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What do we know about the role of enterprise architecture in enterprise integration? A systematic mapping study

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Abstract

Purpose – Constant changes in the environment seem to have become the biggest challenge of a modern enterprise, which emphasizes the constant need to integrate the enterprise into its changing environment. Aiming at eliminating the integration challenges, EA is proposed as a solution. The purpose of this paper is to survey and analyse the available literature on determining the role of EA in EI and also to identify gaps and state-of-the-art in research.

Design/methodology/approach – This paper presents a systematic mapping study that found 50 papers in the intersection of EA and EI, these papers were surveyed, analysed, and classified with respect to research focus, research method, and paper type.

Findings – Based on the analyses of the final 50 articles, the authors realized that "EA framework" is the dominating research focus of these studies. "Evaluation research" is recognized as the most common paper type in this area. However, "Experience paper" was a rare paper type in this research domain. "Constructive research" and "Case study/multiple case studies" are widely applied as the research method. "Survey", "Delphi study" and "Grounded theory" are the least employed research methods. The conclusion was that there is a need for empirical research in this area. After analysing the articles based on their publication year, the authors also noticed a significant growth between 2004 and 2010. After 2010 the number of publications had a downward trend.

Originality/value – To the knowledge of the authors, this study is the first systematic literature study regarding the role of EA in EI. There are several systematic literature reviews about the EA or EI separately but none of them has addressed the specific realm of the research. Hence, the goal of this study is to provide a map of existing literature to enable improvement of the practice with the known research results and to identify gaps for future research.

Keywords Enterprise architecture, Enterprise integration, Systematic mapping study

Paper type Literature review

1. Introduction

Constant change is the inseparable and the most important characteristic of today's enterprises. To survive in this competitive era, the enterprises need to adapt themselves to the change. Enterprise integration (EI) is the task of performance improvement in complex organizations by managing the participants interactions (Huat Lim *et al.*, 1997). EI provides a discipline to organize all the knowledge that is required to identify and carry out the change in the enterprises (Bernus and Nemes, 1997). To achieve EI many scholars have believed in enterprise architecture (EA) as the ultimate solution

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(Anaya and Ortiz, 2005; Chen *et al.*, 1997, 2008; Erol *et al.*, 2009a; Hoogervorst, 2004; Kang *et al.*, 2010; Lam, 2005a; Noran, 2013; Panetto *et al.*, 2012; Peristeras and Tarabanis, 2000; Vernadat, 2007).

Conventionally, EA has been used for EI to align business and Information Technology (IT) in the organizations (Bernus and Nemes, 1997; Chen *et al.*, 1997; IFIP-IFAC TF, 1999; Sowa and Zachman, 1992; Zachman, 1987). EA provides organizations means to cope with the core challenges of the ICT age (Chen *et al.*, 2008; Goel *et al.*, 2009; Kim *et al.*, 2006): integration; interoperability; agility; and change.

While the strategic alignment between business and IT in companies generate added value to business processes, technological complexities will arise (Henderson and Venkatraman, 1993) and meanwhile the companies should also achieve integration and coordination to ensure survival among their competitors. Attaining these goals is tough. EA is believed to provide appropriate concepts, methods, models, and tools to facilitate business IT alignment and integration (Vargas *et al.*, 2014).

In order to get a perspective of existing research we conducted a systematic mapping study (SMS). To the knowledge of the authors, this study is the first SMS study regarding the role of EA in EI. Although, there are several systematic literature reviews (SLR) about the EA or EI separately (Boucharas *et al.*, 2010; Giachetti, 2004; Lucke *et al.*, 2010; Sedek *et al.*, 2011; Stelzer, 2010; Tamm *et al.*, 2011), but none of them have addressed the specific realm of our research. Hence, the goal of this study is to provide a map of existing literature to achieve useful results for practical use and to identify gaps for future research.

The objective is to form a background for further research as well as obtain a deeper insight about the topic. The complexity of the EI has been cited in many sources (Chalmeta *et al.*, 2001; Lim *et al.*, 1998; Ngeru *et al.*, 2009). Also EA is known as a holistic approach to manage complexity (Armour *et al.*, 1999; Ross *et al.*, 2006; Winter and Fischer, 2006). This understanding of the complexity of EA and EI motivated us to conduct this study to find out how the EI issues have been addressed by the EA in literature. Since we found only 50 articles determining the role of EA in EI, choosing SMS as the research approach seems appropriate, because SMS is a valid approach when there is limited number of literature available (Kitchenham, 2007; Petersen *et al.*, 2008).

In total, we analyse the results of 50 scientific papers in this study. The main answered research questions in this study include:

RQ1. What research focuses on determining the role of EA in EI are prevalent?

RQ2. What methodologies and paper types are utilized?

RQ3. How publication trends changed over time?

The outcomes of this study deliver a comprehensive research approach in determining the role of EA in EI as well as implications and guidelines for both scholars and practitioners.

The paper is organized as follows: Section 2 describes EA and EI and the role of EA in EI based on the pervious literature. In Section 3 the applied research method including research questions, search steps, selected publication forum, search string, and exclusion/inclusion criteria are clarified. The classification process and schema are illustrated in Section 4. The results of the mapping study are discussed

exhaustively in Section 5. Section 6 summarizes the findings of the study, discusses about the validity threats, and reports the limitations of this study. Finally, Section 7 contains the conclusions and discusses research.

2. Background

2.1 EI

A variety of definitions have been proposed to clarify the meaning of EI. Lim *et al.* (1998), describe EI as a very complex task to achieve an overall organizational improvement by emphasizing on the unification of enterprise functions. In another study, EI is defined as the organizational function that comprises activities, resources, decisions, and information flow and provides coordination in order to satisfy global objectives and improves performance (Chalmeta *et al.*, 2001). EI, sometimes referred to as system integration, is the process of interconnecting silo business functions to streamline organizational processes (Umapathy *et al.*, 2008). Ngeru *et al.* (2009), refer to EI as a technology that promises to rapid information sharing among business processes both intra and inter organization. All in all, EI refers to the terms, such as coordination, performance improvement, information flow, and processes.

Some studies contrast EI with enterprise interoperability. Enterprise interoperability addresses the ability of interactions between enterprise systems, which is seen as a technical problem (Chen *et al.*, 2008; Vernadat, 2009). In contrast, EI is the task of performance improvement in a complex organization by managing the interactions of participants (Huat Lim *et al.*, 1997). Therefore, EI is a process to ensure the interaction between various entities of the enterprise to attain domain objectives (Chen *et al.*, 2008).

According to Enterprise Integration Council, the ultimate goals of EI are flexibility and agility in order to swiftly respond to new business opportunities. The Enterprise Integration Council proposes benefits of EA as cycle time reduction, cost reduction, and cost containment (Lee *et al.*, 2003).

2.2 EA

Although there are different perspectives to describe EA (Niemann, 2006; Ross *et al.*, 2006; Simon *et al.*, 2014; Winter and Fischer, 2006; Zachman, 1987), they all explain EA as a strategic instrument to control and manage the complexity in an organization through structured description of the enterprise and its relationships. EA has tended into a holistic management of information systems in organizational approaches (Ross *et al.*, 2006; Winter and Fischer, 2006). All the entities, such as systems, stakeholders, relationships and dependencies, and business strategies can be included in an EA effort. In order to minimize the existing gap between business and IT, EA performs as a mediator to improve integration (Wu, 2007). In organizations, EA is placed between IT and business strategy, and it is responsible to translate the strategic principles, capabilities, and goals into the systems and processes (Tamm *et al.*, 2011).

EA is based on the business and IT models with systematic frameworks which detail enterprise structures. EA can be built with a specific architectural framework or adopt and customize a previously defined framework (Plazaola *et al.*, 2008). The outcome of EA is a set of artefacts that describe what business does, how it operates and what resources it requires, these artefacts are often presented graphically (Lankhorst, 2009; Ross *et al.*, 2006; Zachman, 1987).

Several benefits of EA have been recognized, including complexity management, faster adaptability, a comprehensive enterprise view, improved change management, and increased interoperability and integration (Armour *et al.*, 1999; Hoogervorst, 2004; Jonkers *et al.*, 2006; Morganwalp and Sage, 2004; Niemi, 2008).

2.3 EA and EI relationship

EI and interoperability have become one of the major concerns of today's enterprises. To achieve a competitive advantage and to facilitate integration processes, the enterprises must rethink the whole process of EI. Several integration approaches have been proposed since the companies realized the critical role of EI. However, at some point these approaches (such as Enterprise Application Integration, Enterprise Service Bus, and middleware) cannot fulfil EI issues due to tightly coupled applications, lack of interoperability, and poor scalability and security (Tang *et al.*, 2010). For these problems EA approach is proposed to solve EI problems. Several studies explicitly refer to EA as a solution to solve EI issues (Erol *et al.*, 2009b; Goethals *et al.*, 2006; Kang *et al.*, 2010; Kim *et al.*, 2006). To cope with the dynamic business environment, these studies suggest that adopting EA is one of the most successful approaches. Also, companies cannot gain alignment, flexibility, or integration if they do not architect their enterprises.

One of the many benefits of EA reported by Tamm *et al.* (2011) is the improvement of integration. EA has also been suggested to enhance information sharing through EI (Boh and Yellin, 2007; Ross *et al.*, 2006; Spewak and Hill, 1993).

3. Research method

SLR is a secondary study, which has its roots in medical research (Kitchenham, 2004). The application of SLR is to identify, evaluate, and interpret all the available and relevant literature related to a research question or domain of interest (Kitchenham, 2004, 2007; Petersen *et al.*, 2008). The most common reasons for undertaking SLR are: first, to summarize the existing evidence about the topic; second, to identify gaps in current research and provide suggestion for future investigation; and third, to provide background to position new research activities (Kitchenham, 2004).

A SMS or scoping review is another type of literature review that complements SLR (Kitchenham, 2004, 2007). A SMS study is applied to outline the types of research activity that have been engaged in the study. Unlike SLR, SMS describes the study in a high level and "map-out" the research rather than investigating research questions in details (Brereton *et al.*, 2007; Budgen *et al.*, 2008; Petersen *et al.*, 2008). In other words, a SMS can be considered as a method to get an overview of an specific research area (Kitchenham *et al.*, 2011), because, it narrates the studies rather than extracting detailed information (Brereton *et al.*, 2007). A SMS is preferred if during the examination of a domain and before initiating SLR, it is realized that, there is little existing research or the topic is too broad (Kitchenham, 2007; Petersen *et al.*, 2008). Since, our goal is to prepare an overview of the topic, SMS seems to be a viable approach to get an overview of existing research in the intersection of EA and EI.

3.1 Research questions

Research questions in SMS are much broader than in SLR to address the wider scope of study (Budgen *et al.*, 2008; Kitchenham, 2007). The research questions of this study

concentrate on categorizing and structuring the intersection of EA and EI. Table I shows all the research questions of this study.

3.2 Search steps

In order to augment the accuracy of this SMS study the searching and analysing processes have to be as transparent as possible. Thus, the following sections characterize the processes of selecting data sources, the applied strategy for creating the search string, and defining the exclusion and inclusion criteria. We adopt the process of search steps from Petersen *et al.* (2008) study. In this process each step has an outcome and the systematic map is the final outcome of the process. Figure 1 illustrates the complete SMS process used in this paper, which was done according to instructions by Petersen *et al.* (2008) and Wendler (2012).

3.2.1 Data sources and research strategy selection. We did electronic searches in the following databases: ACM Digital Library, Citeseer, Business Source Complete and

No.	Research question	Description
RQ1	What are the main research focuses on the literature about the role of EA in EI?	The answer provides an overview of main fields and research focuses regarding the role of EA in EI studies
RQ2	What are the most common research methods and paper types applied?	Investigations on types of paper and applied methods, determine the most important designs and methods and reveal gaps in the previous studies
RQ3	How has the number of publications changed over time?	This question reveals study trends and publications timeline

Table I.
Research questions of this study

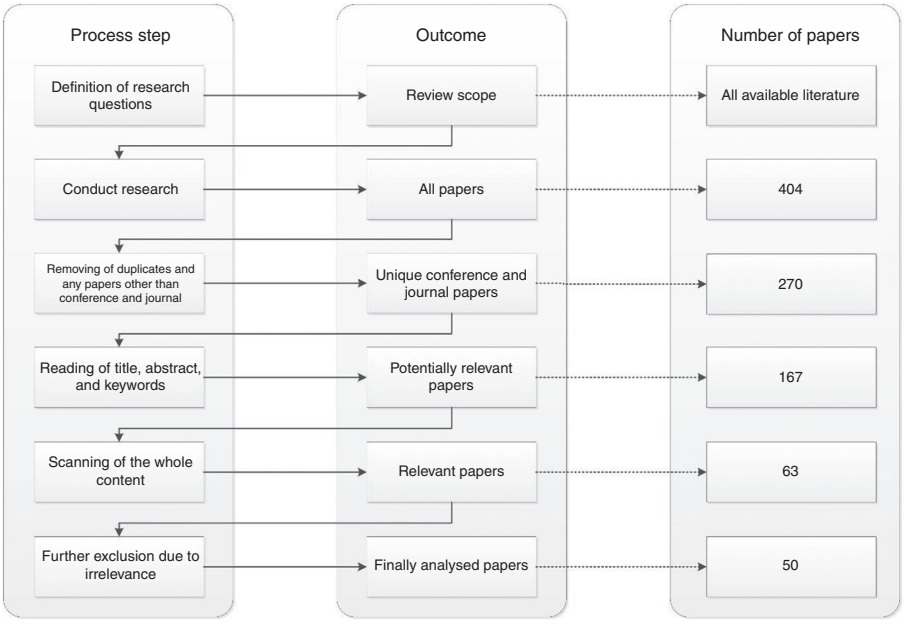

Figure 1.
Search process

Academic Search Elite of EBSCO, Emerald Insight, IEEEXplore Digital Library, ScienceDirect, and SpringerLink. These digital libraries were selected because they are common and important libraries in the field of information systems.

The search string was created using the strategy from Barbosa and Alves (2011): first, we defined the main keywords; second, checked the already known papers in this area; third, looked for alternative forms of the keywords; fourth, we used Boolean operator to synthesize them into one search string. The final search string is as follows:

> "enterprise architecture" AND ("enterprise integration" OR "enterprise interoperability" OR "enterprise coordination" OR "enterprise coherence" OR "integration of enterprise" OR "coordination of enterprise")

This search string was applied to search within the all article parts, such as title, abstract, keywords, and main body. The search process began in May 2014.

The search string synonyms for "EI" were taken from dictionaries. After that we went through some sample articles and confirmed the synonyms. Besides "EI", the synonyms used were "enterprise interoperability", "enterprise coherence", and "enterprise coordination". In order to limit the number of search results and to have a more accurate set of search results from the databases, we placed each part of the search string in quotation marks to find the exact phrase.

3.2.2 Exclusion and inclusion criteria. The inclusion and exclusion criteria step is one of the activities of a mapping study to exclude irrelevant and include relevant studies (Petersen *et al.*, 2008). In other words, it ensures that only appropriate articles will be analysed.

For this study, the authors applied the following criteria for exclusion and inclusion of the articles (Table II).

We excluded book sections and theses because the number of search result would otherwise become too high it would be impossible in practice to analyse all of them. Besides, original scientific research is typically published in scientific journals and conferences for the first time. Thus, we minimized our search scope to only journal and conference papers.

To minimize the risk of excluding relevant articles, the articles that were not clear cases to exclude were read in detail at the last step of the SMS process. This process took place in Step 6 of SMS process, where 13 articles were excluded at last (refer to Figure 1).

Inclusion	Exclusion
Papers that focus both on EA and EI	The papers that lie outside of the EA and EI domain
English Language papers	Papers in other language than English
Only journal and conference papers	Dissertations, theses, book sections, product descriptions, presentations, work reports, trade literature, editorial notes, newsletters, grey literature, and indexes
Peer reviewed papers	Non-peer reviewed papers
	Duplicate papers

Table II. Inclusion and exclusion criteria

We used Zotero as the reference management software application to manage the references and to assist us in the third step of this mapping study to remove the duplicates. To remove the duplicates by using Zotero, first we sorted all the initial 404 articles based on the author's name and then by going through the author's name column, if the author's name was repeated in sequence then we checked the titles and the years and in case of repetition one of the articles that was not downloaded from one of the main publishers, such as Springer, ACM, IEEE, Emerald, and ScienceDirect had deleted. For instance, when we found a duplicate, one from Citeseer and the other one from ScienceDirect, and the original publisher of the article was ScienceDirect, then we deleted the article, which was downloaded from Citeseer database. In this way, we ended up having unique articles.

4. Classification scheme

To analyse and classify the articles, a classification scheme was developed. We took the idea of a classification scheme from Petersen *et al.* (2008) study. The process of classifying the articles is illustrated in Figure 2.

We created three facets to classify the studies. One facet categorized the articles based on their research methods. For research methods we were inspired by the classification provided by Palvia *et al.* (2004) for methodologies in MIS research and modified it based on our needs. The second facet defined the paper type based on the classification presented in Wieringa *et al.* (2006). In addition, we identified five categories of research focus by applying the keyword method described in Petersen *et al.* (2008). Table III describes the classification schemes of this study.

5. Mapping results

In the following sections based on the mapping results the research questions are answered. The results are based on the 50 selected articles. Table IV shows the categorization of the 50 articles based on their research focus, paper type, research method, and database. In total, 11 of these articles are conference papers and 39 journal papers.

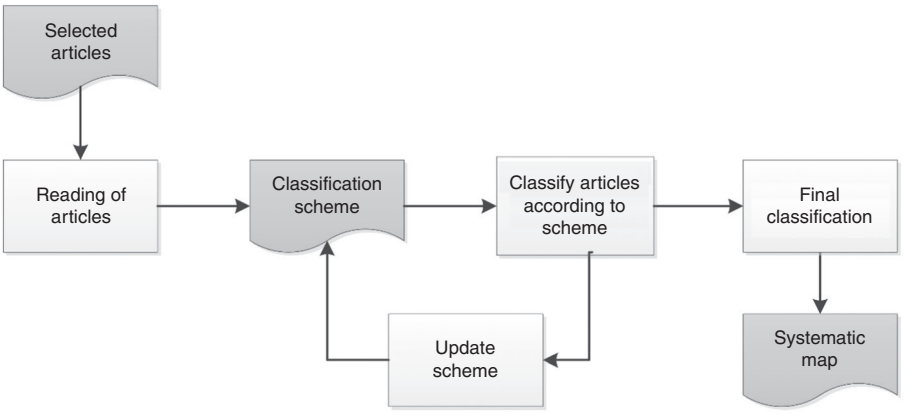

Figure 2.
Classification process

Paper type	
Validation research	Investigated methods are new and not yet implemented in practice
Evaluation research	Investigated methods are implemented in practice and the evaluation of the method is presented
Solution proposal	A solution for a problem is proposed, this solution proposal can be either new or applies and existing approach
Philosophical paper	These papers introduce a new perspective of an existing things by using taxonomy or conceptual framework
Experience paper	Personal experience of the author about what and how something has been done in practice
Research method	
Case study/multiple case studies	Study of a single phenomenon in one or more than one organization over a logical timeframe
Constructive study	Research that intends to construct a new framework, software artefact or conceptual model
Literature study	Research that analyses and extends existing literature
Discussion paper	Research that discusses an argument or a phenomena
Grounded theory	Research that aims towards theory development through the analysis of data
Survey	Research that uses predefined and structured questionnaires to capture data from individuals
Delphi study	Research that consists of two or more rounds of questionnaires answered by experts and it is based on forecasting methods
Research focus	
EA framework	Articles that their focus are on EA frameworks, methods, models, and tools that provide EI and interoperability
EI framework	Articles that their focus are on EI frameworks, methods, models, and tools by paying special attention to the role of EA
Enterprise interoperability	Articles that contains information about enterprise interoperability and its relation with EA and EI
Service-oriented architecture (SOA)	Articles that introduce SOA as an approach towards EI
Enterprise engineering	Articles that apply enterprise engineering approaches to reach to the EI by considering the special role of EA

Table III.
Classification scheme

5.1 Research focuses (RQ1)

To answer *RQ1*, the classification of 50 articles per research topic and focus area is conducted by going through the title, abstract, and keywords. We categorized the research focus in five different categories of EA framework, EI framework, enterprise interoperability, service-oriented architecture (SOA), and enterprise engineering (EE). Description of each research focus is provided in Table III.

The categorization revealed five main topic areas (see Table III). The distribution of these research focuses is presented in Figure 3. We decided to classify each article only by its main research focus.

EA framework with 20 articles and EI framework with 15 articles are the two dominant topic areas. In comparison, only three articles had focused on EE. For instance, Cuenca *et al.* (2010) propose EE as a way to provide alignment between business and IT by utilizing EA to ensure the coherency and integration. Kosanke *et al.* (1999) discussed EE as an enterprise life-cycle oriented discipline to provide EI through modelling.

References	Research focus	Paper type	Research method	Database	Conference/ journal
Anaya and Ortiz (2005)	EA framework	Case study	Solution proposal	ACM	Conference
Rohloff (2008)	EA framework	Case study, discussion	Philosophical paper	ACM	Conference
Chen *et al.* (2005)	EA framework	Constructive research, case study	Experience paper	ACM	Conference
Boh *et al.* (2003)	EA framework	Grounded theory, case study, survey	Evaluation research	Citeseer	Conference
Buckl *et al.* (2009)	EA framework	Case study	Solution proposal	Citeseer	Conference
Goel *et al.* (2009)	EA framework	Discussion	Solution proposal	Citeseer	Conference
Hoogervorst (2004)	EA framework	Literature studies	Philosophical paper	Citeseer	Journal
Kilpeläinen (2007)	EA framework	Constructive research, case study	Evaluation research	Citeseer	Conference
Peristeras and Tarabanis (2000)	EA framework	Constructive research	Solution proposal	Citeseer	Journal
Umar (2007)	EA framework	Constructive research, case study	Evaluation research	Citeseer	Journal
Erol *et al.* (2010)	EA framework	Constructive research, literature studies	Philosophical paper	EBSCO	Journal
Bernus and Nemes (1997)	EA framework	Constructive research, discussion	Validation research	ScienceDirect	Journal
Bernus and Nemes (1996)	EA framework	Constructive research, discussion	Validation research	ScienceDirect	Journal
Kang *et al.* (2010)	EA framework	Constructive research	Solution proposal	ScienceDirect	Journal
Pulkkinen *et al.* (2007)	EA framework	Case study	Philosophical paper	ScienceDirect	Journal
Toh *et al.* (2009)	EA framework	Case study	Evaluation research	ScienceDirect	Journal
Zheng and Zheng (2013)	EA framework	Literature studies	Philosophical paper	ScienceDirect	Journal
Kim *et al.* (2006)	EA framework	Constructive research	Solution proposal	Springer	Journal
Goethals *et al.* (2006)	EA framework	Constructive research, discussion	Validation research	Springer	Journal
Vargas *et al.* (2014)	EA framework	Constructive research	Validation research	Springer	Journal
Chalmeta (2000)	EI framework	Constructive research	Validation research	Citeseer	Journal
Soomro and Awan (2012)	EI framework	Literature studies, discussion	Evaluation research	Citeseer	Journal
Lam (2005b)	EI framework	Case study	Evaluation research	EBSCO	Journal
Wu (2007)	EI framework	Constructive research	Validation research	Emerald	Journal
Lam (2005a)	EI framework	Grounded theory	Philosophical paper	Emerald	Journal

Table IV.
Systematic map overview

(*continued*)

References	Research focus	Paper type	Research method	Database	Conference/ journal
Wang *et al.* (2011)	EI framework	Literature studies	Philosophical paper	IEEE	Conference
Chen *et al.* (1997)	EI framework	Discussion	Philosophical paper	ScienceDirect	Journal
Li *et al.* (2010)	EI framework	Constructive research, case study	Evaluation research	ScienceDirect	Journal
Li *et al.* (2013)	EI framework	Constructive research, case study	Evaluation research	ScienceDirect	Journal
Ni *et al.* (2007)	EI framework	Constructive research, case study	Evaluation research	ScienceDirect	Journal
Noran (2013)	EI framework	Constructive research	Validation research	ScienceDirect	Journal
Panetto *et al.* (2012)	EI framework	Discussion	Philosophical paper	ScienceDirect	Journal
Namba and Iijima (2003)	EI framework	Constructive research, case study	Evaluation research	Springer	Journal
Moynihan (1997)	EI framework	Constructive research, case study	Evaluation research	Springer	Journal
Wang *et al.* (2012)	EI framework	Literature studies, discussion	Philosophical paper	Springer	Journal
Maheshwari and Janssen (2012)	Enterprise interoperability	Constructive research, case study	Evaluation research	ACM	Conference
Chen *et al.* (2008)	Enterprise interoperability	Literature studies, discussion	Philosophical paper	ScienceDirect	Journal
Chituc *et al.* (2008)	Enterprise interoperability	Constructive research, case study, literature studies	Evaluation research	ScienceDirect	Journal
Panetto and Molina (2008)	Enterprise interoperability	Discussion	Philosophical paper	ScienceDirect	Journal
Mezgár and Rauschecker (2014)	Enterprise interoperability	Constructive research, case study	Evaluation research	ScienceDirect	Journal
Vernadat (2007)	Enterprise interoperability	Discussion	Philosophical paper	ScienceDirect	Journal
Utomo (2011)	SOA	Case study	Experience paper	Citeseer	Journal
Erol *et al.* (2009b)	SOA	Constructive research	Validation paper	EBSCO	Journal
Pahl *et al.* (2009)	SOA	Constructive research	Solution proposal	EBSCO	Journal
Erol *et al.* (2009a)	SOA	Constructive research	Validation research	IEEE	Conference
Umar and Zordan (2009)	SOA	Case study	Evaluation research	ScienceDirect	Journal
Tang *et al.* (2010)	SOA	Constructive research, multiple case studies	Evaluation research	Springer	Journal
Cuenca *et al.* (2010)	Enterprise engineering	Case study, literature studies	Solution proposal	Citeseer	Conference
Kosanke and Nell (1999)	Enterprise engineering	Delphi study	Philosophical paper	ScienceDirect	Journal
Kosanke *et al.* (1999)	Enterprise engineering	Discussion	Philosophical paper	ScienceDirect	Journal

Table IV.

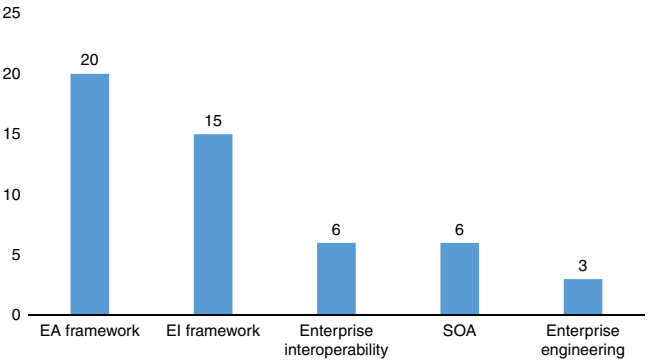

Figure 3.
Number of articles per research focus

Six articles contain descriptions about applying SOA approach to provide integration. Besides EI, enterprise flexibility, enterprise resilience, enterprise application reengineering and enterprise SOA were the other topics that are included in this category (Erol *et al.*, 2009a, b; Pahl *et al.*, 2009; Tang *et al.*, 2010).

Finally, six articles discussed about the role of EA in enterprise interoperability. Among these six articles some of them explicitly mentioned the difference between EI and enterprise interoperability (Chen *et al.*, 2008; Panetto and Molina, 2008), whereas some other articles refer to the enterprise interoperability as a kind of EI (Chituc *et al.*, 2008; Mezgár and Rauschecker, 2014). Despite all the similarities and differences between EI and enterprise interoperability, all of the articles in this classification have emphasized on the role of EA as a concept, method, or entity to reach to the integration.

5.1.1 EA framework. This category contains articles that have their emphasis on an EA framework. This included description of different EA frameworks and conceptual models in order to either manage EA or to implement and develop EA.

The significant role of EA in integrating an enterprise could be perceived even from the primary literature of EA. For instance, Richardson *et al.* (1990), referred to EA as an opportunity to support business functions and manage decision making by interrelating data, hardware, software and communications resources. In another study, Bernus and Nemes (1996) proposed a generic enterprise reference architecture to design and maintain enterprises for their entire life-cycle and to organize existing EI knowledge in the frequently changing environments. According to Kim *et al.* (2006) in order to solve information systems' integration problems, enterprises adopt the EA frameworks as an optimal solution. The criticality of change in enterprises and the role of EA can be realized from Zachman (1997) study that declared, quality, timeliness, and change as the issues that force us to consider EA more seriously. Therefore, it is crucial for an enterprise to be constantly re-architected to achieve integration (Goethals *et al.*, 2006).

The majority of the studies in the EA framework category have focused on frameworks and methodologies suggested to achieve EI (Bernus and Nemes, 1996; Chen *et al.*, 2005; Erol *et al.*, 2010; Goethals *et al.*, 2006; Hoogervorst, 2004; Kilpeläinen, 2007; Kim *et al.*, 2006; Peristeras and Tarabanis, 2000; Rohloff, 2008; Vargas *et al.*, 2014). The rest of the studies in this category have focused on tools, methods, and descriptions on how EA can help enterprises to achieve EI (Anaya and Ortiz, 2005; Buckl *et al.*, 2009; Goel *et al.*, 2009; Kang *et al.*, 2010; Pulkkinen *et al.*, 2007; Toh *et al.*, 2009; Umar, 2007; Zheng and Zheng, 2013).

5.1.2 EI framework. Integration issues have attracted much attention among scholars during the past decade (11 out of 14 articles in this category are between 2005 and 2013). This category contains the articles that emphasize on EI frameworks, methods, tools, and models. For instance, Chen *et al.* (1997) presented GERAM and GRAI, the two frameworks which assist to build integrated enterprise. In another recent attempt Noran (2013) proposed an EI framework to support integration. Besides EI frameworks enterprise modelling has mentioned as another approach to achieve EI, for instance, Moynihan utilized enterprise modelling to provide integration in manufacturing systems (Moynihan, 1997). Ni *et al.* (2007) proposed an approach to achieve business process integration in an enterprise applying modelling of business information model.

5.1.3 Enterprise interoperability. This category includes studies that distinguish integration from interoperability. For instance, the early study conducted by Papazoglou *et al.* (2000) referred to enterprise interoperability as one of the important requirement in order to achieve integrated value chain, and they defined interoperability as "the ability of one system to process information from and to another at a syntactic and semantic level without requiring either system to make changes to accommodate the other".

As mentioned in Section 2, some studies consider integration and interoperability as two different concepts (Chen and Doumeingts, 2003; Kosanke, 2006; Panetto and Molina, 2008; Vernadat, 2003). These studies argue that interoperability has the meaning of coexistence, autonomy, and federated environment, whereas they referred to integration as coordination, coherence, and uniformalization. In terms of coupling degree, Chen *et al.* (2008) referred to integrated systems as tightly coupled and interoperable systems as loosely coupled. In other words, they interpreted enterprise interoperability as loose integration of systems. This view includes that two integrated systems may be interoperable but not necessarily integrated (Chen and Doumeingts, 2003).

5.1.4 SOA. This category contains articles that have emphasized on SOA to gain EI. In spite of being only about ten years old as a concept, SOA has been applied widely as an approach to enterprise information systems development and EI. According to Erol *et al.* (2009a) SOA is recognized as a solution to overcome integration and interoperability issues.

Aiming to solve integration and interoperability problems, SOA provides novel integration patterns and infrastructures (Li *et al.*, 2010). The primary idea of SOA is to decompose applications into reusable components to deliver the business services (Umar and Zordan, 2009).

Pahl *et al.* (2009), referred to SOA as an integration architecture solution that supports various application scenarios. In their study, Pahl *et al.* presented a solution to integrate business information systems applying SOA and web services.

5.1.5 EE. The category of EE contains only three but important articles that highlight the significance of EE in EI. EA is considered to be the foundation of EE, and EI is an essential part of EE. In other words, gaining and maintaining EI are parts of EE tasks; therefore, EE project managers should constantly evaluate the current situation and be prepared for future optimal state (Cuenca *et al.*, 2010; Kosanke, 2005; Kosanke *et al.*, 1999; Lillehangen and Krogstie, 2008; Noran, 2013; Panetto and Molina, 2008). Managers can benefit from EA to manage the on-going EE efforts to achieve and maintain EI (Cuenca *et al.*, 2010; Kosanke *et al.*, 1999; Kosanke and Nell, 1999).

5.2 Paper type and research method (RQ2)

Paper type indicates the classification of papers with the categorization proposed by Wieringa *et al.* (2006), in which research is classified into six categories: validation research; evaluation research; proposal of solution; philosophical papers; opinion papers; and personal experience papers. To provide an answer to *RQ2*, we categorized the final 50 papers with this classification, but because we were not able to find any papers that can be fitted in the criteria of opinion papers, we did not include this type in our classification. Opinion papers are the type of papers that contain the author's personal opinion about something. The explanation of each category can be found in Table III.

Figure 4 illustrates the distribution of paper type based on the research topic of the paper. The most frequent paper type is evaluation research with 32 per cent. The next most frequent paper type is philosophical paper with 30 per cent. Validation research and solution proposal are the third and fourth most frequent paper type with 18 and 16 per cent, respectively. However, only 4 per cent of the papers are experience reports.

The research method classification is based on Palvia *et al.* (2004) classification of MIS research. While analysing the selected 50 articles additional research methods, such as Delphi study, grounded theory, and discussion paper are added. We identified seven research methods in the 50 analysed papers (refer to Table III for explanation of each category). We analysed the employed research methods for each paper. For example Boh *et al.* (2003) applied three research methods in their study. They used grounded theory to develop hypotheses and they used case study and survey to test their hypotheses. In this situation we considered all of these three applied research methods in our analysis for this paper.

Figure 5, shows the distribution of research method based on the research topic of this paper. Constructive research with 35 per cent is recognized as the predominant research method. After that case study or multiple case studies with 30 per cent ranked

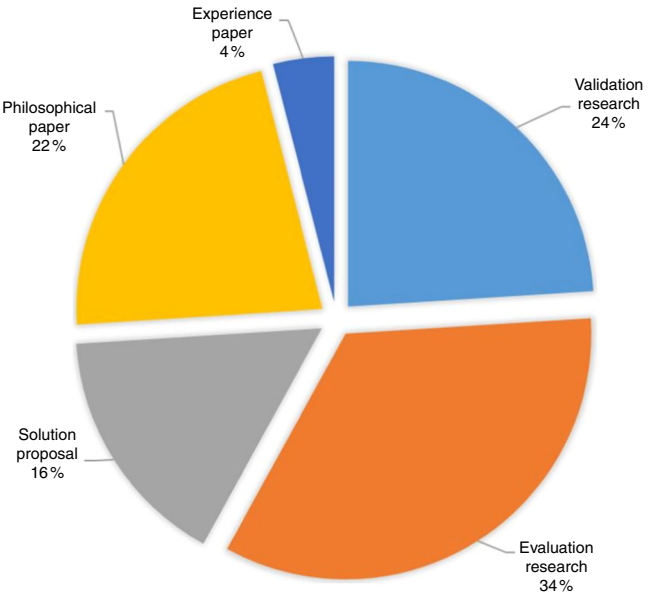

Figure 4.
Distribution of paper types

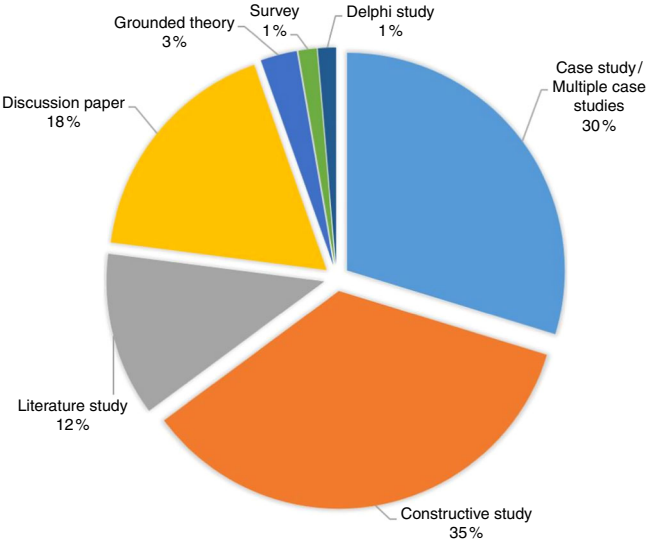

Figure 5.
Distribution of research methods

in the second place of the most frequent research methods. Discussion paper and literature study with 18 and 12 per cent are the third and fourth most used research methods. Grounded theory with 3 per cent, survey and Delphi study both with 1 per cent are the least applied research methods.

Another way of analysis regarding *RQ2* is to disclose the distribution of research content over the research method and research type (see Figure 6). The bubble chart diagram in Figure 6 displays the mapping of the 50 studies based on the research content. This mapping chart illustrates the concentration of the articles. From this bubble chart we can conclude that constructive research and case study are the two most frequent research methods; evaluation research and solution proposal are the two most frequent paper types for the papers focused on an EA framework. Constructive research and case study are the most applied research methods for the papers in the EI framework category and evaluation research is the dominant paper type. Surprisingly, there is only one survey and one Delphi study conducted among the papers in the intersection of EA and EI. Grounded theory is not applied often. Also, the experience paper type is rarely employed in this research topic.

To analyse the distribution of articles from another dimension, Figure 7 presents the number of articles per research method combined with paper type. Constructive research is the predominant research method for the validation research articles (nine articles). For instance, Erol *et al.* (2009b) proposed a conceptual model to create enterprise flexibility using SOA approach. The second most common research method in this mapping study is case study, which is the major research method for the evaluation research type of papers. For instance, Li *et al.* (2013), proposed a framework for the inter-organizational integration and discussed this framework in the content of a real-world case study. Constructive research and case study are the two most frequent applied research methods for the papers considered as solution proposal. As for the philosophical papers, literature studies and discussion are the dominant research methods. Case study and constructive research are the only two research methods applied in the experience papers.

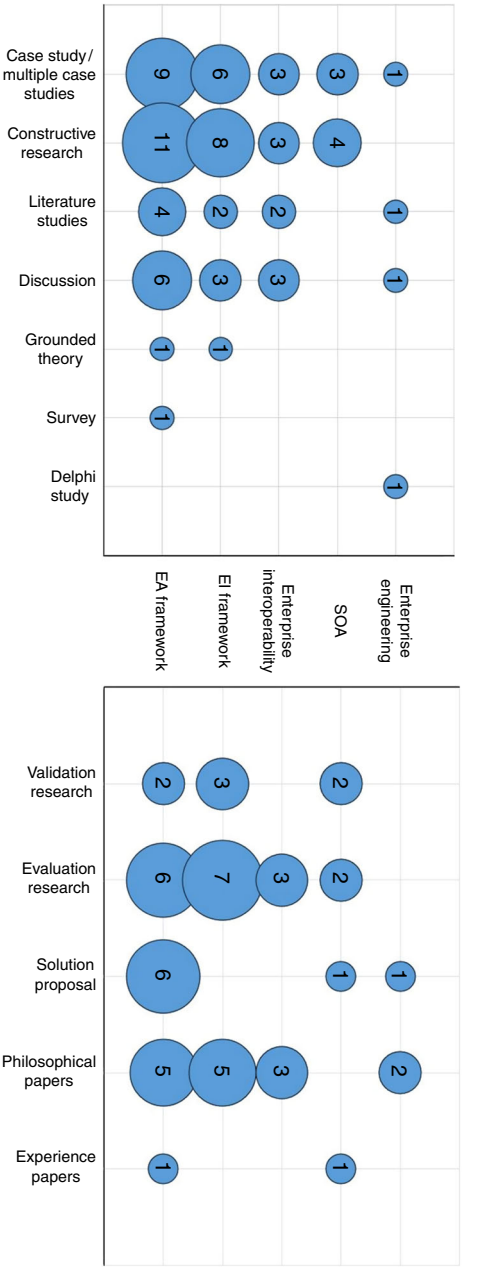

Figure 6.
Number of articles per research method and paper type combined with research focus

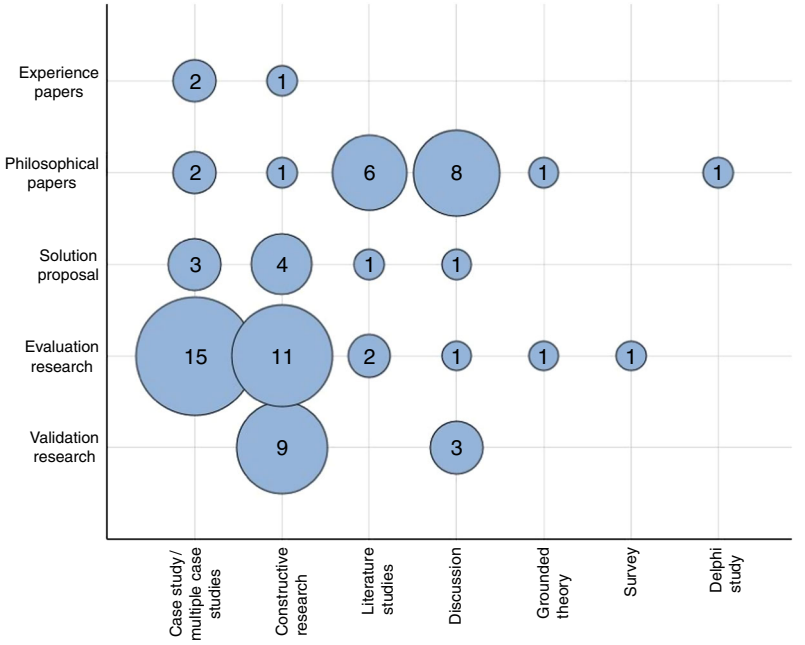

Figure 7.
Distribution of articles per research method combined with paper type

5.3 Research trends (RQ3)

To answer *RQ3*, the distribution of 50 analysed articles is illustrated in Figure 8 in periods of three years from 1996 to the beginning of 2014. Starting from 2004, a steady rise is noticeable, reaching in peak with 16 articles by the end of 2010. This result indicates that the topic to determine the role of EA in EI have become more important for the scholars during the last few years. One reason for this increase could be that governments force organizations to develop EA. However, the number of published articles in this area declined to nine articles between 2011 and 2013. At this time we cannot discuss only about 2014 articles since our time scope is three years.

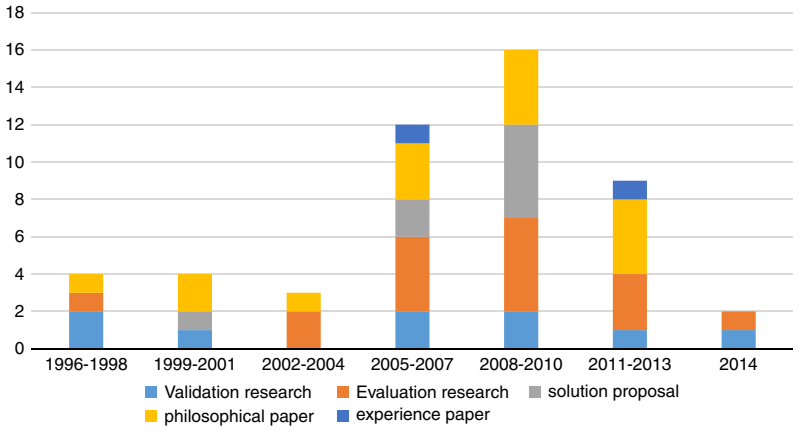

Figure 8.
Publication timeline based on number of articles in periods of three years

The downward trend in the number of publications from 2010 to 2013, could be due to the economic recession (Mayall, 2009), because management may often consider EA development as a low-priority and costly task. Therefore, in situations like in an economic recession CIOs postpone the development of EA and consider it as a low-priority task.

Figure 8 also illustrates the number of paper types in each year. From this stacked column chart we may note that between 1996 and 2001 the dominate paper types were "Philosophical paper" and "Validation research" which means that during these years new frameworks and models were developed but they were not validated in practice. However, from 2002 to beginning of 2014 number of "Evaluation research" papers has increased significantly, which means that during these years new frameworks were developed and evaluated in practice. The number of "Solution proposal" papers have also noticeably growth, which can imply the importance of the role of EA as a solution to facilitate EI.

6. Discussion

6.1 Summary of findings

This study is a SMS that provides a comprehensive overview on the intersection of EA and EI. Researchers and experts, for instance, may use the result of this study as an initial point for their research and projects.

During this study, after defining our research strategy we searched through the selected databases and found 404 articles. Not all of these were relevant and unique, therefore we defined the exclusion and inclusion criteria. Then we had 50 relevant and unique articles to analyse. To analyse the 50 papers, we developed a classification scheme. We classified the articles based on their research focus, paper type, and research method (refer to Table III).

Regarding the research focus, we concluded that "EA framework" with 20 articles is the dominant research focus and "EI framework" with 15 articles is the next dominant one. Regarding the paper type, "Evaluation research" is the most frequently employed paper type. We identified only two papers that can be categorized in the "Experience papers" category, which is the least used paper type.

"Constructive study" and "Case study/Multiple case studies", respectively with 35 and 30 per cent of the papers were the most used research methods in this area. However, "Survey", "Delphi study", and "Grounded theory" were used less often.

"Solution proposal" and "Evaluation research" were the two most employed paper type for papers focused on "EA framework". Employing bubble chart illustration, the gaps in this research area were discovered and highlighted the current emphases in this research.

We concluded that the majority of "Evaluation research" papers employed "Case study/Multiple case studies" as the research method. Moreover, most of the "Validation research" papers were "Constructive research" and majority of the papers that used "Constructive research" as their research method, were "Evaluation research". This means that the articles proposed new framework or conceptual model and they implemented and evaluated the novel proposal in practice. However, the numbers of "Validation research" in this category was still noticeable.

"Validation research" and "Philosophical paper" were the most common paper type between 1996 and 2004, and after that "Evaluation research" was the dominant research paper type. This indicates that the research has been more practical during the last decade. We noticed that number of publications between 2010 and 2013 declined, which may be because of the economic downturn.

6.2 Threats to validity

In this kind of research it is necessary to identify potential problems of bias and validity to permit readers to verify the credibility of the presented results. On account of the fact that there are some threats to the validity of our study, it is crucial to evaluate the validity of this mapping study. There are at least three kinds of threats that should be addressed to validate the credibility of the results (Perry *et al.*, 2000): construct validity; internal validity; and external validity.

Construct validity refers to what extend the inferences can be made with respect to research questions of the study. Construct validity measures the operability of a construct against theory (Perry *et al.*, 2000). To assure construct validity of this article, we explicitly defined the research questions and objectives of the current work in the research method steps, therefore, it helps to provide the same interpretations for other scholars who are interested in replicating this research process in future. To find the maximum number of relevant articles for mapping study regarding our research questions, we defined and refined our search queries based on the obtained results and considered synonym words in our search string and performed the queries in the most well known and related electronic databases.

Another aspect of construct validity that should be taken into account is to assure that all the relevant articles are included (Mohabbati *et al.*, 2013). Thus, we strove to incorporate as many articles as possible by using only the electronic databases. However, it is possible that we might have missed some articles that electronic databases could not find them.

It is also crucial to address internal and external validity threats on a study. Internal validity is related to the extent to which the designing and conducting of the study minimizes the systematic error or bias results. Whereas external validity is related to the extent to which the result of a study can be applied to other situations outside of the study.

Replication of mapping study is one way to mitigate the threats of internal and external validity (Shull *et al.*, 2008). Moreover, in terms of internal validity, to extract data we limited ourselves to the specific techniques mentioned in the research method section and unveiled the results by charts, graphs, and tables. In other words, applying a well defined methodology minimized bias of the study. The external validity is guaranteed since we did not make any generalizations, claims, and projections.

6.3 Limitations

This SMS study suffers from few limitations. First, we limited ourselves to only seven scientific databases, thus we could not cover all the existing journal and conference databases. Moreover, we considered only peer reviewed articles, such as journal and conference papers, and we did not include any book sections or magazines in our study.

In the realm of search keywords, we strove to apply synonym terms as much as possible in order to get maximum amount of results. For instance we used "interoperability", "coordination", and "coherence" as the alternatives for "integration". However, it is possible that we miss some articles that have used other terms, such as "enterprise unification".

7. Conclusion remarks and future work

The main motivation of the presented study was to provide an overview of existing literature that have investigated the role of EA in EI. We applied

a SMS method (Kitchenham, 2007; Petersen *et al.*, 2008) in order to determine what issues have been studied in this research domain. We classified the existing studies based on the employed research methods as well as the paper types. The adopted research method (SMS) is a practical research method to recognize the areas where there is adequate information about a topic, as well as those domains where more research is required. The results of this study provide a guideline to assist researchers in planning future research through the discovery of research gaps.

The presented study, analysed the content of 50 articles and categorized them based on their research focus, research method, and paper type; it also examined the research trend and the distribution of paper types over the years.

By conducting this SMS study we realized that almost two-third of the previous studies were focused on frameworks and conceptual models. Despite the importance of some topics, such as SOA, enterprise interoperability, and EE, however, the modest role of research in these areas is quite surprising. Regarding the paper type we noticed that experience papers appeared rarely in the literature. The significant number of "Evaluation research" in the last decade, emphasizes the development and implementation of EA and EI in practice.

Our research has implications for both researchers and practitioners. Going through the papers categorized as "Evaluation research" in Table IV, practitioners can realize which EA or EI methods are implemented and evaluated in practice. For researchers, this paper provides a good insight into the existing research in the intersection of EA and EI. Also, this study indicated the gaps in this area of research. For instance, the need for having more research using empirical research methods has been realized. Considering the publication trend researchers can realize the tendency in publication of "Evaluation research" in the last decade.

Primary implications for future research include a need for more research using empirical methods, such as surveys and interviews. Delphi study as a research method that employs questionnaires has been applied very rarely in this area of research. Surprisingly, we identified only two papers that applied grounded theory. It is notable that qualitative approaches, such as ethnography and action research are completely missing from the population of the selected 50 articles.

It is important that enterprises can solve their integration issues rapidly and efficiently. Therefore, one important aspect is to first realize the integration challenges and barriers in a company. For future research we can employ empirical research methods, such as surveys and ethnographies to collect data and experience about integration challenges. After that, we can provide solutions on how EA can help enterprises to eliminate the EI challenges. It is also possible in the future to investigate how the trends and attention change in this research domain.

References

Anaya, V. and Ortiz, A. (2005), "How enterprise architectures can support integration", *Proceedings of the First International Workshop on Interoperability of Heterogeneous Information Systems. ACM*, pp. 25-30.

Armour, F.J., Kaisler, S.H. and Liu, S.Y. (1999), "A big-picture look at enterprise architectures", *IT Professional*, Vol. 1 No. 1, pp. 35-42.

Barbosa, O. and Alves, C. (2011), "A systematic mapping study on software ecosystems", Workshop on Software Ecosystems, Brussels, pp. 15-26.

Bernus, P. and Nemes, L. (1996), "A framework to define a generic enterprise reference architecture and methodology", *Computer Integrated Manufacturing Systems*, Vol. 9 No. 3, pp. 179-191.

Bernus, P. and Nemes, L. (1997), "Requirements of the generic enterprise reference architecture and methodology", *Annual Reviews in Control*, Vol. 21, pp. 125-136. doi: 10.1016/S1367-5788(97)00036-9.

Boh, W.F. and Yellin, D. (2007), "Using enterprise architecture standards in managing information technology", *Journal of Management Information Systems*, Vol. 23 No. 3, pp. 163-207.

Boh, W.F., Yellin, D., Dill, B. and Herbsleb, J.D. (2003), "Effectively managing information systems architecture standards: an intra-organization perspective", MISQ Special Issue Workshop on Standard Making: A Critical Frontier for Information Systems, pp. 12-14.

Boucharas, V., van Steenbergen, M., Jansen, S. and Brinkkemper, S. (2010), "The contribution of enterprise architecture to the achievement of organizational goals: a review of the evidence", in Proper, E., Lankhorst, M.M., Schönherr, M., Barjis, J. and Overbeek, S. (Eds), *Trends in Enterprise Architecture Research*, Springer, Berlin Heidelberg, pp. 1-15.

Brereton, P., Kitchenham, B.A., Budgen, D., Turner, M. and Khalil, M. (2007), "Lessons from applying the systematic literature review process within the software engineering domain", *Journal of Systems and Software*, Vol. 80 No. 4, pp. 571-583.

Buckl, S., Ernst, A.M., Kopper, H., Marliani, R., Matthes, F., Petschownik, P. and Schweda, C.M. (2009), "EA management patterns for consolidations after mergers", presented at the Patterns in Enterprise Architecture Management (PEAM2009) Workshop, Kaiserslautern.

Budgen, D., Turner, M., Brereton, P. and Kitchenham, B. (2008), "Using mapping studies in software engineering", *Proceedings of PPIG*, pp. 195-204.

Chalmeta, R. (2000), "Virtual transport enterprise integration", *Journal of Integrated Design and Process Science*, Vol. 4 No. 4, pp. 45-55.

Chalmeta, R., Campos, C. and Grangel, R. (2001), "References architectures for enterprise integration", *Journal of Systems and Software*, Vol. 57 No. 3, pp. 175-191. doi: 10.1016/S0164-1212(01)00008-5.

Chen, D. and Doumeingts, G. (2003), "European initiatives to develop interoperability of enterprise applications – basic concepts, framework and roadmap", *Annual Reviews in Control*, Vol. 27, pp. 153-162. doi: 10.1016/j.arcontrol.2003.09.001.

Chen, D., Doumeingts, G. and Vernadat, F. (2008), "Architectures for enterprise integration and interoperability: past, present and future", *Computers in Industry, Enterprise Integration and Interoperability in Manufacturing Systems*, Vol. 59 No. 7, pp. 647-659. doi: 10.1016/j.compind.2007.12.016.

Chen, D., Vallespir, B. and Doumeingts, G. (1997), "GRAI integrated methodology and its mapping onto generic enterprise reference architecture and methodology", *Computers in Industry, Co-Operation in Manufacturing Systems, CIM at Work*, Vol. 33 Nos 2-3, pp. 387-394. doi: 10.1016/S0166-3615(97)00043-2.

Chen, Y., Chen, M. and Faulkner, G. (2005), "Towards a conceptual design of an intelligent system for an international trade centre in China", *Proceedings of the 7th International Conference on Electronic Commerce. ACM*, pp. 78-84.

Chituc, C.-M., Toscano, C. and Azevedo, A. (2008), "Interoperability in collaborative networks: independent and industry-specific initiatives – the case of the footwear industry", *Computers in Industry, Enterprise Integration and Interoperability in Manufacturing Systems*, Vol. 59 No. 7, pp. 741-757. doi: 10.1016/j.compind.2007.12.012.

Cuenca, L., Boza, A. and Ortiz, A. (2010), "Enterprise engineering approach for business and is/it strategic alignment", *8th International Conference of Modeling and Simulation – MOSIM*, pp. 10-12.

Erol, O., Mansouri, M. and Sauser, B. (2009a), "A framework for enterprise resilience using service oriented architecture approach", *3rd Annual IEEE International Systems Conference. Presented at the IEEE SysCon 2009, IEEE, Vancouver*, pp. 127-132. doi: 10.1109/SYSTEMS.2009.4815785.

Erol, O., Sauser, B.J. and Boardman, J.T. (2009b), "Creating enterprise flexibility through service oriented architecture", *Global Journal of Flexible Systems Management*, Vol. 10 No. 1, pp. 11-16.

Erol, O., Sauser, B.J. and Mansouri, M. (2010), "A framework for investigation into extended enterprise resilience", *Enterprise Information Systems*, Vol. 4 No. 2, pp. 111-136.

Giachetti, R.E. (2004), "A framework to review the information integration of the enterprise", *International Journal of Production Research*, Vol. 42 No. 6, pp. 1147-1166. doi: 10.1080/00207540310001622430.

Goel, A., Schmidt, H. and Gilbert, D. (2009), "Towards formalizing virtual enterprise architecture", *13th Enterprise Distributed Object Computing Conference Workshops, EDOCW, IEEE*, pp. 238-242.

Goethals, F.G., Snoeck, M., Lemahieu, W. and Vandenbulcke, J. (2006), "Management and enterprise architecture click: the FAD(E)E framework", *Information Systems Frontiers*, Vol. 8 No. 2, pp. 67-79. doi: 10.1007/s10796-006-7971-1.

Henderson, J.C. and Venkatraman, N. (1993), "Strategic alignment: leveraging information technology for transforming organizations", *IBM Systems Journal*, Vol. 32 No. 1, pp. 4-16.

Hoogervorst, J. (2004), "Enterprise architecture: enabling integration, agility and change", *International Journal of Cooperative Information Systems*, Vol. 13 No. 3, pp. 213-233.

Huat Lim, S., Juster, N. and de Pennington, A. (1997), "Enterprise modelling and integration: a taxonomy of seven key aspects", *Computers in Industry*, Vol. 34 No. 3, pp. 339-359. doi: 10.1016/S0166-3615(97)00069-9.

IFIP-IFAC TF (1999), "GERAM: generalised enterprise reference architecture and methodology version 1.6. 3", IFIP-IFAC TF, avaialable at: www2.mitre.org/public/eabok/pdf/geram.pdf (accessed 20 January 2016).

Jonkers, H., Lankhorst, M.M., ter Doest, H.W., Arbab, F., Bosma, H. and Wieringa, R.J. (2006), "Enterprise architecture: management tool and blueprint for the organisation", *Information Systems Frontiers*, Vol. 8 No. 2, pp. 63-66.

Kang, D., Lee, J., Choi, S. and Kim, K. (2010), "An ontology-based enterprise architecture", *Expert Systems with Applications*, Vol. 37 No. 2, pp. 1456-1464.

Kilpeläinen, T. (2007), "Business information driven approach for EA development in practice", *The Proceedings of the 18th Australasian Conference on Information Systems*, Citeseer, pp. 5-7.

Kim, J.-W., Kwon, J.-H., Kim, Y.-G., Song, C.-Y., Kim, H.-S. and Baik, D.-K. (2006), "EAFoC: enterprise architecture framework based on commonality", *Journal of Computer Science and Technology*, Vol. 21 No. 6, pp. 952-964. doi: 10.1007/s11390-006-0952-5.

Kitchenham, B. (2004), "Procedures for performing systematic reviews", Keele University, Keele.

Kitchenham, B.A. (2007), "Guidelines for performing systematic literature reviews in software engineering", EBSE Technical Report No. EBSE-2007-01, Software Engineering Group, School of Computer Science and Mathematics, Keele University, Keele, Staffordshire, and Department of Computer Science, University of Durham, Durham, 9 July, version 2.3.

Kitchenham, B.A., Budgen, D. and Pearl Brereton, O. (2011), "Using mapping studies as the basis for further research – a participant-observer case study", *Information and Software Technology*, Special Section: Best papers from the APSEC, Vol. 53 No. 6, pp. 638-651. doi: 10.1016/j.infsof.2010.12.011.

Kosanke, K. (2005), "Standards in enterprise inter- and intra-organisational integration", in Bernus, P. and Fox, M. (Eds), *Knowledge Sharing in the Integrated Enterprise, IFIP – The International Federation for Information Processing*, Springer, pp. 9-20.

Kosanke, K. (2006), "ISO standards for interoperability: a comparison", in Konstantas, D., Bourrières, J.-P., Léonard, M. and Boudjlida, N. (Eds), *Interoperability of Enterprise Software and Applications*, Springer, London, pp. 55-64.

Kosanke, K. and Nell, J.G. (1999), "Standardisation in ISO for enterprise engineering and integration", *Computers in Industry*, Vol. 40 Nos 2-3, pp. 311-319. doi: 10.1016/S0166-3615(99)00034-2.

Kosanke, K., Vernadat, F. and Zelm, M. (1999), "CIMOSA: enterprise engineering and integration", *Computers in Industry*, Vol. 40 Nos 2-3, pp. 83-97. doi: 10.1016/S0166-3615(99)00016-0.

Lam, W. (2005a), "Barriers to e-government integration", *Journal of Enterprise Information Management*, Vol. 18 No. 5, pp. 511-530. doi: 10.1108/17410390510623981.

Lam, W. (2005b), "An enterprise application integration (EAI) case-study: seamless mortgage processing at Harmond Bank", *Journal of Computer Information Systems*, Vol. 46 No. 1, pp. 35-43.

Lankhorst, M. (2009), *Enterprise Architecture at Work: Modelling, Communication and Analysis (The Enterprise Engineering Series)*, 2nd ed., Springer, Berlin Heidelberg.

Lee, J., Siau, K. and Hong, S. (2003), "Enterprise integration with ERP and EAI", *Communications of the ACM*, Vol. 46 No. 2, pp. 54-60.

Li, Q., Zhou, J., Peng, Q.-R., Li, C.-Q., Wang, C., Wu, J. and Shao, B.-E. (2010), "Business processes oriented heterogeneous systems integration platform for networked enterprises. Computers in industry", *Integration and Information in Networked Enterprises*, Vol. 61 No. 2, pp. 127-144. doi: 10.1016/j.compind.2009.10.009.

Li, S.-H., Huang, S.-M., Yen, D.C., Shih, D.-H. and Hsueh, H.-Y. (2013), "Business-to-government application integration framework: a case study of the high technology industry in Taiwan", *Computer Standards & Interfaces*, Vol. 35 No. 6, pp. 582-595. doi: 10.1016/j.csi.2013.04.005.

Lillehangen, F. and Krogstie, J. (2008), "Customer challenges and demands", *Active Knowledge Modeling of Enterprises*, Springer, Berlin Heidelberg, pp. 27-64.

Lim, S.H., Juster, N. and de Pennington, A. (1998), "A role interaction approach to support manufacturing enterprise integration", *Proceedings of the Institution of Mechanical Engineers Vol. 212*, p. 439.

Lucke, C., Krell, S. and Lechner, U. (2010), "Critical issues in enterprise architecting – a literature review", *AMCIS 2010 Proceedings of the 16th Americas Conference on Information Systems, Lima*.

Maheshwari, D. and Janssen, M. (2012), "Measuring organizational interoperability in practice: the case study of population welfare department of government of Sindh, Pakistan", in Gil-Garcia, J.R., Helbig, N. and Ojo, A. (Eds), *Proceedings of the 6th International Conference on Theory and Practice of Electronic Governance*, ACM, New York, NY, pp. 216-225.

Mayall, A. (2009), "Coming out of the recession: the role of enterprise architecture", *Architecture & Governance Magazine*, September, p. 5.

Mezgár, I. and Rauschecker, U. (2014), "The challenge of networked enterprises for cloud computing interoperability", *Computers in Industry*, Vol. 65 No. 4, pp. 657-674. doi: 10.1016/j.compind.2014.01.017.

Mohabbati, B., Asadi, M., Gašević, D., Hatala, M. and Müller, H.A. (2013), "Combining service-orientation and software product line engineering: a systematic mapping study", *Information and Software Technology*, Vol. 55 No. 11, pp. 1845-1859. doi: 10.1016/j.infsof.2013.05.006.

Morganwalp, J.M. and Sage, A.P. (2004), "Enterprise architecture measures of effectiveness", *International Journal of Technology, Policy and Management*, Vol. 4 No. 1, pp. 81-94.

Moynihan, G.P. (1997), "The application of enterprise modeling for aerospace manufacturing system integration", *International Journal of Flexible Manufacturing Systems*, Vol. 9 No. 2, pp. 195-210. doi: 10.1023/A:1007971819123.

Namba, Y. and Iijima, J. (2003), "'EII Meta-model' on integration framework for viable enterprise systems – city planning metaphor based on structural similarity", *Journal of Systems Science and Systems Engineering*, Vol. 12 No. 1, pp. 111-126.

Ngeru, J., David, D. and Hargrove, S.K. (2009), "Developing an enterprise integration strategy using an AHP-Delphi approach", *Journal of Management & Engineering Integration*, Vol. 2 No. 1, pp. 92-101.

Ni, Q., Lu, W.F., Yarlagadda, P.K.D.V. and Ming, X. (2007), "Business information modeling for process integration in the mold making industry", *Robotics and Computer-Integrated Manufacturing*, Vol. 23 No. 2, pp. 195-207. doi: 10.1016/j.rcim.2005.12.006.

Niemann, K.D. (2006), *From Enterprise Architecture to IT Governance*, Springer, MercedesDruck, Berlin.

Niemi, E. (2008), "Enterprise architecture benefits: perceptions from literature and practice", *Proceedings of the 7th IBIMA Conference Internet & Information Systems in the Digital Age, Brescia, 14-16 December 2006*.

Noran, O. (2013), "Building a support framework for enterprise integration", *Computers in Industry*, Vol. 64 No. 1, pp. 29-40. doi: 10.1016/j.compind.2012.09.006.

Pahl, C., Zhu, Y. and Gacitua-Decar, V. (2009), "A template-driven approach for maintainable service-oriented information systems integration", *International Journal of Software Engineering and Knowledge Engineering*, Vol. 19 No. 7, pp. 889-912.

Palvia, P., Leary, D., Mao, E., Midha, V., Pinjani, P. and Salam, A.F. (2004), "Research methodologies in MIS: an update", *Communications of the Association for Information Systems*, Vol. 14 No. 1, pp. 526-542.

Panetto, H. and Molina, A. (2008), "Enterprise integration and interoperability in manufacturing systems: trends and issues", *Computers in Industry*, Vol. 59 No. 7, pp. 641-646.

Panetto, H., Jardim-Goncalves, R. and Molina, A. (2012), "Enterprise integration and networking: theory and practice", *Annual Reviews in Control*, Vol. 36, pp. 284-290. doi: 10.1016/j.arcontrol.2012.09.009.

Papazoglou, M.P., Ribbers, P. and Tsalgatidou, A. (2000), "Integrated value chains and their implications from a business and technology standpoint", *Decision Support Systems*, Vol. 29 No. 4, pp. 323-342. doi: 10.1016/S0167-9236(00)00081-6.

Peristeras, V. and Tarabanis, K. (2000), "Towards an enterprise architecture for public administration using a top-down approach", *European Journal of Information Systems*, Vol. 9 No. 4, pp. 252-260.

Perry, D.E., Porter, A.A. and Votta, L.G. (2000), "Empirical studies of software engineering: a roadmap", *Proceedings of the Conference on the Future of Software Engineering, ICSE '00. ACM, New York, NY*, pp. 345-355. doi: 10.1145/336512.336586.

Petersen, K., Feldt, R., Mujtaba, S. and Mattsson, M. (2008), "Systematic mapping studies in software engineering", *12th International Conference on Evaluation and Assessment in Software Engineering*, p. 1.

Plazaola, L., Flores, J., Vargas, N. and Ekstedt, M. (2008), "Strategic business and IT alignment assessment: a case study applying an enterprise architecture-based metamodel", *Hawaii International Conference on System Sciences, Proceedings of the 41st Annual, IEEE*, pp. 398-398.

Pulkkinen, M., Naumenko, A. and Luostarinen, K. (2007), "Managing information security in a business network of machinery maintenance services business – enterprise architecture as a coordination tool", *Journal of Systems and Software, Methodology of Security Engineering for Industrial Security Management Systems*, Vol. 80 No. 10, pp. 1607-1620. doi: 10.1016/j.jss.2007.01.044.

Richardson, G.L., Jackson, B.M. and Dickson, G.W. (1990), "A principles-based enterprise architecture: lessons from Texaco and star enterprise", *MIS Quarterly*, Vol. 14 No. 4, pp. 385-403.

Rohloff, M. (2008), "An integrated view on business-and IT-architecture", *Proceedings of the 2008 ACM Symposium on Applied Computing*, pp. 561-565.

Ross, J.W., Weill, P. and Robertson, D.C. (2006), *Enterprise Architecture as Strategy: Creating a Foundation for Business Execution*, Harvard Business Press, Boston, MA.

Sedek, K.A., Sulaiman, S. and Omar, M.A. (2011), "A systematic literature review of interoperable architecture for e-government portals", *5th Malaysian Conference on Software Engineering (MySEC)*, pp. 82-87. doi: 10.1109/MySEC.2011.6140648.

Shull, F.J., Carver, J.C., Vegas, S. and Juristo, N. (2008), "The role of replications in empirical software engineering", *Empirical Software Engineering*, Vol. 13 No. 2, pp. 211-218.

Simon, D., Fischbach, K. and Schoder, D. (2014), "Enterprise architecture management and its role in corporate strategic management", *Information Systems and e-Business Management*, Vol. 12 No. 1, pp. 5-42. doi: 10.1007/s10257-013-0213-4.

Soomro, T.R. and Awan, A.H. (2012), "Challenges and future of enterprise application integration", *International Journal of Computer Applications*, Vol. 42 No. 7, pp. 42-45.

Sowa, J.F. and Zachman, J.A. (1992), "Extending and formalizing the framework for information systems architecture", *IBM Systems Journal*, Vol. 31 No. 3, pp. 590-616.

Spewak, S.H. and Hill, S.C. (1993), *Enterprise Architecture Planning: Developing a Blueprint for Data, Applications and Technology*, QED Information Sciences, Inc, Wellesley, MA.

Stelzer, D. (2010), "Enterprise architecture principles: literature review and research directions", in Dan, A., Gittler, F. and Toumani, F. (Eds), *Service-Oriented Computing – ICSOC 2009 Workshops*, Springer, Berlin Heidelberg, pp. 12-21.

Tamm, T., Seddon, P.B., Shanks, G. and Reynolds, P. (2011), "How does enterprise architecture add value to organisations?", *Communications of the Association for Information Systems*, Vol. 28 No. 1, pp. 141-168.

Tang, L., Dong, J., Peng, T. and Tsai, W.-T. (2010), "Modeling enterprise service-oriented architectural styles", *Service Oriented Computing and Applications*, Vol. 4 No. 2, pp. 81-107. doi: 10.1007/s11761-010-0059-2.

Toh, K.T.K., Nagel, P. and Oakden, R. (2009), "A business and ICT architecture for a logistics city", *International Journal of Production Economics, Transport Logistics and Physical Distribution Interlocking of Information Systems for International Supply and Demand Chains Management ICPR19*, Vol. 122 No. 1, pp. 216-228. doi: 10.1016/j.ijpe.2009.05.021.

Umapathy, K., Purao, S. and Barton, R.R. (2008), "Designing enterprise integration solutions: effectively", *European Journal of Information Systems*, Vol. 17 No. 5, pp. 518-527. doi: http://dx.doi.org/10.1057/ejis.2008.39.

Umar, A. (2007), "Intelligent decision support for architecture and integration of next generation enterprises", *Informatica*, Vol. 31 No. 2, pp. 141-150.

Umar, A. and Zordan, A. (2009), "Reengineering for service oriented architectures: a strategic decision model for integration versus migration", *Journal of Systems and Software*, Vol. 82 No. 3, pp. 448-462. doi: 10.1016/j.jss.2008.07.047.

Utomo, W.H. (2011), "Implementation of MDA Method into SOA environment for enterprise Integration", *International Journal of Computer Science Issues (IJCSI)*, Vol. 8 No. 6, pp. 10-18.

Vargas, A., Cuenca, L., Boza, A., Sacala, I. and Moisescu, M. (2014), "Towards the development of the framework for inter sensing enterprise architecture", *Journal of Intelligent Manufacturing*, Vol. 27 No. 1, pp. 1-18. doi: 10.1007/s10845-014-0901-z.

Vernadat, F.B. (2003), *Enterprise Modelling and Integration*, Springer, New York, NY.

Vernadat, F.B. (2007), "Interoperable enterprise systems: principles, concepts, and methods", *Annual Reviews in Control*, Vol. 31, pp. 137-145.

Vernadat, F.B. (2009), "Enterprise integration and interoperability", in Nof, S.Y. (Ed.), *Springer Handbook of Automation*, Springer, Berlin Heidelberg, pp. 1529-1538.

Wang, S., Li, L., Wang, K. and Jones, J.D. (2012), "e-Business systems integration: a systems perspective", *Information Technology and Management*, Vol. 13 No. 4, pp. 233-249.

Wang, S., Xu, L., Li, L., Wang, K. and Choi, J. (2011), "Features of enterprise information systems integration: a systemic analysis", *Proceedings of the IEEE International Conference on Systems, Man and Cybernetics, IEEE, Anchorage, AK, 9-12 October*, pp. 333-339. doi: 10.1109/ICSMC.2011.6083687.

Wendler, R. (2012), "The maturity of maturity model research: a systematic mapping study", *Information and Software Technology*, Vol. 54 No. 12, pp. 1317-1339.

Wieringa, R., Maiden, N., Mead, N. and Rolland, C. (2006), "Requirements engineering paper classification and evaluation criteria: a proposal and a discussion", *Requirements Engineering*, Vol. 11 No. 1, pp. 102-107.

Winter, R. and Fischer, R. (2006), "Essential layers, artifacts, and dependencies of enterprise architecture", *Enterprise Distributed Object Computing Conference Workshops, EDOCW'06. 10th IEEE International*, pp. 30-30.

Wu, R.C.-Y. (2007), "Enterprise integration in e-government", *Transforming Government: People, Process and Policy*, Vol. 1 No. 1, pp. 89-99. doi: 10.1108/17506160710733724.

Zachman, J.A. (1987), "A framework for information systems architecture", *IBM Systems Journal*, Vol. 26 No. 3, pp. 276-292.

Zachman, J.A. (1997), "Enterprise architecture: the issue of the century", *Database Programming and Design*, Vol. 10 No. 3, pp. 44-53.

Zheng, T. and Zheng, L. (2013), "Examining e-government enterprise architecture research in China: a systematic approach and research agenda", *Government Information Quarterly, ICEGOV 2011*, Vol. 30 No. S1, pp. S59-S67. doi: 10.1016/j.giq.2012.08.005.

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