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A First Literature Review On Enterprise Reference Architecture

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A FIRST LITERATURE REVIEW ON

ENTERPRISE REFERENCE ARCHITECTURES

Research full-length paper

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Abstract

Enterprise Reference Architectures have been increasingly emerging as new standardized architectural description artefacts suitable to provide a frame of reference for a particular business domains. Used in an appropriate way, they can be a useful tool for improving enterprise architecture management practices. Whilst from a practitioners perspective several instances of such architectures have been created over the past years, little research on such artefacts has been done to date. Hence, academia still lacks a comprehensible overview of prior literature on Enterprise Reference Architectures, despite the relevance of literature reviews to knowledge advancement in any scientific field. To close this gap, in this paper we present a primer literature review on Enterprise Reference Architectures conducted following general guidelines proposed for undertaking information systems reviews. Similarly to precedent contributions addressing enterprise architecture oriented topics, we introduce a novel classification framework based on Gregor's theory types of information systems to structure and summarize former research. Major findings from significant studies on the topic are then identified, analysed and mapped into the referred framework. Based on the analysis and results of the review, brief suggestions to stimulate further research on the design, improvement and application of Enterprise Reference Architectures are also derived.

Keywords: Enterprise Reference Architecture, Reference Enterprise Architecture, Literature Review, Information Systems Theory

1 Introduction

Enterprise Architecture (EA) is nowadays considered one of the major instruments available to Information Systems (IS) managers in order to cope with traditional alignment tensions between business and technology in organizations (Jonkers, Lankhorst, ter Doest, *et al.* 2006; Saat, Franke, Lagerstrom, *et al.* 2010). It provides a series of practices, frameworks, models, methodologies and artefacts (Bischoff, Aier and Winter, 2014; Kotusev, Singh and Storey, 2015) to "*[apply IT] in an appropriate and timely way, in harmony with business strategies, goals and needs*" (Luftman, Bullen, Liao, et al. 2004, p.69). Over the last years, such tools and practices have been widely extended and adopted in many industries, pushing them towards the increasing adoption of best practices within digital and innovation transformation processes at many levels and affecting multiple stakeholders (Harmsen, Proper and Kok, 2009; Labusch and Winter, 2013).

To foster shared understanding among different stakeholders in these transformation processes, models are usually considered as one of the major means of communication and analysis (Frank, Strecker, Fettke, et al. 2014). Models match the diversity of different perspectives (i.e. business vs. technology) covering dependencies across such different and thus partial views of the enterprise at a higher level of abstraction, and in an holistic view to the many different stakeholders (Abraham, Aier and Winter 2015, p.4). Recently, and drawing on the general principles of generalization and abstraction, the concept of Reference Architectures (RA) has emerged as a standardized architectural description that provides a frame of reference for a particular domain, sector or field of interest (Lankhorst 2014). Hence, and from a practitioners' perspective, numerous RAs and related artefacts have been created and developed over the last years. They range from the most granular and scope-limited spheres of Software Engineering (SE) or IT infrastructures to wider industry-oriented RAs models (Angelov, Grefen and Greefhorst, 2012; Fattah, 2009), including industries such as defense (Department of Defense, 2010), banking (Bonnie, Peters, Delmarcelle, et al. 2012), or telecommunications (Czarnecki and Dietze, 2017), to cite a few. Such "*enterprise-domain*" oriented RAs are frequently known as Enterprise Reference Architectures (ERAs) and can be viewed as a specific sub-type of RA (Haki and Legner 2012).

In contrast, and from a more academic perspective, little research has been done on ERAs (Timm, Sandkuhl and Fellmann, 2017). Therefore, notable research opportunities can arise from this EA subdomain. To bridge this gap (Müller-Bloch and Kranz, 2015), in this paper we propose an structured and comprehensible literature review to uncover what we know about ERAs from an IS academic perspective. Hence, and from an epistemological point of view (Schryen, Wagner and Benlian, 2015), the main goal of this paper is to identify, organize and classify high quality studies addressing knowledge related with the topic of ERAs. In addition, and on the basis of the results obtained from the literature analysis, we will also provide some insights and directions on plausible future research opportunities on the topic. In such vein, with the work at hand we expect to contribute to a better and improved understanding on the yet widely un-researched concept of ERAs. The novelty of the present contribution within the body of knowledge of EA relies on the fact that, up to our knowledge, no previous literature review on ERAs has still been published to date.

The remaining of the paper is structured as follows. In section 2, we present the theoretical background of the review by introducing the concepts of RAs and ERAs as well as similar undertaken research. Following, we describe the framework for analysis and the research review methodology. Next, the major results and main findings of our literature analysis are presented and discussed, including opportunities for further research. Finally, in section 6, we close up the article with a conclusions and research limitations section.

2 Theoretical background

In order to engage readers with the core topics of the article, in this section we define the topics of RAs and ERAs. In addition, brief comments on similar related research conducted are provided.

2.1 Reference Architectures and Enterprise Reference Architectures

The proliferation and diversification of architectural models over time has led to a broad and somewhat divergent set of interpretations and conceptualizations of the concept of RA. This variability is even increased by several terminological inconsistences affecting terms such as "*enterprise architecture*", "*reference architecture*" or even "*reference model*", terms which tend to be used in an interchangeably way in the literature. This flaws have been summarized in a very illustrative way by Cloutier and colleagues, who alleged a lack of maturity of the term "*reference architecture*" since, although "*not being novel (…) in the business world, many architects do not have a consistent notion of what this actually is"* (2010, p.14). Hence, the form that it takes "*is still not solidified (…) and has become a term to mean many things to different people (…) either within the same industry or not*" (Cloutier, Muller, Verma, *et al.* 2010 p.16).

In a general sense, a RA can be seen as an abstract and generic architecture description for a class of systems or a concrete targeted domain. According to Muller (2008) and Muller and van der Laar (2009), RAs can be viewed as a means to cope with the increasing complexity and size of the systems that organizations need to create. In a relatively recent blog post, Lankhost (2014) defines (enterprise) RAs as "*standardized architectures that provide a frame of reference for a particular domain, sector or field of interest (…) provid[ing] a common vocabulary, reusable designs and industry best practices. They are not solution architectures, i.e. they are not implemented directly. Rather, they are used as a constraint for more concrete architectures".* Thus, RAs emerge as abstractions of concrete solution architectures from a certain class of systems used as a foundation for the design of concrete architectures from this class, although their generic nature leads to a less defined architecture design and application contexts (Angelov, Grefen and Greefhorst, 2012). Typically, *"reference architecture includes common architecture principles, patterns, building blocks and standards*" (Lankhorst 2014). In this vein, Reference Models (RMs) – also referred as model patterns – can be viewed as one of such core building blocks or components of a RA, as they provide a clear view (usually on-a-page) of the domain of interest of the RA incorporating best-practice solutions as reusable knowledge that can be later adjusted or tweaked for context-specific needs (Pang, 2015; Angelov, Grefen and Greefhorst, 2012). It should be pointed out here, however, that RMs can also exists independently or autonomously, that is, without formally being an integral part or block of a concrete RA.

The concept of ERA arises as a particular type of RA where the targeted domain is set to a concrete "*class of enterprises*". In consequence, ERAs are abstract architecture descriptions, but to a lesser extent than a RA (see Fig. 1). Hence, and as many EA frameworks, ERAs distinguish among several layers (sub-domains) that, together, capture the whole domain of interest. This point has been reflected by ten Harmsen van der Beek et al. , who defined an ERA as a "*generic EA for a class of enterprises, that is a coherent whole of EA design principles, methods and models which are used as foundation in the design and realization of the concrete EA that consists of three coherent partial architectures: the business architecture, the application architecture and the technology architecture*" (2012, p.99).

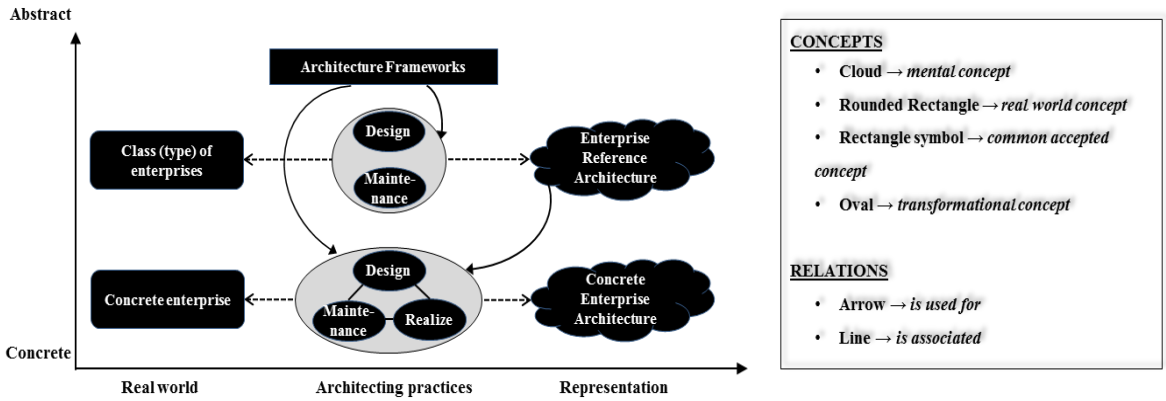

Figure 1. Conceptual model for ERAs, as stated by ten Harmsen van der Beek et al. (2012)

As we were not able to find a more formal and concrete definition of an ERA in the literature, we assumed it as our underlying working definition for the purposes of the present work.

2.2 Previous work

In the running-up of this work, we searched for existing literature reviews in the scope of RAs and ERAs, but we were not able to identify them. Perhaps, the most similar contributions to our work could be associated to several disciplinary narrative reviews in the field of Enterprise Engineering and Integration, which organize the literature in an historical way (Bernus, Goranson, Gøtze, *et al.* 2016; Chen, Doumeingts and Vernadat, 2008). Literature reviews are also frequent in the EA literature, either at a disciplinary scope (Buckl and Schweda, 2011; Rasti, Khayami and Sanatnama, 2015; Simon, Fischbach and Schoder, 2013) or exploring more concrete research topics, as EA goals (Schöenherr, 2009), EA benefits (Tamm, Seddon, Shank, *et al.* 2011), EA implementation (Rouhani, Mahrin, Nikpay, *et al.* 2015) or EA evaluation and assessment models (Andersen and Carugati, 2014; Kurniawan, Nor and Dolah, 2015). However, none of them is explicitly devoted to address RAs or ERAs issues.

In sum, we view the already introduced contribution of ten Harmsen van der Beek et al. (2012) as the closest piece of research with respect to the goals of this paper. It contains a very brief revision of literature concerned with RAs and ERAs in its introductory section, but it could not be formally considered as a standalone literature review (Schultze, 2015; Okoli, 2015). Be that as it may, it can be concluded that there is a clear lack of existing literature reviews on the topic of ERAs. Hence, we see our present review as (up to our knowledge) the first attempt to (partially) fill such research void. Therefore, we concretely further extend existing literature reviews by addressing and focussing on the particular topic of ERAs.

3 Research design

To identify existing research on ERAs and provide the basis for achieving our review goal, we conducted a structured and comprehensible literature review following general IS review guidelines (vom Brocke, Simons, Niehaves, *et al.* 2009; Webster and Watson, 2002). In this section, we describe the analysis framework used for deriving the research questions and the literature search and codification process followed. However, and due to space restrictions, we will not provide a formal and complete research agenda on the topic. In this vein, in the present paper we will just provide a brief insights and suggestions on plausible future research studies on the basis of the findings of our review (see section 5). Finally, and in terms of recently emerged taxonomies of IS literature reviews, we see our work as a rather descriptive literature review (Rowe, 2014; Paré, Trudel, Jaana, *et al.* 2015) aiming to contribute to theory through the synthesis and analysis of the findings that emerge from the reviewed sources (Müller-Bloch and Kranz, 2015; Gregor, 2006).

3.1 Framework of analysis and research questions

Following Webster and Watson (2002) and Rowe (2014) guidelines, we use an analysis framework in order to derive the research questions of the review as well as to guide us in the classification of the uncovered studies. We adopted a similar approach than in previous existing EA literature reviews (Haki and Legner, 2012; Viering, Legner and Ahlemann, 2009) and relied on Gregor's taxonomy of theory types in IS for inferring four general ERA research questions based on the types of goals of theory in IS – i.e. description, explanation, prediction and prescription – (Gregor, 2006, p.619):

- ***RQ1) Understanding the nature of ERAs → What are the characteristics of an ERA?*** This question aims at describing, defining (i.e. purpose and scope) and classifying the research phenomena of interest. It typically results in theory type I (*theory for describing and analyzing*) of Gregor's taxonomy in the form of definitions, classification schemas, frameworks and typologies.

- ***RQ2) ERAs adoption → Why, how and to what extent are ERAs adopted in practice?*** The second research question concerns with analyzing the different suggested approaches for ERA adoption in different organizational contexts, as well as critical success factors for their implementation or use. Such types of research question usually results in theory type II (*theory for understanding and explaining*) in terms of Gregor's taxonomy.
- ***RQ3) ERAs practices → How to design, implement and manage ERAs?*** Our third question aims at specifying how organizations should develop, deploy and manage ERAs. It is associated with either constructivist or Design Science Research (DSR) approaches, which may result in different reference models, methodologies or management frameworks acting as justificatory knowledge (i.e. kernel theories) for the development and implementation of ERAs. . Gregor classifies this type of theory as theory type V (*theory for design and action*).
- ***RQ4) ERAs impact → What are the organizational impacts of ERAs?*** The last research question considers mainly the value (i.e. benefits) derived from ERAs. Hence, it comes up with different approaches aimed to describe and measure the impact of ERAs (both at individual as well as at organizational level) through the establishment of different theoretical constructs and relationships among them. It will be most likely to produce theory type IV (*theory for understanding and explaining*) in terms of Gregor's taxonomy.

All in all, our resulting analysis framework will also be quite similar to Pateli and Giaglis' (2004) framework for organizing and structuring research in eBusiness models into several decomposed research sub-domains (se section 3.3 for further codification details).

3.2 Literature selection process

We based our search process on an extensive selection of electronic databases, including *ACM Digital, AIS electronic Library, EBSCOhost, Emerald, Google Scholar, ProQuest, Science Direct, Springer Link, Scopus, Web of Science and Taylor and Francis.* This set of databases assured us a good coverage of the most relevant EA and IS scholarly and practitioner publications. The initial sample of studies was identified through a keyword search strategy based on finding the terms "*enterprise reference architecture*" and "*reference enterprise architecture*" in title, keyword and abstract of publications referenced in the previous databases. The terms finally chosen were derived both by the aim of conducting a comprehensible review as well as preliminary searches conducted to identify previous related work. As in some of the selected databases the search engine's filters available were sometimes limited, minor adjustments had to be made in order to execute the intended query (see Table 1). As an exclusion criteria, we searched for publications written in English over a period of ten years (from 2007 to April 2017), in line with Rowe's (2014) suggestions for temporal coverage of current IS reviews. Moreover, and in order to guarantee the quality of the retrieved studies, we concentrated on retrieving only peer-reviewed journal articles and conference papers (and workshops) proceedings. The final queries were executed between the 22th and the 28th of May 2017, and yielded a total of 281 initial potentially relevant studies for our review.

Judging by the title and abstract of the initially retrieved studies, 251 contributions were considered as duplicate entries, non-conforming to our working definition of ERA, irrelevant to our review purposes or not available in an electronic version format. For example, a great number of articles dealing with GERAM and similar abstract frameworks (Bernus, Noran and Molina, 2014) had to be excluded as they were out of the scope of our review. The remaining set of 30 papers was retained for further full-text review. As said before, our scope was limited to papers dealing with our working definition of ERA, which lead to the exclusion of papers as Purao, Martin and Robertson (2011) or Lemmetti and Pekkola (2012). However, and given the relatively low number of retrieved studies, papers dealing only partially which ERAs – as for example (Timm, Wißotzki, Köpp, *et al.* 2015) – were included in the review if they provided helpful insights into our research issues. We also included Fattah (2009)

paper, as we learned during the review that such paper was an extended version of an original contribution for an EA practitioners conference where proposals were reviewed by a Program Steering Committee (The Open Group, n.d.). All in all, findings were narrowed down to only 7 items, which were posteriorly complemented with 3 pieces form ours personal collection database – Aulkemeier, Schramm, Iacob, *et al.* (2016), Lange, Mendling and Recker (2016) and Olsen and Trelsgård (2016) – as they were not detected by the previous posed keyword search strategy.

Searched Data Bases	***Search Parameter Filter Options***	***Initial Hits***	***Full Reviewed***	***Finally Relevant***
ACM Digital	[title | abstract | keyword]	*10*	*4*	*0*
AISeL	[tittle | abstract]	*1*	*1*	*1*
EBSCOhost	[tittle | descriptor | abstract]	*3*	*0*	*0*
Emerald	[tittle | abstract | keywords]	*0*	*0*	*0*
Google Scholar	[tittle]	*9*	*3*	*1*
ProQuest	[tittle | abstract]	*7*	*0*	*0*
Science Direct	[tittle | abstract | keywords]	*3*	*0*	*0*
Springer link	[all text]	*197*	*11*	*1*
Scopus	[tittle | abstract | keywords]	*28*	*7*	*4*
Web of Science	[title | topic]	*18*	*3*	*0*
Taylor & Francis	[tittle | keywords]	*5*	*1*	*0*
KEYWORD SEARCH	**-**	***281***	***30***	***7***
	Manually added	-	-	*3*
	Backward/Forward search	-	-	*10*
FINALLY REVIEWED	-	-	-	***20***

Table 1 Results of the literature review search process

In order to identify further relevant papers for the review, we conducted a forward/backward search by reviewing citations found in the previous set of identified papers. Since this approach represents an iterative search process, we proceed until a saturation point was reached (Levy and Ellis, 2006; Boell and Cecez-Kecmanovic, 2014), yielding to an appreciable number of interesting resources that were not uncovered using the initial keyword search. For forward search purposes, we used Scopus and Google Scholar as support services.

On the one hand, and in order to keep the quality and the coherence of the source selection of the review, we maintained previous exclusion criteria in terms of language, time and content. Hence, contributions not written in English, as Greefhors et al. (2009) or de Boer (2011) were finally excluded. Also, well-known articles as Smolander et al. (2008) or Angelov (2012) were finally excluded for the final review. Although they are articles usually referred in the EA literature, they are very focused on software-oriented RAs and, according to ten Harmsen van der Beek et al., "*such kind of architectures do not feet well the definition of ERAs, being too much focused on software elements, software elements and data flows*" (2012, p.98). Contrarily, studies approaching RAs from a systems engineering perspective were finally considered for the final review, as they are "*abstract from certain contextual specifics"* and, in such cases, their findings are *"also valid for an ERA*" (ten Harmsen van der Beek et al. 2012 p.98).

On the other hand, and regarding the publication's type exclusion criteria, we finally decided to slightly relax it, in order to include some references that we considered valuable for our review purposes. Hence, we decided to supplement previous uncovered peer-reviewed literature by including a book chapter (Czarnecki and Dietze, 2017), a master thesis (Kotzampasaki 2015) and the Lankhorst' s (2014) blogpost entry already referred in section 2. The quality of these extra references was assessed

and checked on the basis of reputation and authority of the authors (as well as supervisors, in the case of the master thesis) of the contributions (Adams, Smart and Huff, 2016). To sum up, a total of 10 additional studies were considered for final review, which, together with the previous 10 uncovered contributions by the keyword search strategy, led us to a total set of 20 studies that were finally considered for classification, codification and analysis.

3.3 Analysis, codification and classification process

Following the concept-oriented approach of Webster and Watson (2002), we structured the retrieved literature according to the classification framework introduced in section 3.1. We took each individual contribution as the unit of analysis (Bandara, Furtmueller, Gorbacheva, *et al.* 2015) for such purposes. We preceded downloading all the electronic versions of references to be reviewed and creating a database with Zotero reference manager, including the citation meta-data of each source. This tool was also used for referencing and citation purposes in the write-up of the present paper. In addition, and given the relatively manageable number of documents to review, we finally decided to create a Ms. Excel database for coding the literature alongside the categories of interest for the review. We coded and classified the selected publications through a rather mixed approach (Bandara, Furtmueller, Gorbacheva, *et al.* 2015), focusing on the following three aspects (find the concept matrix in Appendix 1):

- *General metadata*; including sub-codes for the authors, tittle, year of publication and publication type. Such classification was performed through a top-down approach.
- *Descriptive information*; including information of the research method, the level of universality of the contribution (generic or business-specific) and the emphasis level of the publication regarding ERAs (core topic or addressed together/among other topics). For the research methodology, we basically relied on the taxonomies proposed by Recker (2013) and Palvia et al. (2004). As with the previous information regarding metadata, we followed a deductive approach.
- For qualitative content analysis, we proceed in a rather deductive-inductive mixed approach. First, we created an initial coding scheme departing from previous schemes developed in reviews following a similar framework for analysis (Haki and Legner, 2012; Viering, Legner and Ahlemann, 2009; Pateli and Giaglis, 2004). Such an initially developed scheme set the foundation for the topic analysis and also provided us the association of each sub-code into one of the four posed research questions of our framework. Next, we allowed new additional sub-codes to emerge iteratively through several cycles of publication review, as we progressively developed our understanding on the literature retrieved as a whole (Boell and Cecez-Kecmanovic, 2014). Finally, sub-codes reflexing similar or quite related topics were finally integrated and refined into a single homogenized sub-code (Wolfswinkel, Furtmueller and Wilderom, 2013).

4 Results

Our results show that the level of publication activity on ERAs has been low over the last years, although a slightly sustained increase can be perceived in the last four years.

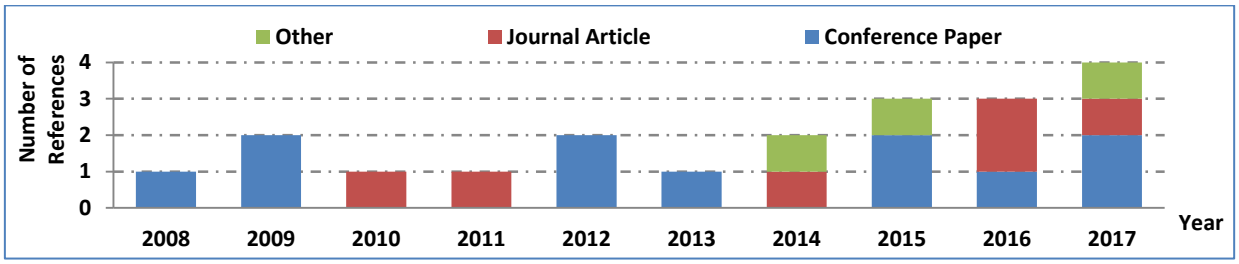

Figure 2. Distribution of studies across journals and conferences per year

In average, only two papers on the research topic are published by year, with a peak of four related studies published in current year 2017. Absolute numbers also clearly show that, contrarily to Software Engineering RAs or IT infrastructure RAs, the topic of ERAs it is not yet a widely accepted research topic over the IS community.

Results derived from the review also show that the number of published studies related with ERAs in conference/workshops proceedings nearly doubles journal articles. The *European Journal of Information Systems* is the most represented source in our pool of analysed studies, with two items included. However, and despite the fact of the low number of total studies published on the research topic, results also point out the fact that ERAs are a topic that generally is considered in relevant publications and events of the IS world. Hence, and besides the couple of articles published in the mentioned outlet, studies related with ERAs can also be found in the *Enterprise Information Systems Journal* or also in important IS conferences and workshops like the *European Conference on Information Systems* (ECIS), the *Wirtschaftsinformatik Conference* (WI), the *Hawaii International Conference on Systems Sciences* (HICSS) or the *Trends In Enterprise Architecture Research and Practice Workshop* (TEAR).

Source of the Study	*Count*
Conference Paper	**11 (55%)**
European Conference on Information Systems (ECIS)	*1*
Hawaii International Conference on Systems Sciences (HICSS)	*1*
INFORMATIK	*1*
International Workshop on Ecosystem Architectures (WEA)	*1*
Internationalen Tagung Wirtschaftsinformatik (WI)	*1*
IFIP WG 8.1 Working Conference on the Practice of Enterprise Modelling (PoEM)	*1*
Trends In Enterprise Architecture Research Workshop (TEAR)	*1*
INCOSE International Symposium	*1*
Annual Conference on Systems Engineering Research	*1*
The Open Group Enterprise Architecture Practitioners Conference	*1*
Conference on ENTERprise Information Systems	*1*
Journal Article	**6 (30%)**
Enterprise Information Systems	*1*
European Journal of Information Systems	*2*
Journal of Theoretical and Applied Electronic Commerce Research	*1*
Systems Engineering	*1*
Software & Systems Modelling	*1*
Other	**3 (15%)**
Total general	**20 (100)**

Table 2 Journals and Conference proceedings including publications related with ERAs

We also analysed the research methods used by each contribution in order to better understand the status quo of undertaken research. The analysis was limited by the fact that, in several cases, the authors do not formally specify the research method followed. Also, several contributions analysed report on partial findings belonging to the same general study – i.e. (Timm, Wißotzki, Köpp, *et al.* 2015; Timm, Köpp, Sandkuhl, *et al.* 2015; Timm, Sandkuhl and Fellmann, 2017) or (Lange, Mendling and Recker, 2012 & 2016) – which further compromises the analysis. Figures shown in Table 3 clearly depict that in studies dealing with ERAs there is a strong predominance of conceptual/theoretical studies and Design Science Research (DSR) approaches, which can be interpreted as an indicator that ERAs are both an emerging as well as a relatively complex research phenomena. From an empirical point of view, case studies and expert interviews are commonly used as complementary instruments

for validating and refining findings uncovered in preliminary literature reviews. We also clearly observe a significative lack of quantitative research, with just 7 studies making use of surveys, and moreover, not in an isolated way but through a mixed method or DSR approach.

CONCEPTUAL/THEORETICAL	**6 (30%)**
DESIGN SCIENCE RESEARCH	**5 (25%)**
Survey + Literature Review + Expert Interview + Reference Modelling + Expert Workshops + (Technical) Action Research	*2*
Literature Review + Reference Modelling + (Single) Case Study	*1*
Literature Review + Expert Interview (requirements) + Prototyping + Expert Interview (validation)	*1*
Literature Review + Expert Interview + Survey (information only available for the relevance cycle)	*1*
MIXED METHODS	**4 (20%)**
Literature Review + Expert Interview	*1*
Literature Review + Expert Interview + Survey	*3*
QUALITATIVE STUDY	**3 (15%)**
Literature Review	*1*
(Single) Case Study + Expert Interview	*2*
QUANTITATIVE STUDY	**1 (5%)**
Survey	*1*
NOT ASSIGNED	**1 (5%)**
Total general	**20 (100%)**

Table 3 Research methods used in ERAs related studies

Finally, and regarding the concrete application domain (i.e. *class-of-enterprises*) to which findings are concerned, as the vast majority of studies analysed are of conceptual/theoretical nature they tend to report findings valid to all-kinds of ERAs. 8 studies report findings specifically contextualized to a concrete type of class-of-enterprise and 2 additional publications report both on general and particularized findings. Types of enterprises and industries addressed include telecommunications (Czarnecki and Dietze, 2017), e-commerce (Aulkemeier, Schramm, Iacob, *et al.* 2016), finance (Schmidt and Buxmann 2011; Haki and Legner 2012), utilities (Timm, Köpp, Sandkuhl, *et al.* 2015; Timm, Sandkuhl and Fellmann, 2017), public sector (Niemi and Pekkola, 2017), eGoverment (Tambouris, Kaliva, Liaros, *et al.* 2014) and higher education (Olsen and Trelsgård, 2016).

5 Findings and discussion

In this section we provide concrete answers for the research questions posed in section 3.1.

5.1 What are the characteristics of an ERA? (RQ1)

Studies dealing with topics related with the nature of ERAs through a rather theoretical/conceptual approach are, by far, the most common contributions that can be found in the literature. For example, and besides the most complete *definitions* of ERAs (ten Harmsen van der Beek et al., 2012; Lankhost, 2014) already presented in the introductory part of the paper; we were also able to identify other literature providing additional definitions of ERAs, but perhaps, in a less elaborated and formal way. Hence, the studies of Cloutier et al. (2010), Muller (2008) and Muller and van der Laar (2009) also contain definitions, but from the more generic perspective of system-oriented RAs. In such cases, the definitions proposed can be considered as compatible with our adopted working definition of ERAs. Contrarily, Fattah (2009) suggest a rather nuanced conceptualization. In his view, an ERA is a somewhat narrower concept that should be understood solely under the specific context of a concrete organ-

ization. Therefore, an ERA is a "*blueprint for the Solution Architecture of a number of potential projects within an organisation that embodies the EA principles, policies, standards and guidelines"* (Fattah 2009 p.3). In other words, in Fattah's eyes an ERA is solution architecture with some of the (architectural) decisions already made and others left open, which can be used as a point of reference for a specific business (strategic) initiative. Such initiative is posteriorly implemented through a set of individual (project) initiatives into the concrete final solution architecture (Fattah, 2009).

Besides definitions, aspects regarding the *components* or building blocks of an ERA have also been relatively well-covered by existing literature (Cloutier et al. , 2010; ten Harmsen van der Beek et al. , 2012; Czarnecki and Dietze, 2017; Muller, 2008; Zimmermann, Sandkuhl, Pretz, *et al.*, 2013). Such studies characterize ERAs as a bundle or package of integrated elements, which may include best practices, patterns, conceptual RMs (architectural sub-domains), architectural viewpoints, (architectural) design principles, requirements, common vocabularies and glossaries and (technical) standards. In this sense, the article of Tambouris, Kaliva, Liaros, et al. (2014) provides an excellent level of detail on ERAs requirements for an eGovernment service provider organization. Proposals of *taxonomies* or *typologies* have also been considered by Cloutier et al. (2010), Muller (2008) and Fattah (2009) in terms of coverage (i.e. applicability) and abstraction as main taxonomy dimensions. However, and in all them the reference point for establishing the classifications were RAs. Hence, ERAs are just typified and considered as a concrete sub-type of RAs in these frameworks. We were not able to locate in the revised literature a concrete or specialized classification exclusively devoted to classify ERAs, which, in our opinion, represents a clear research opportunity – see for example Angelov, Grefen and Greefhorst (2012) or Nakagawa, Oquendo and Maldonado (2014) proposed taxonomies for Software Engineering RAs, which can provide valuable insights in this sense – . Finally, we also identified contributions addressing issues regarding the adequate level of detail and content of an ERAs *documentation* – known as the "*abstract diabolo framework"* (Muller and van de Laar, 2009; Muller, 2008) – and a *conceptual model* establishing the relationship among ERAs, EA frameworks and (concrete) solution enterprise architectures (ten Harmsen van der Beek et al. 2012).

5.2 Why, how and to what extend are ERAs adopted in practice? (RQ2)

Studies covering this sub-research stream are less common than those dealing with the nature of ERAs. Undoubtedly, the most outstanding contribution in this realm is the study by Niemi and Pekkola (2017), who through and case-study approach based on 14 semi-structured interviews in a public sector settlement, derive a theoretical framework for understanding the *use* (i.e. why, how, when and by whom) of EA artefacts. Whilst our impression is that in the contribution the authors rather perceive ERAs in a similar way than Fattah – that is, considering ERAs as "*architectural guidelines for the several groups of operational units, clustered according to the business areas"* (Niemi and Pekkola, 2017) – the article provides important insights on plausible uses of ERAs. Hence, and according to such theoretical framework, ERAs can be used for diverse purposes, as for example, being a communication tool among different stakeholders, as a tool for knowledge accumulation and transfer (i.e. train and instruct), as a decision making model to provide guidance on scoping and design implementation issues for future targeted states (i.e. "to-be") or as high-level description models of the current state-of affairs (i.e. as-is state). In addition, the Niemi and Pekkola also suggest that, in general, EA artefacts can be used for other business-IT planning activities. Consequently, ERAs may also be valuable resources for other additional tasks as providing support for IT acquisition and selection processes, facilitating the analysis of organizational issues (for example, data accuracy) or even IT program and project portfolio evaluation. In our view, Niemi and Pekkola's framework adequately condenses and synthetises insights and comments reflected in additional contributions (ten Harmsen van der Beek et al. 2012 ; Cloutier et al. 2010). Finally, at this point we also want to highlight that combining together Niemi and Pekkola's theoretical model with "*abstract diabolo framework"* (Muller and van de Laar, 2009; Muller, 2008), it can be plausible to establish a concrete relationship among the proper level of detail and content of an ERA documentation with respect to its different intended audience or *stakeholders*; as explicitly demanded by Cloutier and colleagues (2010).

In addition to ERAs usage, publications within this stream have also coped with *adoption factors* and *critical success factors* for ERAs, but in a very superficial way. On the one hand, *critical success factors* for ERAs have been roughly mentioned by Cloutier et al. (2010, p.24), who explicitly emphasize ownership as a critical success factor for ERAs. In addition, but in terms of *pre-requisites* (for success of an ERA), again Cloutier and colleagues (2010) highlight sponsorship of business management. In this vein, Lankhost (2014) further emphasizes the fact that ERAs should be community-based and maintained (i.e. users, and not vendors, should decide on best practices); the need of organizational commitment and enforcement to use them (in order to guarantee their benefits), and the fact that ERAs must provide true and actionable guidance in terms of business functions/processes, building blocks and standards. Unfortunately, no concrete empirical study has been already made up to prove none of such theoretical propositions. On the other hand, a couple of studies have specifically considered *adoption factors* of ERAs in two industries, concretely utilities (Timm, Wißotzki, Köpp, et al. 2015) and higher education (Olsen and Trelsgård, 2016). Among the factors suggested in these papers to encourage firm's adoption of ERAs we found fusions and outsourcing strategies, new legal requirements and regulations, the need of cooperation and standardization in the sector, or the lack of EA frameworks and artifacts specifically tailored for the firms of the concrete industry. To conclude, and in tune with Lankhost considerations on enforcement to make use of ERAs, we see here real chances for further studies to address possible moderating factors on the use of ERAs – see for example Bischoff, Aier and Winter (2014) considerations on the role of pressure for use/utility of EA artefacts –.

5.3 How to design, implement and manage ERAs? (RQ3)

Contributions within this research stream are primarily concentrated on *design methods* for developing ERAs for a determinate class of enterprises. This point has been addressed, for example, by Aulkemeier, Schramm, Iacob, *et al.* (2016), who developed an e-Commerce ERA, or by Timm, Köpp, Sandkuhl, *et al.* (2015), who developed an ERA for small and medium-sized utilities. Moreover, in a recent conference paper (Timm, Sandkuhl and Fellmann, 2017), this last utilities-oriented design model has been further generalized into a meta-method for developing "generic ERAs" (that is, extended to a design method applicable for creating an ERA for any type of "class of enterprises"). In all three cases, the contributions drawn on a DSR approach and propose a relatively similar operationalization of the defined design process, by integrating and consolidating both theoretical and practical expert knowledge in order to define the (design) requirements to be fulfilled by the intended ERAs.

Besides the aforementioned contributions, efforts on this area have also been directed to the development of a *selection model* for choosing a concrete ERA (Kotzampasaki 2015), which, in line with previous design methods, has also been formalized through a DSR approach. We also found a conceptual-oriented study (Zimmermann, Sandkuhl, Pretz, *et al.* 2013) documenting a *mapping method* to establish the correspondence between the components blocks defined for a SOA and cloud-oriented theoretical ERA, with respect to the concrete architectural objects defined (included) in a concrete EA framework (for example TOGAF). All in all, we still see here research opportunities for developing prescriptive knowledge on how-to apply and adapt ERAs in practice, as for example, the construction of models for change management and governance (i.e., the temporal evolution or dynamics) of an ERA (Cloutier et al. 2010), models to assess and analyse a concrete solution EA against a generic ERA taken as a reference; transformation methods for establishing mappings among a concrete solution EA and an ERAs; or decision models for accelerating and improving the design, realization and maintenance of a concrete solution EA implemented on the basis of an ERA (ten Harmsen van der Beek et al. 2012).

5.4 What are the organizational impacts of ERAs? (RQ4)

Research addressing the impact of ERAs can be mainly subdivided into two main inquiry lines: conceptual contributions describing the potential *value (i.e. benefits)* of ERAs and empirical studies addressing indicators or impact measures related to ERAs.

On the one hand, we found 5 contributions that, to lesser or grater degree, describe in conceptual terms the (potential) *value* of ERAs (Muller, 2008; Cloutier *et al.* 2010; ten Harmsen van der Beek et al. 2012; Olsen and Trelsgård, 2016; Lankhorst, 2014). Such studies specially tend to highlight the value of ERAs for time and cost reductions in the development of concrete solution EAs, as a consequence of not having to start from scratch and to scale advantatges. Also, quality improvements and risk mitigation in EA practices can be possible due to the use of well-proven practices and standards introduced by ERAs. They also are considered as a valuable resource for providing commong understanding (i.e. shared lexicons, vocabularies, taxonomies, etc.) among multiple and heterogeneous stakeholders, which can be specially usefull in IT carving-out projects our oursourcing strategies. Finally, ERAs can additionally lead to flexibility in the choice of suppliers; improved knowledge transfer and communication; interoperability, process standarization and benchmarking facilitation across an industrial sector and to regulatory compliance (if the ERA is prescribed by regulators).

On the other hand, we found 4 coing with *impact measurement* issues. Only one of them (Schmidt and Buxmann, 2011) established a direct correlation on the use of ERA and IT flexibility an efficiency. Lange, Mendling and Recker (2012, 2016) present and EA management success model, in which ERAs availability is operationalized as a (sub) construct of the independent variable (IV) *EAM Infrastructure*, which in turn, and trough (other) mediating variables; finally impacts on the direct variable (DV) *EAM Benefits*. However, the model fails to clearly explain which concrete *EAM Benefit* is leveraged and impacted by the direct influence of ERAs. Finally, Jusuf and Kurnia (2017) further extend the previous contribution providing an adapted version of the theorical EA success model. However, and once again, it seems that new model presents similar limitations than its predecessors. To sum up, and given this background, we see clear room for new research opportunities in the form of quantitative-oriented studies defining more and better impact measures and indicators for ERAs

6 Conclusions and study limitations

We have presented the results of a comprehensible literature review on high-quality studies for ERAs. Using Gregor's IS theory types as an underlying framework, we analysed and classified a set of 20 contributions providing a consolidated view of major findings on the topic to date. Although important conceptual descriptive work is done, there is a clear lack of empirical studies on the research phenomena, and especially in those concerned with proving the utility and benefits of such generic architectural models. Furthermore, and given the amount of uncovered literature, the topic can clearly be considered as an under-researched topic within the IS discipline, although exiting research addressing it is typically taken into account in important IS disciplinary outlets and conference events.

As any other, this research piece also comes with limitations. First, concerns regarding the keyword search executed may be raised, as several relevant studies may have not been included in the review. Also, and although the literature selection process has been made made as objectively as possible, there could be some selection bias due to personal judgements made. Furthermore, we finally believe that an extended review adopting a multivocal approach (Garousi, Felderer and Hacaloglu, 2017; Quinn Patton, 1991), including all-type of grey literature, would probably provide additional insights and valuable information on the topic.

Anyway, and despite the few and scattered existing research on ERAs, we believe that the present review can be a valuable resource for both IS practioners and researchers since, up to our knowledge, no previous ERA review has been published before. Hence, we hope that the results disseminated through the paper can contribute to a better understanding of the phenomena of ERAs, as well as to an increase of the volume of IS research contributions addressing such a relatively new topic.

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APPENDIX 1 – Literature Review Conceptual Matrix

	META-DATA AND DESCRIPTIVE INFORMATION				NATURE (RQ1)					ADOPTION (RQ2)				PRACTICES (RQ3)			IMPACT (RQ4)	
	Contribution (Authors / date)	**Research method**	**Level of study**	**Universality of study**	**Definitions**	**Components**	**Conceptual models**	**Taxonomies**	**Documen-tation**	**Adoption factors**	**Success factors**	**Stakeholders**	**Uses**	**Design methods**	**Mapping methods**	**Selection models**	**Value / Benefits**	**Impact measures**
1	(Muller, 2008)	CO	C	G	✓	✓		✓	✓								✓	
2	(Muller and van de Laar, 2009)	CO	C	G	✓				✓									
3	(Fattah, 2009)	CO	C	G	✓			✓					✓					
4	(Cloutier, Muller, Verma, *et al.* 2010)	CO	C	G	✓	✓	✓	✓			✓	✓	✓				✓	
5	(Schmidt and Buxmann , 2011)	MX	O	S														✓
6	(Lange, Mendling and Recker, 2012)	MX	O	G														✓
7	(ten Harmsen van der Beek, Trienekens and Grefen, 2012)	DS	C	B	✓	✓	✓					✓	✓				✓	
8	(Zimmermann, Sandkuhl, Pretz, *et al.* 2013)	CO	C	G	✓	✓									✓			
9	(Lankhorst, 2014)	CO	C	G	✓	✓					✓						✓	
10	(Tambouris, Kaliva, Liaros, *et al.* 2014)	QL	O	S		✓												
11	(Kotzampasaki, 2015)	DS	C	G												✓		
12	(Timm, Köpp, Sandkuhl, *et al.* 2015)	DS	C	S										✓				
13	(Timm, Wißotzki, Köpp, *et al.* 2015)	QT	O	S						✓								
14	(Aulkemeier, Schramm, Iacob, *et al.* 2016)	DS	C	S										✓				
15	(Lange, Mendling and Recker, 2016)	MX	O	G														✓
16	(Olsen and Trelsgård, 2016)	QL	O	S						✓							✓	
17	(Czarnecki and Dietze, 2017)	NA	C	S	✓	✓			✓									
18	(Jusuf and Kurnia, 2017)	MX	O	G														✓
19	(Niemi and Pekkola, 2017)	QL	O	S								✓	✓					
20	(Timm, Sandkuhl and Fellmann, 2017)	DS	C	B										✓				

Level of study *: C → Core topic | O → Other topics covered* ╬ ***Universality of study*** *: G → General | S→ Specific | B→ Both*
Research Method *: CO → Conceptual/theoretical | DS → Design Science Research | QL → Qualitative Research | QT → Quantitative Research | MX→ Mixed Methods | NA → Not Assigned*

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