JYU DISSERTATIONS 350

Jarkko Nurmi

Enterprise Architecture in Public Sector Ecosystems

A Systems Perspective

UNIVERSITY OF JYVÄSKYLÄ
FACULTY OF INFORMATION TECHNOLOGY

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ABSTRACT

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This thesis discusses enterprise architecture (EA) from a systemic perspective in the context of Finnish public sector ecosystems. EA concerns the elements and relationships that exist within a sociotechnical organization, describing and designing coherent wholes. Recently, there has been increased interest in studying the relationship between EA and systems approaches and developing EA to respond to the challenges related to the interconnectedness of organizations. Although EA and systems approaches inherently share common traits, prior research on the theoretical support of systems approaches in the field of EA is scarce. Further, the practical application of EA in ecosystemic environments is an emerging yet little researched topic. The research question of this thesis—How should EA be advanced to be better used in public ecosystems?—is answered by clarifying the concepts and the relationship between concepts involved in the problem and determining the role of various theoretical, conceptual, and empirical conflicts in the problem domain. The practical application of EA in ecosystems is addressed by creating design science artifacts—namely, a management model and principles for the government ecosystem architecture target state design. This thesis contributes to both theoretical and practical discussions. First, a comprehensive and overarching view of the current state of EA is offered, noting that the scope and purpose of EA seem to be shifting to include a new role in the holistic design and development of organizations in systemic environments. Second, systems approaches are explored as providing possible theoretical foundations for EA to design, model, and manage sociotechnical systems. Third, the created design science artifacts contribute to the practical application of EA in ecosystems. Contradicting the traditional view of EA as a structure of one organization, this thesis proposes EA as a concept for the organizational design of a public sector ecosystem.

Keywords: enterprise architecture, ecosystem, systems approach, public sector

TIIVISTELMÄ (ABSTRACT IN FINNISH)

Nurmi, Jarkko
Kokonaisarkkitehtuuri julkisen sektorin ekosysteemeissä: systeeminen näkökulma
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Tämä väitöskirja käsittelee kokonaisarkkitehtuuria Suomen julkisella sektorilla systeemisestä näkökulmasta. Kokonaisarkkitehtuurilla voidaan kuvata ja suunnitella sosioteknisten organisaatioiden elementtejä ja niiden välisiä suhteita. Hiljattain kiinnostus kokonaisarkkitehtuurin ja systeemisten ajatusmallien yhteyden tutkimiseen, ja pyrkimys eri organisaatioiden yhteisten arkkitehtuurien ymmärtämiseen on lisääntynyt. Vaikka kokonaisarkkitehtuuri ja systeemiset ajatusmallit perustuvat samanlaisiin näkökulmiin, aiempi tutkimus systeemisten ajatusmallien tuomasta teoreettisesta tuesta kokonaisarkkitehtuurille on vähäistä. Kokonaisarkkitehtuurin käytännön soveltaminen systeemisissä ympäristöissä, kuten ekosysteemeissä, on kasvava tutkimuskohde. Tämän väitöskirjan tutkimuskysymys on: Kuinka kokonaisarkkitehtuuria pitäisi kehittää, jotta sitä voitaisiin hyödyntää paremmin julkisissa ekosysteemeissä? Tutkimuskysymykseen vastataan tarkastelemalla siihen liittyviä käsitteitä sekä niiden välisiä yhteyksiä, ja analysoimalla tutkimuskysymyksen muodostamaa teoreettista käsitteellistä ja empiiristä ongelmaa. Kokonaisarkkitehtuurin käytännön soveltamista ekosysteemeissä tarkastellaan luomalla malli ja periaatteita julkisen sektorin ekosysteemiarkkitehtuurille. Väitöskirjan tuotoksilla on sekä käytännöllistä että teoreettista kontribuutiota. Kattavan kirjallisuuskatsauksen ja laajojen haastattelujen perusteella todetaan, että kokonaisarkkitehtuurin merkitys on laajentumassa systeemisissä ympäristöissä toimivien organisaatioiden holistiseen suunnitteluun ja kehitykseen. Systeemisiä ajatusmalleja tarkastellaan kokonaisarkkitehtuurin teoreettisina lähtökohtina. Väitöskirjassa kehitetyt suunnittelutieteelliset mallit ja periaatteet edistävät kokonaisarkkitehtuurin käytännön soveltamista ekosysteemeissä. Poiketen aiemman tutkimuksen esittämästä näkökulmasta, jossa kokonaisarkkitehtuuri käsitetään yhden organisaation rakennetta kuvaavaksi, tämä väitöskirja esittää kokonaisarkkitehtuurin julkisten sektorien ekosysteemien kehittämisvälineenä.

Asiasanat: kokonaisarkkitehtuuri, ekosysteemi, systeeminen ajatusmalli, julkinen sektori

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Turku 25.12.2020
Jarkko Nurmi

FIGURES

TABLES

INCLUDED ARTICLES

I Nurmi, J., Penttinen, K., & Seppänen, V. (2019). Examining enterprise architecture definitions: Implications from theory and practice. In *IRIS 41: Papers of the 41st Information Systems Research Seminar in Scandinavia* (pp. 1-12). Association for Information Systems.

II Nurmi, J., Pulkkinen, M., Seppänen, V., & Penttinen, K. (2019). Systems approaches in the enterprise architecture field of research: A systematic literature review. In *EEWC 2018: Proceedings of the 8th Enterprise Engineering Working Conference* (pp. 18-38). Lecture Notes in Business Information Processing, vol. 334. Springer, Cham.

III Nurmi, J., Penttinen, K., & Seppänen, V. (2019). Towards ecosystemic stance in Finnish public sector enterprise architecture. In *Perspectives in Business Informatics Research: 18th International Conference, BIR 2019, Proceedings* (pp. 89-103). Lecture Notes in Business Information Processing, vol. 365. Springer, Cham.

IV Valtonen, K., Nurmi, J., & Seppänen, V. (2018). Envisioning information systems support for business ecosystem architecture management in public sector. In *BIR-WS 2018: Joint Proceedings of the BIR 2018 Short Papers, Workshops and Doctoral Consortium co-located with 17th International Conference Perspectives in Business Informatics Research (BIR 2018)* (pp. 150-159). RWTH Aachen University.

V Nurmi, J., Seppänen, V., & Valtonen, M. K. (2019). Ecosystem architecture management in the public sector: From problems to solutions. *Complex Systems Informatics and Modeling Quarterly*, 19, 1–18.

I, Jarkko Nurmi, am the first author of Articles I, II, III, and V. In Article I, I was responsible for the design, conducting, and analysis of the literature review and did most of the writing, while the second and third authors were responsible for the design of the interviews and the collection of data. The first two authors did analysis of the interview data. Article II was a joint effort by all the authors, and all authors did the conception and design of the research. I was responsible for the literature review and contributed especially to the analysis of the research material and writing the article. In Article III, the second and third authors were responsible for collecting the interview data; all authors contributed to the writing of the article. Article IV was a joint effort by all the authors. In Article V, I was responsible for designing, conducting, and analyzing the interviews as well as writing most of the article.

CONTENTS

1 INTRODUCTION

This section offers an introduction, arguing that both practical and theoretical motives support the study of enterprise architecture (EA) in public sector ecosystems. The scope of this thesis is defined, and the research question is derived. Finally, the contributions and the structure of this thesis are outlined.

1.1 Motivation

Organizations in the public and private sectors alike face the need to manage themselves in an ever more interconnected and fast-paced world. A paradigmatic change from a mechanistic toward a systemic worldview is ongoing, emphasizing the interconnectedness of participating organizations (Guggenberger et al., 2020). In particular, the public sector is being challenged with forming a holistic yet detailed view of society, which is necessary to fulfill its objectives. It has been argued that society can be defined as “a complex set of relationships based on the continuous sharing of resources and on the combination of several expectations culminating in the building of new value,” making society an area that “cannot be analyzed in the light of a mechanistic approach; it requires the adoption of a holistic perspective” (Caputo et al., 2019, p. 110). The concept of an ecosystem has been explained as “the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize” (Adner, 2017, p. 40). This forms new models of public service delivery, suggesting that ecosystem-enabled co-creation is a key innovation (Beirão et al., 2017) that creates new opportunities for business, research, and societal growth. Beirão et al. (2017) note that while new technologies act as enablers for new prospects, the integration of people, processes, technology, and information must be achieved due to increasing complexity.

EA has long been one of the most prominent ways to manage and design the elements of an organization and their relationships to one another. In practice, EA regularly consists of different domains, principles, and a descriptive framework or method (Gong & Janssen, 2019). EA is considered a tool for alignment between business and information technology (IT) (Alaeddini et al., 2017; Ross et al., 2006), an issue repeatedly cited as a top management concern (e.g., Kappelman et al., 2019).

The systemic stance on government and the conceptualization of the public sector as an ecosystem have recently sparked a movement to further develop EA. A need to study the challenges of the interconnectedness of organizations (Drews & Schirmer, 2014) and the relationship between EA and systems approaches (e.g., Bernus et al., 2016; Gong & Janssen, 2019; Korhonen et al., 2016; Lapalme et al., 2016) has been expressed. It has been argued that the scope and purpose of EA have shifted from IT-business alignment to the holistic design of enterprises in a systemic environment (e.g., Korhonen et al., 2016). According to Kappelman and Zachman (2013, p. 93), "the EA trend of applying holistic systems thinking, shared language, and engineering concepts, albeit in the early stages of their application, is here to stay." Furthermore, Rahimi et al. (2017, p. 138) note the "importance of systems thinking and, especially, of adopting the open systems principle, for managing EA design and evolution." Gerber et al. (2020, p. 390) note that "systems theory and systems thinking [i.e., systems approaches] underpin much of the theoretical base of EA." Finally, according to Bernus et al. (2016, p. 96), "EA must encompass both soft [e.g. related to organizational or social phenomena] and hard systems [e.g. engineering problems], model complex systems behavior through self-design, and add the human interpretive behavior and cognition to organizations as living systems."

1.2 Scope of the research

This thesis explores the usage of EA in the specific context of Finnish public sector ecosystems. Prior studies have called for further research into EA in the public sector (e.g., Dang & Pekkola, 2017b; Rouhani et al., 2015; Scholl et al., 2011; Simon et al., 2013), as the problems regarding public sector EA differ from those in the private sector. For example, in the private sector, EA generally applies to individual organizations, while in the public sector, the scope of EA may include many organizations. Finland is a suitable area to study EA in the public sector due to its mature stage of public sector EA. Government EA has been harnessed in Finland since 2006, and the use of EA has been mandated for public sector organizations since 2011. In practice, the implementation has been challenging (see Seppänen et al., 2009; Seppänen et al., 2018; Penttinen, 2018).

The Ministry of Finance, a governing actor in public EA work in Finland, released the first version of the ecosystems EA model for public administration in 2017, which aimed to replace the earlier domain-based model. The former model was criticized as rigid, siloed, and hierarchical, hindering its ability to enable cross-domain co-creation (Ministry of Finance, 2017). Further, the former domain-based model was said to "not represent the reality, as actors form ecosystems instead of hierarchies" (Ministry of Finance, 2017, p. 6). Notwithstanding the merits of the ecosystems model (Ministry of Finance, 2017), detailed insights it provided into how EA should be conducted in public sector ecosystems and which qualities are important for it to be successful were modest. In this regard, this thesis might offer significant contributions.

Additionally, changes in Finnish legislation introduced in early 2020 have changed the way EA is conducted in the public sector. In practice, public sector organizations are expected to specify their architectures by the end of 2020, according to the Act on Information Management in Public Administration (906/2019). It is expected that the modeled architectures, along with information management models and information management maps specified by law, will be maintained in the future.

1.3 Research question

This thesis discusses the essence of EA as a phenomenon, covering the scope and purpose, theoretical aspects, and practical application of EA in systemic environments (i.e., ecosystems). Although systems approaches and ecosystems have been widely discussed in recent research on EA, the specificities of applying EA in public sector ecosystems have not been studied sufficiently. Recently, it has been argued that traditional EA methodologies and frameworks cannot be used in systemic environments (e.g., Anwar & Gill, 2019; Wieringa et al., 2019) and are not appropriate for designing ecosystems (e.g., Aldea et al., 2018; Pittl & Bork, 2017). To contribute to this ongoing discussion, this thesis addresses the following research question: How should EA be advanced to be better used in public ecosystems?

1.4 Contributions

This thesis addresses the research question by clarifying the concepts and the relationship between concepts involved in the problem and determining the role of various conceptual and empirical conflicts in the problem domain. First, the scope and purpose of EA (Article I) and the relationship between EA and systems approaches (Article II) are discussed. The results of this thesis indicate that while both scholars and practitioners have presented several definitions of EA, the scope and purpose of EA seem to be broadening to include the holistic design and development of organizations in systemic areas. Also, the high occurrence of systems approaches may indicate that academic research on EA retains some common system-related notions. Thus, a systems paradigm adapted for EA could enhance the architecture work in public sector ecosystems.

Second, the practical application—how the practitioners would like to see EA utilized in a systems-in-environment setting (Article III) and how EA should be applied in ecosystems in practice (Articles IV and V)—is addressed through practitioner interviews and the creation of design science artifacts. Created artifacts include principles and a management model for a government ecosystem architecture target state design (the latter is introduced in Section 4). The principles (Article V) include dual nature, nestedness, openness, flexibility, evolvability, needs-based utilization, modularity, cooperability, BOLDness, interoperability, holism, and circular causality. Further, according to the results of this thesis (Article III), public sector ecosystems architecture should be developed as follows: (1) EA work utilizes the capabilities of organizations participating in the ecosystem, (2) development work is done in co-creation mode, (3) partners of the ecosystem form a holistic view, and (4) EA modeling is utilized based on need.

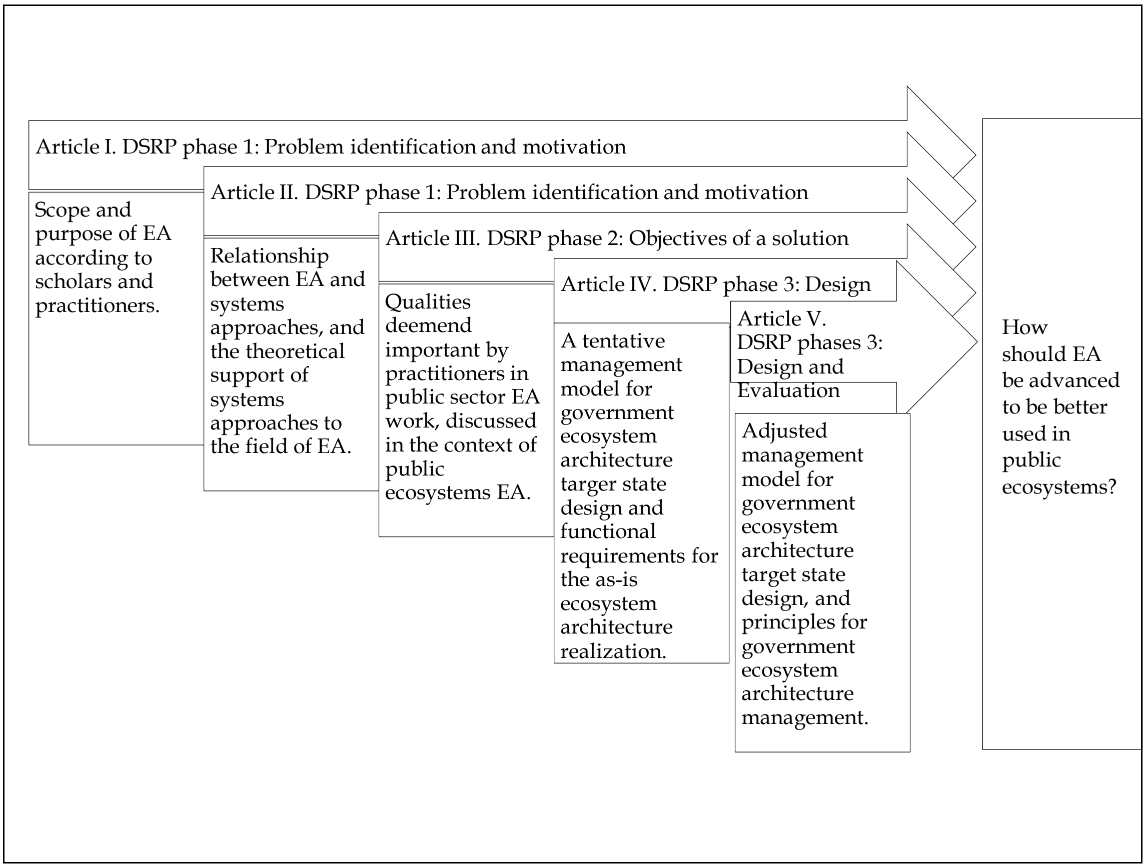
Finally, Article IV outlines the functional requirements for the as-is ecosystem architecture realization. These include (1) basic modeling and metamodeling functionalities that are readily available in many modeling tools; (2) agile analysis and comparison tools that necessitate interdependent, commonly agreed ontologies for business catalogs and organigrams, for example; (3) situational EA frameworks based on the as-is description that can be pulled out of the system according to given parameters.

This thesis contributes to both theoretical and practical discussions on EA. First, a comprehensive and overarching view of the current state of systems approaches and systemic stance in EA research is presented, covering both the scope and purpose as well as the theoretical notions of designing, modeling, and managing sociotechnical systems. Second, this thesis offers practical contributions to public administration EA work by offering principles and a model to design and manage EA in public ecosystems. Contradicting the orthodox understanding of EA as a structure of an organization, this thesis proposes EA as a concept for the organizational design of public ecosystems.

1.5 Structure of the thesis

The overall research process of this thesis is presented in Figure 1, constituting a design science research process (DSRP) (Peffers et al., 2007). Articles I and II constitute the first phase of the DSRP: Problem identification and motivation. Article III corresponds to the second phase of the DSRP: Objectives of a solution. Articles IV and V discuss phases three and five of the DSRP: Design and development and Evaluation. All articles consider the last phase of the DSRP: Communication. As a limitation, this thesis does not offer a real-life demonstration of the created design artifacts, which is the fourth phase of the DSRP. The five articles form a continuum in which Article I addresses definitions of EA from a systemic perspective, Article II focuses on the relevancy of a systems view of EA, Article III discusses the important qualities of EA in public ecosystems, and Articles IV and V finally offer a management model and principles for government ecosystem architecture management. Thus, all five articles jointly address the question of how EA should be advanced for better use in public ecosystems.

The remainder of this thesis is structured as follows: Section 2 provides the theoretical foundations and introduces the main concepts of the thesis: EA, systems approaches, and ecosystems. The research methodology—philosophical positioning, research design, and data collection and analysis methods—is discussed in Section 3. An overview of the included articles, including the results of each included article and their connection to the objectives of this thesis, is presented in Section 4. Finally, in Section 5, a discussion of the results and concluding remarks are given, along with suggestions for future research.



Note. EA = enterprise architecture; DSRP = design science research process.

Figure 1 Overview of the research process.

2 BACKGROUND

This section introduces the main concepts of the thesis: EA, systems approaches (covering systems-related lines of research: "theory" and "thinking"), and ecosystems. As many scholars have noted (e.g., Shipilow & Gawer, 2020), creative insights arise at the intersection of two or more areas of knowledge. This thesis aims to generate new insights into public sector EA work by applying a systemic lens to develop a theory-based and practically oriented understanding of EA in public ecosystems. While the full integration of these distinct yet related research streams (EA, systems approaches, ecosystems) might not be possible, this thesis argues that even partial integration could be beneficial, bringing sound theoretical arguments and fresh insights to the theory and practice of EA.

2.1 Enterprise architecture

EA describes the high-level view of an organization's business and IT and their interrelationship (Tamm et al., 2011). EA comprises artifacts, such as models and standards that can be used to analyze and model the current and future state of an organization, respectively, and to sketch roadmaps to obtain the target state. Although the historical provenance of the field is under debate (Kotusev, 2016), the fundamental ideas of EA can be traced back to various communities, such as information systems industrial engineering, and management (Bernus et al., 2016; Gampfer et al., 2018).

There is considerable heterogeneity in the field of EA due to different fields using their own taxonomies, tools, and methodologies, leading to differing positions on the problem domain and starting point of EA work (Bernus et al., 2016; Gong & Janssen, 2019). For example, Ylinen and Pekkola (2018, 2020) recognized two distinct groups of EA experts: a modeling-focused group forming a comprehensive view of an organization and a development-focused group using EA for organizational development. Kotusev et al. (2015) reviewed the relevant literature and found three approaches to EA management (EAM):

traditional, Massachusetts Institute of Technology (MIT), and dynamic. As discussed by Kotusev et al. (2015), the traditional approach to EAM consists of four phases: documenting the current state, developing the future state, and developing and implementing a transition plan. The MIT approach "advocates the development of a core diagram reflecting a long-term enterprise-level architectural vision." Finally, the supporting core of the dynamic approach is "just enough, just in time," meaning no EA is designed until there is a need for it. (Kotusev et al., 2015, p. 4072.) These approaches differ in scope and purpose, as well as in the underlying view of the organization, its relation to the environment, and the problem-solving paradigm.

The use of EA is presumed to bring value to an organization (Gong & Janssen, 2019), while other benefits of EA include added value and success of IT projects (Kurek et al., 2017), reduced costs and improved decision making (Tamm et al., 2015), enhanced agility and increased performance (Hazen et al., 2017), and various others (e.g., Gong & Janssen, 2019; Shanks et al., 2018). However, as discussed by Gong and Janssen (2019), achieving the potential value of EA is complicated. Furthermore, our understanding of which EA artifacts result in value is limited (Foorthuis et al., 2016; Kurnia et al., 2020). Consequently, although EA has been a growing interest among scholars (e.g., Gampfer et al., 2018) and practitioners (e.g., Kurek et al., 2017) alike for several decades, it still faces challenges. While scholars struggle to define the scope, purpose, and theory of EA, many practitioners do not see the value returned from the investment made (Gong & Janssen, 2019; Kaisler & Armour, 2017).

Despite keen interest, scholars and practitioners have struggled to form a coherent definition for EA (Nardello et al., 2018; Saint-Louis & Lapalme, 2016; Simon et al., 2013; Rahimi et al., 2017), and the definitions proposed differ both in scope and purpose (Lapalme, 2011; Saint-Louis et al., 2017). An "enterprise" refers to the scope of an examination (e.g., a part of one or many organizations). According to ISO/IEC/IEEE 42010:2011, "architecture" is defined as "fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution." Jonkers et al. define EA as

> a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organizational structure, business processes, information systems, and infrastructure. (Jonkers et al., 2006, p. 64).

Ross et al. view EA as

> the organizing logic for business processes and IT infrastructure, reflecting the integration and standardization requirements of the organization's operating model in which it provides a long-term view of an organization's processes, systems, and technologies so that individual projects can build capabilities not just address immediate needs. (Ross et al., 2006, pp. 8–9)

According to Bernard

> EA is a strategy and business-driven activity that supports management planning and decision-making by providing coordinated views of an entire enterprise. These views encompass strategy, business, and technology, which is different from technology-driven, system-level, or process-centric approaches. . . . the analysis and documentation of an enterprise in its current and future states from an integrated strategy, business, and technology perspective. (Bernard, 2012, p. 31)

Rahimi et al. (2017, p. 125) consider EA to be "the fundamental conception of an enterprise in its environment embodied in its elements, these elements' relationships to each other and to the enterprise's environment, and the principles guiding the enterprise's design and evolution." Finally, Lapalme et al. states that

> EA should be understood as being constituted of the essential elements of a socio-technical organization, their relationships to each other and to their changing environment as well as the principles of the organization's design and evolution. Enterprise architecture management is the continuous practice of describing and updating the EA in order to understand complexity and manage change. (Lapalme et al., 2016, p. 104)

Government EA has been discussed in prior research as a means to solve challenges related to the interoperability, integration, and complexity of e-government systems (e.g., Penttinen, 2018). Despite this effort, public sector EA work has been deemed poor performing in many countries. Dang and Pekkola (2017a) studied the problems and root causes related to public sector EA work. They noted that prior studies identified issues related to organizations, EA project teams, EA users, and EA itself. These problems include issues related to complex structures, overemphasis of IT perspectives, a lack of communication among public organizations, capabilities, and skills, and shared understanding of EA itself (Dang & Pekkola, 2017a). Seppänen et al. (2018) discuss resistance toward EA and relevant goals; they cite EA practices as key issues in adopting EA in the public sector. According to Seppänen et al. (2018), examples of these issues include an unwillingness to embrace new practices, a lack of necessary skills to conduct EA work in practice, and a generally negative image of EA due, for example, to troublesome implementation and technical representation.

2.2 Systems approaches

Mingers and White (2010) elaborate on the trajectory of systems approaches, noting that the roots of systems approaches can be found in the early to mid-1900s. Von Bertalanffy (1969), who discussed general systems theory, and Richmond (1994), who coined systems thinking (Arnold & Wade, 2015), later advanced the field of research. Mingers and White (2010) use the generic term systems approaches to cover systems-related lines of research ("theory" and "thinking"), a classification also adopted in this thesis. As systems approaches were developed over a long period and in different fields of research, they constitute an interdisciplinary conceptual framework rather than a carefully defined discipline (Shaked & Schechter, 2017).

Similarly, according to Cabrera et al. (2008), systems thinking suffers from a lack of consensus regarding its definition and has been viewed as a science, a method, an approach, a discipline, and a conceptual framework. Consequently, systems approaches have been defined in various ways. For example, Senge sees systems thinking as

> a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static "snapshots." It is a set of general principles . . . It is also a set of specific tools and techniques. (Senge, 1990, p. 68)

In comparison, Richmond (1994, p. 141) defines it as "the art and science of making reliable inferences about behavior by developing an increasingly deep understanding of underlying structure." According to Checkland, systems thinking can be defined as

> an epistemology which, when applied to human activity, is based upon the four basic ideas: emergence, hierarchy, communication, and control as characteristics of systems. When applied to natural or designed systems, the crucial characteristic is the emergent properties of the whole. (Checkland, 1999, p. 318)

A thorough review of different definitions for systems thinking can be found in Shaked and Schechter (2017).

As discussed by Cabrera (2006), efforts have been made to summarize previous systems-oriented studies. According to Cabrera (2006), Midgley (2003) assembled a comprehensive review of systems thinking into four books, which include 97 seminal articles discussing systems thinking. François (2011) assembled an encyclopedia of systems and cybernetics, consisting of 3,800 distinct systems concepts, and Schwarz (1996) developed a map of "some streams of systemic thoughts," made up of over 1000 nodes. According to von Bertalanffy (1969, as cited in Cabrera, 2006, p. 17) "an attempt to summarize the impact of 'systems' would not be feasible," and therefore, "A few examples, more or less arbitrarily chosen, must suffice to outline the nature of the problem and consequent reorientation." Following these thoughts, this thesis does not discuss different strands of 100 years of systems approaches research in detail but summarizes the common elements, reflecting the thoughts relevant to EA.

Mingers and White summarize the common elements of different systems approaches as follows:

> (1) Viewing situations holistically, as opposed to reductionistically, as a set of diverse interacting elements within an environment; (2) Recognizing that the relationships or interactions between elements are more important than the elements themselves in determining the behavior of the system; (3) Recognizing a hierarchy of levels of systems and the consequent ideas of properties emerging at different levels, and mutual causality both within and between levels; (4) Accepting, especially in social systems, that people will act in accordance with differing purposes or rationalities. (Mingers & White, 2012, p. 1148)

This provides insight into the methodological basis of systems approaches, according to which the traditional analytical methods are, to some degree, inappropriate for studying systems. While some parts of mechanical devices, such as clocks or engines, can be separated and studied separately, the parts of some systems (e.g., social, political, and business systems) cannot be separated without losing the essence of the whole.

2.3 Ecosystems

According to Shipilov and Gawer (2020), networks and ecosystem perspectives are similar as both examine how organizations manage dependencies with the external environment. Unlike research concerning networks, ecosystems research is still in the stage of formulating the basic definitions and drivers of ecosystem evolution (Adner, 2017; Jacobides et al., 2018; Kapoor, 2018; Shipilow & Gawer, 2020). While the unit of analysis in network research is a firm, a relationship, or a whole network, the unit of analysis in ecosystems research is the whole ecosystem or the focal value proposition (Shipilow & Gawer, 2020). Kapoor (2018, p. 3) notes, "the main theoretical premise for ecosystem research is the simultaneous presence of complementarities and interdependencies between actors." The former stems from the functions performed by participants to create or enhance a focal value proposition, whereas the latter stems from connections within a system-level architecture (Kapoor, 2018).

Ecosystems have been defined and classified in a variety of ways and discussed in fields related to social sciences, management, economics, and IS. In information systems research, different kinds of ecosystems include ecosystem as a standalone concept, business ecosystems, platform ecosystems, service ecosystems, innovation ecosystems, and software ecosystems (see Adner, 2017; Faber, 2019; Kapoor, 2018). Guggenberger et al. discuss a fivefold typology of ecosystems in IS literature that include:

> (1) sociocentric ecosystems: "Open communities that are organized around a social power, e.g., a keystone player, and evolve through adaptation to external stimuli"; (2) symbiotic collective ecosystems: "Closed communities focusing on symbiotic relationships to evolve their individual specializations"; (3) centrally balanced ecosystems: "Open communities sharing their resources and specialization on a central object, which is controlled by collective intentions"; (4) orchestrating actor ecosystems: "Communities controlled by a central power and a central object used to orchestrate the individual specializations"; and (5) structures resource sharing ecosystems: "Communities controlled by a central power and a central object used to orchestrate the individual specializations. (Guggenberger et al., 2020, p.9)

Guggenberger et al. (2020) note that prior research has highlighted the abundance of ecosystem conceptualizations that exist in the literature, resulting in conceptual blurring and overlap, and the overutilization of the term ecosystem. Adner (2017, p. 40) defines an ecosystem as "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize." In this thesis, Adner's (2017) definition is adopted, as it is seen to represent the nature of the public administration accurately, where the focus of the ecosystems is not to generate profit, but something of value, such as the wellbeing of citizens.

Some common elements among different types of ecosystems include focal roles, co-specialization, co-evolution and coopetition, interdependence, loosely coupled hierarchical structure, shared vision, a system-level business model, and modularity (Han et al., 2017) as well as sustainability, self-governance, and evolution (Sako, 2018). Guggenberger et al. (2020) reviewed existing literature and concluded that ecosystem elements could be categorized as concerning either (1) population (e.g., distinct roles, specialization, loose coupling), (2) purpose (e.g., innovation, value creation), (3) relationship structure (e.g., interaction, collective intention, centralized power), (4) system configuration (e.g., structuredness, centricity), or (5) system dynamics (e.g., adaptive behavior, self-organization, co-evolution).

Manna et al. (2018) describe the structure of an ecosystem as having four levels: micro-, meso-, macro- and mega-level. At the micro-level, services are directly exchanged between actors, whereas indirect interaction among actors in the same ecosystem takes place at the meso-level and is further enabled or constrained at the macro-level. Interaction and interrelation between ecosystems take place at the highest level, the mega-level. (Manna et al., 2018.) In practice, Beirão et al. (2017) discuss the ecosystem of a national health information system, defining public administration as a whole as representative of a macro-level ecosystem, and the interaction of different public and private health care organizations as occurring at the meso-level.

2.4 Enterprise architecture usage in systemic settings

As previously noted, there has been an increasing number of calls to study the relationship between EA and systems approaches (see Bernus et al., 2016; Gong & Janssen, 2019; Kappelman & Zachman, 2013; Korhonen et al., 2016; Lapalme et al., 2016; Rahimi et al., 2017). Recently, EA has been studied from a systemic perspective (see Bakhtiyari, 2017; Burmeister et al., 2018, 2019a, 2019b; Bernus et al., 2016; Carter, 2016; Drews & Schirmer, 2014; Janssen & Kuk, 2006; Kappelman & Zachman, 2013; Kloeckner & Birkmeier, 2009; Korhonen & Halén, 2017; Korhonen et al., 2016; Lapalme et al. 2016; Pittl & Bork 2017; Rahimi et al., 2017) as a means of understanding networked and ecosystemic settings (see Anwar & Gill, 2019; Cherrabi et al., 2020; Hedges & Furda, 2019; Horlach et al., 2020; Katuu 2018; Lnenicka & Komarkova 2019a; Lnenicka et al., 2017; McBride et al., 2019; Wieringa et al., 2019).

Systems approaches seem to represent a viable means of describing the elements of a society along with their interactions (Caputo et al., 2019). A systemic stance on government EA is discussed by Janssen and Kuk (2006), who analyzed 11 cases of EA usage in the Dutch public administration from a complex adaptive systems perspective and introduced eight architectural design principles, including the usage of modular architectures, favoring sharing and forming coalitions. Similarly, studies concerning ecosystems continue to emerge in top information systems journals (e.g., MIS Quarterly), conferences (e.g., ECIS 2020, ICIS 2020) (Guggenberger et al., 2020), and in the context of public administration and service provision (e.g., Chang et al., 2020; Han et al., 2017; Hynes et al., 2020).

In recent years, research on ecosystem EA has grown. Burmeister et al. (2019a, 2019b) introduced an ecosystem architecture metamodel to support ultra-large-scale digital transformations; in their work, they discuss leveraging architectural thinking for large-scale e-government projects. Lnenicka and Komarkova (2019a) developed a government EA framework to support the requirements of big and open linked data with the use of cloud computing. Anwar and Gill (2019) reviewed seven modeling approaches for digital ecosystem architecture, and Wieringa et al. (2019) introduced a business ecosystem architecture modeling framework. Further, Hedges and Furda (2019) discuss the emerging role of an ecosystem architect. Notwithstanding the many merits of these efforts, the application and evaluation of these ideas in real life have been modest, and they are mostly conceptual or theoretical.

Some of the more thorough studies concerning themes related to EA and systems approaches or the use of EA in systemic environments include doctoral dissertations by Carter (2016), Bakhtiyari (2017), Faber (2019) and Gampfer (2019). Carter (2016) uses the grounded theory approach to discuss a systems theory-based framework for complex system governance. Bakhtiyari (2017) explores the application of EA to business networks, while Faber (2019) concentrates on collaborative modeling and visualization of business ecosystems. Finally, Gampfer (2019) discusses EA in dynamic environments in general. Departing from these efforts, this thesis focuses exclusively on EA in public sector ecosystems.

3 RESEARCH METHODOLOGY

This section discusses the research methodology of this thesis, briefly covering the acquired philosophical position, research principles followed, and overall design of the research process.

3.1 Philosophical position

The philosophical position of this thesis is one of pragmatism, and design science research (DSR) is used as a methodology. Tashakkori et al. (1998, as cited by Goles & Hirtchheim) have described pragmatistic research endeavors as follows:

> Thus, pragmatists decide what they want to research, guided by their personal value systems; that is, they study what they think is important to study. They then study the topic in a way that is congruent with their value system, including variables and units of analysis that they feel are most appropriate for finding an answer to their research question (Goles & Hirtchheim, 2000, p. 262).

The motivation to study EA from a systemic stance stems not only from the need described in the relevant literature and by practitioners but also from personal experience. I have been involved in studying, researching, and teaching EA-related themes at the University of Jyväskylä since my bachelor's studies. After graduating, I began working as an architect in the Finnish public sector. The need to study the topic of this thesis is thus academic, practice-oriented, and personal. Lee and Nickerson state that

> a major benefit of subscribing to the philosophy of pragmatism is that it recognizes the importance of the individual researcher and the research community playing constructive and indispensable roles in the research process. This stands in contrast to e.g. logical positivism, which presumes that a researcher's values and social context can only contaminate the subject matter and bias the research results. (Lee & Nickerson, 2010, p. 4)

DSR is an established methodology frequently used in studies concerning EA and modeling in systemic environments (e.g., Bakhtiyari, 2017; Faber, 2019; Lnenicka & Komarkova, 2019a). According to Baskerville et al. (2018), Hevner et al. (2004), and Peffers et al. (2007), DSR is a keystone IS research paradigm, bringing both practical relevance and scientific rigor to the field of research. Further, Baskerville et al. (2018) state that the use of systems theories as an overarching theory to inform the design of IS artifacts is recognized in DSR projects that address wicked problems among complex systems.

From a philosophical perspective, DSR is rooted in pragmatism (Hevner et al., 2004; Lee & Nickerson, 2010). Both pragmatism (Goles & Hirschheim, 2000) and design science (Baskerville et al., 2018; Hevner et al., 2004) have been suggested as a philosophical and methodological basis for combining practical and academic research. Hevner et al. (2004, p. 77) discuss the roots of DSR as follows: "Philosophically these arguments draw from the pragmatists . . . who argue that truth (justified theory) and utility (artifacts that are effective) are two sides of the same coin and that scientific research should be evaluated in light of its practical implications." According to Hevner and Chatterjee (2010, p. 180), DSR is "concerned with artificial rather than natural methods phenomena and is rooted as a discipline in the sciences of artificial." Thus, DSR artifacts are "designed with fitness of purpose in mind, created to pursue certain ends and evaluated based on conscious selection of alternatives" (Hevner & Chatterjee, 2010, p. 180).

3.2 Research design

In practice, this thesis follows two notable works on DSR: Peffers et al.'s (2007) DSRP (see Figure 2) and Hevner et al.'s (2004) design principles. In this section section, the DSRP phases (Peffers et al., 2007) are discussed in relation to the design principles (Hevner et al., 2004) followed in this thesis (c.f. Faber, 2019).

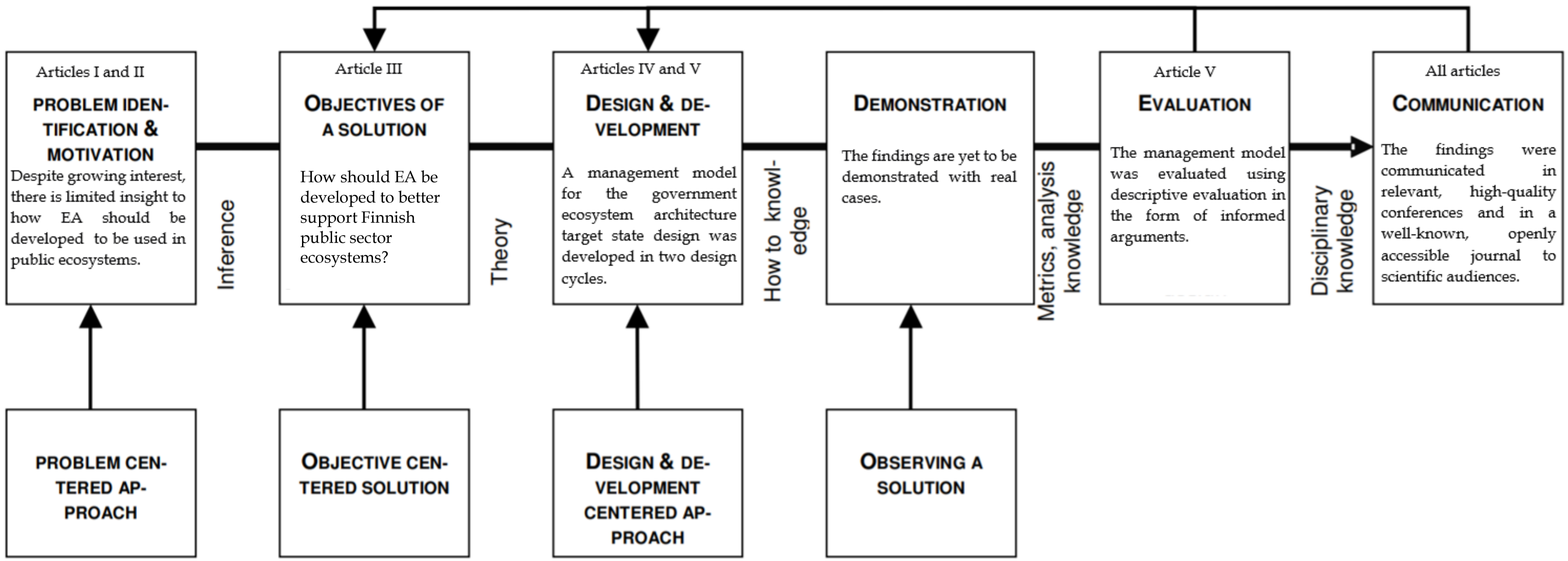


Figure 2 The design science research process of the thesis. Adapted from Peffers et al. (2007).

Design as an artifact

The goal of DSR is to create purposeful design artifacts—constructs, models, methods, and instantiations—that address a particular problem. Hevner et al. define these four DSR products as follows:

> Constructs that provide the language in which problems and solutions are defined and communicated. Models aid in understanding the real world and enable exploration of the effects of design decisions and changes in the real world. Methods provide guidance on how to solve problems. Instantiations demonstrate feasibility, provide empirical evidence that an artifact is suited to its intended purpose, and enable researchers to learn about the real world and how an artifact affects it. (Hevner et al., 2004, p. 78–79)

According to Hevner et al. (2004, p. 83), these artifacts are "rarely full-grown information systems that are used in practice. Instead, artifacts are innovations that define the ideas, practices, technical capabilities, and products." Goldkuhl discusses the consequences of pragmatism in a similar manner:

> pragmatism has an interest not only for what "is," but also for what "might be;" an orientation towards a prospective, not yet realized world. Pragmatism is concerned with an instrumental view on knowledge; that it is used in action for making a purposeful difference in practice. . . . The knowledge character within pragmatism is thus not restricted to explanations (key form of positivism) and understanding (key form of interpretivism). Other knowledge forms such as prescriptive (giving guidelines), normative (exhibiting values) and prospective (suggesting possibilities) are essential in pragmatism. (Goldkuhl, 2012, p. 140)

In this thesis, a management model for the government ecosystem architecture target state design was developed, and principles for government ecosystem architecture management were outlined. Further, some basic functional requirements of an ontology-based shared EA repository were outlined, representing the system needed to execute real-time current state analysis for a complex sociotechnical government ecosystem.

Problem relevance

According to Hevner et al. (2004, p. 84), "the objective of research in information systems is to acquire knowledge and understanding that enable the development and implementation of technology-based solutions to heretofore unsolved and important business problems." The relevance of studying the usage of EA from a systemic stance was endorsed by the relevant literature gathered in the systematic literature review, in-depth expert interviews conducted in the course of this these, and my own experiential knowledge working as an architect in the Finnish public sector. The relevance of publishing systematic literature reviews concerning EA definitions is also noted by previous research (e.g., Kappelman & Zachman, 2013).

The lack of a common understanding concerning the scope and purpose of EA leads to difficulties in structuring a baseline of knowledge in the field (Saint-Louis et al., 2017) and makes it difficult to discuss EA as a discipline (Saint-Louis & Lapalme, 2016). Furthermore, "this lack of generally agreed upon terminology in EA is also a bottleneck for its efficient application because it creates obstacles to its correct understanding in practice" (Gong & Janssen, 2019, p. 2).

The first phase in DSRP, Problem identification and motivation, defines the specific research problem that will be used to develop an effective artifactual solution; thus, "it may be useful to atomize the problem conceptually so that the solution can capture the problem's complexity" (Peffers et al., 2007, p. 89). Phase 1 activities include knowledge of the state of the problem and the importance of its solution (Peffers et al., 2007). In this thesis, Articles I and II constitute phase 1, specifying the problem domain of this thesis by offering the state-of-the-art of EA research, and thus motivating the research question of this thesis. The second phase, Objectives of a solution (Peffers et al., 2007), is the subject of Article III. In the second phase, the objectives of a solution are inferred from the problem definition, with resources such as "knowledge of the state of problems and current solutions and their efficacy, if any" (Peffers et al., 2007, p. 90). Article III offers interview data gathered from different levels of the Finnish public sector, discussing the current limitations and possible solutions to the usage of EA in public sector ecosystems.

To ensure the practical relevance of different contributions, multiple interviews were conducted in the course of this thesis. First, this thesis used data from 26 semi-structured practitioner interviews, conducted as part of a qualitative longitudinal research project on the implementation of the Finnish national EA method (FINEA; see Penttinen, 2018). The research consisted of two rounds of semi-structured interviews. The second-round interview data, gathered during summer 2017, was used to study the scope and purpose of EA (Article I) and the practical application of EA (i.e., how practitioners would like to see EA utilized in a public sector ecosystem) (Article III). The data used during the design cycle for the government ecosystem architecture target state design management model (Article V) was gathered from eight interviews with seasoned EA professionals and managers from four Finnish smart cities representing public sector ecosystems. The analysis of the interviews followed the guidelines of Hsieh and Shannon (2005). Article I utilized directed content analysis based on existing classifications by Lapalme (2011), whereas Articles III and V used conventional content analysis, meaning the analysis was derived directly from the study material. According to Hsieh and Shannon (2005), conventional content analysis is often used when a study aims to describe a phenomenon with a limited existing theory; in comparison, directed content analysis is used to validate a theoretical framework in order to help focus the research question.

Design evaluation

The fifth phase of the DSRP is Evaluation (Peffers et al., 2007). Hevner et al. (2004) state that rigorous evaluation methods are extremely difficult to apply in DSR. According to Hevner et al. (2004), evaluation methods of DSR artifacts include observational, analytical, experimental, testing, and descriptive evaluation. In this thesis, descriptive evaluation was used in the form of informed arguments gathered from the knowledge basis formed by the relevant literature (systematic literature review) and expert practitioners (interviews) (c.f. Hevner et al., 2004). The management model for government ecosystem architecture design and management was developed in two cycles. The first version of the model was outlined based on relevant literature, after which eight interviews were conducted. The model was then modified based on the insights gathered.

Research contributions

As stated by Baskerville et al. (2018), DSR artifacts contribute to design knowledge if they are useful and of a novel nature. Created artifacts and the recited state-of-the-art of EA contribute to theoretical development in the field of EA as well as to the practical application of EA in the Finnish public sector. In the three-level classification by Gregor and Hevner (2013), the contributions of this thesis could be classified as level 2 (contributions that include constructs, models, design principles, and technological rules).

Research rigor

Hevner et al. (2004, p. 80) note that "rigor is achieved by appropriately applying existing foundations and methodologies." The state-of-the-art of EA was used as a basis for artifacts' design. The research process followed established methods and ideas from several notable works on conducting systematic literature reviews (Templier & Paré, 2015), expert interviews (Patton, 1990), interview analysis (Hsieh & Shannon, 2005), and design artifacts creation (Hevner et al., 2004; Peffers et al., 2007).

Design as a search process

The third phase in the DSRP, Design and development (Peffers et al., 2007), includes the creation of the actual artifactual solution, which is the tentative management model in Article IV. Article V further adjusts the management model for the government ecosystem architecture target state design and outlines principles for government ecosystem architecture management, also offering a descriptive evaluation (Hevner et al., 2004) of the management model. In this thesis, a systematic literature review was conducted, and practitioner interviews were analyzed to ensure the relevance of the subject as well as to further specify the problem to be solved. The initial version of the management model was outlined, after which a second design–evaluation cycle was conducted based on relevant literature and practitioner interviews.

Hevner et al. (2004, pp. 88-89) note, that "design is essentially a search process to discover an effective solution to a problem" thus, when designing solutions for complex phenomena, "the search is for satisfactory solutions". They further state that one approach to demonstrating the "goodness" of a design solution is to compare the produced solution with the solutions of expert human designers. This was done by including the expert interviews in the design cycle.

The demonstration of the management model (fourth phase of the DSRP) was considered beyond the scope of this thesis and is thus left to future studies.

Further research and practical validation of the introduced DSR artifacts are obviously needed. While the proposed results still need to be tested with actual use cases, they provide actionable guidelines for organizations operating in public ecosystems.

Communication of research

Phase six of the DSRP, Communication (Peffers et al., 2007), includes the communication of the problem and its importance (Articles I–III) and the artifact (Articles IV–V). Hevner et al. (2004, p. 90) note that "Design-science research must be presented both to technology-oriented as well as management-oriented audiences." The findings were communicated to scientific audiences in peer-reviewed, high-quality conferences as well as a well-known, openly accessible journal. They were also communicated to practitioners of the Finnish public sector EA in person and via social media (e.g., LinkedIn).

4 OVERVIEW AND RESULTS OF THE INCLUDED ARTICLES

This section offers an overview of the research objectives, the main results, and the connection between the results of each included article and the research question of this thesis.

4.1 Article I: Examining enterprise architecture definitions: Implications from theory and practice

Nurmi, J., Penttinen, K., & Seppänen, V. (2019). Examining enterprise architecture definitions: Implications from theory and practice. In *IRIS 41: Papers of the 41st Information Systems Research Seminar in Scandinavia* (pp. 1-12). Association for Information Systems.

Research objectives

Article I (Nurmi, Penttinen, & Seppänen, 2019a) discusses the definition, scope, and purpose of EA. It addresses the following research question: How convergent are the definitions of EA proposed by academics and practitioners? Thus, Article I reviews the definitions presented in previous EA studies as well by the 26 interviewed practitioners and compares them with Lapalme's (2011) "schools of thought on enterprise architecture." Lapalme (2011, p. 37) argues that a threefold taxonomy "creates a starting point for resolving terminological challenges to help establish enterprise architecture as a discipline." According to Lapalme (2011), the first taxonomy class, enterprise IT architecting, limits the scope of EA to IT assets and the operations that use them. The purpose of EA is to reduce IT costs, for example, by eliminating duplicate functionality of the IT assets.

The second school of thought, enterprise integrating, covers all facets of an enterprise, broadening the focus of EA. It aims to maximize the coherency of the structures of different parts of an organization, thus supporting the execution of an organization's strategy. The last taxonomy class, enterprise ecological adaptation, aims to enable organizational learning, innovation, and system-in-environment adaptation, covering both the organization itself and its surroundings (Lapalme, 2011). According to Lapalme, the two latter schools of thought apply a systemic stance.

Findings

The results of Article I (Table 1) indicate that a systemic stance is slightly favored, which reflects the enterprise integrating and enterprise ecological adaptation schools of thought, although the definitions appeared to be distributed somewhat similarly over the classes. A chi-square analysis (4.4711, p = .215) of the contingency table did not suggest that the variables would be dependent, and there was no statistically significant difference between the distribution of the definitions presented in the literature and those proposed by the interviewees. Interviewees belonging to the enterprise IT architecting school of thought defined EA as "addressing the integration of the IT resources and of business resources," as a "discipline that addresses the alignment of IT systems with business," and as "a framework or tool through which systems can communicate and function together."

Definitions classified as belonging to the enterprise integrating school of thought defined EA as a "comprehensive description of all the key elements and relationships that fully describe an enterprise" and as the "planning of all resources under the control of an enterprise, not just IT resources." Additional definitions defined EA and as "describing the whole and the interconnections," as a "method that concerns wholes and its interconnections, a systematic approach to organizations, business processes, knowledge and systems," and as a "catalyst between strategy and execution." The enterprise ecological adaptation school of thought defined EA as "the fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution." Additionally, "the goal of an EA project is to define and implement the strategies that will guide the enterprise in its evolution."

Eight literature definitions and nine practitioner definitions were classified as "Other." While these definitions were not classified as belonging to any school of thought, they still represented ideas similar to the other definitions. Practitioners regularly defined EA as some kind of tool used, for example, to develop documents or to design and develop an organization. Also, it was noted by the interviewees that EA should encompass the organization as a whole rather than involving only the IT management, for example (Nurmi, Penttinen, & Seppänen, 2019a).

Table 1 Classification of the EA definitions presented in the literature and proposed by practitioners (Nurmi, Penttinen, & Seppänen, 2019a)

	Enterprise IT Architecting	**Enterprise Integrating**	**Enterprise Ecological Adaptation**	**Other**
Literature	[8]; [9]; [12]; [36]; [41]; [43]; [44]	[4]; [7]; [17]; [20]; [21]; [31]; [32];[34]; [39]; [40]; [48]	[3]; [5]; [16]; [19]; [27]; [42]; [45]; [46]; [47]	[1]; [10]; [11]; [13]; [15]; [24]; [25]; [35]
Practi-tioner	ITworker1	ITmanager1; ITmanager2; IT-worker2; IT-worker5; PScity1; PScity2; PScity4; PSdepartment3; PSdepartment4; PSsector2; PSstate4	PSdepartment2: PSsector1; PSsector3; PSstate1; PSstate3	ITmanager3; ITmanager4; ITmanager5; ITworker3; ITworker4; ITworker6; PScity3; PSdepartment1; PSstate2
Total	**8**	**22**	**16**	**16**

Connection to the objectives of the thesis

Article I contributes to the aim of this thesis by discussing EA as a phenomenon, covering the scope and purpose of the discipline. This thesis contributes to the conceptual analysis perspective by attempting to clarify the scope and purpose of EA. The results of Article I indicate that a systemic stance is favored by both practitioners and prior research, and EA should, in terms of scope and purpose, cover the elements within an organization and its ecosystem as well as the interconnections between elements. Thus, the results of Article I motivate further studies concerning EA and systems approaches.

4.2 Article II: Systems approaches in the enterprise architecture field of research: A systematic literature review

Nurmi, J., Pulkkinen, M., Seppänen, V., & Penttinen, K. (2019). Systems approaches in the enterprise architecture field of research: A systematic literature review. In *EEWC 2018: Proceedings of the 8th Enterprise Engineering Working Conference* (pp. 18-38). Lecture Notes in Business Information Processing, vol. 334. Springer, Cham.

Research objectives

Article II (Nurmi, Pulkkinen, Seppänen, & Penttinen, 2019) aimed to gauge if and to what extent systems approaches could provide a common theoretical foundation for EA. It addresses the following research questions: (1) To what extent are different systems approaches already in use in EA research? (2) What aspects of theory do earlier studies on systems approaches cover?

The article offers a systematic literature review and discusses the nature of theory in information systems and the related field of enterprise engineering. A total of 47 publications were analyzed and classified based on (1) the systems approach applied (total of eight approaches); (2) the purpose of the study (theory or discipline; ontologies and frameworks; methods and modeling; software tools); and (3) whether a particular study was conceptual or theoretical, or based on or supported by empirical evidence.

Findings

Table 2 illustrates how the included studies frequently referred to different kinds of systems approaches, especially the studies concerning methods and modeling. The examined articles mentioned various systems approaches, and several mentioned more than one approach (most often general systems theory, systems thinking, and unspecified systems theory). The results indicate that the consistent use of systems approaches might be beneficial, as the application of systems approaches appears to be fragmented, and they are rarely used in empirical studies. The included studies applied systems approaches in design and action, although empirical testing and validation of the systems approaches were somewhat lacking, most often occurring in the studies concerning methods and modeling.

Table 2 Classification based on systems approach and type of article (Nurmi, Pulkkinen, Penttinen, & Seppänen, 2019)

For the Advancement of	Argumentation	Systems Approach (n): Paper ID #	Total	
1. Theory or discipline	Conceptual or theoretical	STH (9): #14; #20; #23; #24; #31; #37; #41; #42; #43 CYB (3): #11; #29; #36 GST (2): #39; #47 VSM (1): #21 CAS (1): #44 ORT (1): #38	17	19
	Based on or supported by empirical evidence	STH (1): #34 MHS (1): #28	2	
2. Ontologies and frameworks	Conceptual or theoretical	STH (3): #3; #15; #16	3	6
	Based on or supported by empirical evidence	GST (1): #10 SM (1): #13 MHS (1): #8	3	
3. Methods and modeling	Conceptual or theoretical	STH (8): #1; #17; #25; #30; #33; #35; #45; #46 VSM (2): #26; #27 GST (1): #19 CYB (1): #22 LST (1): #2	13	20
	Based on or supported by empirical evidence	STH (2): #9; #32 GST (2): #12; #18 SM (1): #40 CAS (1): #5 LST (1): #7	7	
4. Software tools	Conceptual or theoretical	LST (2): #4; #6	2	2
	Based on or supported by empirical evidence		0	

Note. CAS = complex adaptive systems (2), CYB = cybernetics (4), GST = general systems theory (6), LST = living systems theory (4), MHS = theory of multilevel hierarchical systems (2), ORT = orientor theory (1), STH = "systems theory," "systems thinking," etc. (23), VSM = viable systems model (5).

Connection to the objectives of the thesis

Article II complements Article I by discussing the conceptual analysis perspective of EA. As the results of Article II suggest, the extensive use of different systems approaches might indicate that their common elements could provide overall theoretical support for EA. Accordingly, a systems paradigm adapted for EA could enhance architecture work in public sector ecosystems.

4.3 Article III: Towards ecosystemic stance in Finnish public sector enterprise architecture

Nurmi, J., Penttinen, K., & Seppänen, V. (2019). Towards ecosystemic stance in Finnish public sector enterprise architecture. In *Perspectives in Business Informatics Research: 18th International Conference, BIR 2019, Proceedings* (pp. 89-103). Lecture Notes in Business Information Processing, vol. 365. Springer, Cham.

Research objectives

Article III (Nurmi, Penttinen, & Seppänen, 2019b) offers a thematic analysis of interview data from 26 practitioner interviews and addresses the following research question: How should EA be developed to better support Finnish public sector ecosystems?

Findings

The results of Article III indicate that fresh insights and new means to design, develop and govern EA in the public sector are required. Organizational capabilities, holistic view, co-creation, and needs-based utilization were identified as essential features of public sector ecosystem EA and were deemed especially important by the interviewed practitioners (Table 3). Here, capabilities are defined as combinations of operations models and processes, employees and skills, and information and systems. The resources most frequently mentioned were time devoted to EA practice, as well as skills and competencies, including both technical and business capabilities. Co-creation was mentioned somewhat often; however, while some interviewees noted the importance of co-creation and the notion of public administration as an ecosystem, others felt that, in reality, cross-organizational cooperation was wretched despite mutual EA efforts. A holistic view of public administration and its organizations was considered potentially beneficial in understanding structures and stakeholders and in enhancing cooperation and better governance. Needs-based utilization was also mentioned, mainly because of the lack of resources for EA work and development in general. It should be noted that law, which may have led to redundant modeling without clear aims, has mandated public EA work in Finland.

Table 3 Themes considered important in developing public sector ecosystem enterprise architecture (Nurmi, Penttinen, & Seppänen, 2019b)

Theme	State	Administrative Sector	Civil Service Department	City	IT Company Manager	IT Company Worker
Capabilities	◑	◔	◑	○	◔	●
Co-creation	◔	◔	◑	◑	○	◔
Holistic view	●	◔	●	◔	◔	◑
Needs-based utilization	◑	◑	◑	◔	◑	◔

○ = not mentioned, ◔ = rarely mentioned, ◑ = occasionally mentioned, ● = frequently mentioned.

Connection to the objectives of the thesis

Article III contributes to empirical and normative perspectives; that is, how the EA practitioners would like to see EA utilized in a systems-in-environment setting and how EA should be applied in ecosystems in practice. Thus, Article III contributes directly to the research question of this thesis—How should EA be advanced to be better used in public ecosystems?—by offering an in-depth analysis of the qualities EA practitioners deem important in public sector EA practice. Based on the results of Article III, it was proposed that EA in public sector ecosystems should form a holistic view of the ecosystem, utilize the capabilities of the involved organization, and conduct development work that is needs-based and co-creative, based on the interrelationships and interactions of the participating organization.

4.4 Article IV: Envisioning information systems support for business ecosystem architecture management in public sector

Valtonen, K., Nurmi, J., & Seppänen, V. (2018). Envisioning information systems support for business ecosystem architecture management in public sector. In *BIR-WS 2018: Joint Proceedings of the BIR 2018 Short Papers, Workshops and Doctoral Consortium co-located with 17th International Conference Perspectives in Business Informatics Research (BIR 2018)* (pp. 150-159). RWTH Aachen University.

Research objectives

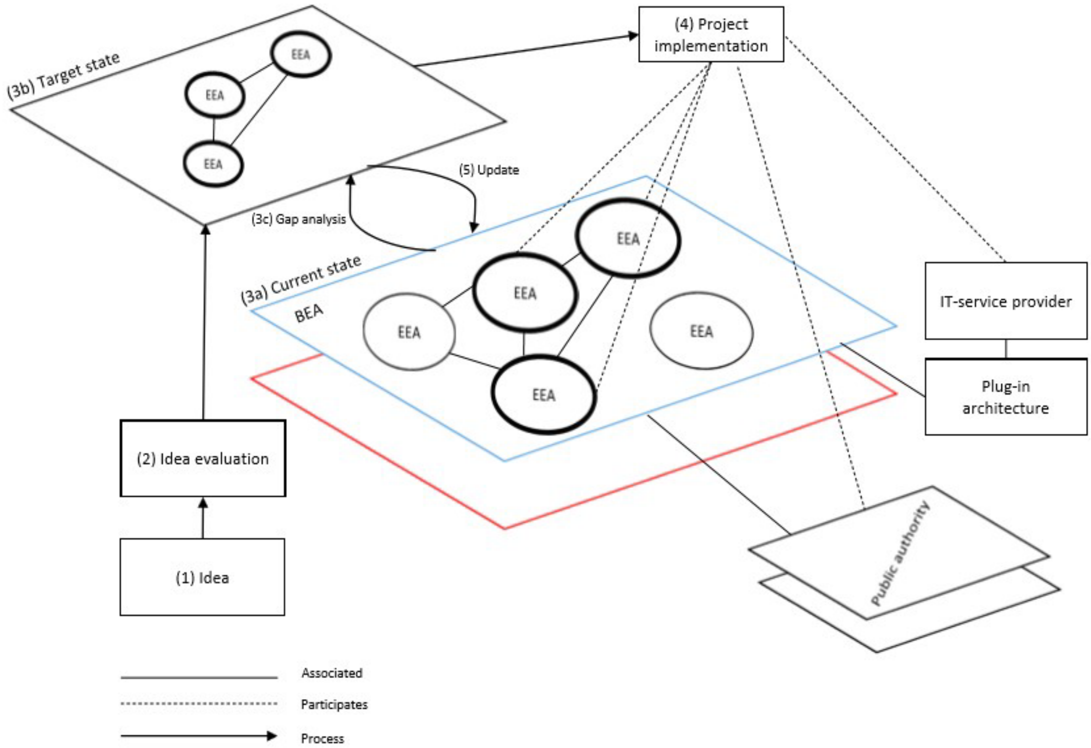
Article IV (Valtonen, Nurmi & Seppänen, 2018) discusses the kind of system that is needed in a complex sociotechnical government ecosystem for real-time current state analysis. Basic functional requirements of an ontology-based, shared EA repository are outlined, and a tentative management model for the government ecosystem architecture is suggested.

Findings

Article IV outlines a concept for real-time, as-is IS support for public sector ecosystem architecture target state design. It suggests that EA descriptions and metamodels should be based on a co-created ontology of local, regional, and national public ecosystems. In practice, four design principles of as-is business ecosystem architecture (BEA) realization are discussed: (1) dynamic as-is content based on suggestions and automatically updated content; (2) scalability on different levels of the public sector ecosystem, from local to regional and national levels; (3) openly available information on public sector ecosystem architectures for residents and organizations; and (4) plug-in architecture that enables organizations from different ecosystems to easily join the ecosystem.

Further, three functional requirements for the as-is BEA realization are outlined. First, basic modeling and metamodeling functionalities should be available. Second, more advanced functionalities, such as comparison and agile analysis, required for common ontologies, should also be available. Third, situational EA frameworks should be able to be withdrawn according to set definitions.

A tentative management model for the government ecosystem architecture is also suggested (Figure 3). Drews and Schirmer (2014) in which the authors discuss the stages from EA to extended EA (EEA) and BEA, comprising several EEAs, base the model on an article. According to Drews and Schirmer (2014), an EEA includes partners, suppliers, and customers, whereas a BEA includes several EEAs, with a central actor overviewing the ecosystem as a whole. The management model suggests a target state design process for co-creating new services in the ecosystem. The phases from idea creation to implementation are discussed with the updated management model in Section 4.5.



Note. EEA = extended enterprise architecture, BEA = business ecosystem architecture.

Figure 3 Tentative management model for the government ecosystem architecture (Valtonen et al., 2018).

Connection to the objectives of the thesis

Article IV outlines a vision of an ontology-based repository for public sector ecosystem architecture current state descriptions and specifies some basic design principles and functional requirements for the system. Following DSR methods, a tentative management model for the government ecosystem architecture target state design is also suggested. Article IV contributes directly to the research question of this thesis by tentatively outlining how EA should be advanced to be better used in systemic settings.

4.5 Article V: Ecosystem architecture management in the public sector: From problems to solutions

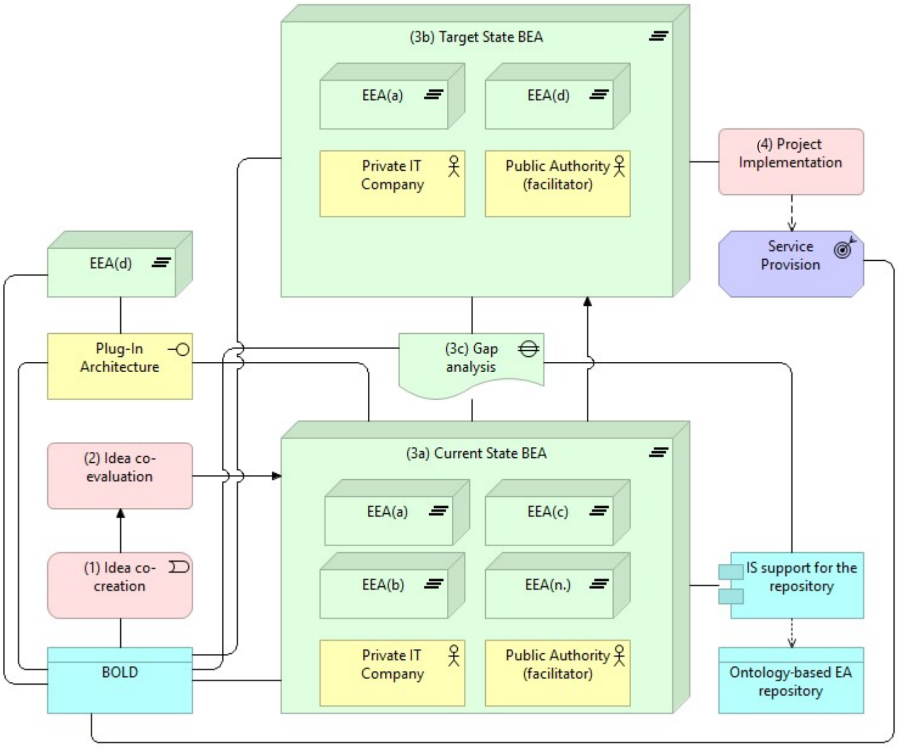
Nurmi, J., Seppänen, V., & Valtonen, M. K. (2019). Ecosystem architecture management in the public sector: From problems to solutions. *Complex Systems Informatics and Modeling Quarterly*, 19, 1–18.

Research objectives

Article V (Nurmi, Seppänen, & Valtonen, 2019) uses interview data from eight interviews conducted with EA practitioners in four Finnish smart cities, serving as representations of public administration ecosystems, to develop the design science artifact created in Article IV. Thus, a management model for the government ecosystem architecture target state design is suggested, and principles for government ecosystem architecture management are outlined.

Findings

Article V suggests a management model for the government ecosystem architecture target state design (Figure 4). Phases 1 to 4 in the figure (marked with numbers) illustrate a target state design process for co-creating new services in the ecosystem. After the idea for a new service has been co-created (Phase 1) in an open manner, involving a variety of actors from inside and outside the ecosystem, the idea is co-evaluated by different stakeholders (Phase 2). After that, the current state is analyzed (Phase 3a), the target state is designed (3b), a gap analysis is performed (3c), and the organizations participating in the project are identified. This results in a subset of necessary, distinct EAs that cover concerns related to customers, partners, and suppliers (i.e., BEA; for a thorough explanation, see Article V). In the course of the project implementation (Phase 4), the as-is architectures of the ecosystem and the participating actors update semi-automatically by increments until the previous target state is obtained. Finally, service provision is achieved. Information systems support of a shared architectural repository is part of the solution, making the architectures of the ecosystem and its participants accessible and automatically updated. According to Gampfer (2019), providing a central architecture repository has major benefits (see also Article IV).



Note. EEA = extended enterprise architecture, BEA = business ecosystem architecture, BOLD = big and open linked data.

Figure 4 Management model for the government ecosystem architecture (Nurmi, Seppänen, & Valtonen, 2019).

Based on the interview data and a rich stream of literature, Article V presents principles for government ecosystem architecture management, here enhanced with the latest research in the field:

- **Dual nature and nestedness**. The architecture of the public sector ecosystem displays high-level abstraction, systems-wide design, highly detailed accuracy, and independence of participating actors on different levels of the ecosystem. Although all organizations participating in or joining the ecosystem have a high level of autonomy, unnecessary redundancies and resulting costs are avoided with an overarching architectural vision. Janssen and Kuk (2006) discuss complex adaptive systems in relation to EA and conclude that finding the right balance of centralized and decentralized layers is crucial to a successful EA practice in systemic settings.
- **Openness and flexibility**. The openness to new actors joining the ecosystem and the flexibility to react to the changes new members bring are key features in a public sector ecosystem. These features are highlighted in plug-in architecture (see Figure 4; for a thorough review, see Article V). Plug-in architecture enables co-creation and co-evolution of the ecosystem by actively promoting new actors to join the ecosystem with clear structures, partly mutual architectures (e.g., data models and interfaces), and

partly shared, individual architectures, gathered in the central architecture repository. Thus, external (and contemporary) organizations are actively given the option to plug into the ecosystem with minimum effort in each individual project.

- **Evolvability, needs-based utilization, and modularity.** New services should be designed and co-created in a modular and agile way. According to Jacobides et al. (2018), ecosystems enhance the coordination of interrelated yet independent organizations that have significant autonomy via modular architectures. These ideas are featured in Figure 4, where a needs-based project is executed, and ecosystems evolve on demand when new actors join them with the plug-in architecture. The need for increased modularity of to-be architectures in dynamic environments (i.e., ecosystems) is emphasized in prior literature (e.g., Gampfer, 2019), as well as in the interviews conducted in the context of this thesis. Consolidation and integration of models and data can support both a common understanding of architectural decisions and common information.
- **Cooperability.** Much like in natural ecosystems, government ecosystems are based on cooperability, as reflected by the co-creation of services. In Figure 4, cooperability is seen in all phases, from idea co-creation and co-evaluation to project implementation, achieved by a variety of voluntary participants (Nurmi, Seppänen, & Valtonen, 2019).
- **BOLDness and interoperability.** An issue frequently mentioned by the interviewees was the usage and sharing of (open/public) as part of service co-creation in the ecosystem. This issue has also been mentioned in the literature, where big and open linked data (BOLD) has been discussed as a key to successful EA usage in ecosystemic environments (c.f. Caputo et al., 2019; Lnenicka & Komarkova, 2019a, 2019b; Lnenicka et al., 2017). It is challenging to promote the modularity and interoperability (technical, syntactical, and semantical interoperability) of the ecosystem architecture simultaneously (c.f. Gampfer, 2019). If, for example, different organizations have their own models and naming conventions for their data elements, the interoperability of the ecosystem cannot be obtained.
- **Holism and circular causality**. A holistic, systemic perspective of the whole ecosystem is needed, noting the interactions and indirect causality between organizations of the same and co-existing ecosystems.

Connection to the objectives of the thesis

Article V uses descriptive evaluation (Hevner et al., 2004) to develop the tentative management model created in the DSR cycle in Article IV. Thus, Article V contributes directly to the aim of this thesis by proposing EA as a concept for the organizational design of a government entirety. Together with the previous four articles described, it addresses the research question of this thesis. The proposed solution has several potential benefits, including the elimination of duplicate and excess work and support for the co-creation and co-evolution of the public sector ecosystem.

4.6 Summary of the main results

The design, objectives, results, and connection of the included articles to the research question of this thesis—How should EA be advanced to be better used in public ecosystems?—are briefly summarized in Table 4.

Table 4 Summary of the results of the included articles

	Activity	**Method**	**Contribution**	**Connection to the RQ**
Article I	DSRP phases 1 and 6: Problem identification and motivation and Communication (Peffers et al., 2007). Analysis and classification of literature and practitioner definitions of EA in relation to Lapalme's (2011) three schools of thought in EA.	Systematic literature review and practitioner interviews.	Contributes to the conceptual analysis perspective by examining the scope and purpose of EA.	Indicates that the scope and purpose of EA are increasingly shifting from their role in IT-business alignment to include a role as a tool of holistic organizational design, thus motivating the research question of this thesis.
Article II	DSRP phases 1 and 6: Problem identification and motivation and Communication (Peffers et al., 2007). Analysis and classification of literature based on (1) the systems approach applied, (2) the purpose of the study, and (3) whether the study is conceptual or theoretical, or based on or supported by empirical evidence.	Systematic literature review.	Contributes to the conceptual analysis perspective by examining the usage and potential of systems approaches in EA research and practice.	Indicates that EA and systems approaches share common traits and that the field of research relies on some generic system-related truths. Thus, a systems paradigm adapted for EA could enhance the architecture work in public sector ecosystems.

	Activity	Method	Contribution	Connection to the RQ
Article III	DSRP phases 2 and 6: Objectives of a solution and Communication (Peffers et al., 2007). Thematic analysis of 26 practitioner interviews and the qualities deemed as important in public sector EA work.	Practitioner interviews.	Contributes to empirical and normative perspectives; that is, how EA practitioners would like to see EA utilized in a systems-in-environment setting and how EA should be applied in ecosystems in practice. Four qualities—needs-based utilization, co-creation, holistic view—and capabilities) were deemed especially important in public sector EA work.	Proposes guidelines to be used in public sector ecosystem EA: (1) EA work utilizes the capabilities of organizations that participate in the ecosystem; (2) development work is done in co-creation mode; (3) partners of the ecosystem form a holistic view; (4) EA modeling is utilized based on needs.
Article IV	DSRP phases 3 and 6: Design and development and Communication (Peffers et al., 2007). DSR artifact creation based on prior studies.	DSR artifact development.	Contributes to the empirical and normative perspectives by creating DSR artifacts.	Suggests a tentative management model for the government ecosystem architecture as well as tentative functional requirements and design principles for as-is BEA realization.
Article V	DSRP phases 3, 5, and 6: Design and development, Evaluation, and Communication (Peffers et al., 2007). DSR artifact creation and evaluation based on previously created artifacts, relevant literature, and practitioner interviews.	DSR artifact development and descriptive evaluation in the form of informed argument (c.f. Hevner et al., 2004).	Contributes to the empirical and normative perspectives by creating and evaluating DSR artifacts.	Further adjusts the management model for the government ecosystem architecture target state design and outlines principles for government ecosystem architecture management.

Note. DSRP = design science research process, DSR = design science research, EA = enterprise architecture, BEA = business ecosystem architecture.

5 DISCUSSION

This section discusses the main results of this thesis, offering contributions to both theoretical and practical discourses. From a practical perspective, this thesis offers design science artifacts, which can be used in public sector ecosystems EA work. The nature of EA in ecosystems and the qualities deemed important by practitioners in public sector EA work are discussed. Table 5 summarizes the common features of systems approaches in relation to EA concepts and related challenges, forming suggestions for future research from a theoretical perspective. While definitive answers to many of these challenges have to be answered in future studies, some initial answers were derived in the course of this thesis.

Table 5 Common systems features in relation to enterprise architecture concepts and research challenges (adapted from Nurmi, Pulkkinen, Seppänen, & Penttinen, 2019).

Common Features of Systems Approaches	**EA Concepts and Challenges**
Systems consist of wholes comprising parts or subsystems.	View of organizations or enterprises (the unit of analysis in EA studies) as systems or systems-of-systems (with different characterizations).
Systems exist in the midst of their environment and are defined by their boundaries.	EA as a tool for managing enterprise IT and information resources and as a tool for corporate and business strategy within these limits. Challenge: EAM for extended, federated enterprises, networks, and ecosystems.
A system can be described as a static entity (system structure) or through its dynamics, i.e., the processes or transformations in the system.	EA modeling, EA descriptions, business architecture descriptions (e.g., business processes as an element or “layer”). Challenge: Modeling the constantly changing (evolving) enterprise.

Common Features of Systems Approaches	EA Concepts and Challenges
Systems change (evolve) over time.	Current and future EA stages ("as-is," "to-be"). Challenge: The synchronized evolution of related enterprise subsystems and sub-subsystems.
Systems (and subsystems) appear as hierarchical. Levels of complexity are hierarchical.	Enterprise and enterprise segments ("domains"). EA describing systems-of-systems. Challenge: EA management for systems consisting of complex systems, where the subsystems change independently.
Within the system and at its boundaries, there are feedback loops (positive and negative) between the structural elements, potentially influencing the system dynamics.	EA and EAM processes. Challenge: Understanding and supporting the nature of feedback as signals from (sub)system to system within the enterprise.
Systems entail information processing, both within the system and in exchange with its environment.	The information architecture dimension of EA. Challenge: Inclusion of information and data architectures and their management as an integral part of EA and EAM.
System and subsystems are normally "open": they take inputs from and send outputs to the environment and possible adjacent (sub)systems.	EA acknowledges the enterprise environment as having diverse influences on enterprise behavior Challenge: EAM for the open systems-of-systems emerging with the evolution of technologies (e.g., industrial internet of things) and digitalization, with federated, loosely coupled, and independently managed systems collaboration.
System thinking is a holistic approach: it considers the whole when examining parts of the system.	The essence of EA and the strength of EA methodology. Challenge: How well are the current EA methods equipped for the aforementioned challenges, especially considering new technology developments?
Systems approaches allow for an observational position, which provides a holistic perspective of the system.	The enterprise architect. Challenge: In large enterprise and networked settings, the task is too broad for any one role but requires coordinated, collaborative activity, presenting a challenge to methodology.

Note. EA = enterprise architecture, EAM = enterprise architecture management.

Next, these challenges are explored reflecting the systemic nature of EA.

5.1 Theoretical implications

The main theoretical contribution of this thesis is its discussion of EA and EAM ecosystems, thus tentatively answering numerous challenges mentioned in Table 5. These challenges are namely (1) EA and EAM in ecosystems (2) EA and EAM for systems consisting of complex systems, where the subsystems change independently, and (3) EAM for the open systems-of-systems emerging with the evolution of technologies and digitalization with federated, loosely coupled and independently managed systems collaboration.

Some scholars and practitioners have suggested that EA can be best understood through a process of analysis and reductionism, dividing an organization into parts in order to understand how the whole works. While analysis and reductionism are certainly essential components of EA, this thesis has argued that EA should possess a dualistic nature, concerning both complicated and complex phenomena. Cilliers offers an elegant explanation of the difference between complicated and complex things:

> Something that is complicated can have many components, and can be quite intricate, but the relationships between the components are fixed and clearly defined. We can use the analytic method to analyze complicated things, i.e., we can take them apart and put them back together again, like a jumbo jet. Something that is complex, on the other hand, is constituted through many dynamic, nonlinear interactions. Therefore, the important characteristics of a complex system are destroyed when it is taken apart, i.e., when the relationships between components are broken. Living things, language, cultural, and social systems are all complex. (Cilliers, 2000, pp. 1–2)

This thesis has argued that in the context of EA, a complicated phenomenon, such as IT infrastructure or systems architecture, can be understood through structural decomposition and can theoretically be fully modeled. Complex phenomena, such as business architecture, need to be considered with functional analysis and are always modeled incompletely.

5.2 Practical implications

The abovementioned theoretical implications also partly answer the practical challenge of the "inclusion of information and data architectures and their management as an integral part of EA and EAM" (see Table 5), an issue also frequently mentioned by the interviewed practitioners in Article V. Applying systems approaches in EA might be beneficial when combining formal, semi-formal, and informal approaches. As noted by Bernus et al. (2016, p. 96), "EA must encompass both soft and hard systems problems, model complex systems behavior through self-design, and add the human interpretive behavior and cognition to organizations as living systems." Systems approaches might be used to enhance EA research and practice to this effect.

Both complicated phenomena, or hard systems, such as modeling the current state of organizational data and ICT, and complex phenomena, or soft systems, such as the future state of organizations' business architecture, are considered by EA. Thus, public sector ecosystem architecture describes both as complex at a high level, while describing as-is complicated models in more detail. In practice, this means that the architecture of the ecosystems must be responsive and flexible in order to allow for spontaneous changes from the environment and the participating organizations, encompassing these requirements in a sufficient manner. From the participating organizations' point of view, this means that they need to be aware of the architectural coordination of the whole ecosystem. In comparison, from the ecosystem's point of view, the needs and peculiarities of each participating actor need to be considered. The architecture of an ecosystem encompasses design principles and models to manage the whole in sufficient detail (c.f. Hedges & Furda, 2019). Richardson et al. note that the problem of designing complex systems in sufficient detail is well-known in the philosophy of complex systems:

> if a model of a complex system were to be constructed that captured all the possible behaviors contained (both current and subsequent) by the system being represented, then that model must be at least as complex as the system of interest. The reason for this is that there will always be something outside of the boundary (i.e., the boundary inferred by the model) that would affect the system's behavior in some way at some time. (Richardson et al., 2001, p. 9)

This view is in line with prior EA research. Gong and Janssen (2019) note that although the literature often emphasizes the importance of having an overall picture of an organization, this does not mean that all elements are considered in detail. While detailed descriptions might be needed to create value, sometimes an abstract description is enough. Gong and Janssen (2019, p. 6) further note that based on their results, "the landscape is changing and an overall picture of it might become inadequate over time," and "a comprehensive and detailed description of the landscape is often neither feasible nor desirable." According to Gampfer (2019, p. 117), target state architectures should be "described and controlled as lightweight as possible by the central EA in order to enable decision making on a lower level," while as-is architectures "should be centrally documented to provide a basis for enterprise-wide decision making."

Korhonen et al. (2016, p. 276) suggest "a juxtaposition of the three schools of thought on EA with the tripartite approach to EA," which is supported by Korhonen and Poutanen (2013) and Korhonen and Halén (2017). These three schools of thought reflect three approaches to EA: (1) technical architecture, focusing on utilizing as-is IT assets, standards, and development guidelines; (2) sociotechnical architecture, focusing on linking strategy and execution on the managerial level of an organization; and (3) ecosystemic architecture. The latter is

> an embedded capability that not only addresses the initial design and building of a robust system but also the successive designs and continual renewal of a resilient system. The architecture must allow for co-evolution with its business ecosystem, industry, markets, and the larger society. (Korhonen & Halén, 2017, p. 351)

These three approaches reflect Lapalme's (2011) three schools of thought.

The authors conclude that an EA focused only on IT (c.f. enterprise IT architecting [Lapalme, 2011]) is maladaptive. When the business perspective is included (i.e., a sociotechnical architecture [Korhonen et al., 2016]), adaptive capabilities improve (c.f. enterprise integrating [Lapalme, 2011]). However, the best adaptivity is achieved when EA notes the environment of the organization (c.f. enterprise ecological adaptation [Lapalme, 2011]). Korhonen and Halén (2017) also outline some essential qualities of adaptive EA in a multi-organizational digital ecosystem, which include real-time updates instead of periodicals, extensive usage of data to recognize environmental patterns, architectural design decisions, modularity, and technological decentralization. The notion that these qualities are essential to adaptive EA is in line with the results of this thesis. The challenges mentioned are initially answered in this thesis, particularly in Article V; however, in terms of practical application, more research is needed to validate and develop the management model and principles introduced further.

6 CONCLUSION

This thesis discussed the essence of EA as a phenomenon, covering its scope and purpose, theoretical aspects, and practical application in ecosystemic environments. The aim was to generate fresh insights into public sector EA work by applying a systemic lens to develop a theory-based and practically oriented understanding of EA in public ecosystems. The following research question was addressed: How should EA be advanced to be better used in public ecosystems?

The growing relevance of EA research and practice in systemic settings were described in Section 1. Based on the research gap noted by prior studies, the research question of this thesis was derived. Then the contributions of the thesis were described, and a chapter outline was presented. To provide a common understanding of the research field, the foundations of the main concepts—EA, systems approaches, and ecosystems—were described in Section 2. Section 3 discussed the philosophical position of this thesis, outlining the rationale of adopting pragmatism as a basis for this thesis. The DSR methodology was introduced, and its use and relation to pragmatism were discussed. The procedures of the conducted DSR cycles, the systematic literature review, and the practitioner interviews were described in detail. Section 4 then offered an overview of each of the five articles included in this thesis and presented the results of the articles in relation to the aim of this thesis. Thus, the research question was answered. Finally, the results and contributions of this thesis were discussed in Section 5, and concluding remarks were offered.

6.1 Answer to the research question

The research question of this thesis was addressed by clarifying the concepts and the relationship between concepts involved in the problem and determining the role of various conceptual and empirical conflicts in the problem domain. First, the scope and purpose of EA (Article I) and the relations of EA and systems approaches (Article II) were discussed. Second, the practical application of EA in ecosystems (Articles III–V) was addressed by creating design science artifacts.

The main results of this thesis can be summarized as follows. The scope and purpose of EA are shifting from their role in IT-business alignment to include a new role as a tool of holistic organizational design and development in the system-in-environment setting. Accordingly, a systems paradigm adapted for EA could enhance architecture work in public sector ecosystems. In the practical application of public sector EA, (1) the capabilities of organizations that participate in the ecosystem should be utilized, (2) development work should be co-created, (3) partners of the ecosystem should form a holistic view, and (4) EA modeling should be utilized based on needs. Thus, in the ecosystem, EA is based on the interrelationships and interactions of the participating organizations.

This thesis proposes EA as a concept for the organizational design of public ecosystems with the following principles: dual nature, nestedness, openness, flexibility, evolvability, needs-based utilization, modularity, cooperability, BOLDness, interoperability, holism, and circular causality. The introduced management model for public sector ecosystem architectures' target state design consists of four phases, illustrating the process for co-creating new services in the ecosystem: (1) idea co-creation, (2) idea co-evaluation, (3a) current state analysis, (3b) target state design, (3c) gap analysis, and (4) project implementation. Also, an IS solution for EA description accessibility and automated updates in the government ecosystem were envisioned in the design process.

6.2 Limitations of the thesis

This thesis has a few limitations. First, regarding reliability (i.e., the degree of consistency of the results) and validity (i.e., the degree of the accuracy of the results) of the conducted interviews, a few notions arise. As in all interviews, the interviewees (Articles I, III, and V) and the authors analyzing the study material interpret the questions and answers in the moment. This means that although the interviews could be repeated with the exact same layout, circumstances, and interviewees, different sentiments could be expressed. Furthermore, as the interviews were conducted in a single country, different opinions as to the important qualities of public sector ecosystem EA, for example, might occur in interviews conducted elsewhere.

Second, according to Hsieh and Shannon (2005), threats to validity regarding content analysis (Article V) include the risk that the researchers fail to understand the whole context and thus miss key categories. This risk was minimized with analysis triangulation, where two authors both analyzed the data. To enhance the repeatability of the interviews (i.e., reliability), example questions are offered in the appendixes of the included articles, where applicable.

Third, the literature coverage of this thesis could have been more thorough. Systems approaches are numerous, and similar ideas are discussed in many fields of research, such as complexity sciences, operational research, and cybernetics. These fields of research were not discussed in detail, as the aim was not to cover all distinct systems-related concepts but rather to discuss how the overall concepts of systems approaches might complement EA. A demonstration of the management model was considered out of the scope of this thesis, which can be seen as a limitation of the applicability of these artifacts.

6.3 Future research opportunities

Although this thesis offered both theoretical and practical contributions with possible answers to the problem of applying EA in public ecosystems, several research challenges persist. In terms of practical application, more research is needed to validate and develop the management model and principles introduced, both of which need to be applied in practice. Furthermore, the generalizability of the results to other contexts, such as the private sector or public sector in other countries, is left to future studies.

In particular, some challenges, such as modeling the constantly changing enterprise, were not adequately answered in this thesis and should be noted by future research (see Table 5). As previously discussed, it has been argued that traditional EA frameworks cannot be used in systemic environments (Anwar & Gill, 2019; Wieringa et al., 2019), and the current EA methodologies are not suitable for bridging internal and external environments and involving customers, suppliers, business partners, and other stakeholders in building successful ecosystems (Aldea et al., 2018; Pittl & Bork, 2017). This thesis discussed the EA of an ecosystem, partially covering the architectures of organizations that participate in the ecosystem at a given time (see Articles IV and V).

In large enterprise and networked settings, the task is too broad for any one role but requires coordinated, collaborative activity, presenting a challenge to methodology. Although the ecosystem is emergent, systems-wide design and planning can be achieved at various levels. Although all organizations that participate in or join the ecosystem have a high level of autonomy, unnecessary redundancies are avoided with an overarching architectural vision. For example, Hedges and Furda (2019) discuss the role of an ecosystem architect, while Faber (2019) and Yilmaz et al. (2020) discuss collaborative modeling. Gampfer's (2019) results suggest that the decentralization of EA competence and the utilization of "architectural thinking" might be beneficial. Architectural thinking refers to a lightweight approach of thinking and acting throughout an organization, where individuals conducting architectural work are not necessarily experts in the field. When architectural work is conducted by the whole organization (its systems and subsystems), effective communication and ensured interoperability are key elements of effective EAM.

YHTEENVETO (SUMMARY IN FINNISH)

Tässä väitöskirjassa käsitellään kokonaisarkkitehtuuria julkisella sektorilla, kattaen kokonaisarkkitehtuurin käsitteelliset, teoreettiset ja käytännön soveltamisen näkökulmat. Kokonaisarkkitehtuuria tarkastellaan systeemisestä näkökulmasta ja sovelluskohteena on Suomen julkisen sektorin ekosysteemit. Väitöskirja tuottaa uutta tietoa ja uusia näkökulmia julkisella sektorilla tehtävään kokonaisarkkitehtuurityöhön vastaamalla seuraavaan tutkimuskysymykseen: Kuinka kokonaisarkkitehtuuria pitäisi kehittää, jotta sitä voitaisiin hyödyntää paremmin julkisissa ekosysteemeissä?

Ensimmäinen artikkeli käsittelee kokonaisarkkitehtuurin käsitteen systeemistä olemusta, ja niitä määritelmiä, joita aiempi tutkimus sekä Suomen julkisella sektorilla työskentelevät kokonaisarkkitehtuurin ammattilaiset ovat kokonaisarkkitehtuurille antaneet. Toisessa artikkelissa tarkastellaan systeemiteorioiden ja systeemiajattelun merkitystä kokonaisarkkitehtuurin tutkimuksessa, ja pohditaan, millainen teoreettinen merkitys systeemisillä lähestymistavoilla voi olla kokonaisarkkitehtuurin tutkimuksessa ja käytännön soveltamisessa. Kahden ensimmäisen artikkelin osalta väitöskirjan pääasiallisen tuloksena on sen toteaminen, että kokonaisarkkitehtuurin merkitys näyttää olevan laajentumassa kohti organisaatioiden holistista suunnittelua ja kehitystä systeemisissä ympäristöissä, ja systeemisistä ajatusmalleista voidaan saada teoreettista tukea tähän.

Kolme viimeistä artikkelia käsittelevät kokonaisarkkitehtuurin käytännön hyödyntämiseen systeemisissä ympäristöissä, joista esimerkkeinä käytetään Suomen julkisen sektorin ekosysteemejä. Artikkelin III haastattelujen mukaan olennaisia piirteitä julkisen sektorin kokonaisarkkitehtuurin hyödyntämisessä ekosysteemeissä ovat (1) ekosysteemiin osallistuvien organisaatioiden kyvykkyyksien hyödyntäminen, (2) yhteiskehittäminen, (3) holistinen kokonaisnäkemys osallistuvista organisaatioista ja ekosysteemistä, ja (4) kokonaisarkkitehtuurityön toteuttaminen tarveperustaisesti. Viidennessä artikkelissa todetaan, että ekosysteemiarkkitehtuuria kuvaavia periaatteita ovat esimerkiksi sisäkkäisyys, avoimuus, joustavuus, kyky kehittyä tarveperustaisesti, modulaarisuus, holistisuus ja datan hyödyntäminen. Neljännessä ja viidennessä artikkelissa esitetään malli julkisen sektorin ekosysteemiarkkitehtuurin tavoitetilasuunnitteluun neljässä vaiheessa: (1) idean yhteiskehittäminen, (2) idean yhteisarviointi, (3a-c) nykytila-analyysi, tavoitetila-analyysi ja kuiluanalyysi, sekä (4) implementointi. Lisäksi neljännessä artikkelissa kuvataan suunnittelua ja kehittämistä tukevan järjestelmäratkaisun perusperiaatteita. Väitöskirjan ydinsanomana on tarkastella kokonaisarkkitehtuurin julkisten sektorien ekosysteemien suunnittelun ja kehittämisen välineenä.

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ORIGINAL PAPERS

I

EXAMINING ENTERPRISE ARCHITECTURE DEFINITIONS – IMPLICATIONS FROM THEORY AND PRACTICE

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Examining Enterprise Architecture Definitions – Implications from Theory and Practice

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Abstract. This study explores the evolving discipline of Enterprise Architecture (EA) and the various definitions given to EA in literature and by practitioners. Due to the potential benefits, such as business and IT alignment, academics and practitioners have maintained an interest in enterprise architecture. EA has been developed outside scientifically tested foundations, and is characterized by diversified views, seen in varied definitions given to the concept. Prior research has identified the need for conceptual strengthening as a necessity for maturing the discipline. We contribute to this ongoing discussion with a systematic literature review on the state-of-the-art of EA definitions and 26 in-depth practitioner interviews. Our study indicates that while there is still no shared definition of EA, its scope and purpose are increasingly extending from the original purpose of IT-business alignment towards a tool of holistic organizational design and development in the system-in-environment setting

Keywords: Enterprise Architecture, Definition, Literature Review, Interview

1 Introduction

Enterprise architecture (EA) has maintained the interest of academics and practitioners for thirty years. EA is often characterized as a tool for aligning business and IT [1], an issue still judged as one of the top three management concerns [22]. Recently the potential of EA has also been acknowledged as a means to cope with the increasingly challenging and continuously changing problems that emerge from, e.g., digitalization, new technological innovations, and progressive complexity of business models and environments [19].

Definition of enterprise architecture varies by its use [18, 39] and a number of definitions have been suggested [35]. Lack of common understanding concerning the scope and meaning of EA occurs among researchers and practitioners [18, 30], which leads to difficulties in structuring a baseline of knowledge in the field [31] and makes it complicated to talk about EA as a discipline [32].

The need for examining various definitions of EA has been noted by previous research. For example, [14] state that a clear academic definition should be established, as well as unified understanding of the separate terms “enterprise” and “architecture”.

[32, p. 81] state that "It is clear there are not enough relevant publications about this theme [lack of shared meaning] even within the increasing publication on EA." In addition, [31] note that the few studies focused on the lack of common understanding have not used a systematic methodology.

EA is an evolving discipline, with its roots outside scientifically tested foundations. Recently various systems approaches have been applied in EA research, and the idea of viewing enterprises as systems has had a growing support [3, 19]. The systemic stance on the research of organizational development has a steady support in related fields, such as enterprise engineering and system of systems engineering, and similarities between EA and various systems approaches can be seen [27]. For example, some common elements covering systems thinking and systems theories are the following: systems approaches are holistic; systems consist of wholes comprising of parts, or subsystems; systems exist in the midst of their environment, are defined by their boundaries and evolve over time; system and subsystems appear hierarchical and can be "open", i.e. they are taking inputs from and sending outputs to the environment [25].

Prior research in the field of EA (e.g. [9, 10]) discusses the systemic nature of an enterprise, and the demand to study the relations between the EA and systems approaches has been phrased [3, 19]. [15, p.93] notice that "[…] the EA trend of applying holistic systems thinking, shared language, and engineering concepts, albeit in the early stages of their application, is here to stay". Furthermore, [30, p. 138] state the "importance of systems thinking and, especially, of adopting the open systems principle, for managing EA design and evolution". Applying holistic principles and system-in environment paradigm in the field of EA is discussed by Lapalme [18], according to whom the diversified views about the scope and purpose of EA can be classified as three schools of thought (see Section 4). These taxonomic classes include Enterprise IT architecting, Enterprise integrating, and Enterprise ecological adaptation. The latter two require, according to [18], holistic principles and apply system-in-environment paradigm.

In this paper, we address the call to find a steady definition of EA that would be shared by both academics and practitioners. We do this by focusing on the streams of studies that have applied systems theories or systems thinking to the EA problem domain. These are not only found as a promising branch in the EA research but also it can be assumed that the systems orientation would encourage the researchers to emphasize the conceptual accuracy. In the light of the previous considerations, the research question of this paper is: How convergent are the definitions of EA by academics and practitioners? Therefore, the goal of this paper is twofold. First, we review the previous systems-oriented EA research and compare the definitions presented therein with Lapalme's [18] "Schools of thought on Enterprise Architecture" to see how these taxonomy classes encompass different views perceivable within the said studies. Then, we analyze the data from 26 in-depth practitioner interviews to find whether the practitioners' perceptions regarding the current nature and objectives of EA do reflect the same ideas.

The remainder of this paper is structured as follows: first, the concept of enterprise architecture is discussed in Section 2. Then, in Section 3 the research methods of this study, i.e. the systematic literature review (SLR) and semi-structured interviews, are discussed. Section 4 present the analysis and the discussion on the results of the SLR and the interviews. Finally, Section 5 discusses the results, concluding remarks from the presented state-of-the-art account of enterprise architecture definitions are given, and topics for the future research are presented.

2 Prior Research on the Concept of Enterprise Architecture

Some work regarding the definition of EA, or the lack thereof, exists. Previous studies have been conducted as analyses of extant literature as well as reasonably large-scale survey studies. In this section, we briefly review representative examples of the both approaches.

[35] reviewed a total of 126 EA related research papers from 1987 to 2008 and concluded that majority of these do not define enterprise architecture in a comprehensive way. Similar results have been published by [32], whose systematic mapping study discussed 171 journal articles from 1990 to 2015 and concluded that 35 % of examined articles do not define enterprise architecture in any way, 35 % mention challenges due to divergent understanding of EA, and 47 recently (2006-2014) published papers mention the lack of shared meaning in the discipline of EA. Furthermore, [31] identified and analyzed 145 definitions. According to their analysis, 42 % of the articles did not present a definition for EA. [30] conducted a literature review covering 85 articles and identified four strands of definitions: the methodology or process guiding the design of EA, the set of principles prescribing the EA design, the blueprint of an enterprise in its various facets, and the inherent structure of an enterprise.

[14] conducted a survey study with 376 responses from executives, enterprise architects and various other professions. The goal of their study was, among others, to examine how the respondents defined the purpose and function of EA. According to the results [14], the purpose and function of enterprise architecture is, respectively, to provide an organizational blueprint, to be a planning tool, to facilitate systematic change, to act as a tool for decision making or alignment, and to help in communicating organizational objectives.

Similarly, [23] compared practitioner and researcher definitions of EA with an interpretation method and conducted a LinkedIn survey of 308 participants. Their results indicated the correspondence between the views of academics and practitioners. [23] used the hermeneutic phenomenology-based interpretation method to compare these results, along with academic definitions gathered by [6] against EA definitions given in TOGAF and Zachman Framework. The results suggest that definitions presented in the latter are partially supported when compared to practitioner definitions. Regarding academic definitions collected by [6], TOGAF was found to be fully supported and Zachman Framework mostly supported.

Although there is some prior research discussing the evolving definition of EA, scholars and practitioners seem to struggle to establish a definitive and commonly agreed definition for the concept. More unsettling is that a significant number of research papers make no attempt to define EA at all. While above mentioned studies make valid contributions on defining EA and fostering shared understanding, the definitive agreement remains still to be found, though often asked in prior research.

3 Methods of Study – Literature Review Protocol and Semi-Structured Interviews

In this section the research methods of this study, namely the systematic literature review (SLR) and semi-structured interviews, are discussed. In order to ensure a comprehensive look on the state-of-the-art account of systems-oriented EA definitions, we screened the prior literature broadly. To see whether the practitioners' perceptions regarding the current nature and objectives of EA reflect the same ideas that literature states, we conducted 26 in-depth practitioner interviews, and compared the distributions between the sources. Next, these methods of study are discussed in more detail.

3.1 Literature Review

In our literature review, we followed the guidelines suggested by [40]: formulating the problem, searching the literature, screening for inclusion, assessing quality, extracting data, and analyzing and synthesizing data.

To ensure a comprehensive look into the state-of-the-art of systems-oriented EA research, relevant literature was searched from Google Scholar, Scopus and IEEE Xplore Digital Library, and to ensure broad enough literature coverage, journal and conference articles as well as books were considered. [40] also make a notion that the review process should be described. This study had the following inclusion criteria. First, we used the following search string: "enterprise architecture" AND ("system thinking" OR "systems thinking" OR "system theory" OR "systems theory"). Second, as the EA is an evolving research area, we excluded all the work not published in the 21st century. Third, the studies had to be written in English and accessible. Due to limited options in filtering the search results in Google Scholar, the amount of initial results was extensive, a total of 3457 results was found. Even the advanced search in Google Scholar allows only two options for search terms to appear: either in the title of the article, or anywhere in the article. We chose to allow the search terms to appear anywhere in the article, and manually screened the titles, abstract and keywords of the articles, until the research material was saturated. As we aimed to review particularly the previous systems-oriented EA research and compare the definitions presented therein with Lapalme's [18] "Schools of thought on Enterprise Architecture", we included articles, that explicitly defined enterprise architecture and mentioned some systems approach.

By using these criteria, 156 studies were chosen for a more thorough inspection. After excluding articles which did not contribute to our research question, we found 35 papers that presented an EA definition suited for the further analysis, were included to the study.

3.2 Practitioner Interviews

This study is part of a qualitative longitudinal research project researching the implementation of the Finnish national enterprise architecture method. The research constitutes of two rounds of semi-structured, in-depth interviews. The aim is to understand different stakeholders' views in a particular context. This study is a cross-sectional analysis of the meanings interviewees have on the EA concept in the second-round interviews.

The second round of data was collected from 26 semi-structured interviews during the summer 2017. The interviewees represented stakeholders from different levels and sectors of Finnish public administration and IT companies (Table 1). The selection of interviewees was based on purposeful sampling [28] in order to capture variation in the data in terms of both assumed information intensiveness and stakeholder population. In one interview there were two representatives of one city simultaneously.

The interview questions concerned the respondents' views of current and future condition of the Finnish national EA. The interview themes and related questions were derived from the results of our previous studies. The interview questions were divided into four parts: questions of 1) background information of interviewees, 2) previous situations, 3) current situation, and 4) future of EA. The questions covered macro- and micro-level issues. Past- and future-related questions covered issues of Finnish national EA and interviewees' perceptions of how it has affected their own work. Current situation questions were different for the interviewees from the public and private sectors. Interviewees from the public sector we asked questions about EA in the organizations they represented, and interviewees from the private sector we asked questions about their public-sector client organizations. The interviews lasted from 36 to 100 minutes, the average being 63 minutes. The interviews were transcribed and analyzed with the ATLAS.ti software.

Table 1. Interviewees' occupational position and experience

Organizational level	ID	Experience in EA (years)
State administration	PSstate1	14
	PSstate2	12
	PSstate3	10
	PSstate4	8
Administrative sector	PSsector1	15
	PSsector2	15
	PSsector3	15
Civil service department	PSdepartment1	10
	PSdepartment2	16
	PSdepartment3	40
	PSdepartment4	10
City	PScity1a	10
	PScity1b	20
	PScity2	10
	PScity3	3

	PScity4	10
IT company manager	ITmanager1	13
	ITmanager2	15
	ITmanager3	17
	ITmanager4	15
	ITmanager5	18
IT company worker	ITworker1	15
	ITworker2	10
	ITworker3	33
	ITworker4	27
	ITworker5	10
	ITworker6	14

4 Analysis and Results

As seen in previous research, EA is characterized by lack of shared meaning and absence of theory. Recently, the relations between EA and systems approaches have been discussed, and the idea of viewing enterprises with a systemic stance seems to have a growing support. Lapalme [18], has presented the "three schools of thought on enterprise architecture", each of which differ in scope and purpose given to the EA. These taxonomic classes include Enterprise IT Architecting, Enterprise Integrating, and Enterprise Ecological Adaptation. While for the first one a mechanistic stance can be applied, [18] argues that the other two require principles of holistic and systemic approaches. According to [18], each of the classes constitutes a different definition to EA, as well as concerns, assumptions, and limitations towards the discipline and its practice. [18, p. 37] also argues that this taxonomy "creates a starting point for resolving terminological challenges to help establish enterprise architecture as a discipline." Moreover, the taxonomy classes serve as a solid basis for examining the recent trend of applying systemic approaches on EA. To examine how convergent are the definitions of EA by academics and practitioners, and how well different schools of thought represent them, we base the analysis of our qualitative data on the taxonomy's classes, which can be summarized as follows (c.f. [18]):

1. Enterprise IT Architecting: Here the scope predominantly covers the IT assets of an enterprise and the various operations that use the IT capabilities. The purpose is to reduce IT costs through technology reuse and by eliminating duplicate functionality.
2. Enterprise Integrating: Here the scope extends to cover all the facets of an enterprise with the purpose to support the strategy execution by maximizing the coherency of the interwoven structure of various aspects within an enterprise including, but not focusing only, on the IT.
3. Enterprise Ecological Adaptation: Here the scope reaches to the surrounding environment of an enterprise with the purpose to enable organizational learning, innovation and system-in-environment adaptation.

Definitions found from literature and given by practitioners were classified to the schools of thought. If certain definition did not, in terms of scope and/or purpose, particularly represent any of the three classes, it was classified as “Other”. As seen in Table 2, definition of EA varies by the source.

Table 2. Classification of the EA definitions presented in the literature and proposed by practitioners

	Enterprise IT Architecting	Enterprise Integrating	Enterprise Ecological Adaptation	Other	Total
Literature	[8]; [9]; [12]; [38]; [43]; [45]; [46]	[4]; [7]; [17]; [20]; [21]; [33]; [34]; [36]; [41]; [42]; [50]	[3]; [5]; [16]; [19]; [29]; [44]; [47]; [48]; [49]	[1]; [10]; [11]; [13]; [15]; [24]; [26]; [37]	35
Practitioner	ITworker1	ITmanager1; ITmanager2; IT-worker2; ITworker5; PScity1; PScity2; PScity4; PSdepartment3; PSdepartment4; PSsector2; PSstate4	PSdepartment2: PSsector1; PSsector3; PSstate1; PSstate3	ITmanager3; ITmanager4; ITmanager5; ITworker3; ITworker4; ITworker6; PScity3; PSdepartment1; PSstate2	26
Total	8	22	14	17	61

The definitions found in the literature and given by the interviewed practitioners appear to distribute somewhat similarly over the classes. Neither does the chi-square analysis (4.4711, $p = .215$) of the contingency table suggest that the variables would be dependent. There is no statistically significant difference between the distribution of the definitions presented in the literature and of those proposed by the interviewees.

Seven literature definitions and one practitioner definition were classified to Enterprise IT Architecting school of thought. In this school of thought EA was defined e.g. as addressing the integration of the IT resources and of business resources [45]; as a discipline that addresses the alignment of IT systems with business [46]; and as a framework or tool through which systems can communicate and function together (ITworker1).

Eleven literature and eleven practitioner definitions were classified to Enterprise Integrating school of thought. The definitions included e.g. the following: EA refers to a comprehensive description of all the key elements and relationships that fully describe an enterprise [17]; EA is the planning of all resources under the control of an enterprise, not just IT resources [50]; EA describes the whole and the interconnections, it discusses development, operation, IT systems and technology (ITworker5); EA is a method that concerns wholes and its interconnections, a systematic approach to organizations, business processes, knowledge and systems (PSstate4); and EA is a catalyst between strategy and execution (PSsector2). Two definitions from the literature [20, 21] were included to Enterprise Integrating school of thought, because they applied systemic stance as opposed to mechanistic stance, although they defined EA as a mean to integrate IT and business resources.

Nine definitions from the literature and five from the practitioners were classified to Enterprise Ecological Adaptation school of thought. Here EA was defined e.g. in the following ways: the goal of an EA project is to define and implement the strategies that will guide the enterprise in its evolution [44]; as the fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution [48]; as thinking and acting, with the implication that "thinking is good design and describing and acting is making things and changes to happen, and leading the change" (PSdepartment2); and as a design idea which concerns the whole and takes different aspects into account (PSstate1).

Eight literature definitions and nine practitioner definitions were classified as "Other". These definitions, although had much of the same features as other definitions, did not accurately represent any single schools of thought regarding the scope and/or purpose of enterprise architecture. These include, for example, EA as a tool for developing documentation for decision makers (PSdepartment1) and EA as a system formed of specific components with distinct attributes [24].

Interestingly, twelve interviewed practitioners defined EA as a tool, but only one literature source [29] considered EA from this point of view, i.e. as a practical appliance. This might indicate differences between the orientations of academic research and practitioner usage of EA. As noted by [23], from a practitioner perspective, a thing, such as EA, has the value based on its applications, whereas from an academic perspective, a scientific meaning is also of value. Therefore, practitioners might see EA more from a practical perspective, as a tool and the affiliated value propositions.

Many practitioners seem to define EA as a business-oriented tool to design and develop organizations, concerning the whole organization from a holistic perspective, and not just its IT-related aspects. Also, several practitioners pointed out that the EA should not only be the concern of the IT management but rather an organization-wide issue. This notion is also made in prior research. For example, the results by [30] challenge the association of EA being solely an IT-related subject and conclude that the definitions of the scope of EA can be divided into three strands: EA concerns IT elements; EA concerns business capabilities and IT elements; and EA concerns business strategy, business capabilities and IT elements. Although our results are in the same vein, regarding the scope, our practitioner results differ from the results of [30]. Where majority of the research cases in [30] seemed to associate the scope of EA as an IT issue, our results indicate that the scope of EA is extending to more broadly cover the organizational design and development. Although there seems to be differing opinions about the scope and purpose of EA, our results indicate that a systemic stance, as opposed to a mechanistic stance, in defining EA seems to be dominating.

5 Discussion and Conclusions

The aim of this study was to contribute to the discussion concerning the evolving definition of enterprise architecture. We conducted a systematic literature review, evaluated prior research and discussed the findings from 26 in-depth practitioner interviews. We compared the EA definitions presented in the literature and by practitioners with Lapalme's [18] schools of thought to see how well these encompass different views perceivable in the EA research. Our study indicates that while Lapalme's schools of thought represent the majority of found definitions, also differing definitions could be found. Notably, the two schools of thought applying holistic thinking and systemic approach, Enterprise Integrating and Enterprise Ecological Adaptation, covered the major part of the presented definitions. Enterprise IT Architecting was the class into which the smallest number of definitions fitted, and only one practitioner considered EA from this perspective. It seems that the scope and purpose of the EA are increasingly extending from the original purpose of IT and business alignment towards a tool of holistic organizational design and development in the system-in-environment setting.

There are few limitations to our study. The literature analysis was done solely by the first author. The data from the practitioner interviews were analyzed by the first two authors, yet the intercoder reliability was not tested. Therefore, it is possible that the results reflect some accents of the individual researchers. Also, due to the extensive volume of definitions given to the enterprise architecture, we could not include all of these in our analysis. In terms of the literature coverage, we could have used different or more general search terms. Still, we believe that the included articles well represent various definitions given to EA, and that the research material was saturated [40]. To ensure the reliability, we described the methods of our study as transparently as possible. As EA is an evolving discipline, also the definitions are expected to evolve. This means that with the same search phrases, different results could occur in the future. Similarly, the interviewees uttered their individual views at the time the research was conducted.

Concerning the recent trend of applying systems approaches in the field of EA, their characteristic elements seem to resonate with the identified EA definitions. One common trait of various systems approaches is to consider systems as wholes, consisting of interrelated subsystems. Similarly, Lapalme's Enterprise Integrating school sees enterprise holistically, where "different aspects of the organization form a complex fabric of reinforcing and attenuating dynamics". Several practitioners and definitions presented in the literature stated that EA should concern the whole enterprise, including interconnections between different parts. Furthermore, a common trait of different systems approaches is to consider systems to evolve over time. Enterprise Ecological Adaptation school of thought sees EA as means of "fostering organizational learning by designing all facets of the enterprise - including its relationship to its environment - to enable innovation and system-in-environment adaptation" According to the interviews, EA is frequently seen as a tool for organizational design and development.

Although Lapalme's taxonomy classes seem to represent current definitions of EA moderately, the inclusion criteria for different taxonomy classes are not entirely unbiguous, and several included definitions did not fit to any particular class either by the scope or the purpose. Future research should examine if these classes accurately represent the evolving definitions of different EA communities, and possibly suggest a different taxonomy. According to the results from practitioner interviews, EA was frequently seen as a tool, a supporting function or a method amongst other methods, with which to design and develop organizations. This practical viewpoint is not distinctly included in the examined taxonomy classes. Also, while definitions are scattered, both academic and practitioner communities seem to favor a systemic stance. There is a clear need for further research discussing the implications of systems thinking in EA.

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II

SYSTEMS APPROACHES IN THE ENTERPRISE ARCHITECTURE FIELD OF RESEARCH: A SYSTEMATIC LITERATURE REVIEW

by

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Systems Approaches in the Enterprise Architecture Field of Research: A Systematic Literature Review

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Abstract. This study explores the use of the systems approaches (systems thinking and systems theories) as the theoretical underpinnings for Enterprise Architecture (EA) research. Both the academic and the practitioner communities have maintained an interest in EA due to its potential benefits, promising for the recent technological and business advances. EA as a research area is, however, characterized by diversified views depicted in different definitions of the concept, and no acknowledged common theoretical foundation. A number of prior studies have noticed this gap in the EA field of research, and called for a strengthening of the theory of EA. Variegated systems approaches have been suggested as a theory base. The aim of this study is to examine if, and to what extent the systems approaches could provide a common theoretical foundation. We contribute with a systematic literature review on the state-of-art of systems approaches in EA research. We find that the systems approaches are, indeed, frequently referred to in the EA studies. However, as of yet, the application of these theories appears to be fragmented, and the approaches are rarely systematically used in empirical studies. We discuss the findings, reflecting to the types of theory and the use of theory in our area of research.

Keywords: Enterprise Architecture, Systems Thinking, Systems Theory, Systems Approaches, Literature Review.

1 Introduction

Enterprise architecture (EA) appears to maintain some interest in research. This might be due to the potential solutions it offers to some of the present problems organizations face with the current emerging technologies and growing complexity [36]. EA presents a tool for alignment between business and IT, an issue still judged as one of the top three management concerns [37]. Further, some evidence of business benefits attained with this approach have been brought up recently [52].

Definition of enterprise architecture varies by its use [35, 42, 58]. However, we start out by defining EA loosely as an approach to manage, plan and develop enterprises and their IT. As a unit of analysis, enterprises or organizations, that, even if networked or federated and thus depending on their environments, have some decision-making authority over their own resources and their goal setting (See e.g. [23]; Definition 2.7). The need for an architectural approach to the management of the business-IT alignment emerged with the diffusion of IT and the emergence of networking technologies already decades ago. Technology developments today keep driving the need, giving new emphasis to the vision: "enterprise analysis tools that are growing in importance and are likely to become mandatory for any business that continues to grow and evolve" [65]. This outlines the need for an approach to apply to at least medium or large size organizations. The need appears in the context of the use of IT in organizations. The term 'enterprise architecture', was coined later, and its focus has been enlarging to cover also the strategic planning [29, 45], to support the business and IT alignment [47].

Various systems approaches are applied in EA research, and the idea of viewing enterprises as systems finds support in the related research areas. In management science, the research of management and organizations, systems theory used to have a strong resonance, summarized in a related special issue of the Academy of Management Journal [1], however, the interest appearing to fade over time [3].

For EA, an early example of systems theory use is the Systemic EA Method (SEAM) [62]. Recently, Santana et al. [49] conducted a literature review and a description of EA network analysis that sees enterprises as complex networks. Fu et al. [17] discussed complexity cybernetics in relation to EA, and, based on an analysis of 33 papers, concluded that despite growing interest, neither EA cybernetics, nor other systems approaches have been yet established as a theoretical foundation for studies in this field. Lapalme [35] encourages taking on the systems thinking and system-in-environment paradigms for the evolving EA approach.

The need for an acknowledged theoretical foundation for EA has been noted by previous research [e.g. 26, 27, 7]. Several other studies [e.g. 20, 22] have discussed the systems nature of an enterprise, and researchers have noted a need to strengthen the theoretical roots of enterprise architecture as well as to study its relations to other fields, such as systems thinking [5, 36]. For example, Kappelman and Zachman [30] point that "[...] the EA trend of applying holistic systems thinking, shared language, and engineering concepts, albeit in the early stages of their application, is here to stay". Furthermore, [45] state the "importance of systems thinking and, especially, of adopting the open systems principle, for managing EA design and evolution".

The aim of this study is to find indications, if, and to what extent, the systems approaches could provide a common theoretical foundation for EA. We conduct a systematic literature review to answer the research questions:

- RQ1: To what extent different systems approaches are already in use in EA research?
- RQ2: What aspects of theory do the systems approaches cover in earlier studies?

The remainder of this paper is structured as follows: First, the concept of enterprise architecture is presented in Section 2. Next, Section 3 presents and briefly discusses the systems approaches, and the elements shared across the different approaches. Additionally, we take a look into the significance of theory for a research area. In Section 4, the research method of this study, the systematic literature review (SLR) protocol is presented. Section 5 and 6, respectively, present the analysis and discussion of the SLR results. Finally, we conclude with some remarks on the state-of-art account of the systems approaches to the field of EA, and questions opening for future research.

2 Enterprise Architecture as an Evolving Research Area

Some work regarding the various definitions of EA already exists. For example, Schönherr [51] discusses a total of 126 references from 1987 to 2008 and concludes that majority of these do not define EA in a comprehensive way. Different language communities are discussed by Schelp and Winter [50]. Rahimi et al. [45] and Saint-Louis et al. [48] conducted comprehensive systematic literature reviews in order to find definitions of EA, and Kappelman et al. [31] discuss the development of EA definition. Also, Korhonen et al. [34] discuss the possible reconceptualization of EA. While these studies make valid contributions, the nature of the complex field of enterprise IT and systems is still not captured in a single definition for EA, even if the need is pointed to by several authors [e.g. 48].

In the field of information systems (IS) research, the area to which IT in an organizational setting is foremost related to, the basic unit of analysis is traditionally an information system. EA, however, as an approach is suggested to cope with the planning and management of a number of systems within an enterprise. The unit of analysis thus is the enterprise, or organization, with numerous systems that is naturally leading to the idea of *a system of systems*. As a baseline theory, the systems thinking, and related theories thus seem to come close.

According to Romero and Vernadat [46], EA, in the form of the EA frameworks, has historically been developed parallel in two different communities – the IS, and the industrial engineering community. Bernus et al. [5] state that EA originates in the disciplines of management, IS and engineering. In IS and management science, the work of e.g. Zachman [66], and Spewak and Hill [54] have been seminal. Within the engineering community, the focus is to engineer the information and material flows of the whole enterprise – hence the term enterprise engineering (EE). Later, the scope of the engineering community extended to cover the whole enterprise and its business networks, including e.g. supply chain [46] and to further rationalize and specify the focus on essential elements of EA [44]. Ambiguity concerning the definition of EA may be partly due to its origins, and Bernus et al. [5] point, that there is a gap between originally intended scope and the present-day scope of EA. However, for the engineering communities (software, systems and enterprise engineering), the “system of systems” engineering (SoSE) the systems nature of the research area is self-evident [18]. We acknowledge this as a related area, but not included in our study.

In order to explore the literature in the EA area, an initial definition should be stated. We cite Lapalme et al. [36], who build their definition upon the ISO/IEC/IEEE 42010 standard: "EA should be understood as being constituted of the essential elements of *a socio-technical organization*, their relationships to each other and to their changing environment as well as the principles of the organization's design and evolution. Enterprise architecture management is the continuous practice of describing and updating the EA in order to understand complexity and manage change."

3 Systems Approaches – a Theory for the EA Research Area?

According to Mingers and White [40], systems approaches emerged in early to mid-1900's, and were developed, among others, by von Bertalanffy [60] in the form of Systems Theory, and further, by Wiener [64] and Beer [4], who discussed with these approaches among other things cybernetics. Arnold and Wade [2] note that systems thinking was coined by Barry Richmond in the late 1980's, and define systems thinking consisting of elements, interconnections and a purpose. Probably the most applied General Systems Theory (GST) approach in the IS field of research is the nine-fold hierarchy of Boulding [9] presented initially to the management field of science (see e.g. [1]). It has found resonance in the study of IS-related semiotics through the work of Stamper [55, 56], that continues to impact as an underlying theory in foundational research on enterprise modeling [8]. Relying on Boulding, Daft and Weick [13] lay out a theoretical baseline for organizational information and the management and processing of information in organizations, well-cited within the IS field.

As a practical application, Checkland [12] developed the Soft Systems Methodology to support the systemic organizational design and change, and in order to serve these goals, to enhance the involvement of stakeholders at the implementation of technical systems. In the same vein, Senge's [53] learning organization as a further application of systems idea to organizational development take on this approach to stress the interdependencies within the organizational subsystems, and the socio-technical system perspectives. Mingers and White [40], use the generic term *systems approaches* to cover systems related lines of research (“theory” or “thinking”). They discover the following common elements, reflected here for the setting of EA.

- Systems consists of wholes comprising of parts, or sub-systems.
- Systems exist in the midst of their environment and are defined by their boundaries.
- A system can be described as a static entity (system structure), or through its dynamics, i.e. the processes, or transformations in the system.
- Systems change (evolve) over time.
- Systems (and subsystems) appear as hierarchical, and there is a hierarchy of levels of complexity.
- Within the system and at its boundaries, there are feedback loops (positive and negative) between the structural elements, potentially influencing the system dynamics.
- Systems entail information processing, regarding both the system and in exchange with its environment.
- System and subsystems are normally “open”, i.e. they are taking inputs from and sending outputs to the environment, and possible adjacent (sub-)systems. (This influences the analysis of a system, its components and their evolution.)
- System thinking is a holistic approach, i.e. taking into consideration the whole also in the examination of parts of the system.
- Systems approaches afford for an observer, i.e. a point of view, or a position taking a holistic perspective to the system.

For the EA-related EE research area, we find a thorough elaboration on enterprise engineering *theories* [15]. Further, some questions on the role and the nature of theories in the field of IS have been elaborated [19]. In accordance, to find a theory or theories for a research focus area, the following points or basic questions are involved:

- *Establishing the domain*. What are the characteristics of the domain of interest? What phenomena are in the focus of the study, and what problems are to solve? [19] The outlining of the disciplinary boundaries is done by applying a standard definition of organization for enterprise. Further delineation are the problems related to the IT in the organizations in questions going *beyond one information system*. Single information systems (with their entire life cycles) are dealt with in various research areas within the IS field of study.
- The *ontological* theories [15], or the structural or *ontological* questions [19]. Although theory for EA is claimed missing, it appears that the research has indeed brought forth several suggested ontologies, the Zachman [66] Framework as the most prominent one. Suggested structures ("contributions to knowledge", or expressions of theory [19]) for the area are abundant, but none commonly accepted. Neither are patterns for research questions or the resulting claims [19].
- The *epistemological* questions relate to the nature of knowledge in the research area [19]. This raises questions of how to capture, and by which methods to validate and verify knowledge. Dietz et al. [15] thus join with epistemology also logics, mathematics and phenomenology. With the complexity of the research target, this apparently presents challenges to both the research, and to the question of the theoretical base. With different viewpoints to EA, different epistemological foundations and research methods not only apply but are fundamental.
- Gregor [19] points also to the broader environment, where the research is undertaken: The influential socio-political questions, seen by Dietz et al. [15] as a category of *ideological theories*. The related questions remind of the role of diverse stakeholders within and outside of the research area, and further, the complexity of social behaviors, and the challenges of objectivity in research.
- Further, Dietz et al. [15] see the *technological theories* as a distinct category in their theory framework. This seems to map to the theory for "design and action" [19]: to know how to accomplish something in reality.

For EE, Dietz et al. [15] propose eight specific kinds of theory for the different aspects of enterprise and the diverse systems belonging to enterprises. Systems approaches, or their applications [e.g. 60, 10, 12] are pointed at as the basis of several of these theory classes, emphasizing the relevance to the enterprise systems area. In our exploration on theories in the area of study, it is of interest what the theory offers for the research, and to what extent it is indeed applied. The five functions of theory listed in [19] give a starting point:

1. *Analysis*: 'what is', i.e. the ontology and structure of the focus area. At this level, the theory remains descriptive, showing elements and relationships, but not making inferences to causality, or making predictions.

2. *Explanation* – extends analysis with explanations, also attempting to answer the questions how, why, when, and where. However, this does not imply prediction or hypotheses.
3. *Prediction* – the theory allows for developing predictions and hypothetical propositions but does not explain causalities.
4. *Explanation and prediction* – the theory answers the questions what is, how, why, when, where, what will be. It allows for developing testable hypotheses, predicts the future states, and provides causal explanations.
5. *Design and Action* – an applicable theory, that *prescribes* how to do or achieve something, meaning the development of articulate instructions (as e.g., methods, techniques, principles of form and function) for constructing an artifact.

We seek to find out, how the systems approaches are reflected in the EA research and in the use of theories in it presently, and discuss if a potential could be detected for a common theoretical foundation.

4 Method of Study: Literature Review Protocol

According to Templier and Paré [59], leading researchers, e.g. Webster and Watson [61], have noted the relevance of publishing quality standalone literature reviews. In an attempt to strengthen the theoretical foundations of EA, we conducted a comprehensive systematic literature review. We followed the guidelines proposed by [59], hence our work included the following phases: (1) formulating the problem, (2) searching the literature, (3) screening for inclusion (3) assessing quality, (4) extracting data, and (5) analyzing and synthesizing data.

To ensure a comprehensive look into the contributions of systems paradigms on EA we chose to look for relevant literature from three databases: Google Scholar, Scopus and IEEE Xplore Digital Library. We used the following search phrases appearing anywhere in either the title of the article, in abstracts or in keywords: "enterprise architecture" AND ("system thinking" OR "systems thinking" OR "system theory" OR "systems theory"). The search was conducted in February 2018.

Initially, a total of 3457 results was found, 3380 of these from Google Scholar, 71 from Scopus and 6 from IEEE Xplore Digital Library. The amount of initial results was extensive, mainly due to Google Scholar's search algorithms and limited options in filtering the search results. Google Scholar's "Advanced search" allows search terms to appear either in the title of the article, or anywhere in the article. To find all the relevant articles, the search terms were allowed to appear anywhere in the article. In terms of literature coverage, we aimed to conclude the search and selection process when the research material was saturated [59, 61]. In order to gather all relevant literature, the first 960 papers from Google Scholar and all papers from Scopus and IEEE were screened. At this stage, we read the titles, abstracts and keywords of the articles, and included those that mentioned EA and referenced "systems thinking" or some systems theory. We included journal and conference articles as well as books. We excluded articles that were not written in English as well obviously those that were inaccessible.

156 articles and books were chosen for a more thorough inspection. Also, 18 articles found with forward search were included. After crossing out the doubles and excluding articles that did not contribute to the research question, we ended up with a total of 47 publications (see Appendix).

5 Results and Analysis

The included studies were published in various journals and conferences, although the systems nature of enterprises has been mostly discussed at the Hawaii International Conference on System Science (7 items), IEEE International Conference on Systems, Man and Cybernetics, International IEEE EDOC Conference, and the Journal of Enterprise Architecture (5 each). In retrospective, a broad search covering also less well-known journals and conference proceedings was needed. Our sample shows varying quantity per annum. Eight articles were published 2012 (most publications), while only one article was published in 2008 and 2015, none in 2004. Although we did not have preconceived inclusion or exclusion criteria concerning the year of publication, all the included articles were published 2000 onwards.

Several systems theories, e.g. General Systems Theory [e.g. 22], Living Systems Theory [e.g. 63] and Complex Adaptive Systems [e.g. 25] are taken as underlying theory. Further, Viable System Model [e.g. 68], simply System of Systems [e.g. 57], and own coinages such as "complex adaptive living system" [#27], appear in EA studies. Most studies did not name a particular theory, but refer to Systems Thinking [e.g. 43], (which however has been theorized as well [11]), or merely to "systems theory" [e.g. 39], without specifying which approach the study relies on. Notably, not only several different approaches came up, but multiple studies mention more than one systems approach.

According to the analysis of the articles included, *enterprises* are perceived as a type of *system*. There are mentions of *a system of systems,* some kind of a *complex system*, such as a [*complex*] *socio-technical system,* or *complex network,* if not a *Complex Adaptive System*. GST, Systems Thinking and an unspecified "systems theory" are the most frequent theoretical starting points. Enterprise architecture is defined in a number of ways, most often as a comprehensive view of an interconnected and networked whole of an organization with multiple information systems, possibly in two different states: as-is and to-be.

- This reflects to the first fundamental question to develop theory: Establishing the research domain, in this case EA. We can conclude that the systems nature of the target domain is widely recognized.

For the question on ontology, systems elements have been suggested. E.g. Wegmann [#1] notes that "an enterprise is a system in which the components are the enterprise's resources". Schuetz et al. [#32] see that "Following a system theoretical perspective we consider EA as a system, consisting of components (or 'things') and relations", also making a very clear relation between the two and reflecting the basic concepts of systems approaches. Santana et al. [#44], reflecting the ideas of the theory of Complex

Adaptive Systems, define EA as a "complex network" and elaborate it as an "interwoven system of strategic goals, business processes, applications and infrastructure components", which "is subject to a variety of relationships and dependencies among its several components."

Table 1 classifies the 47 articles based on the dominant systems approach referenced in each study. We classify the studies according to the purpose of the theory (first column) following roughly the aristotelian classification [19], see above. We also distinguish, whether the article presents only conceptual or theoretical ideas, or if the study is based on, or supported by, evidence from empirical work (second column).

Table 1. Classification based on systems approach and type of article

For the advancement of	Argumentation	Systems approach (n): Paper ID #	Total	
1. Theory or discipline	Conceptual or theoretical	STH (9): #14; #20; #23; #24; #31; #37; #41; #42; #43 CYB (3): #11; #29; #36 GST (2): #39; #47 VSM (1): #21 CAS (1): #44 ORT (1): #38	17	19
	Based on or supported by empirical evidence	STH (1): #34 MHS (1): #28	2	
2. Ontologies and frameworks	Conceptual or theoretical	STH (3): #3; #15; #16	3	6
	Based on or supported by empirical evidence	GST (1): #10 SM (1): #13 MHS (1): #8	3	
3. Methods and modelling	Conceptual or theoretical	STH (8): #1; #17; #25; #30; #33; #35; #45; #46 VSM (2): #26; #27 GST (1): #19 CYB (1): #22 LST (1): #2	13	20
	Based on or supported by empirical evidence	STH (2): #9; #32 GST (2): #12; #18 VSM (1): #40 CAS (1): #5 LST (1): #7	7	
4. Software tools	Conceptual or theoretical	LST (2): #4; #6	2	2
	Based on or supported by empirical evidence		0	

Legend: CAS = Complex Adaptive Systems (2), CYB = Cybernetics (4), GST = General Systems Theory (6), LST = Living Systems Theory (4), MHS = Theory of Multilevel Hierarchical Systems (2), ORT = Orientor Theory (1), STH = 'Systems Theory', 'Systems Thinking' etc. (23), VSM = Viable Systems Model (5)

Comparing to the theory functions (p. 6), the results show that to a good portion, 'systems' idea is seen as an analytical expedient of the research domain, i.e. analytical tool for managing enterprises and their IT. Missing the theories for explanation and prediction is likely due to the research methodologies used, and further, the complicated nature of the research target. To pinpoint causalities and develop predictions would require simplified views, loosing from sight the holistic systemic nature of the research target. However, with a more established theoretical outline, the reduction needed to study causal relationships could become possible.

Most often, systems approaches appear in the studies of methods and modeling, i.e. the practicable knowledge "for design and action", for which, empirically founded studies are more frequent. Even if frameworks used to be often on the fore in discussions on EA, the systems approaches appear less often as a basis for explicit ontological structuring for EA study, and only half of the studies for this purpose rely on empirics.

- A commonly acknowledged, consistent systems theoretical ontology for EA remains to be established.

To summarize, despite of keen interest on the systems approaches, they seem still more rarely contribute to empirical efforts. Different systems approaches, and some specific models are used in the studies. In the following, we present and discuss the individual systems approaches found in this study.

6 Discussion

It appears plausible to anchor EA in the field of system sciences, a discipline providing the necessary theoretical foundations to design, model and manage socio-technical systems. The literature review results show maybe a more fragmented theory base than could be expected. The specified systems approaches that appear in the included papers have, however, each contributed to an understanding of the problem field of EA. We attempt to summarize with a brief characterization of each theory or model in the following paragraphs.

GST – As an early systems approach, especially in the studies of organization and management, the General Systems Theory suggests hierarchically layered systems at nine distinct levels, with growing autonomy and increasing complexity towards the top levels [9]. Human deliberation enters at level 7, leading to less predictable actions and introducing complexity. Enterprises as such at level 8 of the GST hierarchy, as social (or rather socio-technical) systems, consist of several, both more and less complicated and complex (sub)systems. EA elements, such as the technical systems on one, and the human activity systems on the other hand, can be described, and their behaviors to an extent also explained through GST. Openness (cf. Open Systems, [60]) is assumed, meaning interactions with the environment and across system boundaries, as no enterprise exists in isolation, but within an environment with which it is in multiple relationships. The purpose of GST is to be "a body of systematic theoretical constructs which will discuss the general relationships of the empirical world" [9], and it has found application in empirical EA work both on ontologies or frameworks [#10], and methods or modelling [#12] [#18].

LST - In addition to an eight-level hierarchy, building on the GST, the Living Systems Theory [41] purports a division of labor between the system components. In LST, processing and transmission of information is in focus, making it apt to the study of IS and IT in organizations. The parts of a living system are classified to those processing either matter and energy, or information, or both [32]. In addition to this division, more refined roles are specified, e.g. for enabling managed interactions with the system environment at its boundaries. Openness is naturally also an attribute of an LST. System states and event cycles, as well as the 'in-, out- and throughput' concepts are a root for the current understanding of enterprises as a set of (business) processes, transforming inputs to outputs. The LST has been seminal in early EA research, especially in the extensive, well known work on the SEAM methodology [#1], [#2], [#4], [#6], [#10], leaning on the LST, but also supported by GST. Following SEAM, with LST as a theoretical base, a process meta-model for EA management has been presented in an empirical study investigating the partitioning of the complex whole to manageable parts in EA ("EA domains") [#7]. In alignment with the systems approach, feedback loops in this model ensure informed decisions by the upper levels in the systems hierarchy. The LST is conceptually rich, and has found application both in organization and management, and e.g. in industry automation, where it is the basis for Multilevel Hierarchical Systems **MHS**, [38]. MHS has been tapped on also directly in an EA study [#28] included in our SLR.

VSM - The Viable Systems Model proposes a simplified view for formal modelling to a system "capable of independent existence". A viable system, however, in also exchange with its environment (which may be another viable system, as implied by the recursion principle). The challenge of a VS is to cope with 'variety', and it is deploying 'intrinsic control' as means to sustain its viability. Cybernetics (CYB) as such complements the theory, rather than being an independent systems theoretical approach. Cybernetics is presented as an aspect of information processing and diffusion within the VSM.

From a Viable System Model perspective, [#13] analyzes EA management functions, proposes a method framework for EAM, and describes the results from a case study. Here, VSM provides a framework through which complex management systems can be described from a systemic perspective, and with five subsystems – operation, coordination, control, planning and identity. In the context of EA, operation is formed via EA projects, by the enterprise-level management functions, whereas the communication function of EAM forms systems two – coordination [#13]. Control systems forms the reactive function of EAM, establishing higher level control over the coordination system function, i.e. ensuring stability in the enterprise-level management process interaction. Furthermore, the authors argue that EAM encompasses a proactive function (planning), which anticipates and addresses environmental changes. Lastly, identity system concerns EAM governance – the scope and reach of EAM. [#11] is another paper deploying the VSM. Similarities between EA and the Viable System Model, as well as with Cybernetics have been found in other studies as well [#26, #27].

An adaptation of **Cybernetics** is applied in [#21] that the authors call Enterprise Architecture Cybernetics as the research framework for their study, to formulate methods to calculate and reduce the structural complexity of collaborative networks. Furthermore, they use the extension of Axiomatic Design Theory as an approach to treat complex systems whose operation cannot be fully predicted. The decisions regarding such systems are based on incomplete information, and therefore the ability to estimate and control their complexity can yield better guided decisions. The paper provides an interesting example of the use of systems approaches to propose an applicable method as a solution to a problem that stems from a high structural complexity of the domain.

CAS – Complex Adaptive Systems has raised interest more recently, likely following the technological developments with non-human agents interacting alongside of humans within networks. [21]. The main emphasis is in the system adaptive behavior conditional to the signals received from the environment and explained through the common characteristics of evolution, aggregate behavior (parts or subsystems contributing to the overall system behavior), and anticipation, where the system aims at adapting in anticipation to the changes of the environment. [#5]

The Orientor Theory (**ORT**) complements the views to system with the orientors defining the overall desired system outcomes (or system states). As pointed out by [#38], in the case of EA, the orientors can be seen the desired EA principles to follow in design and development activities.

The highest number of studies fall into the category Systems Thinking that may, or may not be explained in the individual studies in more detail. The high occurrence of the Systems Thinking or unspecified systems theory may indicate that the field of research does rely on some generic system related truths, as maybe a common 'mental model' [53] that potentially supports the research community in learning on the subject. As pointed out for organization and management [3], maybe in the EA field of research there are also "missed opportunities", for not more consistently relying on the systems approach. Rather than mere metaphorical use, a systems paradigm tuned for EA could support the description, explanation and even prediction of the enterprise and its information systems phenomena. We assume that this is a call for unifying the view of this paradigm in the EA field of research. The common features presented in this paper (based on [40], cf. Section 3) is an attempt in this vein. As a summary (Table 2), where the EA research stands, with examples we suggest how the common systems features reflect to well-known EA concepts in use in the EA studies. Further, we consider with these concepts, what challenges could be ahead for the systems related EA research.

Table 2. Common Systems Features vs. EA Concepts, and EA Research Challenges

Common Features of Systems Approaches	EA Concepts and Challenges
Systems consists of wholes comprising of parts, or sub-systems.	View of 'organizations' or 'enterprises', the unit of analysis in EA studies, as systems / systems of systems (with different characterizations).
Systems exist in the midst of their environment and are defined by their boundaries.	EA as a tool for managing enterprise IT and information resources, a tool corporate and business strategy within these limits. *Challenge:* EAM for the extended, federated enterprises, networks and ecosystems.
A system can be described as a static entity (system structure), or through its dynamics, i.e. the processes, or transformations in the system.	EA modelling, EA descriptions; Business architecture descriptions; E.g. business processes as an element ("layer").

	Challenge: Modelling of the evolving / constantly changing enterprise.
Systems change (evolve) over time.	EA current and future stage ("as-is", "to-be") *Challenge:* The synchronized evolution of related enterprise subsystems and sub-subsystems
Systems (and subsystems) appear as hierarchical, and there is a hierarchy of levels of complexity.	Enterprise and enterprise segments ("domains"), EA describing systems-of-systems *Challenge:* EA Management for systems consisting of complex systems, where also the subsystems change independently.
Within the system and at its boundaries, there are feedback loops (positive and negative) between the structural elements, potentially influencing the system dynamics.	The EA Process / The EAM Process *Challenge:* Understanding and supporting the nature of feedback as signals from (sub)system to system within the enterprise.
Systems entail information processing, regarding both the system and in exchange with its environment.	Information Architecture Dimension of EA *Challenge:* Inclusion of Information and Data Architectures and their management as an integral part of EA and EAM.
System and subsystems are normally "open", i.e. they are taking inputs from and sending outputs to the environment, and possible adjacent (sub-)systems.	EA acknowledges the enterprise environment as source of diverse influences for enterprise behavior. *Challenge:* EAM for the open systems-of-systems emerging with the evolution of technologies (e.g. Industrial Internet of Things) and digitalization; with federated, loosely-coupled and independently managed systems collaboration
System thinking is a holistic approach, i.e. taking into consideration the whole also in the examination of parts of the system.	The essence of EA, the strength of EA methodology. *Challenge:* With the above mentioned challenges, how well are the current EA methods equipped for this, especially with the new technology developments?
Systems approaches afford for an observer, i.e. a point of view, or a position taking a holistic perspective to the system.	The 'Enterprise Architect' *Challenge:* In large enterprise and networked settings, the task is too broad for any one role; but requires coordinated, collaborative activity, presenting a challenge to methodology.

7 Conclusions

The purpose of this study was to discuss firstly, to what extent the systems approaches are already in use in EA research (RQ1). Secondly, we wanted to examine the specific aspects of theory in this regard. This means, we look into the basic theory types or basic questions on theory, and further, the functions of theory (analytical, predictive, causal or "technological", i.e. for design and action), and aimed to find out if the EA research already deploys the systems approaches for these purposes (RQ2). In order to account for the contribution of the systems approaches in the field of EA, we look into the use of the theories in the studies we examine, and take account where empirical work supports the theory development in these studies. Further, we count the occurrence of the different systems theories and models, and discuss their contribution to this field of inquiry.

The common elements of systems theories that are discussed with reflections to existing concepts in the EA studies could be seen as signifying a systems theoretical starting point for EA, with the various theories and models providing further support for specific cases of inquiry. With this summarizing view also some further challenges are presented, that in our view are emerging for EA with the evolving technology landscapes.

More consistent use of the systems paradigm could move the research closer to being on the same page. To an extent, testing and validation of the theories in empirical efforts is taking place, but a common account of general systems ontology as the EA core is yet to develop. Beyond analysis and explanation, the use of systems paradigm for design and action seems to be taking place: There are already numerous empirical examples for methodologies and modelling, where also the strengths of EA as an approach lie for the enterprise information and systems management and development.

Systems paradigm is promising also from the point of view of the combination of formal, semi-formal and non-formal approaches. As noted in prior research [5]: "EA must encompass both soft and hard systems problems, model complex systems behavior through self-design, and add the human interpretive behavior and cognition to organizations as living systems." Systems theories are feasible candidates for extending and enriching EA research in order to achieve exactly that effect. Systems models are used for formal modelling, and this aspect indeed is successfully made use of. However, the paradigm can also be a starting point for exploratory approaches. A comprehensive paradigm depicted already in the GST, from mechanistic, simple systems to highly complex social systems, further explicated with the diverse constant roles and sub-system relationships as the strength of the LST approach, seems to be fitting for EA.

The question is, however, not which systems approach to take, but how the specific approaches complement the overall systems approach for EA. The more recently introduced CAS paradigm that emphasizes the independent decision making within systems – and their subsystems, a facet not so much emphasized! – as well as the autonomous (re-)orientation of systems, illustrates in our view very well the challenges of EA management. In engineering, the mindset can be to manage systems, or even systems of systems, where the decision making can remain with the systems engineer, or manager. In EA, or especially EAM, relating to management and organization, the task is to manage the complexity of influences within the enterprise(s) and their segments (subsystems and sub-subsystems), that have decision making power over their own resources and strategy setting.

According to the soft systems methodology, there is a distinction between problems faced by soft systems and hard systems. While hard systems discuss types of problems that can be seen as engineering problems, soft systems deal with problems related to e.g. organizational or social problems [5] - both of which can thus be seen as dealing with problems also considered in EA. Furthermore, Bernus et al. [5] note that Cybernetics can provide a theoretical backbone for analysis of relationships between social and psychological systems – for example organizations and individuals. From the early, basic systems theories (GST and LST) emphasizing the composition of the systems and hierarchical levels of complexity, indeed the shift of focus seems to be towards the dynamic features of the systems in models like VSM and Cybernetics, as well as CAS. For EA, and its management, both the structural and the dynamical views will be needed. The diverse theories and models can be seen as complementary – for the management, also the analytical views to the structures and dynamics in EA are, however, still needed.

There is an extensive volume of prior work discussing the systems nature of enterprises, as well as the systems approaches, as a means of solving various problems also considered in the field of EA. A limitation of our study is that prior work spread out to various fields, such as cybernetics [17] and EA network analysis [49], and not covered in detail here. Further, comparisons with the work in SoSE [18] as another promising line of research, is out of the scope of this study. In terms of literature coverage, we could have used additional search phrases, concerning for example enterprise architecture and various specified systems theories, enterprise engineering, and system-of-systems related keywords. Still, as stated by [59], a developmental literature review strives to include a sample of articles covering important aspects of concerned topic. We believe that this sample enables us to answer the research questions at an adequate level. Beyond the list of all included ones (Appendix 1), the authors retain the list of papers excluded (see Section 4 for the exclusion criteria) at different phases of the search process for future referral.

We strive to contribute to the discussion on EA to solidify the theoretical foundations. We hope that this study elucidates the current knowledge and academic endeavors concerning Systems Thinking, Systems Theories and Enterprise Architecture. Further research is obviously necessary, as well as probing by practitioners, in order to establish EA as a field of study within the broader systems research area. It could learn from insights in related fields, e.g. Systems of Systems Engineering, Enterprise Engineering and Organization Design.

Appendix

Included articles	ID
Wegmann, A. (2002). The systemic enterprise architecture methodology (SEAM). Business and IT alignment for competitiveness (No. LAMS-REPORT-2002-009).	#1

Wegmann, A., & Preiss, O. (2003, September). MDA in enterprise architecture? The living system theory to the rescue. In Enterprise Distributed Object Computing Conference, 2003. Proceedings. Seventh IEEE International (pp. 2-13). IEEE.	#2
Harmon, K. (2005, October). The" systems" nature of enterprise architecture. In Systems, Man and Cybernetics, 2005 IEEE International Conference on (Vol. 1, pp. 78-85). IEEE.	#3
Le, L. S., & Wegmann, A. (2005, January). Definition of an object-oriented modeling language for enterprise architecture. In System Sciences, 2005. HICSS'05. Proceedings of the 38th Annual Hawaii International Conference on (pp. 222a-222a). IEEE.	#4
Janssen, M., & Kuk, G. (2006, January). A complex adaptive system perspective of enterprise architecture in electronic government. In System Sciences, 2006. HICSS'06. Proceedings of the 39th Annual Hawaii International Conference on(Vol. 4, pp. 71b-71b). IEEE.	#5
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III

TOWARDS ECOSYSTEMIC STANCE IN FINNISH PUBLIC SECTOR ENTERPRISE ARCHITECTURE

by

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Towards Ecosystemic Stance in Finnish Public Sector Enterprise Architecture

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Abstract. Governments and organizations in both public and private sector are operating in fields of ever-growing uncertainty and complexity. To study this complex environment, the concept of ecosystems has been suggested, interpreting organizations as intertwined systems among layers of evolving ecosystems. While offering possibilities, operating in an ecosystemic environment might prove to be challenging, and the change from traditional governance structures might be difficult to manage, requiring holistic yet detailed view. Enterprise Architecture (EA) has been an interest of academics and practitioners for few decades, offering one of the most prominent solutions to managing complex organizations. Recently, it has been discussed that EA should further evolve to respond to the interconnectedness of organizations', thus extending the focus of enterprise architecting from intra-organizational to the ecosystems level. Based on data from 26 in-depth practitioner interviews in Finland, we discuss how EA should be developed to better support Finnish public sector ecosystems. Our data indicates that qualities such as organizational capabilities, holistic view, co-creation and needs-based utilization are essential features of public sector ecosystem EA.

Keywords: Enterprise architecture, Public sector, Ecosystem

1 Introduction

As the world alters towards networked and complex structures, the changes within the organizations and in the environment are becoming more frequent, yet more difficult to perceive. The underlying complexity is prone to increase, making it near impossible for governments to achieve public policy endeavors by dividing complex issues into smaller pieces [4, 13]. Contrariwise, embracing holism and the interconnections among organizations might be a key to solve some of the problems occurring, as ecosystems-enabled co-creation is seen as a key innovation in public service delivery [6]. To study this complex environment, the concept of an ecosystem has been suggested as "*the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize*" [1, p. 40]. Public administration structures and actors such as cities [58] and state [5] are increasingly interpreted as service systems and ecosystems. As an example, [13, p. 110] argue, that "*the society could be defined as a complex set of relationships based on the continuous sharing of resources and on the combination of several expectations culminating in the building of new value*", thus making society a domain which "*cannot be analyzed in the light of a mechanistic approach; it requires the adoption of a holistic perspective*". Ecosystems have attracted interest in private and public sector, and both new models of public services delivery and new business models have been suggested. Ecosystemic perspective can enhance understanding of complex contexts with systems-level thinking [9] and could be beneficial in the public sector, bringing forth benefits such as avoidance of duplication, enhanced transparency, faster service delivery and increased flexibility [51]. Further, a United Nations e-government survey stresses the need for a holistic approach to governance, bringing forth ecosystemic stance as a crucial strategy to achieve holism. In the same vein, the World Economic Forum has envisioned some features of future world government, where the cornerstones are such as networked governance, interconnection and collaboration. [51].

Whilst interpreting public administration as an ecosystem could bring forth benefits, the transition from traditional government structures might prove to be challenging and difficult to manage, requiring holistic yet detailed view. As [9] note, prior research has found that while technology creates opportunities in ecosystem service innovation, its complexity is prone to increase, necessitating the integration on people, processes, technology and information. Here, Enterprise Architecture (EA) could have a vital role. EA has been an interest of academics and practitioners for a few decades, offering one of the most prominent solutions to managing organizations. EA is traditionally used in modelling of organizations in current and future states and has gained attention as an approach for achieving IT-business alignment [2], bringing numerous other potential benefits along (e.g. [19, 33, 55]).

Changes in business-environments have sparked a discussion of further evolving EA to respond to the challenges related to interconnectedness of organizations [17]. While EA can be used to examine organizations and its elements, i.e. processes, systems and information, t has been argued, that current EA methodologies are not suitable in bridging internal and external environments, and in involving customers, supplier, business partners and other various stakeholders for building successful ecosystems [3, 18, 47]. EA might need a reconceptualization on methods and tools, to provide requisite coherence and adaptability in reacting internal and external change demands [32]. As the scope and purpose of EA seems to be expanding from mechanistic IT-business alignment to a holistic design of an organization in an ecosystemic environment (ibid), a systemic stance on enterprise architecture seems to have a growing interest among scholars and practitioners [10, 35]. Well-known scholars have explicitly stated the need to study the relations between systemic thinking and EA. As an example, Kappelman and Zachman [29, p. 93] state, that "[…] *the EA trend of applying holistic systems thinking, shared language, and engineering concepts, albeit in the early stages of their application, is here to stay*". Further, Rahimi et al. [48, p. 138] discuss the "*importance of systems thinking and, especially, of adopting the open systems principle, for managing EA design and evolution*". Recently, EA has been applied in networked [4, 14, 52] and ecosystemic [21, 38, 47] settings. Systemic and ecosystemic stance on public administration, and government architectures have been discussed especially in the context of e-government [26] and smart cities [7, 27, 38, 39], as well as other endeavors [e.g. 15, 31]. Although EA has been used to enhance interoperability of inter- and intra-organizational IT systems in the public sector, the means of extending the focus of enterprise architecting from intra-organizational to the ecosystems level is an area not yet sufficiently studied.

EA in the public sector differs from the private sector context, due to differences in usage - while in the private sector EA is often used in one organization, the scope in the public sector is much larger. Especially in the public sector, EA initiatives seem to face challenges in practice. Thus, as noted in prior studies, further research about EA in the public sector is also needed [16, 50, 53, 56]. The somewhat mature usage of government EA makes Finland a viable area to study EA usage in the public sector. Finland introduced government enterprise architecture in 2006 and has since 2011 mandated the use of EA in public sector organizations. In 2017, Ministry of Finance, the key actor governing public EA efforts in Finland, published first drafts of ecosystems model for public administration EA. In Finnish public administration, the state government and local government co-exist, comprising 12 ministries, about 50 special agencies, and some 200 regional state agencies. Prevailing reform in Finnish Social and Health services aims at to form 18 counties and an ecosystem including shared IT services as the common platform for currently siloed and fragmented data resources.

Our research question: "How enterprise architecture should be developed to better support Finnish public sector ecosystems?" is answered with thematic analysis of data from 26 in-depth practitioner interviews, conducted in different levels of Finnish public administration. While EA is much used in the public sector, its power in organizational interoperability and coherence is yet to be seen, and new ways of designing, developing and governing public administration EA are needed. Our data indicates that qualities such as organizational capabilities, holistic view, co-creation and needs based utilization are essential features of public sector ecosystem EA.

The remainder of this paper is structured as follows. In the following sections, the main concepts of this study - ecosystem and EA - are briefly introduced. Section 3 explains the methods of this study, and in Section 4, we offer the results of our study. Results are discussed with concluding remarks in Section 5.

2 Background

2.1 Enterprise Architecture in the Public Sector

Enterprise architecture has been defined and used in manifold ways. An "enterprise" indicates to the scope of the examination, and can be defined e.g. as an organization, a part of the organization or several organizations forming a whole. According to ISO/IEC/IEEE 42010:2011, "architecture" is defined as "*fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution*". Although the definitions of EA are numerous, with no common definition, it's scope and purpose seem to be increasingly extending from the purpose of IT-business alignment towards a tool of holistic organizational design and development in the system-in-environment setting [42].

Prior research discusses government EA as an efficient tool to overcome the challenges and problems related to e.g. interoperability, integration and complexity of e-government systems. [e.g. 19, 37]. In the public sector, government-as-a-whole architectures have been studied using various terminology, such as government architecture [24], government enterprise architecture [44, 51] and national enterprise architecture [25, 36]. [46] cites earlier studies, and states, that public sector policymakers initiate EA programs to enhance productivity, improve interoperability and improve the standard of service systems.

Although EA has been used in public sector in more than 20 countries [49], the efforts have not been only successful, numerous problems have occurred and many government organizations have performed poorly in their EA efforts. As an example, [16] discuss the problems and their root causes of EA in the public sector. They conclude, that previous research has recognized numerous problems, including problems related to the organization, EA project teams, EA users, and EA itself. Examples include complex structures, minimum collaboration among agencies, lack of broader understanding and guidance, lack of capabilities and skills, overemphasizing IT perspective, and lack of shared understanding of EA itself. [54] studied key issues in EA adoption in the public sector, concluding that there are three broad categories: resistance towards EA, relevant EA goals, and EA practices in use. These include issues such as lack of practical skills required in EA development, reluctancy to adopt new ways of working and general image problem of EA, due to e.g. troublesome implementation and technical representation.

Public administration in Finland has been in continuous change as in all Western Countries, if not globally. Although EA has emerged as a prominent tool to manage the change, the proof of its success in organizational interoperability and coherence is yet to be seen. In Finnish public administration, the state government and local government co-exist, comprising 12 ministries at the state level, steering their branches along of about 50 specialized central agencies. The semi-independent local governments consist of about 300 municipalities, which are self-governing units by Constitution, with the right to tax the residents. The municipalities have formed collaborative networks and joint ownerships with third-party vendors, which creates a complex ecosystem per se. Altogether, the Finnish public administration forms a complex ecosystem of organizations of high complexity, diverse goals and services, as well as some common infrastructure. In addition to that, various cross-organizational management forms, such as policy programs, and other endeavors are ongoing via various forms of organizations. Prevailing reform in Finnish Social and Health services aims to an ecosystem that will include shared IT services as the common platform for currently siloed and fragmented data resources. 18 counties are to be formed, with the liability to produce social and health care service.

In order to enable and ensure the interoperability of public administration, The Act on Information Management Governance in Public Administration (634/2011) has since 2011 necessitated the use of EA in public administration. Finnish public sector authorities must plan and describe their EA and adhere to the created and maintained

EA, descriptions, and definitions of interoperability. Public sector organizations should use the Finnish national EA (FINEA) method and its guidelines in EA planning and management. In practice, the implementation and use of the method have been challenging [46, 54].

2.2 Ecosystems in the Public Sector

Having emerged from the field of biology, different types of ecosystems have been widely discussed in various academic disciplines, such as marketing, strategy, social sciences, innovation management, engineering and information technology, gaining popularity especially in recent years [28]. Ecosystem have been defined and classified in manifold ways, and different kinds of ecosystems include business ecosystem, innovation ecosystem, service ecosystem, ecosystem as a standalone concept as well as various others. Some common elements among different types of ecosystems include focal roles, co-specialization, co-evolution and co-opetition, interdependence, loosely coupled hierarchical structure, shared vision, system level business model and modularity [20]. Adner [1, p. 40] offers one definition for an ecosystem, that is both reasonably cited, and seems like a suitable metaphor for public administration: an ecosystem is "*the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize*". In the public administration, diverse actors, i.e. state administration, civil service department, city officials and so forth come together, not to generate profit, but something of value - such as wellbeing of citizens. Similarly, [23] have identified three streams of ecosystems literature; business ecosystems stream, innovation ecosystems stream and platform ecosystems stream. While the first one centers on a firm in an environment and the second concerns an innovation or a value proposition among the constellation of actors supporting, the third discusses actors organized around a platform (ibid). So, the innovation ecosystems stream, discussing a focal value proposition, is focused on the system of service provision, not the individual enterprises.

As a structure, ecosystems can be interpreted in four nested and interrelated levels [40]: micro-, meso-, macro- and mega-level. At micro-level, service-for-service exchanges through actor-to-actor structures are allowed. Indirect interaction occurs at meso-level, involving actors in the same ecosystem. At the macro level, complex networks, such as institutional arrangements, arise, enabling or constraining activities at micro-, and meso-levels. Interdependencies between co-existing ecosystems occur at mega-level (ibid).

Ecosystems have been studied, to some extent, in the context of public administration and service provision. As an example, [9] show with a case study, that national health information system can be interpreted as an ecosystem, where public and private health care organizations act in meso-level, and the whole ecosystem represents a macro-level. Systemic stance on government EA is further discussed by e.g. [26], who examine the use of EAs in the Dutch public administration from a complex adaptive systems perspective. Based on the analysis of 11 cases, they derive eight architectural design principles, including development of modular architectures, stimulation of sharing and formation of coalitions. Further examples include the study by [37], who discuss developing a government EA framework to support the requirements of big and open linked data with the use of cloud computing. [8] provides an overview on different types of ecosystems and their characteristics and proposes views for the modelling of ecosystems with insights to three aspects: goal modelling, ecosystem modelling and platform modelling.

3 Methods of Study

This study is part of a longitudinal research project, researching the implementation of the Finnish national enterprise architecture method (the whole project is reported in [46]). The research constituted of two rounds of interviews, and the data used in this research was collected from 26 semi-structured interviews during the summer 2017. The selection of interviewees was based on purposeful sampling [45] in order to capture variation in the data in terms of both assumed information intensiveness and stakeholder population. The interviewees were asked to sign a written informed consent and were allowed to discontinue participating at any given time of the study. Transcribed interviews were stored securely, and the results of the interviews are reported anonymously. Further, the questions were presented in a manner that excludes interviewer bias [34]. The interviewees represented stakeholders from different levels and sectors of Finnish public administration and IT companies, with representatives from state administration (4), administrative sector (3), civil service department (4), cities (5) as well as managers (5) and workers (6) from private IT companies. The interviewees had an average of 15 years of experience in EA-related activities, ranging from 3 to 40 years.

The interview questions were divided into four parts: questions of 1) background information of interviewees, 2) previous situations 3) current situation and 4) future of EA. The questions covered macro- and micro-level issues. The past- and future-related questions covered issues of FINEA and the interviewees' perceptions of how it has affected their own work. The current situation questions were different for the interviewees from the public and private sectors. The interviewees from the public sector were asked questions about EA in the organizations they represented, and the interviewees from the private sector we asked questions about their public sector client organizations. To enhance repeatability (i.e. reliability), example questions are offered in the Appendix.

The interviews lasted from 36 to 100 minutes, the average being 63 minutes. The interviews were audio recorded, and transcribed. The quotations were translated into English and edited for brevity, thus removing hesitations, words and such, which were not essential for overall understanding of the data. We conducted a thematic analysis consisting of six phases: familiarization, initial coding, search of themes, reviewing potential themes, defining and naming themes, and producing the report [11]. The coding was done with the ATLAS.ti software, using both inductive and deductive approaches. To minimize the impact of individual bias, all authors did participate in the analysis, although no intercoder reliability was tested.

4 Results

During the data analysis, we were able to form four major themes of importance: co-creation, capabilities, holistic view and needs-based utilization. Summary of the themes and their incidence by stakeholder groups is presented in Table 1. There were also minor themes that were mentioned only few times. Among them were interoperability, cost savings, EA framework, digitalization and governance. Next, we explain the meaning of the formed themes and illustrate them with excerpts from the interviews.

Table 1. Themes considered important in developing public sector ecosystem EA

Theme	State	Administrative sector	Civil service department	City	IT company manager	IT company worker
Capabilities	◑	◔	◑	○	◔	●
Co-creation	◔	◔	◑	◑	○	◔
Holistic view	●	◔	●	◔	◔	◑
Needs-based utilisation	◑	◑	◑	◔	◑	◔

○ = not mentioned, ◔ = rarely mentioned, ◑ = occasionally mentioned, ● = frequently mentioned.

4.1 Capabilities

Capability concept was added in the latest FINEA version and is defined as combinations of: a) operations models and processes, b) employees and skills, and c) information and systems. Of these, the most mentioned in our data were resources that most often mean employees' time that they can use in EA. Interviewee from state government said: "Organizations should invest enough in it [EA], give enough resources, to see what the benefits in their own operations are". Without proper resources, the benefits will be modest. Skills and competence were also mentioned, and the interviewees emphasized both technical and business capabilities. While IT consultants mentioned capabilities often, the managers of the companies discussed capabilities only rarely. Moreover, while other public sector interviewees mentioned capabilities rarely or occasionally, city personnel gave no mention of this issue.

4.2 Co-creation

Co-creation has recently received a lot of attention in the public sector. In the beginning of the FINEA work, co-creation was quite unfamiliar. Especially, the stakeholders from civil service departments, cities and employees of IT companies have realized the value of co-creation in EA. A public sector representative said: "We have come far in ten years, and the need for co-creation has been recognized and understood”. This theme constitutes of things like achieving a common understanding, communication, dialogue, co-operation and different kinds of groups for people doing EA. Senior specialist of a city describes their cross-sectoral operations: “We have got governance over the operations in our city. Without communication and forum, this work would be impossible. This is the biggest value.” In their city, EA is connected in the project management model and in the strategy. They have an EA group and architects do co-creation with operations personnel. Representative of another city mentioned that they do an operations model picture in cooperation with substance or process owner and this leads into understanding of what really needs to be done. When discussing about stakeholders and co-operation with private actors, one public sector representative stated that “[…] and then there are enterprises with which we have this ecosystem thinking. If we would not have mutual architecture, we could not have mutual and decentralized development.”. This viewpoint on co-operation was also shared by the private sector interviewees, one of which noted that: “I think that in public administration there is, at least to some extent, thinking of being this platform-type of platform for third party vendors and private actors”. Although many interviewees mentioned, that co-creation is of value, some felt that it has not been enhanced by EA: “The reality in cross-organizational cooperation seems to be more wretched than before and EA has not been able to bring anything to the table.”. Further, IT company managers gave no mentions about co-operation.

4.3 Holistic view

Holistic view is the big picture that comes through EA’s four viewpoints: information, business, information systems and technology. These four architecture domains are in FINEA framework and in many generally known EA models, such as TOGAF. Holistic view was the most often mentioned issue in our interviews. It was considered to have many benefits and potential uses, such as identify structures, understand different stakeholders, and help in co-operation, governance, risk management, and cyber security. Interviewee from the state government describes the idea well: “To be able to make a holistic view of this complex public administration and its functions that consists of different segments and their relationships. And to be able to give structure and understand different actors and co-operate with stakeholders. And the services and systems and to be able to form a holistic view, it helps in many ways in decision making […] management […] It has potential in this. And in my opinion, we need more of this […] in this change in society […] to make the complex whole simpler”. Another state interviewee continued, that: “We chose from the beginning to look public administration as a whole […] it requires systematic and systemic thinking.” Further it was noted that “EA has been good in endorsing thinking of public administration as, in a way, one organization.”. Although the holistic view was recognized as one of the important aspects of EA, and public administration was regularly looked from this viewpoint, also organization-specific EA-work was valued: ”On the other hand there are the things in common [in public administration], but also some that are organization-specific. It is kind of a buzzword, but there is an ecosystem.” When asked about different viewpoints of EA work in public sector, the state administration interviewee noted that: “[we look at EA] rather in the macro-level. Of course, it is important to examine the architecture from the viewpoint on an organization. But we are more looking on what is shared in public administration […] the strategic objectives of the whole-of public administration, at this moment, begins from digitalization and also from developing an ecosystems-model. We are developing the next version of the public administration enterprise architecture […] it has been developed for a year with various stakeholders, and emphasis is on developing public, citizen-oriented services. It is about cost-efficiency, avoidance of overlapping and utilizing collected data at large”. Further, a private sector interviewee noted, that “The world is complex and always changing, these frameworks and their methods tend to age, and new ones are needed.”.

4.4 Needs-based utilization

There is a constant struggle to get enough resources for EA work and development work in general. This is the main reason why needs-based utilization came up in all stakeholder groups. Needs-based utilization is an important issue in successful EA in the public sector. If EA project starts without setting proper goals and understanding of the problem area, the result is often excessive modelling which is waste of resources. In Finland the FINEA is mandated by law, which has led to EA work that is done to fulfil regulations. Hence, motivation is a problem. Many interviewees saw needs-based utilization as a means to motivate and to help in setting relevant goals for EA. Interviewee from state administration noted that: “This is the most important thing in EA work, do not start without answering a couple of why questions…then things get easier, you do better EA and know redundant work”. According to interviewees, it is important to think what are the problems that need to be solved with EA work and then use the method as a tool. Interviewee from the administrative sector says: “[…] rigid EA work, where current and future stare are modelled similarly, textbook like, it is a lot of redundant work. And we have modelled many things that are insignificant in the big picture.”

5 Discussion and concluding remarks

Enterprise architecture has been one of the leading ways of modelling the structures of an organization, and based on the interviews, one that currently is used. Still, the results of this study indicate that new ways of designing, developing and governing public administration are needed. In addition, new ways of interpreting government EA are needed - ones that can justify themselves in the world of growing complexity, speed of change and interrelations among actors. As prior noted, Finland introduced government EA in 2006 and has since 2011 mandated the use of EA in public sector organizations. In 2017, first drafts of ecosystems model for public administration EA were published, replacing the formerly used domain-based model. The former model was described as rigid, siloed, hierarchical and such that it does not enable cross-domain co-creation [41]. Further, the domain-based model is described to “*not repre-*

sent the reality, as actors form ecosystems instead of hierarchies" [41, p. 6], and being unable to foster the forming of ecosystems. Although the new ecosystems model may better enable successful EA work in the Finnish public sector, it does not discuss in detail, how EA work should be done, and which qualities are important for public sector EA to be successful. Based on our data, we argue, that Finnish public sector EA should foster holistic view, co-creation, needs-based utilization and capabilities as prominent possibilities to successful EA-work.

Interpreting public sector as an ecosystem might enhance successful implementation and usage of EA. While holistic view of an organization has traditionally been one of the key features of enterprise architecture, it can be argued that it is not altogether clear what holistic means in the government EA, or in different levels and sectors of public administration. As prior discussed, [16] looked into the problems and their root causes of EA in the public sector, one of these being minimum collaboration among agencies, an issue also mentioned as a problem in the domain-based model of FINEA [4141]. The idea of ecosystems is exploiting the resources and capabilities of different actors in a given time. As stated by [1], ecosystems are "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize". Similarly, our results indicate that capabilities, needs-based utilization and holistic co-creation have a vital role in public sector EA work. If the public sector is interpreted as an ecosystem, government EA could be adapted in co-created projects where the capabilities of different actors are exploited in order to materialize a given goal. When EA projects are done when needed, and connect to a focal value proposition, a lot of unnecessary modelling can be omitted

In practice, extending the scope of EA to the level of ecosystems has been prior discussed by e.g. [12, 17, 43], and our results are in line with these studies. [17] discuss the stages from EA to Extended Enterprise Architecture, to Collaborative Network Enterprise Architecture and Focused Business Ecosystem Architecture and, finally, to Business Ecosystem Architecture These ideas are further discussed by [43], who enhance ideas of Drews and Schirmer and conclude with a tentative management model for the government ecosystem architecture, and [12] who, by discussing four case studies and identifying six architectural perspectives, offer an ecosystem architecture metamodel.

As prior noted, there were notable differences in terms of how often, if at all, the issues were mentioned by different interviewee groups. The city personnel did not mention capabilities and IT managers did not consider co-creation as a notable issue. Although, judging from the data, it is not evident, where these distinct differences come from, and especially, why the city personnel did not mention capabilities at all, some speculation is possible. In 2017, there was an ongoing trend of talking about capabilities in the context of EA, especially by some of the private sector EA consultants, which might have affected to the answers given by IT company workers. Also, Archimate is much used in the Finnish public administration, it is the recommended notation in FINEA. Capabilities as elements were introduced in Archimate 3.0, and were added to FINEA in spring 2017, just before our interviews. It might be possible that private sector interviewees were more familiar with the concept than those working in cities. State personnel might have been familiarized with the concept while working with the new versions of FINEA. This may also reflect the different maturity levels of capability driven EA design in public and private organizations. As for the lack of discussion on co-creation by the IT company managers, less can be speculated. The differing opinions between private and public sector interviewees, as well as differences between public sector personnel are important, and should be further studied in a separate study. In an effort to contribute to stream of studies on public sector EA, as well as those discussing developing EA to be better utilized in ecosystemic environments, we answered the following research question: "How enterprise architecture should be developed to better support Finnish public sector ecosystems?". We concluded that while EA is widely used in the public sector, new ways of designing, developing and governing public administration EA are needed. Our interviewees, 26 professionals from different levels of Finnish public and private sectors, recognized organizational capabilities, holistic view, co-creation and needs-based utilization as important factors in government EA. Based on the results, we propose the following guidelines to be used in the public sector ecosystem EA:

- EA work utilizes capabilities of organizations' participating in the ecosystem
- Development work is done in co-creation mode
- Partners of the ecosystem form a holistic view
- EA modelling is utilized needs-based

The aim of the ecosystem is to create value to participating partners and citizens. This contradicts the traditional view of EA, as a structure of one organization. Instead the EA in ecosystem is based in the interrelationships and interactions of the participating organizations. We argue, that EA should be further developed with these thoughts in mind.

This study mainly concerns public sector EA in Finland, and the interviewees were based on a single country. Therefore, different aspects might be emphasized elsewhere, and there might occur differing opinions concerning important and redundant qualities of EA. As discussed, EA is used in public sector internationally, and is also mandated by law in some countries other than Finland. Although the findings of this study may have significance in other contexts, more research is definitely needed, for example in other countries. Especially constructive studies, as well as case studies, forming and testing new ways of conducting EA, would be valuable. Further, some features of EA in public administration ecosystem are probably common also in the private sector. The generalizability of our results in wider contexts is hopefully to be validated by future research.

Appendix

For background information we asked for interviewees: name, organization, job description, duration of work in EA field. We also asked them to describe their EA work and their viewpoint to EA work (government-as-a-whole or own organization). Second, we asked backward questions:

- What do you think about the public sector EA method?
- Have you used the method in your work?

- The results of the interviews ten years ago included 1. implementation ability and governance, 2. structures of government and 3. advancement of interoperability as key challenges. In your opinion, are these still challenges?
- Has EA work increased cross-sectoral co-operation?
- Are you familiar with the law that mandates the use of EA? Has the law affected EA work?
- Ten years ago, there was not a mutual understanding about what EA means and what are the main goals of the EA work. In your opinion, is there currently a mutual understanding?

Third, we asked about current EA work:

- Is EA work done in your organization/client-organization? Why/why not?
- What kind of strategic goals are set for EA work?
- What are the stakeholder groups of EA?
- In your opinion, what is important in EA work?
- In your opinion, what is redundant in EA work?
- What is learned from EA work?
- How does EA support the digitalization of the public sector?

Fourth, we asked about the future of EA:

- What are the next steps of EA work in your organization/client-organization?
- How should the EA method be further developed?
- How information security should be noticed in forthcoming co-operation and public information systems?
- In your opinion, what kind of future EA work has in public sector?

Last, we asked: Is there something you would like to add?

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IV

ENVISIONING INFORMATION SYSTEMS SUPPORT FOR BUSINESS ECOSYSTEM ARCHITECTURE MANAGEMENT IN PUBLIC SECTOR

by

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Envisioning Information Systems Support for Business Ecosystem Architecture Management in Public Sector

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Abstract. Based on our research concerning Finnish national enterprise architecture (EA) adoption in long run, we discuss here how EA concept and tool are to be developed to support business ecosystem and organization design. Our research context indicates, beyond a federal government or a state one, that even a single municipality, like a city concern, can be perceived as an ecosystem of its sectoral domains, subsidiaries etc. We outline a vision of an overall ontology-based, shared EA repository for the-whole-of-government current state descriptions. We specify the central design principles and functional requirements for such a system and illustrate some potential use cases of it. The study suggests further abductive studies on the best design for such a system. Consequentially, we propose EA as a concept for organizational design of a government entirety.

Keywords: business ecosystem, enterprise architecture, ontology, public sector.

1 Introduction

The world has become interconnected so that the organizations are intertwined with business partners and integrate into networked business models. This enhances efficiency by focusing on company's core competencies while leveraging capabilities of their partners. The concept of a business ecosystem is suggested as an economic community of interacting organizations and individuals [28, p. 9] to create value through the increased information, services, and products for the customer [18, p. 28]. Ecosystems have attracted interest also in the public sector, and inspired new models of public services delivery, where the ecosystems-enabled co-creation is suggested as key innovation [5]. Recent examples include Nordic Smart Government project aiming at the data driven Nordic region, based on the interoperable digital ecosystem for data exchange between systems and authorized parties. Prevailing reform in Finnish Social and Health services aims at a shared business ecosystem that will include shared IT services as the common platform for currently siloed and fragmented data resources. The ecosystem model is believed to improve the quality of social and health services, and create new opportunities for business, research, and societal growth [39].

Enterprise architecture (EA) is commonly considered as a valuable approach to coherently manage and align the organizations' key assets, such as business processes and services, information systems, and data. EA has been applied in large and complex organizational change endeavors, business mergers (e.g. [9, [34]), electronic government (e.g., [6, 15]), and building business ecosystems platforms [39]. However, EA methodologies fall short in bridging internal and external environments, and in involving customers, supplier, business partners and other various stakeholders for building successful ecosystems [37]. Drews and Schirmer [12] propose a plausible idea of how intra-organizational EA should evolve to respond the organizations' interconnectedness.

For the interconnectedness of the *public administration (PA) as a business ecosystem*, (later *government ecosystem*), the paper proposes a vision of the real-time information system support. We ask, what kind of information system (IS) is needed in a complex socio-technical government ecosystem for real-time current state analysis. We outline basic functional requirements of an ontology-based, shared EA repository. The work is constructed as a design research, based on our observations in Finnish public administration EA adoption, e.g., [41, 24], as well as the literature anticipations of the future EA in business ecosystems, e.g., [12]. We recognize the far-reaching nature of the vision. However, the rapid development of the enterprise modeling and meta-modeling methodologies (e.g., [10, 38]), should anticipate that no long will take to the vision to be implementable. Artificial intelligence, neuro technologies etc., are the future options for creating and maintaining the as-is *business ecosystem EA* (BEA). We use Finnish National PA as an example to illustrate the given vision. The aim of the study is to encourage evolutionary studies, and pilots, especially constructive ones, to reach out to more specific specifications and design principles for the BEAM solution.

The remainder of this paper is structured as follows. In Chapter 2, the EA management is presented as a tool in collaborative networked environments. In Ch. 3, the research setting of the constructive study is described. In Ch. 4, the Finnish PA is illustrated as an example of the government ecosystem. We shortly outline the previous exploratory research of the EA adoption in Finland, that inspired the vision at the paper. In Ch. 5, the vision of the public sector EA management IS and its foreseen usage is described, with some core requirements and illustrations. In Discussion (Ch. 6) we answer the challenges presented for the execution of the business ecosystem EA management in [12]. Chapter 7 presents conclusions and suggests further studies of the subject.

2 EA Management in Networked Environments

Visnjic et al. [42] present cities as "ecosystems of ecosystems". Business ecosystems (later, *ecosystem*) have been much studied and defined in a variety of ways (e.g. [20, 31]). Similar ideas have been discussed in other fields under different terminology [1, 17]. Governments and the economy are perceived as complex social systems by several authors [3, 30]. As the world alters towards networked and complex structures, the changes within the organizations and in the environments are becoming more frequent, yet more difficult to perceive and foresee. This creates the demand for organizations to evolve constantly, to move out of the traditional, possibly stagnant structures and operating models. Public organizations have been struggling with the agile ideology [35], as means to the frequently changing environments.

The research of social architectures that are embodied in organizational design thinking, are concerned by social sciences [27], whereas technical architectures are discussed by engineering sciences, such as enterprise engineering and EA. The need to integrate technological and social perspectives in the design and engineering of organizations, is urgent [27]. Social nature of systems seems to be necessary to be taken into account in design of the ecosystem of organizations. Poli [33] distinguishes complex and complicated systems: a complicated one can be understood through structural decomposition, whereas complex ones can be understood via functional analysis. This suggests, that complicated systems can be modelled fully (in theory), while complex systems remain heuristic in nature, and cannot be fully captured. Therefore, disciplines (e.g. EA) which concern the analysis and design of an organization should possess a dualistic nature - concerning both complex and complicated problems.

The current EA methodology is lacking in the capabilities of business ecosystems analysis and design [13, 32]. Recently, a systemic stance on an organization in an ecosystemic environment has been supported, e.g., in [12, 19]. EA might need a reconceptualization on methods and tools, to provide requisite coherence and adaptability in reacting internal and external change demands [19, p. 278]. In the paper, we suggest the current state EA modeling to follow the engineerable path as the complicated problem, by semi-automated models of the as-is, whereas the target state design of BEA is left with situational, heuristic practices, however benefiting of the as-is repository.

3 Research Setting

The research follows the principles of the design research (DR) [16], where the theoretical knowledge base and the real-life environment are married for the researchers to create an artefact that is needed in the environment. In the study, we envision an IS solution for EA descriptions' accessibility, and automated update in government ecosystem. The IS vision stands for the design artifact in terms of [16]. The IS vision also proposes the hypothesis that is to be evaluated in future studies in government ecosystems, e.g., in a municipal corporate, or a national government. Beyond the EA research endeavors of the Finnish EA adoption, the authors hold EA development or EA education roles in Finnish PA. We build on the personal research and development endeavors, as well as the latest enterprise modeling and architecture knowledge base, where the most influential for the work have been the EA frameworks and methodologies [29, 14, 8, 10]; EA conceptual foundations [7, 21, 23]; EA studies from the business ecosystem perspective [4, 12]; and enterprise modeling and engineering [38, 22, 11, 36].

The proposed IS vision forms a continuum in abductive DR cycles concerning EA framework adaption in Finnish PA [39, 40, 41], that suggested two things. First, the current state EA descriptions of a government ecosystem were to be modeled as structural, re-arrangeable descriptions e.g., like in [29]. Secondly, the current state descriptions elements were to be represented in relation to the prevailing management structures in real-time. This requires a common meta level representation of PA management structures – i.e., a contextual ontology. Finally, as for the current state EA descriptions, the EA framework for public sector was proposed to be implemented as a dynamic data model of the current management structures [41]. In this paper, the described previous results are further enlarged by abductive logic reasoning to present the hypothesis for future iterative and constructive case studies. Abductive logic forms a 'process of discovery' where inferences are drawn to the next best explanation in each cycle, with wider set of data [25]. Consequentially, the paper presents the IS vision for government ecosystem EA based on the ontology of the government management context.

4 Challenges of the Finnish PA as Ecosystem

Finnish national PA, as a 'whole-of-government' forms a complex ecosystem of actors. The actors are organizations of high complexity, e.g., with variety of products, services, official responsibilities, and complex administration structures. The political organization comprises a parallel hierarchy with the administration. Further, various cross-organizational management forms, such as policy programs are typical. According to our observations, these management structures are not always documented transparently.

Re-organization of the administrative structures has become an established practice in Finnish PA. The trends to centralize and decentralize are simultaneous. New Public Management related reforms have taken place since 1987. Gradual outsourcing of prominent business areas can be perceived in both state and local sectors. Simultaneously, the mergers have been encouraged by the State government especially in the municipal sector. The municipalities have conglomerated in many ways, e.g., via forms of collaborative networks, joint ownerships or by strict mergers. A conglomerate form of management is typical to public sector organizations, creating a complex system per se with various corporate governance functions, deep administrative hierarchies, and multiple types of actors, like sectoral domains, in-house enterprises, subsidiaries etc.

Re-organization and re-structuring are not typically based on profound systematic analysis and design. The current state organizational structures form a hindrance to the recurring transformation efforts. In a network of organizations, the management structures and classifies should be transparent at high usability levels, to enable the comparative analysis of the as-is corporate structures of the ecosystem, before the design of the common goals implementations. Finnish Information Management Act 2011 necessitates PA actors to publicly model their EA. However, despite of the serious endeavors in launching the shared EA modeling tools among PA actors, the open sharing of the EA descriptions is not at adequate level. Innovations and best practice sharing has to be based on mutual agreement on personal level first. The search algorithms and comparisons are neither profoundly supported at model element level. Furthermore, as Finnish administrations are trending towards citizens-as-partners type practices in service development, the customers and citizens might form a remarkable resource in innovating public services and structures, based on an open source EA description.

5 Vision of The Ontology-based Real-time EA Repository

We outline the vision for the IS support of the government ecosystem EA at conceptual level, 1) to enable the comparative analysis across 'whole-of-government', and 2) to provide the real-time as-is information of the ecosystem for target state design. Sect. 5.1 describes the vision, and 5.2. outlines the tentative target state BEA design process.

5.1 IS support for the Ontology-based Real-time EA (OREA)

We suggest co-creating the public sector ontology of the different level government ecosystems (local, national, federal), and mapping the EA descriptions and metamodels to them. We would like to see the output as the contextual ontology of government ecosystem EA modeling and enterprise engineering, on which you could build the corresponding shared digital IS ecosystem for EA management and development. We yield below the design principles and some central functionals requirements for this IS vision, illustrated by exemplary use cases. The envisioned system provides kind of a semantic web, enabling many types of data mining and comparative analyses.

For the design principles of as-is BEA realization we suggest following: 1) *Dynamic as-is contents* - automated updates or suggestions for updates. 2) *Scalability*, from the local ecosystems to the national, and the federal ones. 3) *Open access EA information* for citizens, and partners. 4) *Plug-in architecture* options - external organizations outside of the ecosystem are facilitated to plug into the government ecosystem EA. The plug-in architecture enables co-creation, and co-evolution of the ecosystem also with the private actors. Plug-in option offers the option to the new actors to join the ecosystems, thus supporting spontaneous evolution of the BEA. Next, we present three functional requirements (R1, R2, R3) for the as-is BEA realization:

R1. Basic modeling and meta-modeling functionalities, that are readily available in many modeling tools, (e.g., [38, 36]**)**. Modeling techniques have still to be innovated more for the organizational coherency and co-evolution purposes. In our development work, e.g., the strategy architecture models of the city were iteratively designed for the best fit to the purpose. The model notations and templates are to be designed situationally, where the model elements and attributes may associate to each other. The real-time as-is descriptions can be automatically visualized via metamodel rules, based on the structural information yielded regularly in everyday-work of the civil servants.

R2. Agile analyses and comparisons tools, that necessitates interdependent, commonly agreed ontologies, e.g., for business catalogues, and organigrams. For example, the as-is management structures can be made transparent in real-time and used to categorize the EA descriptions and their elements. Each description model and element are associated to relevant management structures. Also, different types of organizations, different types of management structures, and different types of management classifications are represented in the shared ontology. They facilitate the management needs for re-structuring the model instances according to their needs. Leaders and enterprise analyst may search descriptions and their elements according to shared ontologies, into which the metamodels of different description types are associated. For example, the Minister of Commerce may browse for the different organizational options of the municipalities entrepreneurial services, to decide whether each municipality has organized them as a subsidiary, in-house-enterprise, via joint ownership, or other. Along the organigrams, he might get the visualized volumes of the actors. The citizen can compare, e.g., the service catalogues between the municipalities.

R3. Situational EA frameworks of the as–is description can be pulled out of the system according to given parameters. The system might offer different EA frameworks templates to different organization types, too. Each organization may instantiate their framework and choose the EA models they prefer in their EA. EA frameworks are sketched as printed outlines as functionally. For instance, the CEO of a water supply subsidiary may request the outline of the EA descriptions realized in his organization, and in those of the neighboring cities.

5.2 Target State Design in the Government Ecosystem.

Figure 1 suggests a tentative management model for the government ecosystem architecture. The stages 1 to 5 illustrate the tentative target state design process for co-creating new services in the ecosystem (Fig. 1): In the phase 1 (Idea), an initiative appears, e.g., from citizens, government actor, or private companies (cf. [24]). To support the innovation, the phase should be as open as possible. This creates a socio-technical dimension to the idea co-creation. In Phase 2 the idea evaluation is done by a variety of stakeholders. Agencies might have a special interest in the financial analysis, whereas local citizens might appreciate the geographical locations of the services. The balance between financial and functional performance must be achieved [24]. This is followed by Phases 3a Current state analysis, 3b Target state design, and 3c Gap analysis. In (3a), the participating actors are identified, resulting in the subset of necessary distinct EA's, covering concerns such as customers, partners and suppliers [12], i.e., *EEA* (see below). In Phase 4, Project implementation starts with suitable project organization, involving the configuration of internal and external ecosystem actors, and IT-service providers. The as-is BEA updates semi-automatically by increments in the project implementation, finally fully reflecting the previous target state. The deployment may be also ceased at any time based on the feasibility checks, too.

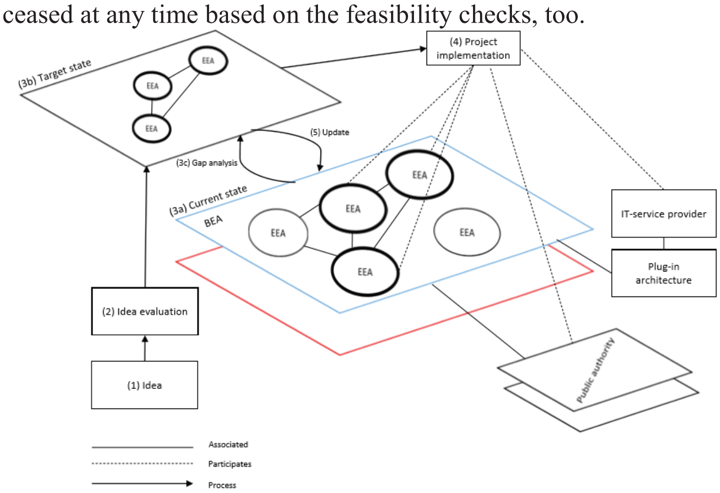

Fig. 1. BEA management: the blue and red layers illustrate as-is BEA repositories for a couple of government ecosystems. The phases 1-5 indicate the target state design of the ecosystem.

6 Discussion

The domain of EA methodologies has evolved towards the holistic organizational design and development [23]. Al-Kharusi et al. [2] note in their study of EA at dynamic environments that the human and organizational aspects is neglected in target state design. While [37] acknowledge the EA as a way to cope with organizations' ever-increasing complexity, they argue that the EA methodologies do not efficiently advocate the cross-organizational interactions between business entities. They call for business ecosystem architecture models to allow filling the gaps between internal and external operating environments, such as customers, suppliers, and business partners. Drews et al. [12] discuss the stages from the traditional EA to *Extended Enterprise Architecture* (EEA), and finally to the *Business Ecosystem Architecture* (BEA). While they suggest EEA to already extend to cover concerns such as customers, partners and suppliers, they argue that that for BEA, a central actor must have an overview of the whole ecosystem, i.e. the infrastructure and interfaces to all connected EEA's.

Drews and Schirmer [12] also present challenges of extending EA towards a value-producing instrument in complex and networked environments. Based on their four cases, 16 challenges for business ecosystem architecture management are displayed. and classified into four groups: (1) challenges regarding the (meta-)modelling of EEA and BEA; (2) challenges regarding the tool support; (3) challenges regarding the management of EEA and BEA; (4) challenges regarding the socio-technical dimension. We divide the challenges into the two categories: the complicated problems, i.e., those that can be dealt with by using engineering practices; and the complex problems, i.e., those that mandate the use of heuristic practices. Next, these problems, along with our proposed answers them are further discussed. The answers are derived from the afore-envisioned IS support of the OREA management of the government ecosystem. The answers can be seen as the anticipated benefits of the envisioned digital system.

6.1 As –Is BEAM as Complicated Problems

Our proposed solution to complicated problems is an ontology-based, shared EA repository for the-whole-of-government real-time updating descriptions.

Challenges concerning modelling include inter-organizational interfaces on all layers, finding the right level of abstraction and identifying shared business objects [12]. The shared ontology would support associating intra-organizational EA models inter-organizationally. The shared ontology might also help mapping the abstraction levels of the EA descriptions and their elements, whereby comparative cross-agency analysis were enabled. It would provide a common search index for comparative analyses and data mining, which would further enable the recognition of shared architecture objects, overlaps and bottlenecks.

The challenges [12] include those associated with ultra-large-scale architectures with a large number of actors in BEA. As a solution, the envisioned BEAM IS support semi-automatically would provide the ultra-scale current state descriptions. Updates would be based on the content changes in structural documents and automatically visualized as EA models in all EA layers. Therefore, the ultra-large-scale BEA descriptions would remain continuously updated. In future times, artificial intelligence might even make inferences based on less structured input or even graphic contents.

Challenges concerning tools include tool support for ontologies as well as those concerning open standards for data exchange (import/export). Here, we propose envisioned IS support per-se as described in the paper. Common modelling standards such as ArchiMate, UML, and BPMN could be mapped to the (core) concepts of the shared ontology to enable search and comparison regardless of the modelling language.

6.2 To – Be BEAM as Complex Problems

Concerning the complex problems, our proposed solution is the proposed target state analysis and design process.

Challenges concerning management**,** such as inter-organizational tasks and roles can be approached with more transparency both in inter- and intra-organizational levels via ontologies that apply to management structures [41]. Managing the aspects concerning BEA service provision can be solved with open network structure of actors and service providers. Also, our 'plug-in architecture' enables new (and temporary) actors to attach and contribute towards the development of ecosystems and services.

Challenges concerning socio-technical aspects, e.g. citizens and consumers as actors, and the lifeworld of customers and partners [12]. Our solution provides an open channel for citizens and consumers to suggest and peer-evaluate ideas for the development of the ecosystem.

The modelling and tool in Drews and Schirmer's challenges, is the part which our vision of ontology-based hits best, as the shared EA repository for the-whole-of-government, updating in real-time. It encounters with EEA and BEA modelling and tool challenges, since they can be seen as "complicated", engineerable ones. The management and socio-technical aspects are more related to the complex issues, where solutions can be considered mostly heuristic and situational in nature. Therefore, the tentative practice of the target state BEAM design given in Ch. 5, tentatively answers these complex challenges.

7 Conclusions

We presented the design principles and central functional requirements of the ontology-based as-is government ecosystem architecture repository, that is meant to be applicable to any chosen whole-of-government entirety. The proposed solution has several anticipated benefits. The system might maintain transparency and comparability across the entirety of the government, eliminate duplicate work, enhance the sharing of the best practices, and most importantly, support the co-evolution of PA structures towards higher coherency and synergies. Shared EA descriptions would support also co-creation and co-evolution of the ecosystem. However, the implementable solutions require further studies. Especially it requires the design of a future common, wider ontology of the public administration sector and concepts. This implies application of ontology engineering knowledgebase in further development and research of the subject (cf. [24]).

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V

ECOSYSTEM ARCHITECTURE MANAGEMENT IN THE PUBLIC SECTOR – FROM PROBLEMS TO SOLUTIONS

by

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Ecosystem Architecture Management in the Public Sector – From Problems to Solutions

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Abstract. Based on our research concerning enterprise architecture (EA) in the Finnish public sector, we discuss how EA concept and tool need to be developed to support government business ecosystem and organization design. Our research context indicates, beyond a federal government or a state one, that even a single municipality, like a city concern, can be perceived as an ecosystem of its sectoral domains, subsidiaries and such. We outline a vision of an overall ontology-based, shared EA repository for the-whole-of-government current state descriptions and specify the central design principles and functional requirements for such a system, illustrating some potential use cases of it. Based on interview data from four smart city cases in Finland, we suggest a management model for the government ecosystem architecture target state design, specifically a design process for co-creating new services in the ecosystem. Further, we outline some principles for government ecosystem architecture management.
Keywords: Enterprise Architecture, Ecosystem, Public Sector, Ontology.

1 Introduction

The world has become interconnected so that the organizations are intertwined with business partners and integrate into networked business models. This enhances efficiency by allowing companies to focus on their core competencies while leveraging capabilities of their partners. The concept of a business ecosystem is suggested as an economic community of interacting organizations and individuals [1] to create value through the increased information, services, and products for the customer [2]. While the underlying complexity of the public administration is prone to increase, governments struggle to achieve public-policy endeavours by dividing complex issues into smaller pieces [3]. Contrariwise, embracing holism and the interconnections among organisations might be a key to solve some of the problems occurring. Ecosystems have

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attracted interest also in the public sector, and inspired new models of public services delivery, where the ecosystems-enabled co-creation is suggested as key innovation [4]. Recent examples include Nordic Smart Government project aiming at the data driven Nordic region, based on the interoperable digital ecosystem for data exchange between systems and authorized parties. Prevailing reform in Finnish Social and Health services aims at an ecosystem that will include shared IT services as the common platform for currently siloed and fragmented data resources. The ecosystem model is believed to improve the quality of social and health services, and create new opportunities for business, research, and societal growth [5].

While offering possibilities, operating in an ecosystemic environment might prove to be challenging, and the change from traditional government structures might be difficult to manage, requiring holistic yet detailed view. Enterprise architecture (EA) is commonly considered as a valuable approach to coherently manage and align the organizations' key assets, such as business processes and services, information systems, and data. EA has been applied in large and complex organizational change endeavours, business mergers [6], [7], electronic government (e.g. [8], [9]), and building business ecosystems platforms [5]. However, EA methodologies fall short in bridging internal and external environments, and in involving customers, supplier, business partners and other various stakeholders for building successful ecosystems. Prior studies (e.g. [10]) for a thorough review, see [11]) have discussed Extended Enterprise Architecture. Further, Drews and Schirmer [12] propose a plausible idea of how intra-organizational EA should evolve to respond the organizations' interconnectedness. Still, the means of extending the focus of enterprise architecting from intra-organizational to the ecosystems level is an area not yet sufficiently studied. Although previous research (e.g. [13], [14], [15]) has discussed EA in a smart city context, we differentiate from these valuable contributions by focusing to government ecosystem architecture per se, and only use smart city as an example of public administration (PA) ecosystem.

This study is constructed as a design science research, based on our observations in Finnish public administration EA adoption, (e.g. [16], [17]), as well as the anticipations of the future EA in business ecosystems, (e.g. [12]). Based on these explorations, our objectives are the following. For the interconnectedness of the PA as a business ecosystem (later, government ecosystem):

I. We aim to outline some basic functional requirements of an ontology-based, shared EA repository for government ecosystem and to propose a vision of a real-time information system support for such a repository.
II. Based on our latest generate/test cycle, we use interview data from four smart city cases, and further develop previously introduced [18] management model for the government ecosystem architecture target state design, as well as outline some principles for government ecosystem architecture management.

The usage of ontologies for EA integration and analysis [19] and combining EA modeling and enterprise ontology [7], [20], [21], [22] are not unheard of. Further, Fischer, Aier and Winter [23] and Hansen and Hacks [24] have discussed federated repository approaches for the maintenance of EA models. The rapid development of the enterprise modeling and metamodeling methodologies [25], [26] should anticipate the vision to be implementable in the near future. Artificial intelligence, among other solutions, could be the future option for creating and maintaining the as-is *business ecosystem EA* (BEA). Automatic data collection for EA models [27] modeling [28] and documenting EA [29] have already been discussed. As an example, Gladden [30, p. 1] discusses enterprise mega-architecture, which "*disengages human enterprise architects from the fine-grained details of architectural analysis, design, and implementation, which are handled by artificially intelligent systems functioning as active agents rather than passive tools*."

We use Finnish National PA as an example to illustrate the given vision. This research aims to make a contribution to the discussion concerning the evolving discipline of enterprise architecture, and its usage in ecosystemic environments as well as enhancing the interconnectedness of the public administration as an ecosystem. First, we aim to contribute by advancing the work of EA usage on PA by envisioning requirements for information system (IS) for real-time current state analysis in PA ecosystem. Second, we outline the basic functional requirements of an ontology-based, shared EA repository. Third, we suggest a management model for the government ecosystem architecture target state design, specifically a design process for co-creating new services in the ecosystem, and outline some principles for government ecosystem architecture management.

The remainder of this article is structured as follows. In Section 2, the EA management is presented as a tool in collaborative networked environments. In Section 3, the research setting of the constructive study is described. In Section 4, the Finnish PA is illustrated as an example of the government ecosystem. We shortly outline the previous exploratory research of the EA adoption in Finland that inspired the vision at the article. In Section 5, we discuss the challenges presented for the execution of the business ecosystem EA management in [12], and present some solutions for these challenges. We discuss the vision of the public sector EA management IS, and describe its foreseen usage with some core requirements and illustrations. Further, the government ecosystem target state design process is illustrated along with the results of our latest research cycle. Section 6 presents conclusions and suggests further studies of the subject.

2 EA Management in Ecosystemic Environments

As the world moves towards networked and complex structures, the changes within the organizations and in the environments are becoming more frequent, yet more difficult to perceive and foresee. This creates the demand for organizations to evolve constantly, to move out of the traditional, possibly stagnant structures and operating models.

Organizations of different kinds are increasingly perceived as systems operating in ecosystems. For instance, Visnjic et al. [31] present cities as "ecosystems of ecosystems". Further, governments and even the society are perceived as complex social systems by several authors [32]. As noted by Caputo et al. [3], "*the society could be defined as a complex set of relationships based on the continuous sharing of resources and on the combination of several expectations culminating in the building of new value*", thus making society a domain which "*cannot be analysed in the light of a mechanistic approach; it requires the adoption of a holistic perspective*". The idea emerged from the field of biology, different types of ecosystems have been widely discussed in academic disciplines, such as marketing, strategy, social sciences, innovation management, engineering and information technology, gaining popularity especially in recent years. Ecosystems have been defined in a variety of ways, and different kinds of ecosystems include business-, innovation-, service-, and platform ecosystems as well as various others. Adner [33] sees ecosystems as "*the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize*", and makes a separation between ecosystems-as-affiliation ("*ecosystems as communities of associated actors defined by their networks and platform affiliations*") and ecosystem-as-structure ("*ecosystems as configurations of activity defined by a value proposition*"). In line with Adner, we see the latter as a suitable metaphor for government ecosystem, where diverse actors come together to meet a shared value proposition. Han, Lowik and de Weerd-Nederhof [34] have recognized common elements of different ecosystems, including focal roles, co-specialization, co-evolution and co-opetition, pooled and loosely coupled interdependence, hierarchical structure, shared vision, system-level business model, and modularity. Further, ecosystems can be interpreted as nested in layers, ranging from micro-level (service exchange between actors) to interdependencies between co-existing ecosystems at mega-level [35]. Ecosystems have been used as a conceptual paradigm in the public sector, as seen, as an example, in the case study of a national health information system, where public and private health care organizations act in meso-level, and the whole ecosystem represents macro-level [36].

Enterprise architecture (EA) has been defined as a discipline focused on the alignment between business and information technology (IT). With EA organizations can define their current and future states, as well as a roadmap between them, taking into consideration aspects such as processes, capabilities, applications, systems, data and IT infrastructure [37], [38], [39]. However, as argued by Lankhorst [40, p. 205], *"In practice these domains are not approached in an integrated way. Every domain speaks its own language, draws its own models, and uses its own techniques and tools. Communication and decision making across domains are seriously impaired"*. Kloeckner and Birkmeier [41] in their article about enterprise architecture from a systems perspective, state that *"A comprehensive enterprise architecture therefore specifies, amongst others, the goals and strategies of an enterprise, its business processes as well as the associated resources like production systems, information systems and humans. While the former aspects are often included in current concepts of EA, especially humans, as integral parts of enterprises, are often not taken into consideration. But only such a complete picture would essentially support necessary transformations of organizations in a flexible and agile way*". Current EA methodologies fall short in bridging internal and external environments, and in involving customers, suppliers, business partners and other various stakeholders for building successful ecosystems.

According to Magalhães and Proper [42], the research of social architectures – embodied in organizational design thinking – is concerned by social sciences. Contrary, technical architectures are discussed by engineering sciences, such as EA (ibid). In the same vein, Pennock and Rouse [32] state, that there are at least two broad perspectives viewing enterprises as systems – architecting enterprises (i.e. analyzing and designing the functions, structures and processes) and managing the enterprise. Bernus et al., [43, p. 96], note that *"EA must encompass both soft* [e.g. related to organizational of social phenomena] *and hard systems* [e.g. engineering problems]*, model complex systems behavior through self-design, and add the human interpretive behavior and cognition to organizations as living systems."*. Interestingly, Poli [44] distinguishes between systems that are complex and those that are complicated: a complicated system can be understood through structural decomposition, whereas complex systems can be understood via functional analysis. This means, that while complicated systems can (in theory) be modelled fully, modeling complex systems is always incomplete. Regardless of the view, concerning the nature of social systems seems to be necessary when the emphasis is on an ecosystem of organizations.

Therefore, disciplines (e.g. enterprise architecture) which concern the analysis and design of an organization should possess a dualistic nature – concerning both complex and complicated systems [44], soft and hard systems [43], social and engineering problems [42] and architecting and management problems [32]. In practice, this means combining two perspectives: modeling the state of, e.g. the infrastructure and data of the organization (complicated problem) as well as managing social phenomena in the midst of ecosystemic environment (complex problem). Two kinds of requirements of architectural development are apparent in said environments. First, the practices of enterprise architecture management (EAM) must allow flexible and responding designs to make it possible to answer the unexpected changes in environment, and to grasp the newly emerged requirements and possibilities that often ensue. On the other hand, operating in complex networked environments necessitates carefully planned EAM that considers various interconnected yet independent parties as well as able command of various concurrent contingencies. The development activities in complex business ecosystems call for possibility for emergent design at the same time as they necessitate strictly coordinated architecture planning and management. The former must extend to interfacing networked organizations operating in a same ecosystem and to acknowledge their individual business strategies and processes as well as software and technology landscapes.

To conclude, although a systemic stance has recently received notable interest in the EA field on research (e.g. [43], [45]–[50]), and EA has been studied as a means of understanding networked and ecosystemic settings (e.g. [13]–[15], [51]–[57]), the current EA methodology is still lacking in the capabilities of business ecosystems analysis and design (see, e.g. [10], [57],

[58]). EA might need a reconceptualization on methods and tools, to provide requisite coherence and adaptability in reacting to internal and external change demands [59].

In the article, we suggest the current state EA modeling to follow the engineerable path as the complicated problem, by semi-automated models of the as-is, whereas the target state design of BEA is left with situational, heuristic practices, however, benefiting of the as-is repository.

3 Research Setting

This research follows the principles of the design science research (DSR) [60], where the theoretical knowledge base and the real-life environment are married for the researchers to create an artifact that is needed in the environment. DSR as discussed by Hevner et al. [60] is frequently used in studies concerning the modeling of ecosystems, such as smart cities (e.g. [61]), as well as in discussing EA in ecosystems [62]. In this study, we envision an IS solution for EA descriptions' accessibility, and automated update in government ecosystem. Also, previously introduced [18] management model for the government ecosystem architecture target state design is further developed, and some principles for government ecosystem architecture management are outlined. These stand as design artifacts in terms of [60], forming hypothesis that is to be evaluated in future studies in government ecosystems, e.g. in a municipal corporate, or a national government. Beyond the EA research endeavors of the Finnish EA adoption, the authors hold EA development or EA education roles in Finnish PA. We build on the personal research and development endeavors, as well as the latest enterprise modeling and architecture knowledge base, where the most influential for the work have been the EA frameworks and methodologies [25], [63], [64], [65]; EA conceptual foundations [43], [48], [66]; EA studies from the business ecosystem perspective [12], [51] and enterprise modeling and engineering [26], [67], [68], [69]. The described previous results are further enlarged by abductive logic reasoning to present the hypothesis for future iterative and constructive case studies. Abductive logic forms a 'process of discovery' where inferences are drawn to the next best explanation in each cycle, with wider set of data [70].

To elucidate our vision, we present excerpts from our most recent research cycle, a multiple case study of four smart cities in Finland. The interview data is used in a generate/test cycle [60] to further enhance our previously introduced [18] model for PA ecosystem target state design process. We conducted a total of eight interviews with seasoned enterprise architecture professionals as well as a diverse range of managers from Jyväskylä, Helsinki, Espoo and Turku. Of these, the latter three are part of a 6Aika – a collaborative smart city ecosystem of six of the largest Finnish cities [71], while Jyväskylä is a frontrunner of Finnish smart city endeavors with its smart city districts such as Hippos and Kangas [72]. The interviewees were selected with the purposeful sampling.

We conducted semi-structured interviews between November 2018 and January 2019. The interviews were audio recorded, transcribed and analyzed using conventional content analysis, according to Hsieh and Shannon [73]. The interviews lasted between 43 and 56 minutes, the average being 50 minutes. As discussed by Hsieh and Shannon (ibid), conventional content analysis can lead to concept development and model building. The excerpts presented in the following sections were translated into English and edited for brevity, thus removing hesitations, words and such, which were not essential for overall understanding of the data.

The proposed IS vision and the tentative government ecosystem architecture target state design process form a continuum in abductive DSR cycles concerning EA framework adaption in Finnish PA [5], [16], [74], that suggested two things. First, the current state EA descriptions of a government ecosystem were to be modeled as structural, rearrangeable descriptions, e.g. like in [63]. Secondly, the current state descriptions elements were to be represented in relation to the prevailing management structures in real-time. This requires a common meta level representation of PA management structures – i.e. a contextual ontology. Finally, as for the current state EA descriptions, the EA framework for public sector was proposed to be implemented as a dynamic data model of the current management structures [16].

4 Challenges of the Finnish PA as an Ecosystem

Finnish national PA, as a 'whole-of-government' forms a complex ecosystem of actors. The actors are organizations of high complexity, e.g. with variety of products, services, official responsibilities, and complex administration structures. The political organization comprises a parallel hierarchy with the administration. Further, various cross-organizational management forms, such as policy programs are typical. According to our observations, these management structures are not always documented transparently.

Re-organization of the administrative structures has become an established practice in Finnish PA. The trends to centralize and decentralize are simultaneous. New Public Management related reforms have taken place since 1987. Gradual outsourcing of prominent business areas can be perceived in both state and local sectors. Simultaneously, the mergers have been encouraged by the State government especially in the municipal sector. The municipalities have conglomerated in many ways, e.g. via forms of collaborative networks, joint ownerships or by strict mergers. A conglomerate form of management is typical to public sector organizations, creating a complex system per se with various corporate governance functions, deep administrative hierarchies, and multiple types of actors, like sectoral domains, in-house enterprises, subsidiaries etc.

Re-organization and re-structuring are not typically based on profound systematic analysis and design. The current state organizational structures form a hindrance to the recurring transformation efforts. In a network of organizations, the management structures should be transparent at high usability levels, to enable the comparative analysis of the as-is corporate structures of the ecosystem, before the design of the common goals implementations. Finnish Information Management Act 2011 necessitates PA actors to publicly model their EA. However, despite of the serious endeavors in launching the shared EA modeling tools among PA actors, the open sharing of the EA descriptions is not at adequate level, and the implementation and use of the method have been challenging [75]. Innovations and best practice sharing has to be based on mutual agreement on personal level first. The search algorithms and comparisons are not profoundly supported at model element level. Furthermore, as Finnish administrations are trending towards citizens-as-partners type practices in service development, the customers and citizens might form a remarkable resource in innovating public services and structures, based on an open source EA description.

5 EAM in Ecosystems – From Problems to Solutions

The domain of EA methodologies has evolved towards the holistic organizational design and development [48]. Al-Kharusi et al. [76] note in their study of EA at dynamic environments that the human and organizational aspects are neglected in target state design. While [77] acknowledge the EA as a way to cope with organizations' ever-increasing complexity, they argue that the EA methodologies do not efficiently advocate the cross-organizational interactions between business entities. They call for business ecosystem architecture models to allow filling the gaps between internal and external operating environments, such as customers, suppliers, and business partners. Drews and Schirmer [12] discuss the stages from the traditional EA to Extended Enterprise Architecture (EEA), and finally to the Business Ecosystem Architecture (BEA).

Drews and Schirmer [12] also present challenges of extending EA towards a value-producing instrument in complex and networked environments. Based on four cases, 16 challenges for business ecosystem architecture management are displayed (ibid). The presented challenges are classified into four groups: (1) challenges regarding the (meta-)modeling of EEA and BEA; (2) challenges regarding the tool support; (3) challenges regarding the management of EEA and

BEA; and (4) challenges regarding the socio-technical dimension. We divide the challenges into the two categories: the complicated problems, i.e. those that can be dealt with by using engineering practices; and the complex problems, i.e. those that mandate the use of heuristic practices. Next, these problems, along with our proposed answers for EEAM and BEAM for the PA as an ecosystem, are further discussed.

5.1 As-Is BEAM as a Complicated Problem

We outline a vision for the IS support of the government ecosystem EA at conceptual level, 1) to enable the comparative analysis across 'whole-of-government', and 2) to provide the real-time as-is information of the ecosystem for target state design. Our proposed solution to complicated problems is an ontology-based, shared EA repository for the-whole-of-government real time updating descriptions.

As discussed by Bakhshandeh [78], ontologies can be used for identifying and disambiguating concepts with formal semantics, facilitating knowledge transfer and computational inference, thus allowing the analysis and detection of logical inconsistencies. The use of logic-based ontologies as the representational basis of EA models makes the use of computational inference and mappings between elements of different domains possible, enriching the overall architecture description [78]. Hinkelmann et al. [21] note that "*because of the complexity of enterprise architecture, machine intelligibility of enterprise architecture descriptions is considered essential for agile enterprises"*. Further, as noted by [21], prior research shows, that an ontology could be a solution to the above mentioned problems. We suggest co-creating the public sector ontology of the different level government ecosystems (local, national, federal), and mapping the EA descriptions and metamodels to them. We would like to see the output as the contextual ontology of government ecosystem EA modeling and enterprise engineering, on which we could build the corresponding shared digital IS ecosystem for EA management and development. We yield below the design principles and some central functional requirements for this IS vision, illustrated by exemplary use cases. The envisioned system provides kind of a semantic web, enabling many types of data mining and comparative analyses.

For the design principles of as-is BEA realization we suggest the following: 1) *Dynamic as-is contents* – automated updates or suggestions for updates. 2) *Scalability*, from the local ecosystems to the national, and the federal ones. 3) *Open access EA information* for citizens, and partners. 4) *Plug-in architecture* options – external organizations outside of the ecosystem are facilitated to plug into the government ecosystem EA. The plug-in architecture enables co-creation, and co-evolution of the ecosystem, offering the option to the new actors to join the ecosystems, thus supporting spontaneous evolution of the BEA. Next, we present three functional requirements (R1, R2, R3) for the as-is BEA realization:

- *R1. Basic modeling and metamodeling functionalities*, that are readily available in many modeling tools, (e.g. [26], [69]). Modeling techniques have still to be innovated more for the organizational coherency and co-evolution purposes. In our development work, e.g. the strategy architecture models of the city were iteratively designed for the best fit to the purpose. The model notations and templates are to be designed situationally, where the model elements and attributes may associate to each other. The real-time as-is descriptions can be automatically visualized via metamodel rules, based on the structural information yielded regularly in everyday-work of the civil servants.
- *R2. Agile analyses and comparisons tools*, that necessitates interdependent, commonly agreed ontologies, e.g. for business catalogues, and organigrams. For instance, the as-is management structures can be made transparent in real-time and used to categorize the EA descriptions and their elements. Each description model and element are associated to relevant management structures. Also, different types of organizations, different types of management structures, and different types of management classifications are represented in the shared ontology. They facilitate the management needs for re-structuring the model

instances according to their needs. Leaders and enterprise analysts may search descriptions and their elements according to shared ontologies, into which the metamodels of different description types are associated. For instance, the Minister of Commerce may browse for the different organizational options of the municipalities entrepreneurial services, to decide whether each municipality has organized them as a subsidiary, in-house-enterprise, via joint ownership, or other. Along the organigrams, he might get the visualized volumes of the actors. The citizen can compare, e.g. the service catalogues between the municipalities.

R3. Situational EA frameworks of the as–is description can be pulled out of the system according to given parameters. The system might offer different EA frameworks templates to different organization types, too. Each organization may instantiate their framework and choose the EA models they prefer in their EA. For instance, the CEO of a water supply subsidiary may request the outline of the EA descriptions realized in his organization, and in those of the neighboring cities.

Next, concerning the as-is BEAM, we discuss the challenges by Drews and Schirmer [12], as well as our proposed solutions to the complicated problems, i.e. an ontology-based, shared EA repository for the-whole-of-government real time updating descriptions.

Challenges concerning modeling include inter-organizational interfaces on all layers, finding the right level of abstraction and identifying shared business objects. As a solution, we propose a shared ontology, which supports associating intra-organizational EA models inter-organizationally. This shared ontology may represent the abstraction levels of the EA description and their elements, whereby comparative analysis is enabled inter-organizationally. Also, it provides a common search index for comparative analyses, which enables the recognition of shared architecture objects.

Further, challenges include those associated with ultra-large-scale architectures with a large number of actors in BEA. As a solution, the envisioned BEAM IS support semi-automatically provides the ultra-scale current state descriptions. Updates are based on content changes in structural documents and automatically visualized in all EA layers. Therefore, the ultra-large-scale BEA descriptions remain continuously updated.

Challenges concerning tools include tool support for ontologies as well as those concerning open standards for data exchange (import/export). Here, we propose envisioned IS support per-se as described in the article. Common modeling standards such as ArchiMate, UML, and BPMN could be mapped to the (core) concepts of the shared ontology to enable search and comparison regardless of the modeling language.

The modeling and tool aspects in Drews and Schirmer's [12] challenges, is the part which our vision of ontology-based hits best, as the shared EA repository for the-whole-of-government, updating in real-time. It encounters with EEA and BEA modeling and tool challenges, since they can be seen as "complicated", engineerable ones. The management and socio-technical aspects are more related to the complex issues, where solutions can be considered mostly heuristic and situational in nature. Therefore, the practice of the target state BEAM design, given in the next section, tentatively answers these complex challenges.

5.2 To-Be BEAM as a Complex Problem

Concerning the complex problems, our proposed solution is the government EA target state analysis and design process outlined below. As stated by one of our interviewees, enterprise architecture still seems to be a solid option for the government ecosystem design and governance: *"We have a development-model, and there, architecture has a distinct role. Architecture has a very tense role in everything before the implementation, where we model operations, data and business-architecture, stakeholders and actors and their dependencies, in order to get an understanding of the whole ecosystem. What we are developing and how it relates to everything else. And there we use enterprise architecture. When the project starts, it's more of making sure that everything matches the architecture."* Another interviewee, an enterprise architect, stated that EA is even more important in ecosystemic environments than before, noting that the current and target states should be updated in an agile manner: *"I think that it is even more important that we apply enterprise architecture ... but that does not mean that EA should not adapt to the change, when we are making it. We have the target state, to which we take some kind of agile transitions. But in this developing world, it does not mean that we would necessarily reach that target state. Also, the target state has to be developed from time to time. In my mind, the idea of enterprise architecture is that we have an idea of our operations, where we are making strategic change, a clear target state. And we take small steps towards it."*

Next, we discuss some relevant problems of broadening the focus of EA to BEA as discussed by [12], before proposing an ecosystem architecture target state design management model and principles.

Challenges concerning management, such as inter-organizational tasks and roles can be approached with more transparency both in inter– and intra-organizational levels via ontologies that apply to management structures [16]. Managing the aspects concerning BEA service provision can be solved with open network structure of actors and service providers. Also, our Plug-In architecture enables new (and temporary) actors to attach and contribute towards the development of ecosystems and services. As noted by one of the interviewees, another enterprise architect, the modeling functionalities should be easy to use and agile enough so that each organization can develop fit for purpose descriptions, as well as enable co-creation between the actors in the ecosystem: *"Modeling each organization's own architectures is something that different organizations could do themselves, because of the differing needs. But future scenarios, the big picture, – it is something where cocreation in the ecosystem could enhance the understanding of the realm."*

Challenges concerning socio-technical aspects, e.g. citizens and consumers as actors, and the lifeworld of customers and partners [12]. Our solution provides an open channel for citizens and consumers to suggest and peer-evaluate ideas for the development of the ecosystem. It seems, as noted by one interviewed manager, that in a public smart city ecosystem, the public administration needs to function as a central actor, though not necessarily as a leading actor: *"The city could act as an operator, matching organizations. Ecosystems are grounded on voluntary participation. ... I don't see the city as a leading actor, more like being a coordinator, ... but if the city can influence on the way things work out and bring other actors to the same table ... in that way, yes."* This viewpoint of public administration acting as a facilitator rather than leading actor in idea co-creation and idea evaluation was a recurring theme in our interviews: *"We have also another goal, which is enabling services outside of those produced by the public administration. Co-creating and co-innovating with, e.g. enterprises, so trying to find a role as a facilitator, where ideas and open data could develop business activity to the area"*, stated one manager. In prior research [79], roles within ecosystems are discussed. These include (1) niche provides, who form the majority of most ecosystems, (2) physical dominators, controllers of the bulk of the innovations occurring, (3) value dominators, who extract value from the ecosystem, and (4) keystone organisations, i.e. leaders. Further, ecosystems governance, i.e. decision-making covers two modes of governance: integrator and a platform hub (ibid). Drews and Schirmer [12] also discuss about the roles in BEA. While they suggest EEA to already extend to cover concerns such as customers, partners and suppliers, they argue that that for BEA, a central actor must have an overview of the whole ecosystem, i.e. the infrastructure and interfaces to all connected EEA's. Our results indicate that in smart city ecosystem, public administration sees itself as a facilitator, not a leader. In line, [31] presents cities as "platform hubs", which facilitate the interaction of third-party service providers with customers, citizens and companies.

Figure 1 suggests a management model for the government ecosystem architecture. The stages 1 to 4 illustrate the tentative target state design process for co-creating new services in the ecosystem.

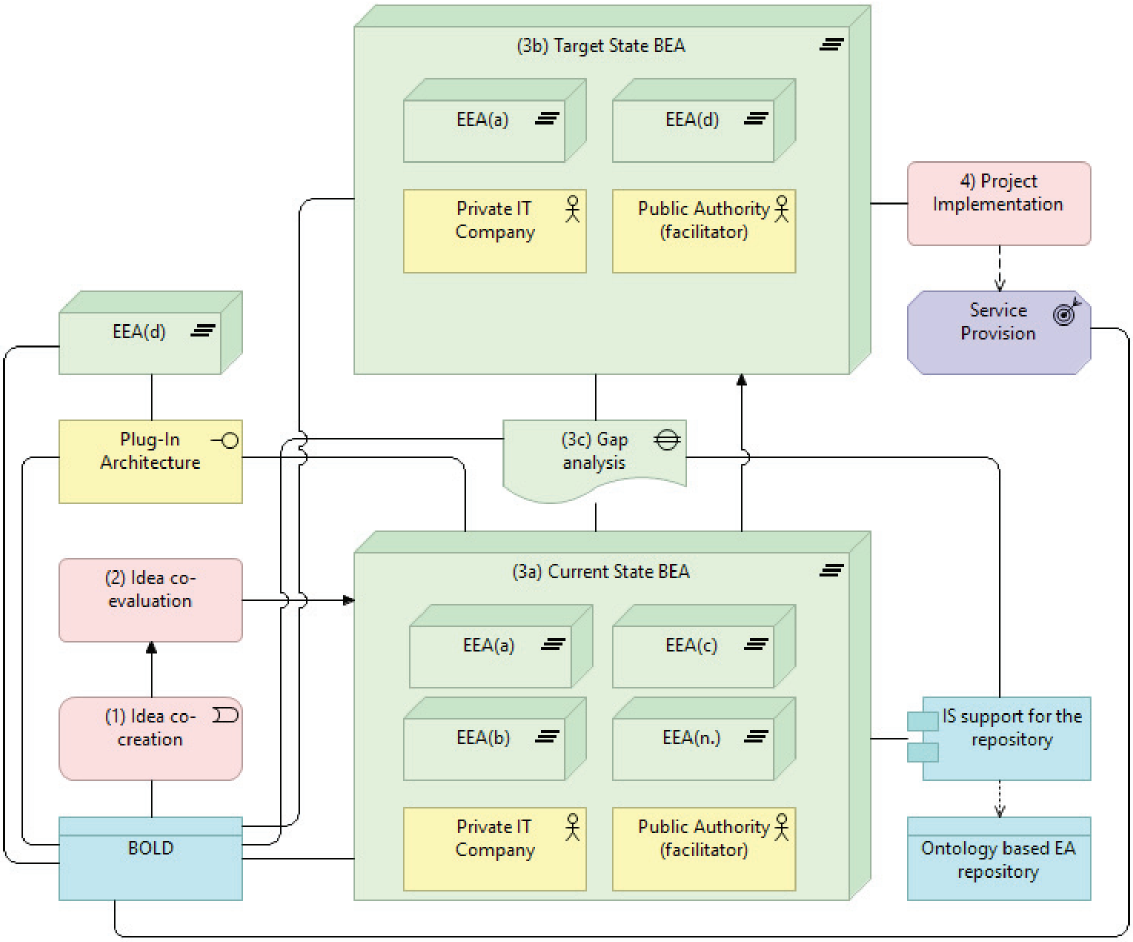

Figure 1. BEA management model in ArchiMate

In the phase 1, idea co-creation, an initiative appears, e.g. from citizens, government actor, or private companies (cf. [17]). To support the innovation, the phase should be as open as possible. Idea evaluation in the ecosystem seemed to be both a challenge as well as richness of the ecosystem approach. One interviewee, who acted both as a manager and a business architect, noted the following: *"It is a challenge… what kind on platform would enable the participation of citizens …, and maybe some enterprise or an organization could seize those ideas."* This creates a socio-technical dimension to the idea co-creation, which was noted also by the interviewees: *"We have created models for co-creation, meaning a way to operate with enterprises and research institutes, when we are developing or helping enterprises to develop services."* A challenge frequently mentioned was the storing of data and the creation of shared data models. As an example, one interviewee mentioned, that majority of the interviewed cities belong to Helsinki Region Environmental Services, a municipal body, which produces waste management and water services. Although waste management is a vital theme in smart city and PA endeavours, no shared repository or data models exist. Caputo et al. [3] further discuss the vital themes of linking smart technology and big data in a smart city ecosystem from a systems thinking perspective. They conclude, that efforts should be made to make the data freely available, as value is generated from the usage of the data, not the data itself, although noting that smart technologies and big data are as key levers able to produce effects only as a consequence of actors' participation and collaboration. Fostering Big and Open Linked Data (BOLD) [62] seems to be a key to successful EA usage in the ecosystemic environments.

In Phase 2, the idea co-evaluation is done by a variety of stakeholders. For instance, public agencies might have a special interest in the financial analysis, whereas local citizens might appreciate the geographical locations of the services, and private enterprises can have goals of their own. The balance between financial and functional performance must be achieved [17], and those ideas recognized, which benefit the ecosystem as a whole. As stated by one of our interviewees, a manager: *"We have this challenge with new services and ideas from the citizens. If we get a good idea somewhere, from citizens, it does not mean that we as a public actor can manage that. But maybe some enterprise or other community could do it with us."*

This is followed by Phases 3a Current state analysis, 3b Target state design, and 3c Gap analysis. In 3a, the participating actors are identified, resulting in the subset of necessary distinct EA's, covering concerns such as customers, partners and suppliers [12], i.e. *EEA* (see below). The as-is BEA updates semi-automatically by increments in the project implementation, finally fully reflecting the previous target state. The deployment may be ceased at any time based on the feasibility checks, too. Also, the architectures of each individual EEA participating can be updated alongside. Here, as well as in prior phases, the ontology discussed above is necessary to ensure consistent and coherent data content between different actors of the ecosystem. For instance, if different actors in the ecosystem would not have mutual naming conventions for their information architecture elements and data content, co-creation would not be realized optimally.

Phase 4, Project implementation starts with suitable project organization, involving the configuration of internal and external ecosystem actors, and IT-service providers. Almost all of the interviewees mentioned the usage of (open/public) data as well as sharing data between the actors of the ecosystem as a crucial aspect in service co-creation. The usage of data seems to cover the whole design process, from idea creation to implementation. As noted by one of our interviewees, an enterprise architect, *"Data is the thing. We should understand the citizen-data and the essence of whole, so that we can use that data and implement services where needed ... with data we should provide services across the ecosystem, not just public services, but services provided by that area."* This view was shared by a manager of another city: *"In my mind the key is to gather data about the environment and use that data in design and management".* The data can be used to create a sense of the whole ecosystem, as well as to decide which projects to implement: *"Big enough picture is needed, but the experiments need to be small. Our idea is, that we take one segment, cluster some data ... and then begin the concrete project".*

As discussed in Section 3, in DSR [60], the theoretical knowledge base and real-life environment are married for the researchers to create an artifact that is needed in the environment. In line with that thought, we refer to prior research, alongside our interview data, and propose principles (P1 – P6) for government ecosystem architecture management. Hedges and Furda [79] discuss architectural principles based on earlier research, offering three perspectives: decomposition, modularity and design rules, which cover four rules: simplicity, resiliency, maintainability and evolvability. Janssen and Kuk [46], examine the use of EAs in the Dutch public administration from a complex adaptive systems perspective, and based on analysis of 11 cases, derive eight architectural design principles, including development of modular architectures, stimulation of sharing and formation of coalitions. Further examples include the study by Lnenicka and Komarkova [62] who discuss developing a government enterprise architecture framework to support the requirements of big and open linked data with the use of cloud computing. Carter [53] discusses Systems Theory based architecture framework for complex system governance, and introduces a method, along with some principles. Jacobides, Cennamo & Gawer discuss ecosystems more generally. These valuable contributions offer a baseline for our pondering:

P1. Dual nature and nestedness: government ecosystem architecture should, at its highest level of abstraction (to-be complex level), be simple; yet thrive to capture as-is complicated architecture accurately and unambiguously, harnessing latest technological achievements (see Section 6.1, cf. [79]). The ecosystem forms of different systems, such as participating actors. Although the ecosystem is emergent, systems-wide design and planning can be achieved at various levels.

P2. Openness: ecosystem should strive to openness, where new actors could join the ecosystem (ibid). Openness does not only mean the lack of restricting new actors to join, but also actively promoting the ecosystem. This is done with Plug-In architecture (see Figure 1), (cf. [79]).

P3. Evolvability, Needs-based utilization and Modularity: to foster the evolution of the ecosystem, not only should openness be fostered, new services should be designed in modular and agile way. [80] note, that while not regularly noted, an important characteristic of ecosystems is that they help coordinate interrelated organizations that have significant autonomy via modular architectures, which allow for coordination of independent yet interdependent firms through ecosystems In Figure 1, a particular project is implemented in means of modularity: participants include existing ecosystem members, as well as a new member, joining through the Plug-In architecture. The ecosystem evolves through projects, where participants are decided on demand. (cf. [46])

P4. Co-operability: much like in natural ecosystems, government ecosystem is based on co-operability, such as co-creation of services. In Figure 1, project implementation is achieved by a variety of voluntary participants. Although participating to any given project is voluntary for the ecosystem actors, public administration actors frequently act as facilitators (cf. [46], [80]).

P5. BOLDness: from idea co-creation to new service provision, to automated As-Is BEAM, actions in the ecosystem are based on fostering Big and Open Linked Data (BOLD) [62].

P6. Holism and Circular Causality: to foster the benefits of the ecosystem, a systemic stance is needed, embracing holism, e.g. interactions among actors, as well indirect causality among actors. Holism also includes notion of complementary viewpoints, where different actors have varying perspectives about the actions in the ecosystem (cf. [53]).

These principles, along with the management model and the IS-supported, ontology-based EA repository form the tentative basis for the government ecosystem architecture design and management. As discussed prior (see Section 2), disciplines such as EA possess a dualistic nature – concerning both complex and complicated systems [44]. We argue, that this is to be achieved by combining two perspectives: modeling the state of, e.g. the infrastructure and data of the organization (complicated problem) as well as managing social phenomena in the midst of ecosystemic environment (complex problem). We suggest the current state EA modeling to follow the engineerable path as the complicated problem, by semi-automated models of the as-is, whereas the target state design of BEA is left with situational, heuristic practices, however benefiting of the as-is repository.

6 Conclusions

Based on our research concerning Finnish national enterprise architecture (EA) adoption in long run, this study discussed the development of EA in order to support business ecosystem and organization design. We discussed, what kind of information system (IS) is needed in a complex socio-technical government ecosystem for real-time current state analysis, and what kind of management model is needed for the government ecosystem architecture target state design. Our research context indicates, beyond a federal government or a state one, that even a single municipality, like a city concern, can be perceived as an ecosystem of its sectoral domains, subsidiaries etc. The objectives of the study were, to:

I. Outline some basic functional requirements of an ontology-based, shared EA repository for PA ecosystem and to propose a vision of the real-time information system support for such a repository.

II. Further develop previously introduced [18] management model for the government ecosystem architecture target state design.

In this study, we outlined a vision of an overall ontology-based, shared EA repository for the-whole-of-government current state descriptions. Further, the central design principles and functional requirements for such a system were specified, and some potential use cases were illustrated. A tentative management model for future state ecosystem architecture was discussed via a model of design process for co-creating new services in the ecosystem, and government ecosystem architecture management principles were outlined. We envision an IS solution for EA descriptions' accessibility, and automated update in government ecosystem. The IS vision and presented tentative model stand for design artifacts in terms of [60]. As discussed prior, we used abductive logic reasoning to enhance our vision, which forms a 'process of discovery' where inferences are drawn to the next best explanation in each cycle, with wider set of data. As for our latest research cycle, we used interview data from four smart city cases in Finland, serving as representations of PA ecosystems. Thus, we propose EA as a concept for organizational design of a government entirety.

There are some limitations to our study, and, in the following reliability and validity are discussed in relation to our last interview round. Reliability is seen as to what degree the results are consistent. Validity concerns the accuracy of the measure, which means the degree to which measurements are what they should be. Concerning validity, there are at least few notions to consider. Interviewees interpret the questions in a way that is in concordance with their rendition of the reality in that particular time and place. We as scholars have made our own interpretations about the study material in the analysis phase, and therefore, some preconceptions may have affected the analysis. Therefore, although this research could be repeated with the exactly same layout, with same circumstances and with the same interviewees, different sentiments could occur. According to Hsieh and Shannon [73] threats to validity regarding content analysis further include the risk that the researchers fail to understand the whole context, and thus missing key categories. We tried to minimize this risk with analysis triangulation, where two authors both analysed the data. To enhance repeatability of the interviews (i.e. reliability), example questions of a manager interview are offered in the Appendix. The case studies reported were based on only a single country, its public sector, and four cities, and different aspects might be emphasized elsewhere. Therefore, more research is definitely needed, for instance, on other countries.

This article is based on a working paper, presented at the Workshop on Resilient Enterprise Architecture, in liaison with the International Conference on Perspectives in Business Informatics Research. Prior to the conference, the paper was reviewed by two blind reviewers. This could be seen as some form of cross evaluation, adding the soundness of the results and analysis. After the conference, the paper was further revised based on the discussion and additional data. Several pages were added, and the original management model was further enhanced, and design principles were outlined.

We presented the design principles and central functional requirements of the ontology-based as-is government ecosystem architecture repository, that is meant to be applicable to any chosen whole-of-government entirety. The proposed solution has several anticipated benefits. The system might maintain transparency and comparability across the entirety of the government, eliminate duplicate work, enhance the sharing of the best practices, and most importantly, support the co-evolution of PA structures towards higher coherency and synergies. Shared EA descriptions would support also co-creation and co-evolution of the ecosystem. However, the implementable solutions require further studies. The aim of the study is to encourage evolutionary studies, and pilots, especially constructive ones, to reach out to more specific specifications and design principles for the BEAM solution. Especially it requires the design of a future common, wider ontology of the public administration sector and concepts. This implies application of ontology engineering knowledgebase in further development and research of the subject (cf. [17]). Secondly, the tentative target state design process should be both tested at a real environment, and further enhanced based on the results.

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Appendix: Example questions of a manager interview

- Name?
- Occupation and job description?
- What projects are going on in your city?
- What in your opinion is the “nature” of a smart city? What about an ecosystem?
- What elements constitute the above mentioned?
- Do you see smart city/ecosystems endeavors as project work?
- Do you see smart city/ecosystems endeavors as a whole or as several individual projects?
- Who are the participants of the above mentioned?
- How the participants are “decided” or how the whole is composed?
- What is the motivation or goal in your endeavor?
- Who/what are the target of your endeavors?
- What kind of problems you are trying to solve?
- How the smart city/ecosystems-thinking helps you to solve these problems?
- What kind of changes there has been from the beginning of the project?
- How do you manage the design and development of your smart city/ecosystem?
- What kind of methods do you use in different phases?
- What positives and negatives have you had in your endeavors?
- Have you identified some best practices?