, therefore, essential to understand and plan EA evolution (MacLennan & Belle, 2014; McKendrick, 2010; Shah & Golder, 2011).

EA evolution needs to be planned on both the level of architectural descriptions (the EA frameworks, meta-models, concepts etc.) as well as on the level of architectural representations (Martin, Purao, & Robertson, 2009). The level of *architectural representations* relates to the models that represent the architecture of the analysed organisation from a business and IT perspective and thus form the central deliverable of the EA practice. When EA evolution is not managed and aligned at this level, misrepresentation and occasionally even failures result (Martin, et al., 2009).

Related architecture models must be accurately and traceably linked to their implementation to manage the complexity, development and maintenance of evolving systems. Any changes to the implementation have to be reflected back in the architecture to keep EA evolving and correctly describing the organisation (Mens, Magee, & Rumpe, 2010). To align EA models with the corresponding real world, enterprise architects have to be aware of changes affecting the enterprise and its EA (Roth, Hauder, Farwick, Breu, & Matthes, 2013).

*Architectural descriptions*, on the other hand, are the "vehicle" for building architectural representations (Martin, et al., 2009). On this level EA as a discipline faces the fundamental challenge of re-thinking EA frameworks, meta-models and concepts in response to emerging business and IT paradigms and capabilities, such as, for example, Service-Oriented Architecture (SOA) and cloud computing (McKendrick, 2010), and embedding them adequately in existing EA frameworks (Jung, 2009; Mens, et al., 2010; Roth, et al., 2013). This may require changes to architectural elements and the relationships that are used as part of the EA practice. The architectural elements are the elements that enclose and describe an organisation's business, people and technology (more specifically, its strategies, business principles, stakeholders, locations, functions, activities, processes, products, information, applications, systems, infrastructure, etc.) (Schekkerman, 2004, p. 22). When new paradigms, such as SOA, emerge and change the enterprise, new architectural elements and relationships may need to be considered (Banerjee & Aziz, 2007; Infosys, 2009; Postina, Trefke, & Steffens, 2010; Varnus & Panaich, 2009).

The phenomenon of EA evolution is still poorly understood. While EA evolution presents significant challenges to organisations (Land, Proper, Waage, Cloo, & Steghuis, 2009; Short, 2013), research on this phenomenon so far is very limited and *there is a lack of understanding of how EA actually evolves, in particular on the level of architectural descriptions*. More specifically, there are no empirical studies that describe or explain how EA in organisations evolves due to emergent business and IT trends such as SOA (Knippel & Skytte, 2007; McKendrick, 2010; Postina, et al., 2010; Saat, Aier, & Gleichauf, 2009; Shah & Golder, 2011). A limited number of studies have either focused on the representational changes of EA, such as changes to applications (e.g. see Buckl, Ernst, Matthes, & Schweda, 2009; Farwick, Schweda, Breu, Voges, & Hanschke, 2012), or provided examples of EA evolution on the architectural descriptions level without considering the underlying process of evolution or what may impact the evolution (e.g. see Banerjee & Aziz, 2007; Correia & Silva, 2007; Postina, et al., 2010; Shankararaman & Kazmi, 2011; Sharma, 2013 ). The existing approaches do not clearly consider external influences on the EA planning process or changing conditions in an organisation's environment (Saat, et al., 2009).

The emphasis of this research lies on changes to architectural descriptions that result from the emergence of new business or IT paradigms, which introduce new concepts, architectural elements and new ways of thinking about organisations. We specifically study the introduction of SOA as this is one of the major, relatively recent new architectural paradigms with the potential to trigger substantial EA evolution. SOA is defined 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" (The Open Group, 2010). SOA is among the top issues that organisations are trying to address using EA (Varnus & Panaich, 2009) and SOA integration into EA needs more attention (Dico, 2012). In fact, many studies explicitly argue that EA needs to evolve to address and integrate SOA (Khoshnevis, Aliee, & Jamshidi, 2009; MacLennan & Belle, 2014; Postina, et al., 2010; Sanders, Hamilton, & MacDonald, 2008; Sharma, 2013 ; Viering, Legner, & Ahlemann, 2009). Kistasamy, Van der Merwe, and De La Harpe (2012) argue that, although both EA and SOA have matured, there is a lack of understanding of the relationship between them, which has resulted in a marginal realisation of their combined benefits (Kistasamy, et al., 2012).

*The objective of this study* is to describe the EA evolution process and explain observed EA evolution outcomes at the level of architectural descriptions. It specifically focuses on the introduction and implementation of SOA in an organisation as one exemplary trigger for an EA evolution process. From a conceptual point of view, this research views EA evolution as an interaction between the existing EA and the action of introducing a new IT phenomenon, which may result in EA evolution outcomes using Archer's (1995) morphogenetic theory as a foundation. We have chosen a case study-based approach to be able to derive rich empirical observations from an organisation that has introduced SOA, which had an impact on the evolution of the organisation's EA.

We proceed as follows. The next section will lay the theoretical foundation for the study by introducing the morphogenetic theory as the analytical lens to examine the EA evolution phenomenon and developing the study's research model. After that, the research methodology is outlined and background information about the case organisation and the data collection and analysis is provided. The following section presents the case study findings in detail, structured along the components of the research model presented in the second section. Finally, a discussion of the findings and a report on the insights gained from the study conclude the paper.

## 2 Theoretical foundations

To add a unique contribution to the body of EA knowledge, we position this research from two perspectives: its focus (EA evolution at the level of architectural descriptions) and its theoretical basis (i.e., theory building or theory testing). With respect to the latter, EA is still a young domain that presents many challenges for researchers and EA studies often lack sound theoretical foundations (Schmidt & Buxmann, 2011; Simon, Fischbach, & Schoder, 2013). Therefore, this research aims at building theory that describes and explains how EAs evolve as a complex, organisational level phenomenon and an important aspect of EA management (Winter, Buckl, Matthes, & Schweda, 2010). Lynham (2000) argues for theory building (1) to advance professionalism in and maturity of a given field and (2) to help bridge the gap between research and practice. For the purposes of this research, we use Lynham's (2000, p. 222) definition of theory as "a coherent description, explanation, and representation of observed or experienced phenomena".

To theorise about EA evolution, this research recognises both the inherent complexity and the temporality of EA evolution and the need for an analytical lens for understanding its evolution. The study investigates EA evolution using the morphogenetic theory (Archer 1995), a critical realism-based theory, to comprehend the evolution process triggered by SOA introduction. Archer's morphogenetic theory is adopted because it considers an explicit temporal dimension to study change, which is fitting for an investigation of EA evolution (see Figure 1). It provides a useful conceptualisation for the examination of organisational changes, particularly those involving technology (Mutch, 2010).

According to Archer (1995), every morphogenetic cycle (see Figure 1) differentiates between three broad analytical phases which comprise: "(a) a given structure (a complex set of relations between parts), which conditions but does not determine (b), social interaction". The social interaction is also influenced by agents' orientations and "in turn leads to (c), structural elaboration" (Archer, 1995, p. 91). Archer (1995) argues that the analysis must start at time (T1) to include the structural conditioning that is formed by previous actions, not at the time of (T2) when the social interaction takes place. Cuellar (2010, p. 41) states that "previous cycles have created a particular set of existing structures and distributions of resources as the result of prior cycles which condition the actions of existing agencies". The interaction phase is enabled or constrained by pre-existing conditions. It is also influenced by agents' orientations, interests, and interpretations (Archer, 1995; Danermark, Ekström, Jakobsen, & Karlsson, 2002). The third analytical phase is the elaboration phase, which can be either the reproduction or transformation of pre-existing structure: Structures may stay as they are with no changes (reproduction) or may change (transformation) (Archer, 1995). The three phases: conditioning, interaction, and elaboration are continuous through time but, as an analytical tool, dualism is employed to let the researcher cut into reality and project cycles forwards and backwards.

According to Archer (1995), the point of examining any morphogenetic cycle is to provide an analytical perspective on the emergence of outcomes under investigation (EA evolution outcomes in this case). The interplay between the architectural conditioning phase (T1) and the architectural interaction phase (T2-T3) occurs in a morphogenetic cycle (SOA integration into EA), which defines how the architectural elaboration (EA evolution outcomes) occur (Archer, 1995; Cuellar, 2010). Building on the morphogenetic theory, the elaboration (EA evolution outcomes) is the result of the interplay between the action-formation mechanisms of the interaction (SOA introduction) and the conditional generative mechanisms of the conditioning phase. The bottom half of Figure 1 shows the appropriation of the theory in the context of this study to conceptualise the EA evolution process by distinguishing three phases: (1) architectural conditioning (due to an organisation's pre-existing EA), (2) architectural interaction (e.g., SOA introduction) and (3) architectural elaboration (outcomes of EA evolution). Next, we developed the model into more detail (Figure 2) based on a literature review and explorative interviews as described in previous work (Alwadain,

Fielt, Korthaus, & Rosemann, 2014). For the architectural elaboration (T4), five possible levels of EA evolution outcomes were identified: business architecture, information systems architecture, technology architecture, EA governance, and EA methods and tools. The first three outcome levels are commonly addressed in EA frameworks as perspectives or layers. The latter two were added to the research model as a result of the explorative interview phase which was reported in Alwadain, et al. (2014).

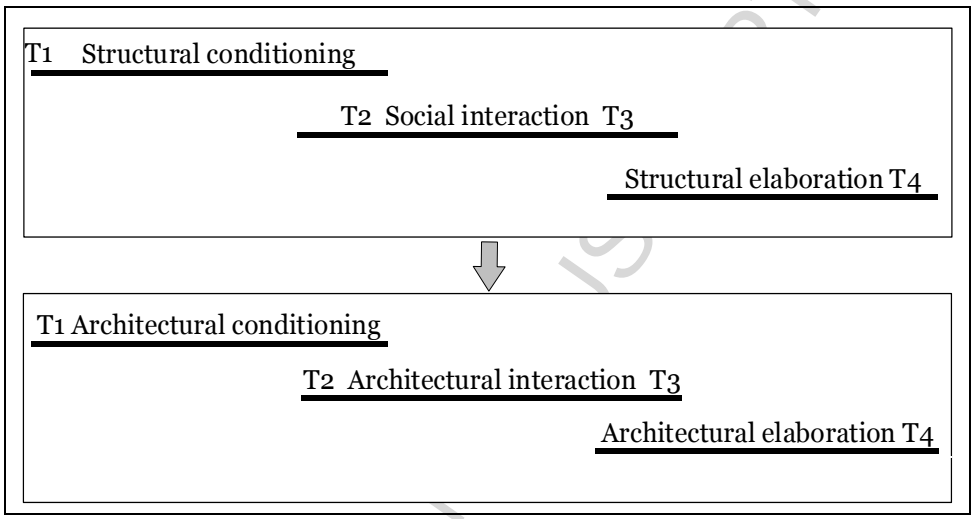


**Figure 1.** Mapping between morphogenetic theory and EA evolution

Of particular interest for this study are the generative mechanisms related to the architectural conditioning (T1) and architectural interaction (T2-T3) phases that can explain EA evolution outcomes. Generative mechanisms (causal powers) are one of the main components of critical realist studies. A central aspect of mechanisms in the critical realism tradition is that they present a source of explanatory power (Archer, 1995; Bhaskar, 1998). Archer (1995) states that structures have properties that enable them to influence the world around them (Archer, 1995; Cuellar, 2010). The architectural conditioning phase includes mechanisms that are situational (conditional) and the architectural interaction phase includes action-formation mechanisms (Volkoff & Strong, 2013). We identified three conditional generative mechanisms related to architectural conditioning (T1): EA framework, EA objectives and EA maturity, and six action-formation generative mechanisms related to architecture interaction (T2-T3): View of SOA, SOA perceived benefits, SOA scope, SOA governance, SOA design and Business-IT collaboration.

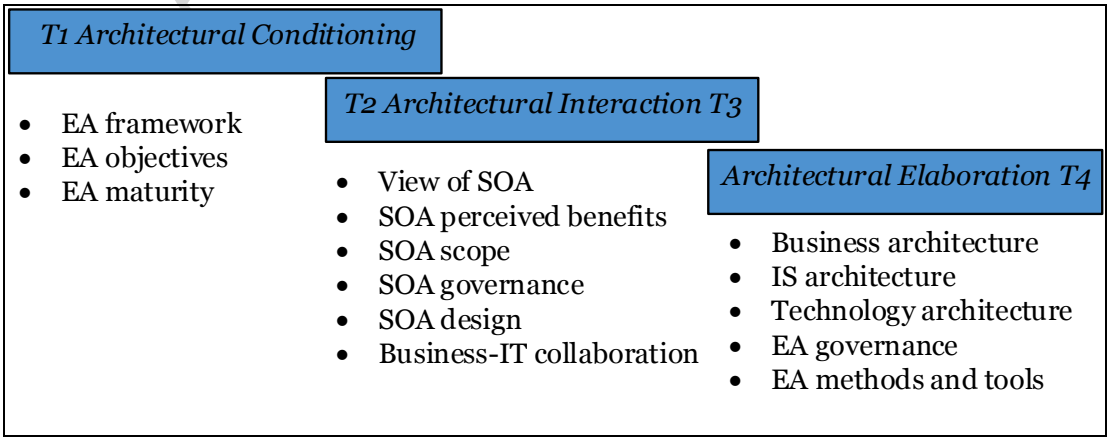


**Figure 2.** The study's theoretical model

In this study, the phases of the morphogenetic cycle of SOA's integration into EA were determined by using the stability-change-stability approach (Njihia, 2008; Trosper, 2005), which suggests that the researcher tentatively adopt a set of periods, distinguished by times of stability and times of change, to identify the analytical morphogenetic cycle boundaries (Njihia, 2008; Trosper, 2005), where each morphogenetic cycle signifies a substantial change in the structure (Njihia 2008). The scope of change under investigation here is limited to SOA introduction as a trigger of EA evolution. Any other aspects that potentially cause changes to EA (e.g, new corporate strategy, emerging technologies such as mobile or social) are outside the scope of this study.

# 3 Research Methodology

Given the complexity of EA evolution as a phenomenon to be investigated and the nature of the research, a qualitative approach involving explorative interviews, reported in Alwadain, et al. (2014), followed by a case study was undertaken to collect and analyse the empirical data. A qualitative approach is generally considered appropriate for conducting critical realism-based studies (Danermark, et al., 2002; Sayer, 1992). In this paper, we will present the findings of a case study conducted at a public sector agency in the United Arab Emirates. The case study method was chosen to contextualise the developed research model of EA evolution, reported in Alwadain, Fielt, Korthaus, and Rosemann (2013b) and Alwadain, et al. (2014), as suggested by (Danermark et al. 2002), and to further understand EA evolution in real world settings.

The case study method is one of the most extensively used qualitative research methods in information systems research (Benbasat, Goldstein, & Mead, 1987). Yin (2003, p. 13) defines the case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly defined". It is an appropriate method to investigate emerging phenomena about which few previous studies have been conducted. Indeed, Eisenhardt (1989) highlights that the case study method is "especially appropriate in new topic areas" or in areas in which few studies have been conducted (Benbasat et al., 1987). Furthermore, the case study method is well suited to conduct critical realist research when studying contemporary socio-technical phenomena (such as EA evolution) to uncover the causal mechanisms that generate evolution outcomes (Easton, 2010; Mingers, 2004; Wynn & Williams, 2012; Wynn Jr & Williams, 2008).

Another aspect related to the case study design is identifying the unit of analysis. The unit of analysis is a fundamental aspect in qualitative research studies: it defines what the case is (Yin, 2003). Easton (1998) proposes a form of embedded unit of analysis based on time; that is, the case must have a longitudinal component and should be seen as a series of cases (embedded) depending on the period of time being investigated and described. As such, in this thesis, the overall unit of analysis is EA evolution due to SOA's introduction, which includes embedded units of analysis. These embedded units of analysis are the investigation of EA prior to SOA's introduction, a detailed examination of SOA's introduction, and the outcomes of SOA's integration into EA. The aggregation of analyses of the sub-units composed the analysis of EA evolution (here: SOA's integration into EA).

## 3.1 Background of the case

The case study organisation being reported on in this paper is a government agency in the United Arab Emirates. It has approximately 3,000 employees. The agency is a leader in delivering innovative services supporting national objectives and improving customer experiences. According to an internal document of the agency ([D-11], see Table 2), contemporary systems, easy practices and cooperative and chivalrous service are and will be maintained as keystones of the agency practices. For a long time, the agency has contributed to the wide country development, creating a far-reaching sphere of operations, and facilitated the country's economical power.

The agency adopted an Enterprise Architecture program in 2006 to facilitate its strategy, business and technology alignment. Its EA program was part of a larger transformation initiative and EA was used to support fast decision-making and the dynamic business needs of the organisation. Moreover, the agency was one of the first leading public agencies in the United Arab Emirates to undergo an e-government transformation and to progress toward the broad electronic delivery of services. In particular, the agency introduced SOA in 2008 to support the delivery of services.

### 3.2 Data collection and analysis

During June 2012, eight interviews were conducted with eight senior executives at the agency premises. Table 1 presents the participants' information. Interviews were conducted following a case study protocol. Each interview lasted between 40 and 90 minutes and was recorded and transcribed.

**Table 1.**Participants' demographics

| Participant | Position | Years in org. | Years of experience | Background |
|---|---|---|---|---|
| P-1 | Head of IT planning and enterprise architecture | 5 | 7 | Business and management |
| P-2 | IT strategist | 6 | 15 | Strategy/planning |
| P-3 | IT strategist | 4 | 0 | IT/strategy |
| P-4 | Senior business architect | 6 | 20 | Business |
| P-5 | Senior business architect | 6 | 25 | Business |
| P-6 | Senior business architect | 5 | 5 | Business |
| P-7 | Senior tech architect | 5 | 10 | Technology |
| P-8 | Senior tech architect | 3 | 10 | Technology |

To achieve triangulation, besides the conducted interviews, sixteen documents, see Table 2, related to both EA and SOA were obtained from the department (internally) or online from the agency's website or other websites. These documents are cited as D-1, D-2, and so on throughout this paper. The transcribed interviews and the obtained documents were imported to NVivo 9 to prepare them for analysis. Analysis of the collected data was informed by a thematic analysis procedure and, more specifically, a deductive approach using the theoretical model, shown in Figure 2, as a lens (Fereday & Muir-Cochrane, 2006).

**Table 2.** Collected evidence (documents)

| ID | Source | Description |
|---|---|---|
| D-1 | Online | A presentation about the implementation of EA and its benefits (2007). |
| D-2 | Online | A presentation about the use of EA as a governance practice (2007). |
| D-3 | Internal | A suitability report represents the agency efforts and practices to achieve sustainability (2011). |
| D-4 | Online | Report of COBIT implementation: the government efforts to assess governance levels at different agencies. |
| D-5 | Online | A white paper from IBM about the benefits of using EA to align business and IT. The agency was presented as one of the examples that achieved benefits from its EA implementation. |
| D-6 | Internal | This document presents an e-services delivery excellence model for the electronic provision and improvement of government services. It outlines guiding principles for services enablement evaluation. |
| D-7 | Internal | A presentation on the use of EA for knowledge management and knowledge sharing tool. |
| D-8 | Internal | An internal document for services identification and classification. |
| D-9 | Internal | Classification of the agency's domains. |
| D-10 | Internal | The agency's EA meta-model. |
| D-11 | Internal | A document with information related to the agency's SOA program. |
| D-12 | Internal | A document with information related to the SOA program (guide of SOA program). |
| D-13 | Internal | A presentation about the agency's EA implementation and benefits. |
| D-14 | Internal | A report from IBM describing the implementation of EA in the agency. |
| D-15 | Online | A report about the launch of the agency's SOA-based electronic system. |
| D-16 | Internal | Information about some technical aspects of SOA implementation. |

### 3.3 Application of the theoretical framework

The agency's morphogenetic cycle comprising SOA integration into EA is shown in Figure 3. It was determined by using the stability-change-stability approach as discussed in section 2. EA was established in 2006 and was completed by the end of 2007. The period between the establishment of EA (end of 2007) until SOA introduction in

2008 is considered the architectural conditioning (T1) of the morphogenetic cycle (SOA integration into EA). The change period (architectural interaction) began when SOA was introduced in mid of 2008 and finished in 2010. This study was conducted two years later, in June 2012, after SOA introduction was complete.

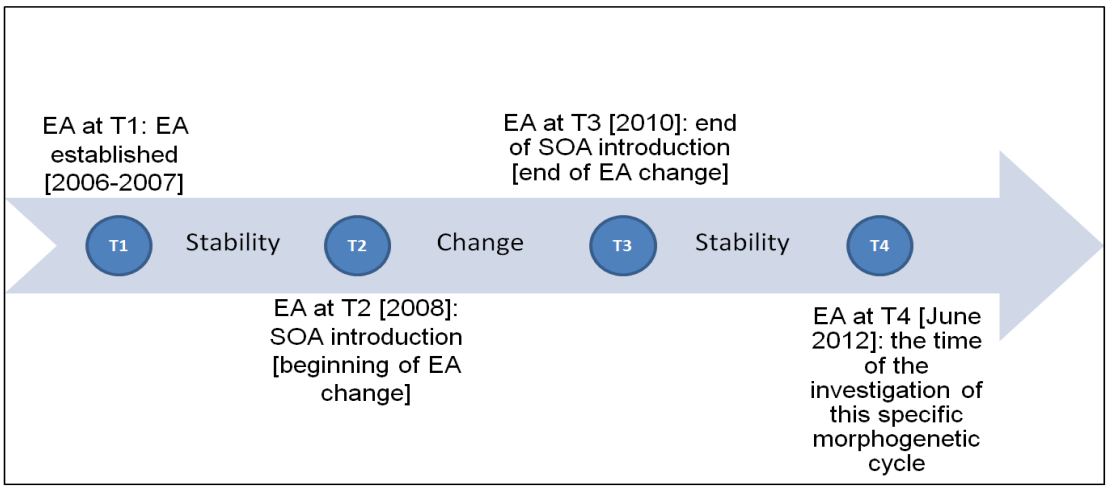


**Figure 3.** The morphogenetic cycle of SOA integration into EA

Thus, to understand the outcomes of the integration of SOA into EA, the event (SOA introduction) and the status of EA prior to the interaction were studied retrospectively (see Figure 4). The retrospective analysis was achieved through intensive interviews with executives involved in EA and SOA, and was supported by the analysis of obtained relevant documentations. In an effort to address the possible limitations of exploring a time-consuming phenomenon through retrospective interviews, multiple participants with different backgrounds and hierarchical levels were interviewed, and internal and online documents were examined to provide multiple triangularly perspectives as mentioned above in section 3.2.

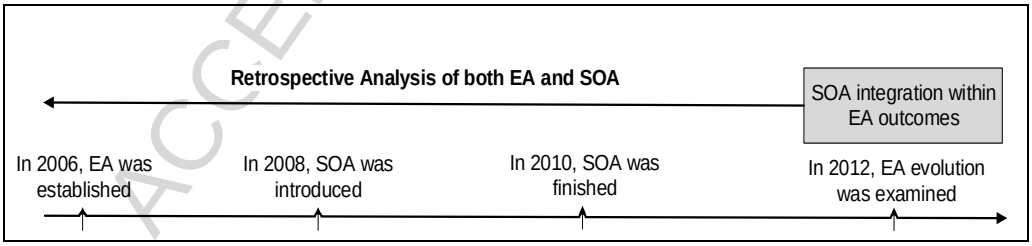


**Figure 4.** Retrospective analysis

## 4 Case Study Findings

This section presents the case study findings using the three analytical phases of the theoretical model of this study. The development division, which is one of five main divisions, is the custodian of the agency's enterprise architecture. The development division ensures constant modernisation and development of the agency's procedures, operations, projects, and services to keep pace with the most recent international practices and techniques. Participant [P-2] described the division's role as being in charge of the organisation's development and changes:

> *"Any changes, any development within the organisation is actually done within the [agency's] development division. So, we deal with people, processes, technology and information."*

The agency has a business and IT perspective of EA where EA encompasses both domains and provide the needed support for decision making and changing business needs. For example, as reported in [D-13] EA *"articulates and*

*connects organisational information to support fast decision making and to have a single point of truth containing information to support the dynamic business needs..... Enterprise architecture is the broker between Business and IT. It provides the benefit of knowing why we need to build, what to build, when to build it, and how to build it"* [D-13].

### 4.1 Architectural conditioning T1

This section addresses the EA-related conditions prior to the architectural interaction (SOA introduction). The basic argument for considering the architectural conditioning phase that precedes the action (here: SOA's introduction) is that EA evolution cannot be fully explained without reference to antecedent architectural conditioning (Archer, 1995). This section briefly presents an overview of the EA implementation and then organises the findings according to the following three conditional generative mechanisms: EA framework, EA objectives and EA maturity. These conditional generative mechanisms condition (enable or constrain) the subsequent architectural interaction phase, which leads to the architectural elaboration (Archer, 1995).

The agency has adopted EA to align its strategy, business and technology. A Senior Business Architect [P-4] reported that the EA program was part of a large transformation initiative. It was adopted to make sure that the transformation objectives were realised. He stated: *"When the transformation initiatives started… the organisation wanted a mature practice to be followed to ensure that the realisation of the objectives happens"*.

The program was implemented in three phases. The EA program was launched in late 2006 and the first two phases were completed by June 2007. By November 2007, most EA artefacts such as strategies, business processes, activities, technical artefacts and their relationships were documented and stored into IBM System Architect (a software tool) [D-1]. The EA program was successfully implemented across the organisation [D-1].

When the EA program started in 2006, efforts focused on the processes and technical levels of the organisation. The organisation identified the value chain, business groups, business processes and functions at the business level. Then, the business architecture was mapped to the technical architecture by identifying how business processes are realised at the technology level to answer questions such as what applications support what processes, and what applications run on what infrastructure [P-4 and P-5]. According to the participants' statements, the organisation's EA approach, which focused on business processes, was based on an internal perspective of the organisation itself. This approach was called "inside-out" by an IT strategist [P-2].

#### 4.1.1 EA Framework

The agency built their own customised EA framework following the principles of the Zachman (Sowa & Zachman, 1992) and TOGAF (The Open Group, 2009) frameworks. The organisation needed a way to help decision-makers make the right decisions by providing all the information needed about the organisation from different angles. The organisation divided EA into multiple layers: strategy, resources, process, information and technology. The first layer, strategy, encompasses the organisation's business vision, objectives, enablers and performance measures. This layer holds strategy-related elements such as directions, guidance, objectives, the means of delivering these objectives and performance KPIs [P-3]. The second layer, resources, holds elements such as people, assets, organisation and locations. The third layer, process, holds business processes, business process definitions and metrics. The information layer includes information models and information flow. The technology layer includes applications, data models, technical reference models, hardware and network.

According to a senior business architect [P-5], the whole organisation was decomposed to understand its current (as-is) state. It became a reference point for identifying the gaps and the changes that might be required to move to a future state. These as-is business architecture models were used to discuss project proposals and demands. EA documentation outcomes were stored in a repository using the IBM System Architect tool.

To improve access to the information stored in their IBM System Architect, the organisation internally developed the enterprise connected view (ECV), an interactive interface used for navigating and querying stored information. The executive director of the development division stated: "*we use System Architect as the basis for our enterprise*

*connected view (ECV), which enables us to manage enterprise information, run impact analysis, and make decisions more effectively"* [D-5].

**4.1.2 EA Objectives.**

Since the early adoption of EA at the agency, a strategic long-term vision was held. Reported EA objectives, in this case study, are classified into strategic, operational, IT and governance-oriented objectives (see Table 3) as suggested in EA literature and the previous explorative interview findings (Alwadain, Fielt, Korthaus, & Rosemann, 2013a).

EA holds organisational strategies for the corporation, departments and divisions. It holds business and technical information and stores them in one repository. The agency uses EA to align its strategy with that of the government. EA enables effective governance of both business and technical architecture and facilitates fast responses to changes in business and IT requirements [D-2]. According to the Head of IT planning and EA [P-1], EA focuses fundamentally on documenting all informational assets in the organisation to manage and govern the organisation on multiple levels: strategy, business, information, and technology. EA and ECV were introduced to generate blueprints of the organisation and to be the single source of official information. They were used for planning, governance, decision-making, and impact-analysis purposes.

Participant [P-4] commented on the reasons for establishing EA at the agency. He mentioned that EA was adopted to improve the decision-making process, prioritise work, develop new capabilities, improve technology implementation and guide the future of the organisation. The organisation has used EA to achieve benefits in areas such as business and IT alignment, impact analysis and strategic decision-making assistance [D-7].

**Table 3.** EA objectives at the agency

| EA objectives | |
|---|---|
| Strategic | Business and IT alignment, strategic decision-making assistance, change management, knowledge management and gaps identification |
| Governance | Holds strategies, holds business and technical requirements, and effective governance of both business and IT architectures |
| Operational | Documentation of all enterprise components, reuse of components, impact analysis, discovery of duplications and standardisation |
| IT | Provide solutions requirements, monitor their development, reduce IT duplications and manage IT complexity |

**4.1.3 EA Maturity**

As mentioned before, the agency adopted an organisation-wide EA program in late 2006. By the end of 2007, most of the architectural artefacts were captured and stored in the EA repository. The EA maturity assessment was based on: (1) the obtained documentations, which describe the early stages of EA prior to SOA introduction, (2) participants' responses and (3) an EA maturity assessment survey questionnaire based on the NASCIO maturity model (NASCIO, 2003), which was handed to the participants. Four completed forms were received.

**Table 4.** EA maturity dimensions of the agency

| EA maturity dimensions | Description of the agency's EA maturity level as reported |
|---|---|
| Documentation | • EA documentation was comprehensive<br>• Strategy, business, IS & infrastructure information were captured and stored in a repository<br>• An interface tool was built to browse, query and navigate the repository and its content by business and IT personnel |
| Planning | • EA program was well defined and had a structured framework and timeline for developing the EA<br>• EA planning was well integrated with major strategic initiatives to help the organisation to achieve these initiatives objectives |

| | |
|---|---|
| | • EA was involved in building roadmaps for organisational improvements<br>• EA enabled assessment of the current situation, identification of gaps and development of roadmaps and action plans |
| Governance | • EA governance standards, processes and procedures were established and employed. EA roles were defined and review committee was established. |
| Evaluation | • EA and its products were evaluated on two sides. First, EA methodology & meta-model were reviewed and assessed periodically every two years. Second, EA was reviewed and changed when needed (e.g., new trends or requirements) |
| Team and resources | • EA team was defined. Tools, frameworks and resources were available for EA team to support their activities |
| Business Support | • EA and its activities were supported by top management.<br>• EA was engaged with business and IT |

The documentation of the whole organisation was comprehensive and it was stored in the EA repository. EA had a well-defined methodology. EA governance practices were established and integrated with organisational governance. EA was involved in demand and project governance to ensure that projects were aligned with both strategy and architectural (business and IT) standards. EA's content and its meta-model were kept up-to date. EA had diverse and skilled team members. There were about twelve strategists, business architects and technology architects. EA was supported by top management.

Based on the findings of the interviews, the obtained documents and the answers to the accompanying survey regarding EA maturity (see Table 4), it is evident that the agency's EA practices were quite mature (between level 3: well-defined program and level 4: managed program out of 5) before SOA introduction when considering the fact that EA practices internationally are still emerging and in the early stages of maturity (Gartner, 2012b).
In summary, the findings of the architectural conditioning phase built the foundation of the analysis to understand how EA evolved due to SOA introduction. Following the architectural conditioning phase, the architectural interaction (SOA introduction) began in 2008 and lasted for two years. The findings of that phase are presented in the next section.

### 4.2 Architectural interaction T2-T3

This section presents the findings relevant to the second analytical dimension of the theoretical model. It first provides an overview of SOA introduction at the agency and then presents the six action-formation generative mechanisms of the research that influence SOA introduction.

While other potentially change-inducing activities may have been in process during the architectural interaction phase, the scope of our study covers only SOA-related activities and the outcomes of its integration into EA. However, participants did not mention another large-scale event other than SOA introduction that could have significantly affected the observed evolution outcomes, nor were any identified in the obtained documents.
The data showed that the agency took initiatives to improve its service delivery. In particular, a service-oriented initiative in 2008 to deliver eServices to citizens, called eServices Delivery Excellence Model [D-6], accompanied by internal thoughts to embrace what an IT strategist [P-2] called an "outside-in strategy", had led to changes in the organisation and its EA. The outside-in strategy takes an external view of an organisation (customers' needs) and targets its restructuring based on that view. For example, some participants described the move to service-orientation:

> *"But later we noticed, we were lacking in this area and the global trend is purely from service-orientation perspective." [P-4]*
>
> *"The challenge at the IT level implementation is until you define your services at the business level, customers' level, you can't do them right." [P-2]*

The service-oriented initiative started in 2008 and was officially completed in 2010. It was well-described in a report (Oracle., n.d.):

> *"[The agency] required a new operating model, based upon a service-oriented approach, to deliver the flexibility and scalability needed to accommodate existing and projected levels of trade. Additionally, to*

*increase efficiency and reduce unneeded use of internal resources, [the agency] aimed to implement a Web-based, self-service system for its customers."*

The SOA introduction (SOA implementation) initiative involved a web-based, scalable and feature-rich business-to-government suite for the agency's customers and partners. It has been large: a great deal of funds, effort and time has been put towards the success of its implementation [D-12]. At the beginning of the project, during the design phase, the agency contracted external vendors to plan and develop its requirements. It was developed by a competent internal work force with the help of external expertise when needed. In a nutshell, the SOA suite was developed using a combination of in-house development and products from vendors such as Oracle, IBM and Microsoft [D-12]. Further, to ensure successful SOA implementation, employees were trained, the organisational restructuring was completed and the assessment and training section was established. This initiative was managed and supervised by experts to facilitate the transition to the new system. A selection of clients representing all trade sectors were involved in development of the SOA, primarily in the design of the system. Multiple focus group meetings were held with clients to announce the new procedures. The project was successful and led to paperless operations, cost reductions and improved customer service.

The previous paragraphs have provided an overview of the agency's SOA introduction and the following paragraph examines SOA introduction-related action-formation generative mechanisms.

Based on the developed theoretical model (Figure 2), there are six action-formation generative mechanisms that influenced the introduction of SOA in this case study. First, SOA introduction was driven by both business and IT perspectives of SOA. It was undertaken to redesign business processes and improve services delivery. Second, SOA implementation was associated with perceived benefits at the strategy, process and IT levels, and most of these benefits were reported as achieved in the SOA implementation documentation and by some participants. Third, SOA introduction encompassed the whole organisation and lasted for two years. Fourth, SOA introduction was governed on multiple levels. It was governed by the eServices delivery excellence model and organisational wider governance practices (COBIT). Fifth, SOA was introduced based on a long-term roadmap that employed a defined SOA reference architecture. Services were identified using a top-down approach and were classified into business and technical services. Also, a service repository (IBM System Architect) was employed to track these services in relation to other architectural elements. Finally, SOA introduction was a large project that involved key business and IT stakeholders during design and implementation. It was supported and driven by the organisation's top management as part of a transformation initiative to improve services delivery. External and internal (business and IT) highly skilled team members were involved in SOA implementation. Table 5 summarises the SOA introduction-related generative mechanism in this case study.

**Table 5.** Summary of generative mechanisms relevant to SOA introduction

| Generative mechanisms | Description as reported in the case |
|---|---|
| View of SOA | • SOA introduction was driven on both business and IT levels<br>• It was undertaken to redesign business processes and improve services delivery. |
| SOA perceived benefits | • SOA implementation was associated with perceived benefits at the strategy, process and IT levels<br>• Most of these benefits were reported as achieved in SOA implementation documentation and by some participants |
| SOA scope | • SOA implementation was organisation-wide<br>• It lasted for two years |
| SOA governance | • SOA implementation was governed on multiple levels<br>• It was governed by the eServices delivery excellence model<br>• It was governed by the adopted IBM SOA reference architecture<br>• It was governed by internal governance practices (COBIT) and EA governance |
| SOA design | • SOA was implemented using a long term roadmap<br>• It employed a defined SOA reference architecture. Services were identified using a top-down approach |

| | |
|---|---|
| | • Services were classified into business and technical services<br>• A service repository (IBM System Architect) was adopted to track these services in relation to other architectural elements |
| Business and IT collaboration | • Business and IT stakeholders were involved during design and implementation<br>• It was supported and driven by the top management of the organisation as part of a transformation initiative to improve services delivery<br>• Diverse skilled teams were involved in SOA implementation<br>• External vendors and consultants were involved in SOA's implementation |

### 4.3 Architectural elaboration T4: reproduction or transformation

Using the last phase of the theoretical model, this section discusses architectural elaboration (EA evolution outcomes). Possible outcomes are that the pre-existing architectural settings are either reproduced or transformed on five levels: business architecture, Information Systems architecture, technology architecture, EA governance and EA methods and tools. In this case study, the five levels were transformed as EA evolved to accommodate SOA on all the five levels. Following the data analysis, the observed architectural elaboration (evolution outcomes) are summarised in Table 6.

**Table 6.** The observed architectural evolution

| Architectural transformation level | Description |
|---|---|
| Business architecture (*transformed*) | • Process layer became "business layer" to incorporate business services besides the other elements of the business architecture<br>• Re-design of the organisation in terms of domains, and each domain has its provided services<br>• Design of business architecture in terms of services<br>• New SOA-related elements were added to business architecture, such as business services, their descriptions, supported channels, client groups, service scenarios and owners<br>• Business services were mapped to other business architecture elements<br>• Business services viewpoints were added |
| IS architecture (*transformed*) | • Applications were designed and documented in terms of technical services that support business processes and services<br>• A technical service was represented, which had a schema, used a service operation, and had a service realisation diagram<br>• Technical services were aligned and used by business processes and services on the business architecture<br>• Granularity of technical services was considered at the design level to ensure proper reuse<br>• Services were used to integrate internal systems and external systems such as external payment services<br>• Use of SOAP protocols, WSDL for services description and XSD for services schema definitions<br>• Technical services were mapped to business processes and supporting infrastructure |
| Technology architecture (*transformed*) | • SOA infrastructure such as BPEL engine, web services manager and ESB documented using technology environment, instance, interface, interface messaging and message structure<br>• Use of services-related communication protocols such as SOAP and services security protocols such as WS-security to document used SOA protocols<br>• Service repository (integrated into IBM System Architect) that hosts the meta-data of services and related information<br>• Services/infrastructure mapping to show the infrastructure that supports |

| | |
|---|---|
| | services<br>• Services SLAs were configured and monitored at the application and the infrastructure layer to make sure that the SLAs were met |
| EA governance (*transformed*) | • EA covered governance aspects regarding demands management and alignment with strategy and architectural standards<br>• SOA (and its projects) had its own governance frameworks that were aligned with the overarching EA governance<br>• EA governed service documentation, service identification and service delivery<br>• Services were monitored using the orchestration engine<br>• SOA demands were also governed by EA, similar to any other demands, against the architectural standards and strategy<br>• Every service was governed by technical and business SLAs<br>• Every business service had an owner |
| EA methods and tools (*transformed*) | • EA was integrated with demands/projects, which include SOA projects New SOA-related elements and new relationships were created in the used EA tools.<br>• New views were created in used EA tools to support services and associated elements<br>• Service identification methods and services were identified using EA products (repository) |

## 5 Discussion

Using Archer's (1995) morphogenetic theory as a lens, the architectural elaboration (the evolution outcomes in terms of integrating SOA into EA) can be explained by looking retrospectively at both the architectural interaction (SOA's introduction) and the conditioning (pre-existing EA) phases. The architectural conditioning phase shapes the architectural interaction (T2-T3) that generates the evolution outcomes. Figure 5 presents a high-level overview of the case study findings using the theoretical model of this study. Next we will discuss the most important findings (propositions) from the case study related to EA settings and its conditioning role, the intervention (here: the implemented SOA and its characteristics), and the resulted EA evolution outcomes.

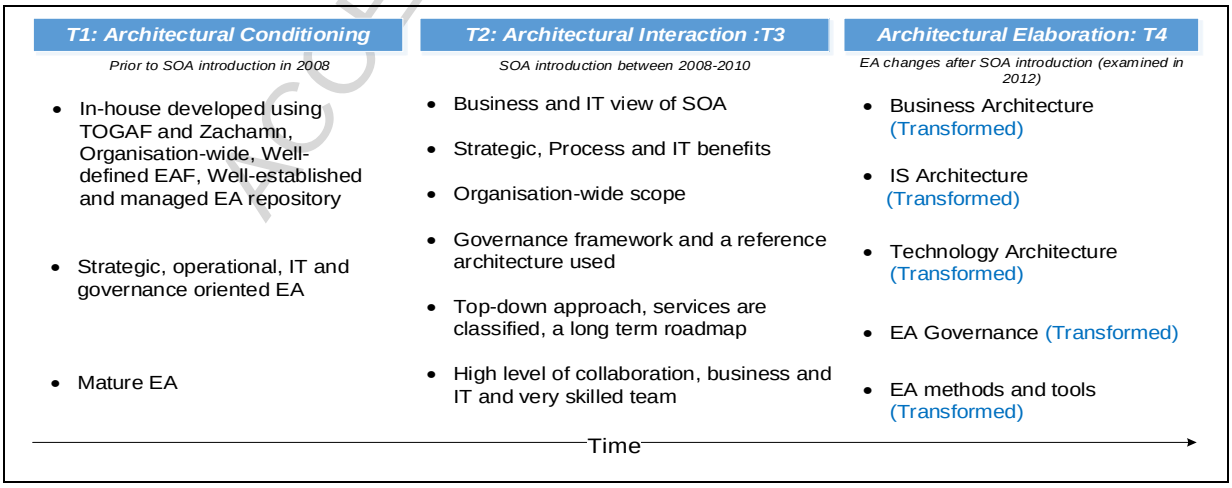


**Figure 5.** The case study's morphogenetic cycle of SOA's integration into EA

*Proposition 1: Extensive SOA integration into EA can benefit from pre-existing EA as enabling context when the EA framework is advanced, EA objectives are comprehensive and EA practices are mature.*

The context is described in terms of three conditional generative mechanisms that conditionally influence EA evolution. In our case study, the three conditional mechanisms created an *enabling* context for EA evolution and the

outcome was a *transformation* of the EA due to the introduction of SOA. The first conditional generative mechanism is *EA framework*. In this case, EA framework had an organisation-wide scope, a well-defined meta-model, a well-defined methodology and well-maintained deliverables. Such practices create an enabling context for EA related activities in general (Bui, 2012) and EA evolution specifically. The second generative mechanism is *EA objectives*. In this case, EA objectives were strategic, business and IT oriented. The agency realised EA benefits and appreciated them. Thus, it seems that the realisation and maintenance of comprehensive objectives of EA improves the likelihood of EA engagement with organisational activities that may require EA's evolution. This finding is supported by another argument by Haki, Legner, and Ahlemann (2012) who state that organisations follow different EA development approaches based on the architecture objectives, which, in turn, may affect EA activities in later stages. The third conditional generative mechanism is the *EA maturity*. In this case, the agency's EA practices were mature on several dimensions. For example, well-established architectural governance facilitated the EA team's engagement with the SOA introduction and, thus, SOA introduction's compliance with EA. The well-established and populated EA repository contributed to the SOA introduction process through the use of existing EA models and information to design and implement SOA. The three conditional mechanisms collectively facilitated SOA integration into EA.

Archer (1995) calls this type of context, marked by the three EA-related conditional mechanisms in this study, an "enabling context" whereas it could be a "constraining" one in other cases when opposite conditions are present. In other words, it is expected that EA evolution might be impeded when EA framework is not well-developed, EA objectives are not clearly defined and when EA is not mature enough. While not explicitly studied in terms of architectural elaboration, this is aligned with related insights as discussed below.

Enterprise architecture needs to be mature in order to have an impact on the enterprise (Lagerstrom, Sommestad, Buschle, & Ekstedt, 2011). Kotusev, Singh, and Storey (2015) reported that ambiguous EA vocabulary, unclear objectives of EA, and incompetence to promote EA practices are key factors of a poor adoption of EA and isolation of EA practices. Deficient governance practices, inadequate support for the EA development from key stakeholders, as well as insufficient resources and skills hinder the realization of the strategic alignment potential of EA (Löhe & Legner, 2014). Companies that did not consider mechanisms to update their EA artifacts, such as through after-project changes, end up with outdated and low quality EA repositories leading to a low utilization of EA artifacts (Löhe & Legner, 2014).

Further, an example that echoes Archer's (1995) argument of the constraining impact of the architectural conditioning phase is provided by Carvalho and Sousa (2014). They address how incomplete and immature EA (architectural conditioning as reported in this study) influences new IS implementation. They found that three domains of EA: data, application, and technology architectures were poorly documented resulting in EA's lack of support for the new IS implementation. The efforts needed to implement the new tool were increased to improve and generate EA artefacts in order to compensate for the immature state of EA prior to the new IS implementation. The EA in this case was needed to achieve organizational agility through the implementation of the new IS tool, but due to the EA's immature state, EA needed to be re-developed and improved during the change situation (Carvalho & Sousa, 2014).

Nevertheless, treating these conditional generative mechanisms as the primary factors in the EA evolution process is not suitable according to the findings and Archer's (1995) argument that states neither the structure (EA) nor the action (SOA introduction) alone determines the outcomes. Thus, the next paragraph discusses the SOA introduction phase and its impact on SOA integration into EA.

*Proposition 2: The extent of SOA integration into EA results from the actions related to the introduction of SOA that are influenced by the agents' view of SOA, perceived SOA benefits, SOA scope, SOA design, governance and business/IT collaboration.*

Archer (1995) recognises the influence the agent's orientation, interests and resources can have on the action (T2-T3). In this study, SOA introduction is influenced by the six identified action-formation generative mechanisms (view of SOA, perceived SOA benefits, SOA scope, SOA design, governance and business/IT collaboration) summarised in Figure 5. The findings support the theoretical arguments of Archer (1995), Hedström and Ylikoski

(2010) and Cuellar (2010) about the influence that a combination of interests, orientations and resources can have on the action (SOA introduction). The action-formation generative mechanisms collectively (acknowledging that one generative mechanism may counterbalance others) shape the way SOA is introduced. This conclusion is supported by Mutch's (2010) argument that IS implementations could be configured in different ways based on different factors to produce very different outcomes for organisational arrangements. Thus, when introducing SOA, organisations need to consider the implications of the combination of these generative mechanisms on (1) SOA implementation and (2) the organisation and its enterprise architecture in general.

*Proposition 3: Extensive SOA integration into EA involves transformation at all five possible levels of EA evolution outcomes.*

The evolution outcomes (architectural elaboration) are classified into five levels. In other words, EA could be transformed (integrated with SOA) or not (reproduced) on one or more of these levels. In this case study, EA was transformed on all five architectural levels due to the introduction of SOA (in the form described above) in an enabling context (architectural conditioning phase). In other words, both the enabling context and the introduction of SOA in the way described above (the actualisation of the generative mechanisms as shown in Figure 5) resulted in SOA's integration into EA on all the identified five architectural levels. Such separation of the five levels facilitates the examination of whether an emerging capability requires EA evolution and, if so, what levels of EA need to be evolved.

*Proposition 4: EA evolution in organisations can be described and explained by three analytical phases: architectural conditioning, architectural interaction and architectural elaboration as part of a morphogenetic cycle.*

Building on the morphogenetic theory (Archer 1995), the introduction of SOA (T2-T3) in a given architectural conditioning (T1) results in an architectural elaboration (evolution outcomes) (T4) based on the interplay between the action-formation generative mechanisms and the conditional ones. In this case, looking at one EA alone or SOA introduction in isolation of pre-existing EA would not provide a comprehensive picture of EA evolution process and outcomes. While a pre-existing EA can be an enabling context if EA framework is advanced, EA objectives are comprehensive and EA practices are mature, this will not guarantee SOA integration in EA. Specific attention to SOA introduction is required. On the other side, while specific attention to SOA introduction is important, it may be difficult to achieve SOA integration in EA when the pre-existing EA does not provide an enabling context.

## 6 Conclusion

Due to the dynamic nature of environmental and internal factors, EA development in an organisation is not a one-off activity that leads to static descriptions of the business and IT artefacts of that organisation. Rather, it is a process that parallels the evolution of the organisation and its strategy (Shah & Golder, 2011). EA needs to change over time to provide value for its stakeholders. However, the phenomenon of EA evolution is still poorly understood, in particular at the level of architectural descriptions. Using Archer's morphogenetic theory as a foundation, this paper conceptualises three analytical phases of EA evolution in organisations, namely architectural conditioning, architectural interaction and architectural elaboration. Moreover, motivated by the lack of empirical studies that investigate EA evolution, a case study was conducted with a government agency to contextualise the developed theoretical model and to enrich the understanding of how an organisation evolves its EA.

The case study findings provide first theoretically and empirically grounded insights into EA evolution, in particular in relation to SOA. The potential changes in EA are the outcomes of a process that is conditioned by the pre-existing EA, and influenced by the way in which SOA is introduced. The findings provided deeper insights into how the three identified conditional mechanisms related to the pre-existing EA: EA framework, EA objectives, and EA maturity, which enable or constrain EA evolution based on their actualisations in a given context. The study also showed that the six identified action-formation mechanisms related to the SOA introduction: view of SOA, perceived SOA benefits, SOA scope, SOA governance, SOA design and business and IT collaboration, influence SOA introduction. These mechanisms reflect the actors' orientations, beliefs, interests and resources (Archer, 1995;

Hedström & Ylikoski, 2010),. Thus, it is crucial to explicitly pinpoint these mechanisms prior to introducing SOA not only to ensure successful SOA implementation but also to understand their influence on SOA's integration into EA. The process eventually results in an architectural elaboration (evolution outcomes) based on the interplay between the described conditional generative mechanisms and the action-formation generative mechanisms. The interplay and the actualisations of these generative mechanisms are expected to be dissimilar in different contexts, which plausibly explain varied EA evolution outcomes. That is, EA is evolved (transformed) or reproduced on one or many of the five identified levels (business architecture, IS architecture, technology architecture, EA governance and EA methods and tools). More generally, the findings show the significance of the impact of the new emerging business and IT trends on EA frameworks, methodologies, governance and tools. Thus, it is essential for organisations to explicitly examine whether these emerging trends require EA evolution and, if so, what levels of EA need to be evolved.

The paper derives its significance and relevance from interrelating important contemporary phenomena based on a sound theoretical foundation. By providing new empirical and theoretical insights into EA evolution describing relevant generative mechanisms affecting EA evolution and outcomes in light of SOA, it builds a foundation to further examine the impact of other IT trends such as mobile or cloud-based solutions on EA evolution. At a practical level, the paper delivers a model that can be used to guide professionals to manage EA and continually evolve it in response to emerging business and IT capabilities.

There are a number of limitations in this study. First, the paper only reports on the findings of a single case study where more cases could provide more insights. Yet, Sayer (2000) argues that one or two cases is enough when using intensive (qualitative) research methods. This paper intensively examined EA evolution using a case study method (involved many interviews, several documents, and online materials). The case study was enlightened by preceding explorative interviews and a comprehensive literature review.

The other limitation is the need for longitudinal data to examine EA evolution prior to the intervention, during the intervention and post the intervention. In this case, we tried to collect as much data as possible to cover the three phases but a longitudinal case study is an option for future research.

The results of this study open opportunities for further research in the field of EA evolution. For example, to further address the impact of poor initial conditions, e.g. incomplete EA framework, fuzzy EA objectives, and low EA maturity level, on EA evolution, future work is needed to comprehensively understand the influence of these initial conditions as well as how to overcome them. In addition, further efforts are required to examine EA evolution in response to other IS interventions such as cloud computing or mobility.

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