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EXAMINING ENTERPRISE ARCHITECTURE: DEFINITIONS AND THEORETICAL PERSPECTIVES

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ABSTRACT

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This thesis consists of two articles discussing the evolving discipline of Enterprise Architecture (EA), along with introduction and discussion of EA, systems approaches and the nature of theory in Information Systems Science. Despite decades of research, diversified views of the definition, scope and purpose of the concept occur, and no common theoretical foundation has been acknowledged. Recently, different systems approaches have been of interest in the field of EA research, both as means of evolving the scope of EA, and by strengthening theoretical foundations of the field. In the first part of the study, the definitions of enterprise architecture, gathered from previous literature and 26 in-depth practitioner interviews, are examined through Lapalme's Schools of Thought on Enterprise Architecture. The second part of this study contributes with a systematic literature review on the state-of-art of systems approaches in EA research, which have been phrased as a possible theoretical basis for the field. The findings are discussed, reflecting to the types of theory and the use of theory in EA field of research. The results of this study indicate that while there is still no shared definition of EA, its scope and purpose are increasingly extending from IT-business alignment towards holistic organizational design and development in the system-in-environment setting. Although various systems approaches are frequently referred to in the EA studies, the application of systems theories appears to be fragmented, and the approaches are rarely systematically used in empirical studies.

Keywords: Enterprise Architecture, Literature Review, Interview, Systems Thinking, Systems Theory, Definition.

TIIVISTELMÄ

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Tämä tutkielma koostuu kahdesta kokonaisarkkitehtuuria käsittelevästä artikkelista, sekä kokonaisarkkitehtuurin, systeemiajattelun ja tietojärjestelmätieteen teorian käsittelystä. Kokonaisarkkitehtuuria on tutkittu vuosikymmeniä, mutta sen määritelmä, laajuus ja tarkoitus jakavat mielipiteitä, eikä yhtenäistä teoriapohjaa ole. Systeemiajattelu ja eri systeemiteoriat ovat olleet viimeaikaisen tutkimuksen kohteina, ja on mahdollista, että niitä hyödyntämällä kokonaisarkkitehtuurin laajuutta ja teoreettisia lähtökohtia voidaan edistää. Tutkielman ensimmäisessä osassa tarkastellaan 26:ta haastatteluista kerättyä kokonaisarkkitehtuurin määritelmää Lapalmen koulukuntaluokituksen (Schools of Thought on Enterprise Architecture) avulla. Tutkielman toisen osan muodostaa systemaattinen kirjallisuuskatsaus systeemiajatteluista ja systeemiteorioista kokonaisarkkitehtuurin tutkimuksessa. Kirjallisuuskatsauksen tuloksia tarkastellaan suhteessa teoriatyyppeihin sekä teorian käyttöön kokonaisarkkitehtuurin tutkimusalueella. Tutkielman tulokset viittaavat siihen, että vaikka kokonaisarkkitehtuurin määritelmät eivät ole yhteneviä, sen ala ja tarkoitus ovat laajentumassa IT:n ja liiketoiminnan yhteensovittamisesta kohti holistista organisaatioiden suunnittelua ja kehittämistä osana systeemistä ympäristöä. Systeemiajatteluun ja eri systeemiteorioihin viittaaminen vaikuttaa olevan yleistä kokonaisarkkitehtuurin tutkimuksissa, mutta niiden käyttö on pirstaloitunutta ja harvinaista etenkin empiirisessä tutkimuksessa.

Asiasanat: Kokonaisarkkitehtuuri, Kirjallisuuskatsaus, Haastattelu, Systeemiteoria, Systeemiajattelu, Määritelmä.

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LIST OF INCLUDED ARTICLES

I Nurmi, J., Penttinen, K., Seppänen, V. (2018). Examining Enterprise Architecture Definitions – Implications From Theory and Practice. In *Information Systems Research Seminar in Scandinavia*.

II Nurmi, J., Pulkkinen, M., Seppänen, V., Penttinen, K. (2018). Systems Approaches in the Enterprise Architecture Field of Research: A Systematic Literature Review. In *Enterprise Engineering Working Conference*.

I, Jarkko Nurmi, was the first author on both included articles. In the Article I, the first author was responsible for the literature review. The second and third author, along with Hanna-Kaisa Isomäki and Pasi Tyrväinen, were responsible for the design of the interview. The second and third author, along with Hanna-Kaisa Isomäki, were responsible for collecting the interview data. Analysis of the interview data was done by the first two authors, and analysis of the literature review was mostly done by the first author. While designing the research and writing the article was a joint effort of all authors, I was responsible for majority of the writing. The Article II was also joint effort of all the authors, and the conception and design of the research was done by all authors. I was responsible for the literature review and contributed especially to the analysis of the research material and writing the article.

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1 INTRODUCTION

Enterprises and organizations are operating in ever-growing fields of uncertainty, changing and volatile business-environments and the need to adapt to these challenges in order survive, better yet to thrive. Organizations must adopt emerging technologies and align them to the business needs, processes and possibly siloed technological structures with complex dependencies. More than two thirds of CEOs believe, that the changes in the next few years will be more critical than the ones in the recent fifty, that the speed of the changes will be exponential, and many have doubts about whether their organization can keep up with the changes (KPMG, 2016). Albeit vital, these changes might be difficult to manage, and require a holistic yet detailed view of the organization. Enterprise Architecture (EA) has been an interest of academics and practitioners for few decades, and has been stated, among others, as a tool for alignment between business and IT (Alaeddini, Asgari, Gharibi & Rad, 2017; Ross, Weill & Robertson, 2006), an issue judged as a top management concern (Kappelman, McLean, Johnson & Gerhart, 2014; Luftman & Ben-Zvi, 2010). EA can enhance responsiveness to disruption (Gartner Inc., 2017), while other possible benefits of EA include added value and success of IT-projects (Kurek, Johnson & Mulder, 2017), reduced costs (Tamm, Seddon, Shanks & Reynolds, 2015), enhanced agility and increased performance (Hazen, Bradley, Bell, In & Byrd, 2017) and various others (e.g. Foorthuis et al., 2010; Shanks, Gloet, Someh, Frampton & Tamm, 2018; Simon, Fischbach & Schoder, 2014).

In the academic community, EA seems to have a steadily growing interest as a research area, seen in the extensive literature review by Gampfer, Jürgens, Müller and Buchkremer (2018). According to their analysis of approximately 4000 articles, the number of peer-reviewed EA articles has increased from 1987 to 2015 by 21% on year per average, compared to increase of scientific publications (3%) and IT publications (5%) overall. In the industry, Kurek, Johnson and Mulder (2017) examined the use of EA in 3076 IT projects from 2007 to 2016, offering impressive results. Among others, the results of their study indicate an increase of 14,5% of successful projects, and a decrease of 26,2% of failed projects; an increase of 14,8% of projects on budget, and a decrease of 10.4% not

completed on budget, and an increase in the number of projects with very high value by 25,56%, when very low value projects decreased with 12.8%. EA is clearly an important and relevant topic on research and practise.

Despite keen interest, scholars and practitioners struggle to form a coherent definition for EA (Nardello, Møller & Gøtze, 2018; Saint-Louis & Lapalme, 2016; Rahimi, Gøtze & Møller, 2017) and the definitions proposed differ both in scope and purpose (Lapalme, 2012). Furthermore, EA is a developing discipline, and due to it being rooted in various domains of research and practice, no commonly acknowledged theoretical foundation exist. As the scope and purpose of EA seem to be expanding from mechanistic IT-business alignment to a holistic design of an enterprise in an ecosystemic environment (Korhonen, Lapalme, McDavid & Gill, 2016), traditional tools of EA might fall short. A number of prior studies have noted these gaps in the field of enterprise architecture and called for scholars to examine EA definitions and to strengthen the theory of the field.

The need to study the definitions of EA is urgent. The lack of common understanding concerning the scope and purpose of enterprise architecture leads to difficulties in structuring a baseline of knowledge in the field (Saint-Louis, Morency & Lapalme, 2017) and makes it complicated to talk about EA as a discipline (Saint-Louis & Lapalme, 2016). Previous research has phrased the need for examining these evolving definitions. Kappelman, McGinnis, Pettite and Sidorova (2008) state that a clear academic definition should be established, as well as unified understanding of the separate terms "enterprise" and "architecture". According to Rahimi et al. (2017, p. 81) "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, Kappleman and Zachman (2013) note that the few studies focused on the lack of common understanding have not used a systematic methodology.

As enterprise architecture is an evolving discipline, with its roots outside of academia, the need for an acknowledged theoretical foundation for EA has been noted by previous research (Bernus, Noran & Molina, 2015; Kandjani & Bernus, 2012; Kandjani, Bernus & Nielsen, 2013). Prior research in the EA field of research discusses the systems nature of an enterprise (e.g. Harmon, 2005; Hoyland, 2011), and demands to study the relations between enterprise architecture and systems approaches have been phrased (Bernus et al., 2016; Lapalme et al., 2016). For example, 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) state the "importance of systems thinking and, especially, of adopting the open systems principle, for managing EA design and evolution" and Korhonen et al., (2016, p. 272) discuss about EA in "enterprise-in-environment ecosystemic perspective". Current EA practices apply methods, tools and frameworks integrating four architectural views (business, applications, data and technology) into a holistic model of the organisation and its subdomains. Extending the scope of EA from solely an IT per-

spective to include all the facets of an enterprise (i.e. extended EA) (Korhonen et al., 2016; Gampfer et al., 2018), and to concern not only documenting the landscape of said enterprise, but to also design it, challenges some of the current methods and paradigms of EA. As an example, Hope, Chew and Sharma (2017) base their argument on a case study, and conclude, that success factors such as use of formal methods and use of architectural tools were not present more often in successful EA projects than in those that were unsuccessful. Further, Goerzig & Bauernhansl (2018) argue, that while EA can enhance the digital transformation of enterprises in Industry 4.0 setting, current approaches are not sufficient.

This study contributes to the discussion concerning the evolving discipline of EA by addressing two topics: the definition of EA and the theoretical foundations of EA. The research questions are stated as follows:

- RQ1: To what extent the systemic paradigm is seen in the EA definitions?
- RQ2: To what extent different systems approaches are used in EA research?

The definition of EA is discussed by offering a systematic literature review of the state-of-the-art of EA definitions as well as 26 in-depth practitioner interviews, specifically noting the recent trend of applying systemic stance on EA field of research. The definitions gathered are analysed to see how convergent they are and compared with Lapalme's (2012) "Schools of Thought on Enterprise Architecture" to see how these taxonomy classes encompass different views of academics and practitioners. According to Lapalme (2012, p. 37) the taxonomy "creates a starting point for resolving terminological challenges to help establish enterprise architecture as a discipline.". Furthermore, two of the three taxonomy classes favor systemic stance (Lapalme, 2012), hence serving as a basis for discussing the relations between enterprise architecture and systems approaches. As a result, this study indicates that while there is still no shared definition of EA, its scope and purpose are increasingly extending from the purpose of IT-business alignment towards a tool of holistic organizational design and development in the system-in-environment setting.

The second part of this study discusses if, and to what extent the systems approaches could provide a common theoretical foundation for EA. A systematic literature review is conducted, and the nature of theory is discussed both within the Information Systems (IS) and related Enterprise Engineering (EE) communities. A total of 47 studies are classified into four categories based on the purpose of the said study: (1) theory or discipline; (2) ontologies and frameworks; (3) methods and modelling; (4) software tools, as well as to eight different systems approaches applied. Also, the reviewed articles are differentiated based on whether a particular study (1) is conceptual or theoretical, or (2) is based on or supported by empirical evidence. As a result, it is stated that although the systems approaches are frequently referred to in the EA studies, the

application of these theories appears to be fragmented, and the approaches are rarely systematically used in empirical studies.

This study has several contributions, academic implications as well as industry-relevance. First, it presents a comprehensive and overarching view of current state of systems approaches in the EA field of research. Second, by offering in-depth practitioner interviews, the definitions of EA are discussed along with scholarly definitions and reflected to the prior taxonomy by Lapalme (2012). This allows the discussion on the recent systemic stance in reference to the definitions, as well as gives valuable insight to the world of practitioners. Third, by examining the definitions as well as systems approaches in the field of EA, steps are taken towards native theory in EA field of research and implications for future research are offered.

The rest of this study is structured as follows: Section 2 offers theoretical background: the following chapter, 2.1, discusses enterprise architecture – mainly offering a brief overview on the development of the field and giving an initial definition of EA. After that, chapter 2.2 discusses various systems approaches – systems theories and systems thinking, and chapter 2.3 concerns the nature of theory in Information Systems and Enterprise Engineering communities. In Section 3, methods of the study, systematic literature review and semi-structured interviews are presented, while an overview of the included original papers is presented in Section 4. Finally, Section 5 presents concluding remarks from the state-of-the-art account of enterprise architecture definitions and the contributions of systems approaches to the field of EA. The limitations, reliability, validity and ethics of the study are discussed, and topics for the future research presented.

2 Theoretical Background

In this section, the main concepts of the thesis - enterprise architecture and various systems approaches – are introduced, and theory in Information Systems and Enterprise Engineering communities is discussed.

2.1 Enterprise Architecture – A Brief Look

Examining EA and the definitions given to it can be approached at least by discussing the historical development of the field, by examining the concept through linguistics and standards, and by reviewing previous literature. In this section, the concept of enterprise architecture and the development of EA as a field of research and practice are briefly discussed. Also, the overlapping discipline of Enterprise Engineering is introduced.

The fundamental ideas of EA originate from various different communities, such as IS, industrial engineering and management (Bernus et al, 2016; Gampfer et al., 2018; Romero & Verdanat, 2016). In IS, the Zachman Framework (Zachman, 1987) and works of e.g. Spewak and Hill (1993) have been seminal. Recently, Kotusev (2016) has stated, that the historical provenance of EA traces back to Business Systems Planning in the 1960s, thus arguing against the originality and significance of especially Zachman's contribution. According to Bernus et al. (2016) industrial engineering community focused on engineering the material flows of an enterprise, later extending the scope to the entire enterprise as well as its business networks (e.g. supply chains) – hence the term "enterprise engineering".

Bernus et al. (2016) further note, that the originally intended scope and present-day scope of EA differ, which might partly explain the differing definitions given to the concept. As a result, the numerous definitions given to EA emphasize different aspects of the field, and while defining EA has been in the interest of many academics, also differing opinions occur. For example, Penttinen (2018, p. 12) cites Hope (2015) and Van Den Berg & Van Steenbergen

(2006), arguing that "Each organisation adopting EA should define the purpose and scope for the organisation's work. From the purpose and the scope, the definition of EA in that particular instance emerges".

Not only is there a lack of common understanding concerning the concept of EA, the definitions of distinct terms "enterprise" and "architecture" are also debated. Furthermore, enterprise architecture is used to refer to the result of the architecture work as well as to the work itself (Korhonen et al., 2016). An "enterprise" indicates to the scope of the examination, and can be defined e.g. as an organization, a part of the said organization or several organizations forming a whole. The second part, "architecture", can be defined e.g. 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" (ISO/IEC/IEEE 42010:2011). This standard is also regularly cited when defining EA itself, when EA is seen as a system.

Prior research discusses defining enterprise architecture. For example, a survey of 376 responses from executives, enterprise architects and various other professions found, that the purpose and function of enterprise architecture is 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 (Kappelman et al., 2008). Furthermore, Rahimi et al., (2017) found four strands of EA definitions from 85 articles: 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.

Some prior literature concerning the difficulties scholars and practitioners have on structuring a coherent definition of the concept, exists. Schöenherr (2008) garnered 126 EA themed research papers from 1987 to 2008 and concluded that majority of examined studies do not define enterprise architecture in a comprehensive way. Saint-Louis and Lapalme (2016) conducted a systematic mapping study of 171 articles from 1990 to 2015. In conclusion, they found that a third of examined articles give no definition to EA, a third state differing understanding of EA as a problem, and the lack of shared meaning in the discipline of EA was mentioned frequently. Similarly, Saint-Louis et al. (2017) discuss 145 articles, of which almost half do not define EA.

Related field of Enterprise Engineering (EE) is characterized by many of the same themes as EA – a plethora of definitions exists, EE is a developing discipline concerning design of enterprises and the need for theory-development is noticed. EE is seen as overlapping EA (Yildiran, Kilic & Sennaroglu, 2018), and EA is among the most common topics in EE conferences (Molnar & Korhonen, 2014). Further, EE is an interdisciplinary field, rooted in fields such as IS and organizational sciences. Enterprise engineering sees enterprises as systems, strives to provide a theory-based methodology to (re)design organisation, and has been defined for example in the following ways: EE is an "enterprise lifecycle oriented discipline for identification, design, and implementation of enterprises and their continuous evolution.", which strives to "define, structure,

design and implement enterprise operations as communication networks of business processes, which comprise all their related business knowledge, operational information, resources and organisation relations." (Kosanke, Verdanat & Zelm, 1999, p. 83; p. 85.) More recently, Dietz et al. (2013) have defined EE as a holistic approach to address enterprise changes.

Although prior research discusses the definition of EA, and the struggles of scholars and practitioners seem to have in defining the concept, a definitive and commonly agreed definition is still lacking, and a substantial amount of studies choose not to define EA in any explicit way. Moreover, enterprise architecture is developed in parallel on different communities, such as in IS and EE. In order to discuss the definitions of EA, an initial definition is offered, citing Lapalme et al. (2016, p. 104), who's definition is based on ISO/IEC/ 42010:2007: "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.". This definition is neutral and broad enough yet notes the recent systemic stance on enterprise architecture and is thus seen as a solid basis for the discussion concerning the evolving interpretations on defining EA.

2.2 Systems Approaches – Systems Theory and Systems Thinking

In this section, systems approaches – systems thinking and systems theories – are briefly introduced, as it is in the interest of this study to discuss the extent to which different systems approaches are already in use in EA research.

The fundamental origins of modern systems thinking were developed in early 20th century across multiple disciplines (Mingers, 2017). Mingers and White (2010, 1148) summarize systems approaches in the following way: "Viewing situations holistically, as opposed to reductionistically, as a set of diverse interacting elements within an environment. Recognising that the relationships or interactions between elements are more important than the elements themselves in determining the behaviour of the system. Recognising a hierarchy of levels of systems and the consequent ideas of properties emerging at different levels, and mutual causality both within and between levels. Accepting, especially in social systems, that people will act in accordance with differing purposes or rationalities.". This gives insight to the methodological basis of systems approaches, according to which the traditional analytical methods are, to some degree, inappropriate for studying systems. While parts of mechanical devices, such as clocks or engines, can be separated and studied separately without losing its essential elements, parts of some systems (e.g. social, political and business systems) cannot be separated without losing the essence

of whole. (Phillips, 1972.) Further, Phillips (1972) cites Angyal (1962, p.26) who explicates this viewpoint: "[…] 'part' means something different when applied to aggregate from what it means when applied to wholes. When the single objects a, b, c, d, are bound together in an aggregate they participate in that aggregation as object a, object b, object c, etc., that is, as lines, distances, color spots, or whatever they may be. When, however, a whole is constituted by the utilization of objects a, b, c, d, the parts of the resulting whole are not object a, object b, object c, etc., but α, β, γ, δ…". Therefore, systems approaches examines systems in the midst of their surroundings, consisting of subsystems and interrelations among them.

Various systems theories include, among others, General Systems Theory (GST), advanced by von Bertalanffy (1968) and Boulding (1956), Miller's (1978) Living Systems Theory (LST) and Cybernetics, discussed by, among others, Wiener (1948) and Beer (1972). System thinking, reflecting the same common concepts, was coined in the late 1980's by Barry Richmond (Arnold & Wade, 2015). Systems thinking suffers, in some extent, from lack of consensus on the definition (Cabrera, Colosi & Lobdell, 2008) and has been viewed e.g. as science, method, approach, skill, discipline and conceptual framework. Practical applications of systems approaches include, among various others, Soft Systems Methodology, developed by Checkland (1981) in which the goal is to advance the stakeholders' involvement to the implementation of technical systems, which supports the systemic organisational design and change. Next, some of the most applied systems approaches are briefly introduced.

General Systems Theory (Boulding, 1956) presents a hierarchy of real-life complexity in nine levels, where higher levels of hierarchy incorporates lower levels. Level 1 concerns frameworks and structures with static behaviour, while at Level 2 (clockworks) objects model predetermined motion, an example being the solar system. Level 3 is studied by cybernetics and discusses closed loop-controlled systems, while open systems exhibiting structural self-maintenance are discussed at Level 4. Level 5 studies lower organisms with functional parts, planned growth and reproduction, and Level 6 concerns animals with brain and capability to learn. At Level 7 are self-conscious people, at Level 8 are socio-cultural systems, and at Level 9 are transcendental systems.

Viable System Model (VSM) was developed by Beer (1972; 1979) based mainly on cybernetics. As noted by Bernus et al. (2016), cybernetics could provide EA a viewpoint to analyse relationships between psychological and social systems, such as individuals and organisations. According to Huygh and De Haes (2018) the key concepts underlying VSM are viability (i.e. systems capability to maintain itself with a problem-solving capacity); requisite variety (i.e. measure of complexity, where variety of control elements should be at least equal to the variety of the controlled elements); recursion (i.e. "any viable system contains, and is contained in, a viable system" (Beer, 1979, p. 118)); and transduction (i.e. the communication of two entities is translated into terms understandable to receiving entity, while preserving the intended variety). Furthermore, VSM describes systems (1, 2, 3, 3*, 4 and 5), first of which is the com-

bination of all embedded viable systems, while system 2 coordinates the activities of prior. System 3 manages the operations of the system, system 3* links the operational units to the system, while system 4 is in charge of scanning for threats and opportunities in the environment. Finally, system 5 is responsible for creating and managing the system, as well as setting its purpose, values and directions. (Huyng & De Haes, 2018). Lastly, VSM discusses four variety loops, also called communication channels: command axis, communication with the environment, algedonic channel and System 3 – System 4 homeostat (Huyng & De Haes, 2018).

Jackson (2009, p. 524) introduces three variants of what is called Applied Systems Thinking (AST) – "systems thinking that has as its primary purpose the enhancement of management practise". First, functionalist AST uses mechanistic (GST Levels 1-3) and organismic (Levels 4-6) to make certain that systems function properly. Knowledge is gained through models and scientific methods, concerning the interrelationships between parts and between the system and the surrounding environment (Jackson, 2009). Second, according to Jackson (2009), structuralist AST follows the route Boulding (1956) set to establish General Systems Theory, and emphasizes the similarities at different Levels, as von Bertanlaffy (1968) suggested: "there exists models, principles and laws that apply to generalized systems or their subclasses, irrespective of their particular kind". Miller's (1978) Living Systems Theory (LST) follows this intent with 8 hierarchical levels and 19 critical subsystems, along with other structuralist systems approaches, such as system dynamics (Senge, 1991), Cybernetics and VSM (Beer, 1972; 1979). Third, interpretive AST, such as Checkland's (1981) Soft Systems Methodology, seeks to work with different interpretations of reality in contrary to building systems models (Jackson, 2009), and is summarized by Ackoff and Gharajedaghi (1996, p. 22): "Our society and the principal private and public organizations that it contains have reached a level of maturity that eliminates whatever effectiveness applying deterministic and animalistic models to social systems may once have had".

The common features among different systems approaches, discussed by Mingers and White (2010), are reflected to the EA setting in the second included original paper (Nurmi et al., 2018b, p. 4) like follows:

- 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.
- 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 its environment.
- System and subsystems can be "open", i.e. they are taking inputs from and sending outputs to the environment, and possible adjacent (sub-)systems.
- 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.

As this study examines, what aspects of theory do the systems approaches cover in earlier EA studies, as well as discusses theoretical perspectives in EA field in general, the nature of theory in Enterprise Engineering and Information Systems is briefly discussed in the next chapter.

2.3 Theory in EE and IS Communities

Mueller and Urbach (2017) argue, that theoretical basis is crucial for a discipline and offers an understanding to move beyond routines to meaningful actions. In order to properly examine the extent to which different systems theories (and systems thinking) are applied in the EA field, as well as the advancements they could make, the nature of theory in Enterprise Engineering (EE) and Information Systems (IS) communities is briefly discussed.

According to Dietz et al. (2013) EE distinguishes eight theories, classified into four theory classes. First, ideological theories (devising and choosing things to make) concerns the goals that people strive to achieve. In EE, there is one ideological theory, σ-theory. Second, technological theories (designing and making things) address the core of engineering, the means-end relations between phenomena, and are evaluated by rigor and relevance. In EE, technological theories include β-theory and ν-theory. Third, ontological theories (understanding the nature of things) are theories which address explanatory and/or predictive relationships in observed phenomena, i.e. are theories about the nature of things. In EE, ontological theories, ψ-theory and π-theory, are evaluated by soundness and appropriateness, i.e. whether a particular theory is rooted in sound philosophical theories. Fourth, philosophical theories (theoretical foundations) address epistemology, phenomenology, logic and mathematics. In EE, philosophical theories are evaluated based on truthfulness of said theories, and include three theories: φ-theory, δ-theory and τ-theory. Dietz et al. (2013).

The nature of theory in Information Systems (IS) is discussed by e.g. Gregor (2006; 2017) and Mueller and Urbach (2017). Gregor's five types of theory can be summarized as follows: theory of analysis is a descriptive theory concerning ontologies and structures of the area of interest. This type of theory does not make predictions, but rather answers to 'what is'. Theory of explanation, although not implying prediction or hypothesis, explains a phenomenon,

i.e. answers to questions what, how, when, where and why. With theory of prediction, hypotheses and predictions can be made, although causality is not explained whereas fourth theory type, explanation and prediction, adds causal explanations to the analysis. Finally, theory of design and action gives guidance – methods, principles or other - on developing an artefact. (Gregor, 2006.)

In addition to different kinds of theory in IS (Gregor, 2006) and EE (Dietz et al., 2013), there are a plethora of different definitions for a theory. For example, Weber (2012, p. 3-4) sees that theories "provide a representation of how a subset of real-world phenomena should be described" and are "a particular kind of model that is intended to account for some subset of phenomena in the real world". Gregor (2017) sees, that differences in defining theory reflect e.g. different interpretations of philosophy, such as epistemology and ontology, which are formed in a long interplay of science and external environment. This is particularly interesting in the context of this thesis, as systems approaches have influenced theoretical thinking. Logical empiricism flourished from 1920s to 1950s, and systems approaches, such as cybernetics and General Systems Theory influenced scientific thinking broadly (Gregor, 2017). In other related fields, the nature of theory as well as relations to systems approaches have also been discussed. As an example, Academy of Management Journal (1972) has released a special issue on General Systems Theory. Further, concerning theory, Suddaby (2010) suggests four criteria on construct clarity in the field of management: (1) empirical phenomena [such as EA] should be expressed in theoretical constructs by means of definition which is comprehensive, precise and parsimonious; (2) the scope of constructs should be clear; (3) theory should be logically consistent; and (4) relationships between the constructs should be understandable.

Recently, Siponen and Klaavuniemi (2018) discussed the philosophy of middle-range and grand theories. Middle-range and grand theories have been widely concerned in IS community (e.g. Gregor, 2006; Weber, 2012), and as a part of the discussion, Siponen and Klaavuniemi (2018) propose a new classification of theories: grand, wide range, midde-range, small-range, narrow-range, very narrow range, extremely narrow range and unique. Of these, according to Siponen and Klaavuniemi (2018), grand theories aim to "explain all the observed uniformities of behaviors in IS", while wide range theories exist between middle-range and grand theories. Other proposed new theory classes are defined as follows: small-range theories have narrower focus than middle-range theories, an example being theory concerning the use of social media; narrow-range theories concern *explanada* which are not adequately accounted by higher-level theories (theory for password memory is given as an example). An example of an extremely narrow range theory would be discussing habit development in Facebook use, while unique theories could be for example a case study concerning certain phenomena. (Siponen & Klaavuniemi, 2018.) As the authors state, scholars should ponder explanation accuracy on one hand, and generality of the theory in other, while concerning e.g. the scope of the theory discussed. While generality of a theory could prove to be of value (e.g. in cases of grand

theories), explanation accuracy could be beneficial while discussing separate phenomenon, i.e. "If two *explananda* can be adequately understood using the same *explanans*, then they are most likely about the same phenomenon. If two explananda have different *explanans*, then this is an indication that these are two separate phenomena" (Siponen & Klaavuniemi, 2018).

2.4 Section Summary

This section offered an introduction and a motivation to the study. Research questions were stated, and the main topics of this study – enterprise architecture and systems approaches – were briefly introduced, along with discussion on the nature of theory.

EA constitutes 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." (Lapalme et al., 2016, p. 104). Systems approaches include different systems theories such as General Systems Theory, Living Systems Theory and Cybernetics, as well as systems thinking. While these are vast areas of research spread into different domains, some general elements were introduced, such as: systems consists of wholes comprising of parts or sub-systems, systems exist in the midst of their environment and are defined by their boundaries and systems evolve over time. Concerning theories, the nature of theories in IS (Gregor, 2006) and in the near field of EE (Dietz et al., 2013) were briefly discussed, while also discussing different theory types (Siponen & Klaavuniemi, 2018).

3 RESEARCH METHODOLOGY

In this section the research methods of this study - systematic literature review and semi-structured practitioner interviews - are presented. In order to establish a comprehensive look on the state-of-the-art account of systems-oriented EA definitions, and the extent to which the different systems approaches are already in use in EA research, prior literature was screened broadly. To see whether the practitioners' perceptions regarding the current nature and objectives of EA reflect the same ideas that literature states, 26 in-depth practitioner interviews were conducted. Next, these methods of study are further discussed.

3.1 Systematic Literature Review

In an attempt to contribute to the discussions of defining enterprise architecture and strengthening the theoretical foundations of EA, a systematic literature review was conducted. The relevance of publishing systematic literature reviews concerning EA definitions is noted by prior research (Kappelman & Zachman, 2013). In this study, the guidelines proposed by Templier and Pare (2015) were followed, hence the literature review consisted of the following phases: (1) formulating the problem, (2) searching the literature, (3) screening for inclusion (3) assessing quality, (4) extracting data, and (5) analysing and synthesizing data.

To ensure a comprehensive look into the various systems-oriented definitions given to EA, as well as to the contributions of systems paradigms on EA, relevant literature was searched from three databases: Google Scholar, Scopus and IEEE Xplore Digital Library, with the following search phrase: *"enterprise architecture" AND ("system thinking" OR "systems thinking" OR "system theory" OR "systems theory")*. The search was done 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 phrases

to appear either in the title of the article or anywhere in the article. To find all the relevant articles, the search phrase was allowed to appear anywhere in the article. In terms of literature coverage, the aim was to conclude the search and selection process when the research material was saturated (Templier & Pare, 2015). 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, the titles, abstracts and keywords of the articles were read, and articles that explicitly defined EA and referenced systems thinking or some systems theory, were included. Journal and conference articles as well as books were included at this stage. Articles that were not written in English as well obviously those that were inaccessible, were excluded. 156 articles and books were chosen for a more thorough inspection. Also, 18 articles found with forward search were included at this stage. Doubles, as well as articles that did not contribute to the research questions (i.e. did not explicitly define EA; did not apply systems approaches in the EA problem domain), were excluded. The final research material of the literature review consists of 35 (first paper) and 47 (second paper) articles in 22 journals and conferences:

- (Proceedings of the) Hawaii International Conference on System Sciences
- IEEE International Conference on Systems, Man and Cybernetics
- Lecture Notes in Business Information Processing
- (Proceedings of the) International IEEE Enterprise Distributed Object Computing Conference
- Journal of Enterprise Architecture
- Computers in Industry
- Proceedings of the International Conference on Enterprise Information Systems.
- IEEE International Conference on Business Informatics
- IFAC Proceedings Volumes
- Lecture Notes in Computer Science
- Annual Reviews in Control
- Proceedings of European Conference on Information Systems
- Cybernetics and Systems
- Proceedings of International Conference on Information Systems
- Journal of Computer Information Systems
- The European Conference on Information Systems Management
- International Conference on Complex Systems Design & Management
- Information Technology and Management
- IT Professional
- Procedia Computer Science
- International Joint Workshop on Technologies for Context-Aware Business Process Management, Advanced Enterprise Architecture and Repositories and Recent Trends in SOA Based Information Systems
- Business/IT Alignment and Interoperability

3.2 Semi-structured Interviews

In order to examine the definitions given to EA by practitioners, 26 semi-structured in-depth interviews were conducted as part of a qualitative longitudinal research project researching the implementation of the Finnish national enterprise architecture method (FINEA). The research constituted of two rounds of semi-structure interviews. The interview and analysis methods are described in the first article (Nurmi et al., 2018a): second-round interviews were conducted during the summer 2017, forming the study material, i.e. a cross-sectional analysis of interviewees interpretations of the EA at the time of the interviews. Table 1 (Nurmi et al. 2018a) gives an overview on the interviewed stakeholders from different levels and sectors of Finnish public sector and IT companies, selected with purposeful sampling (Patton, 1990). Purposeful sampling was used to capture information intensiveness and stakeholder population variation in the data.

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

The interview questions concerned the interviewees interpretations of the state of the Finnish national EA, i.e.: questions of 1) background information of interviewees, 2) past situations, 3) current situation, and 4) future of EA. The interview themes and related questions were derived from the results of the first-round interviews. Full list of example questions can be found from the Appendix 1, interview themes including e.g. EA in the organization the interviewee represents, or which is the client organization of the interviewee, and interviewees perceptions of Finnish national EA and its effects on interviewees work. The interviews lasted on average 63 minutes, while variating from 36 to 100 minutes. Transcription and analysis of the study material was done with the ATLAS.ti software.

3.3 Section Summary

This section introduced the research methods of this study: systematic literature review and semi-structured practitioner interviews. A comprehensive systematic literature review was performed, and a total of 35 articles were included to the first, and 47 to the second article. 26 Semi-structured interviews were conducted using purposeful sampling (Patton, 1990), as part of a longitudinal research project concerning implementation of the Finnish national enterprise architecture method.

4 OVERVIEW OF THE INCLUDED ARTICLES

This Section presents the main results of each included article. The results of the first article are briefly discussed in chapter 4.1, followed by the results of the second article in chapter 4.2.

4.1 Article I - Examining Enterprise Architecture Definitions – Perceptions from Literature and Practice

Nurmi, J., Penttinen, K., Seppänen, V. (2018). Examining Enterprise Architecture Definitions – Implications from Theory and Practice. In Information Systems Research Seminar in Scandinavia.

The first article addresses the call to find a steady definition for EA, shared by both academics and practitioners, thus partially answering to the first research question of this thesis. The article aims to contribute to abovementioned discussion by focusing on the streams of studies that have taken a stance of systems theories or systems thinking to the EA problem domain. Previous systems-oriented EA research is reviewed and, along with the practitioner definitions garnered from in-depth interviews, definitions presented therein are compared with Lapalme's (2012) "Schools of Thought on Enterprise Architecture". Lapalme (2012, p. 37) argues that the 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, the analysis of the qualitative data is based on the taxonomy classes.

According to Lapalme (2012), first of the three taxonomy classes - Enterprise IT Architecting - strives in terms of purpose to reduce IT costs, which is done e.g. by eliminating duplicate functionality through technology reuse. Re-

garding the scope of EA, the first taxonomy class covers the IT assets of an enterprise and the various operations that use the IT capabilities. Contrary to the first class which applies mechanistic stance, the latter two require principles of holistic and systemic approaches (Lapalme, 2012). Enterprise Integrating school of thought strives to the purpose of supporting the strategy execution by maximizing the coherency of the interwoven structure of various aspects within an enterprise, including, but not only focusing, on IT, and covers all the facets of an enterprise. The last taxonomy class, Enterprise Ecological Adaptation, covers in terms of scope the enterprise as well as its surrounding environment. Here the purpose is enabling organizational learning, innovation and system-in-environment adaptation. (Lapalme, 2012.)

The results of the first article indicate that there seems to be differing opinions about scope and purpose of enterprise architecture. Still, applying a systemic stance seems to be favored. The inclusion criteria for taxonomy classes are not entirely unambiguous, and while the three schools of thought seem to represent current definitions of EA moderately, several included definitions (28%), did not fit to any particular class either by scope or purpose. Further, the scope of EA seems to be extending to cover the organizational design and development, and especially practitioners see EA as a tool to acquire abovementioned. Several practitioners define EA from a business-oriented tool perspective, whose purpose is to design and develop organizations, with the scope of whole organization from a holistic perspective. Notably, while twelve interviewed practitioners defined EA as a tool, there was only one explicit literature definition of this viewpoint, i.e. as a practical appliance. Furthermore, this practical viewpoint is not distinctly included in the examined taxonomy classes. Thus, the first article gives valuable insights to the interpretations of the practitioners and contributes to the discussion of defining EA. Also, the results indicate, that Lapalme's taxonomy, while being popular and quite cited, may need to be revised.

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. (2018). Systems Approaches in the Enterprise Architecture Field of Research: A Systematic Literature Review. In Enterprise Engineering Working Conference.

The second article examines to what extent systems approaches are used in the EA field of research, and what aspects of theory do the systems approaches cover in earlier studies. This discussion contributes to the second research question of the thesis. The article offers a systematic literature review and discusses the nature of theory in IS and related field of EE, as well as offers a state-of-the-art overview of the research field. A total of 47 publications are analysed and

classified based on (1) the system approach applied (total of eight approaches); (2) the purpose of the said study (theory or discipline; ontologies and frameworks; methods and modelling; software tools), and (3) whether a particular study is conceptual or theoretical, or based on or supported by empirical evidence.

As a result, it is stated that the systems approaches are frequently referred to in the EA studies. Examined articles mention various systems approaches, and several mention more than one approach (most often GST, systems thinking and unspecified "Systems theory"). Still, the application of the systems approaches appears to be fragmented and they are rarely used in empirical studies. The results indicate, that 'systems' idea is seen mostly as an analytical expedient of the research domain. The systems approaches are mostly used in studies of methods and modelling, although almost as frequently in studies concerning theory or discipline of EA. Further, there is no unified view of the type of system an enterprise is considered (e.g. systems of systems, complex sosio-technical systems or complex adaptive systems). Also, the examined articles define EA in manifold ways. As an example, EA appears to be seen as a comprehensive view of an interconnected and networked whole of an organization, possibly in two different states: as-is and to-be.

The article gives valuable insight to the use of systems approaches, as well as to the aspects of theory they concern. Extensive use of different systems approaches might indicate, that the common elements among them could provide an overall systems theoretical starting point for EA problem domain. Different systems approaches, and models could thus be applied in specific cases, and systems theories could possibly contribute to native EA theory.

4.3 Section Summary

This Section briefly presented the main results of the two included articles.

The first article examined EA definitions gathered with systematic literature review and 26 in-depth practitioner interviews. Lapalme's (2012) taxonomy on schools of thought on enterprise architecture was used as a basis for the examination. The results of the first article indicate that while Lapalme's taxonomy represents majority of the definitions, almost a third of the definitions are not represented by the taxonomy. The scope of EA seems to be extending to cover the organizational design and development, and practitioners seem to favor EA as a tool.

The second article examined the extent to which systems approaches are used in EA field of research and what aspects of theory do the systems approaches cover in earlier studies. A comprehensive literature review was offered, indicating that systems approaches are frequently mentioned, although rarely offering empirical efforts. Enterprises are seen as systems, but there is no unified view of the type of system, nor the systems approach to be applied.

5 DISCUSSION AND CONCLUSIONS

This Section discusses the results of the articles (chapter 5.1). The limitations, reliability, validity and research ethics of the study are discussed in chapter 5.2., while and topics for future research are presented, and conclusions offered, respectively, in the last two chapters of the thesis.

5.1 Discussion

As mentioned above, EA is an emerging field of research and practice, and has been developed parallel in different communities, such as Information Systems (IS) and Enterprise Engineering (EE). While requests to further advance the theoretical basis of EA and specify the definition – scope and purpose – of the discipline have been phrased, both academics and practitioners seem to have differing perceptions about EA. Different interpretations of EA were perceived in the first article of this thesis, to the extent where the taxonomy by prior research (Lapalme, 2012) did not fully represent all of the definitions. As discussed by Golafshani (2003), constructivism is one paradigm used in qualitative research. In this paradigm, knowledge is viewed as socially constructed, and changing with the circumstances, e.g. time. Considering EA as a phenomenon, which can be defined in terms of scope and purpose, does not necessarily mean that there could be only one definition accurately representing all the interpretations. Different descriptions, assertions and interpretations of the same phenomenon can occur, yet only one of them can be truthful in a given circumstance. Still, from another perspective, in another time or in different circumstances, another interpretation of the same phenomenon could be truthful.

Colquitt and Zapata-Phelan (2007) introduce a taxonomy of theoretical contributions for empirical articles and differentiate between theory building and theory testing, arguing that testing prior theory with empirical data is a valid contribution. Comparing to the types of theory introduced by Gregor (2006), Lapalme's taxonomy could be seen as a Type I theory – theory for ana-

lyzing. As Gregor (2006) notes, variants of Type I theory are such as classification schema, frameworks and taxonomies. Therefore, this study offers a decent scientific contribution on theory testing and guiding future research on the important topic of EA definition. Lapalme (2012, p. 37) argues that the taxonomy "creates a starting point for resolving terminological challenges to help establish enterprise architecture as a discipline.". Still, as indicated by the results of this study, a total of 28% of the examined definitions could not be classified to the taxonomy classes and the inclusion criteria for different schools of thought are not entirely unambiguous. Concerning Type I theories, Gregor (2006, p. 624) states the following: "The logic for the placement of phenomena into categories should be clear, as should the characteristics that define each category. In addition, important categories or elements should not be omitted from the classification system, that is, it should be complete and exhaustive. A previous classification system could be revised as new entities come to light, or some preferable way of grouping or naming categories in identified". As such, Lapalme's (2012) classification offers a valid contribution, yet one that could be updated and further enhanced. Notably, Enterprise Integrating and Enterprise Ecological Adaptation schools of thought covered the majority of found EA definitions, whereas only one practitioner considered EA from the perspective of Enterprise IT Architecting. As stated in the results of the first included article (Nurmi et al., 2018a): "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.". Also, practitioners seemed to favour practical viewpoints, and frequently referred to EA as a tool, method or supporting function to organizational design and development, a viewpoint not distinctly included in the schools of thought.

The results of the second article indicate, that while different systems approaches are often mentioned, there is no unified view of the type of system enterprise is, which leads to numerous different systems approaches to be used. The results of the second article do not explicate the system-theoretical features to which EA research and practise leans on. Still, the high number of occurrences of different systems approaches might indicate, that the common elements among them could provide an overall systems theoretical starting point for EA problem domain. Different systems approaches, and models could thus be applied in specific cases. If EA strives to be a discipline with a solid theoretical basis, it seems that non-native theories, such as systems theories, may not be enough on their own, but could serve as a basis for a native theory. As noted by Bernus et al., (2016, p. 96), "EA must encompass both soft [e.g. related to organisational 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.".

Abovementioned IS theory classification by Siponen & Klaavuniemi (2018), could advance the EA field of research at least in guiding the theoretical contributions, e.g. in pondering of questions such as: what kind of theory (or theories)

should be developed in terms of explanation accuracy and generality? Is it likely, possible or even desirable to strive to develop a single theory for EA, or should there be multiple theories? Is it reasonable to advance the theoretical endeavours with case studies (unique theories), or with epistemological discussion, such as in the EE community (Dietz et al., 2013)? What kind of theories, if none, should be borrowed or taken as a basis from reference fields and how are these theories classified?

If EA is seen as a field of research inside IS, related (or reference) fields could be, for example, EE and management. In EE, Dietz et al. (2013) discuss about the theoretical perspectives applied: eight theories, distinguished into four theory classes. Suddaby (2010) suggests four criteria concerning the construct clarity in the field of management: (1) empirical phenomena [such as EA] should be expressed in theoretical constructs by means of definition which is comprehensive, precise and parsimonious; (2) the scope of constructs should be clear; (3) theory should be logically consistent; and (4) relationships between the constructs should be understandable. Concerning the first criteria, based on a systematic literature review, prior research by Lapalme (2012) and practitioner interviews, EA as a phenomenon could be expressed as a tool of holistic organizational design and development in the systems-in-environment setting (Nurmi et al., 2018a).

This definition offers few contributions. First, as discussed earlier, enterprise architecture is used to refer to the result of the architecture work as well as to the work itself (Korhonen et al., 2016), whereas the results of this study indicate, that one of the purposes of EA is to serve as a tool, contributing to the first criteria (definition) of Suddaby (2010). Second, enterprises are often considered to be systems, operating in systems-in-environment setting. EA is seen as a way to design and develop organizations and govern changes, and systems approaches are seen as a suitable basis for advancing the theory of EA. This initially answers Suddaby's (2010) second criteria (scope), although should be further clarified in future research. Suddaby (2010) notes, that organizational constructs tend to be sensitive to contextual conditions, such as how large the organization is, or where it operates. EA has been successfully applied both in private and public sector, in small and big organizations and projects, and with different technological components (see e.g. Kurek et al., 2017). Still, this should also be a subject of future research. As noted above, following constructivist paradigm in qualitative research enables different perceptions of a same phenomenon. While this is true, if understanding of the fundamental elements of EA are not shared among individuals in different sectors, it might be hard for EA evolve as a unified discipline. If practitioners use EA differently than what is supposed in academic community, or have multiple ways of using EA, depending the situation (e.g. project or organisation they work in), then EA could be considered to be sensitive to contextual conditions. As mentioned above, this is a notion already made in the prior literature (see Penttinen, 2018).

5.2 Limitations, Reliability, Validity and Research Ethics

The first article of this study is part of a longitudinal research project, researching the implementation of the Finnish national enterprise architecture method. The research constituted of two rounds of interviews, where the participants were selected with purposeful sampling. The research material used in this study is collected from the second-round interviews. Participants were asked to sign a written approval indicating willingness to participate to the study 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. The results of this study are not concerned to be particularly sensitive. Also, it is hardly possible to recognize individual participants based on given information, i.e. organizational level and years of experience with EA.

The second included paper was presented at the Enterprise Engineering Working Conference 2018, where each paper was given a total of 40 minutes to present, including the discussion. Prior to the conference, the paper was reviewed by three blind reviewers. After the conference, the paper was further revised based on the discussion, and approximately four pages were added to the camera-ready version, which is presented in the appendix. This could be seen as some form of cross evaluation, adding the soundness of the results and analysis. Similarly, two blind reviewers offered comments to the first included article, presented in the Information Systems Research Seminar 2018.

The concepts of reliability and validity have excited discussion among qualitative research. For example, while Stenbacka (2001, p. 552) states, that "the concept of reliability is even misleading in qualitative research", according to Patton (2002) validity and reliability should be concerned in qualitative study design, analysis and quality-judgement. Discussion concerning whether validity and reliability are relevant is summarised by Golafshani (2003).

Reliability is seen as to what degree the results are consistent– i.e. the similar under the same conditions. Concerning the reliability of the interviews, it is highly possible that interviewees would define EA differently in different time, should the research be repeated. Enterprise architecture is an evolving discipline, and, similarly, the definitions given are expected to evolve. To enhance repeatability of the interviews (i.e. reliability), example questions of a private-sector interview are offered in the Appendix 1. 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. For example, at the interview-stage, it might be, that interviewees have understood a particular question differently than the interviewer intended. Therefore, some individual answers might not be valid. Also, interpretations may have occurred during the analysis of the data.

As Eskola and Suoranta (2000) state, language does not only reflect the reality, it also creates reality in a particular context. As an example, although this

research could be repeated with the exact same layout, with same circumstances and with the same interviewees, different definitions for EA could occur. Similarly, repeating the literature review in the future would be likely to give at least partly different results. Concerning the results invalid, not reliable or valid, or the study to be limited could still be wrong. Eskola and Suoranta (2000) discuss about the interpretation occurring in different phases of the study. Interviewees interpret the questions in a way that is in concordance with their rendition of the reality in that particular time and place. Researches makes their interpretations about the study material in the analysis phase, and another interpretation, when choosing which parts of the study material are included to the study. Finally, the reader of the study may interpret the results differently. This can be seen as a limitation, as the literature analysis of the EA definitions was done solely by one person, and whereas the data from practitioner interviews was analysed by two persons, no intercoder reliability was tested. Therefore, some preconceptions of the researchers may have affected the analysis. Choosing and interpreting the study material and classifying it to the taxonomy classes is prone to human-bias, although the process was made as transparent as possible, and individual definitions of the interviews are quoted (see the first included article).

The limitations to this study, further discussed in each included article, can be summarized as follows. There is an extensive volume of definitions given to enterprise architecture and an extensive volume of prior work discussing the systems nature of an enterprise and systems approaches. As especially the latter work is spread out to various field, all of the prior work is not covered in detail. As an example, Fu, Luo, Luo and Liu (2016) discuss EA cybernetics, while Santana, Fischbach and Moura (2016) offer a literature review on EA network thinking. In terms of the literature coverage, the aim was to garner enough articles so that those included would represent the prior literature on the EA field of research, and that the research material would be well saturated. As enterprise architecture is an evolving discipline, also the definitions and theoretical foundations are expected to evolve. Therefore, with the same search phrases, different results could occur in the future, and even with the same interviewees, differing opinions could be uttered. Further, as language reflects and creates reality, and is prone to interpretations of interviewers, interviewees, researchers and reader, this surely affects to the results of this study.

5.3 Future Research

There are several possible topics for future research. Concerning the definitions of EA, both theoretical and practical contributions are needed. As stated earlier, a total of 28% of examined definitions could not be classified to the taxonomy classes. While Lapalme (2012, p. 37) argues that the taxonomy “creates a starting point for resolving terminological challenges to help establish enterprise architecture as a discipline.”, this seems not to be the case. Further research

could propose a new classification better representing the definitions by both scholars and practitioners. As Gregor (2006, 624) states concerning Type I theories, "A previous classification system could be revised as new entities come to light, or some preferable way of grouping or naming categories in identified"

Also, emerging technologies seem to enable interesting ways of conducting research. For example, Nardello et al. (2018) used topic modeling and Gampfer et al. (2018) artificial intelligence technologies to scope the research field. A possible utilization of these recent technologies could be, for example, a trend analysis or use of text mining to examine how the explicit definitions of EA have been developing in recent decades.

Concerning the relationship between EA and different systems approaches, as well as advancing the theory of the field, further research is also needed. As mentioned (Hope et al., 2017), it seems that albeit they are still popular, especially among practitioners, EA is not all about models and frameworks. This can be seen from the small amount of publications concerning modelling (Gampfer et al., 2018; Nardello et al., 2018), the decline of modelling related topics in Gartner's Hype Cycle (Blosch & Burton, 2017), and in recent trends on trying to partly automate modelling (Hinkelmann et al., 2016). The journey from practitioner-oriented craft to theoretically solid field, is still far from finished. The next steps could be taken towards related fields of systems thinking and theory, enterprise engineering and organizational design. The two latter mentioned, somewhat overlapping fields of research, are also making contributions to unite and flourish (Magalhães & Proper, 2017). Also, advancing theory could be helped by looking to related, more mature fields, such as earlier discussed management (Suddaby, 2010), which partly concerns the same problem-domain. As stated in the results of the second article, is seems, that a unified view of the systemic nature of an enterprise as well as applicable systems approaches, is yet to be obtained. Further, as empirical work seems to be scarce, especially future empirical research could be valuable.

5.4 Conclusions

This study strived to contribute to the discussion concerning the evolving discipline of EA by addressing two research questions:

- RQ1: To what extent the systemic paradigm is seen in the EA definitions?
- RQ2: To what extent different systems approaches are used in EA research?

In order to answer the first research question, a systematic literature review was offered, along with 26 in-depth practitioner interviews, specifically noting the recent trend of applying systemic stance on EA field of research. Garnered definitions were analysed through Lapalme's (2012) "Schools of Thought on Enter-

prise Architecture" to see how these taxonomy classes encompass different views of academics and practitioners. The results of the study indicate, that although examined definitions scatter among taxonomy classes, and almost a third were not accurately represented by any of the taxonomy classes, a systemic stance seems to be favoured. The scope and purpose of EA are increasingly extending to holistic organizational design and development in the system-in-environment setting, which answers to the first research question. To answer the second research question, a comprehensive literature review was conducted, and the nature of theory in IS and EE communities was discussed. A total of 47 studies were classified into four categories based on the purpose of the said study, noting whether the studies offered empirical evidence or theoretical ideas. As a result, it is stated that although the systems approaches are frequently referred to in the EA studies, the application of these theories appears to be fragmented, and the approaches are rarely systematically used in empirical studies.

While there are certain limitations to the study, valid contributions were made. This study offers, to the current body of knowledge, the first systematic literature review concerning specifically systems approaches in the EA field of research. Concerning the definitions of enterprise architecture, Kappelman and Zachman (2013) note, that studies applying a systematic methodology are scarce. As mentioned, systems approaches are seen as possible means to advance the theory of EA – an urgent topic of research itself (Bernus et al., 2015; Bernus et al., 2016; Lapalme et al., 2016) - as well as means to cope with changing environment. Applying systems approaches in EA seems to be here to stay (Kappelman & Zachman, 2013) and as such, this study may serve as a starting point for further research.

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ORIGINAL PAPERS

I

EXAMINING ENTERPRISE ARCHITECTURE DEFINITIONS – IMPLICATIONS FROM THEORY AND PRACTICE

by
Jarkko Nurmi, Katja Penttinen & Ville Seppänen, 2018
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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 ITbusiness 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.

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

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.

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 classified the EA definitions presented in the literature and by practitioners to Lapalme's [18] schools of thought to see how well the taxonomy classes represent the current views on EA and how convergent found definitions are. 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, namely 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 enterprises 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 unambiguous, and several included definitions did not fit to any particular class either by the scope or the purpose. More than one fourth (28 %) of the definitions were classified as "Other", i.e. not represented by any of the schools of thought. 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

EXAMINING ENTERPRISE ARCHITECTURE DEFINITIONS – IMPLICATIONS FROM THEORY AND PRACTICE

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 evolu-

tion. 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 struc-

tures (“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 struc-

tural 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	#5

Annual Hawaii International Conference on(Vol. 4, pp. 71b-71b). IEEE.	
Lê, L. S., & Wegmann, A. (2006, January). SeamCAD: object-oriented modeling tool for hierarchical systems in enterprise architecture. In System Sciences, 2006. HICSS'06. Proceedings of the 39th Annual Hawaii International Conference on (Vol. 8, pp. 179c-179c). IEEE.	#6
Pulkkinen, M. (2006, January). Systemic management of architectural decisions in enterprise architecture planning. four dimensions and three abstraction levels. In System Sciences, 2006. HICSS'06. Proceedings of the 39th Annual Hawaii International Conference on (Vol. 8, pp. 179a-179a). IEEE.	#7
Winter, R., & Fischer, R. (2006, October). Essential layers, artifacts, and dependencies of enterprise architecture. In Enterprise Distributed Object Computing Conference Workshops, 2006. EDOCW'06. 10th IEEE International (pp. 30-30). IEEE.	#8
Wegmann, A., Regev, G., Rychkova, I., Lê, L. S., & Julia, P. (2007, October). Business and IT alignment with SEAM for enterprise architecture. In Enterprise Distributed Object Computing Conference, 2007. EDOC 2007. 11th IEEE International (pp. 111-111). IEEE.	#9
Wegmann, A., Kotsalainen, A., Matthey, L., Regev, G., & Giannattasio, A. (2008, September). Augmenting the Zachman enterprise architecture framework with a systemic conceptualization. In Enterprise Distributed Object Computing Conference, 2008. EDOC'08. 12th International IEEE (pp. 3-13). IEEE.	#10
Buckl, S., Matthes, F., & Schweda, C. M. (2009, October). A viable system perspective on enterprise architecture management. In Systems, Man and Cybernetics, 2009. SMC 2009. IEEE International Conference on (pp. 1483-1488). IEEE.	#11
Sousa, P., Lima, J., Sampaio, A., & Pereira, C. (2009). An approach for creating and managing enterprise blueprints: A case for IT blueprints. In Advances in enterprise engineering III (pp. 70-84). Springer, Berlin, Heidelberg.	#12
Buckl, S., Matthes, F., & Schweda, C. M. (2010). Towards a method framework for enterprise architecture management–a literature analysis from a viable system perspective. In 5th International Workshop on Business/IT Alignment and Interoperability (BUSITAL 2010) (pp. 46-60).	#13
Kloeckner, S., & Birkmeier, D. (2010). Something is missing: Enterprise architecture from a systems theory perspective. In Service-Oriented Computing. ICSOC/ServiceWave 2009 Workshops (pp. 22-34). Springer, Berlin, Heidelberg.	#14
Kotzé, P., & Neaga, I. (2010). Towards an enterprise interoperability framework.	#15
Meschke, M., & Baumoel, U. (2010). Architecture Concepts for Value Networks in the Service Industry. In ICIS (p. 266).	#16
Bider, I., Bellinger, G., & Perjons, E. (2011, November). Modeling an agile enterprise: reconciling systems and process thinking. In IFIP Working Conference on The Practice of Enterprise Modeling (pp. 238-252). Springer, Berlin, Heidelberg.	#17
Dietz, J. L., & Hoogervorst, J. A. (2011, May). A critical investigation of TOGAF-based on the enterprise engineering theory and practice. In Enterprise Engineering Working Conference (pp. 76-90). Springer, Berlin, Heidelberg.	#18
Hoyland, C. A. (2011, October). An analysis of enterprise architectures using general systems theory. In Systems, Man, and Cybernetics (SMC), 2011 IEEE International Conference on (pp. 340-344). IEEE.	#19
Wang, S., Xu, L., Li, L., Wang, K., & Choi, J. (2011, October). Features of enterprise information systems integration: A systemic analysis. In Systems, Man, and Cybernetics (SMC), 2011 IEEE International Conference on (pp. 333-339). IEEE.	#20
Kandjani, H., & Bernus, P. (2012, June). The enterprise architecture body of knowledge as an evolving discipline. In International Conference on Enterprise Information Systems (pp. 452-470). Springer, Berlin, Heidelberg.	#21
Kandjani, H., Wen, L., & Bernus, P. (2012). Enterprise Architecture Cybernetics for Collaborative Networks: Reducing the Structural Complexity and Transaction Cost via Virtual Brokerage. IFAC Proceedings Volumes, 45(6), 1233-1239.	#22
Lapalme, J. (2012). Three schools of thought on enterprise architecture. IT professional, 14(6), 37-43.	#23
Wan, H., & Carlsson, S. (2012, September). Towards an understanding of enterprise architecture analysis activities. In European Conference on Information Management and Evaluation (p. 334). Academic Conferences International Limited.	#24
Wang, S., Li, L., Wang, K., & Jones, J. D. (2012). e-Business systems integration: a systems perspective. Information Technology and Management, 13(4), 233-249.	#25
Zadeh, M. E., Millar, G., & Lewis, E. (2012a). Reinterpreting the TOGAF® enterprise architecture principles using a cybernetic lens. Journal of Enterprise Architecture, 8(2), 9-17.	#26
Zadeh, M. E., Millar, G., & Lewis, E. (2012b, January). Mapping the enterprise architecture principles in TOGAF to the cybernetic concepts--An exploratory study. In System Science (HICSS), 2012 45th Hawaii International Conference on (pp. 4270-4276). IEEE.	#27
Abraham, R., Tribolet, J., & Winter, R. (2013, May). Transformation of multi-level systems–theoretical grounding and consequences for enterprise architecture management. In Enterprise Engineering Working Conference (pp. 73-87). Springer, Berlin, Heidelberg.	#28
Kandjani, H., Bernus, P., & Nielsen, S. (2013, January). Enterprise architecture cybernetics and the edge of chaos: Sustaining enterprises as complex systems in complex business environments. In System Sciences (HICSS), 2013 46th Hawaii International Conference on (pp. 3858-3867). IEEE.	#29
Kappelman, L. A., & Zachman, J. A. (2013). The enterprise and its architecture: ontology & challenges. Journal of Computer Information Systems, 53(4), 87-95.	#30
Korhonen, J. J., & Poutanen, J. (2013). Tripartite approach to enterprise architecture. Journal of Enterprise Architecture, 9(1), 28-38.	#31

Schuetz, A., Widjaja, T., & Kaiser, J. (2013). Complexity in enterprise architectures-conceptualization and introduction of a measure from a system theoretic perspective. In 21st European Conference on Information Systems, Utrecht (pp. 1-12).	#32
Bernus, P., Noran, O., & Molina, A. (2014). Enterprise architecture: twenty years of the GERAM framework. IFAC Proceedings Volumes, 47(3), 3300-3308.	#33
du Preez, J., van der Merwe, A., & Matthee, M. (2014, September). Enterprise architecture schools of thought: An exploratory study. In Enterprise Distributed Object Computing Conference Workshops and Demonstrations (EDOCW), 2014 IEEE 18th International (pp. 3-12). IEEE.	#34
Hoyland, C. A., M. Adams, K., Tolk, A., & D. Xu, L. (2014). The RQ-Tech methodology: a new paradigm for conceptualizing strategic enterprise architectures. Journal of Management Analytics, 1(1), 55-77.	#35
Kandjani, H., Tavana, M., Bernus, P., & Nielsen, S. (2014). Co-Evolution Path Model (CePM): Sustaining Enterprises as Complex Systems on the Edge of Chaos. Cybernetics and Systems, 45(7), 547-567.	#36
Noran, O., & Romero, D. (2014). A Pluralistic Approach towards Sustainable Eco-Industrial Networking. IFAC Proceedings Volumes, 47(3), 4292-4297.	#37
Schneider, A. W., & Matthes, F. (2014). Using Orientor Theory for Coherent Decision Making for Application Landscape Design. In CSDM (Posters)(pp. 161-172).	#38
Syynimaa, N. (2013). Theoretical perspectives of enterprise architecture.	#39
Zadeh, M. E., Lewis, E., Millar, G., Yang, Y., & Thorne, C. (2014, October). The use of Viable System Model to develop guidelines for generating Enterprise Architecture Principles. In Systems, Man and Cybernetics (SMC), 2014 IEEE International Conference on (pp. 1020-1026). IEEE.	#40
Bernus, P., Goranson, T., Gøtze, J., Jensen-Waud, A., Kandjani, H., Molina, A., ... & Turner, P. (2016). Enterprise engineering and management at the crossroads. Computers in Industry, 79, 87-102.	#41
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APPENDIX 1: EXAMPLE QUESTIONS

The example questions from a public-sector interview are translated from Finnish to English.

1. Name?
2. Organization?
3. Job description?
4. How long have you been working in the EA field?
5. What kind of tasks have you managed?
6. To what kind of clients have you been working?
7. In what kind of tasks are you currently working with?
8. What is your viewpoint (client-organization, state administration, public administration) to EA?
9. What is your opinion about JHS 179 Enterprise architecture planning and development – recommendation?
10. Have you personally used JHS 179?
11. In the first-round interviews three main challenge in the public-sector EA were recognized: governance, the structure of the public administration and enhancing interoperability. Do you think that mentioned are also current challenges?
12. Do you think that EA has enabled new (public) services?
13. Do you think that EA has enhanced cross-administrative co-operation?
14. Has mandating EA had effect on the EA-work?
15. Is there a mutual understanding about the meaning of EA?
16. Are there currently any EA-related efforts in your client-organization?
17. What kind of strategic goals your client-organizations has for EA?
18. Do you think that EA is part of continuous development?
19. What kind of stakeholders EA-work has?
20. What things you have seen to be important in EA-work in the public administration?
21. Is there something that you have seen as unnecessary [in the public administration EA]?
22. What are the things that have been learned from prior EA-work?
23. How is EA-related issues communicated? Who is responsible about communication?
24. How does EA support the digitalization of public administration?
25. How does the EA-work continue in your client-organization?
26. How should JHS179 be developed?
27. Are there some new technologies that could change the operating models of public administration?
28. How information security should be noticed in forthcoming co-operation and public information systems?

29. Are there organizational changes in your client-organization that would imfluence EA-work?
30. How do you see the future of EA-work in public administration?
31. Is there something you would like to add?