

Enterprise Architecture Management - State of Research Analysis & a Comparison of Selected Approaches

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Abstract. IT alone is no longer sufficient for business success. Companies need to control enterprise-wide processes and adopt matching actions. This paper presents an overview of existing approaches of Enterprise Architecture Management (EAM). By reasoning, the importance of integrated EAM for small and medium-sized enterprises (SME) is underlined. The study is structured as a systematic literature review of papers published by selected journals and book series from 2006 till 2012.

Keywords: Enterprise Architecture Management, systematic literature analysis, small and medium-sized enterprises, IT Management, Business Architecture, Business Engineering, Business IT Alignment

1 Introduction

It is essential to make the organization more sensitive towards the interaction of business strategies, customers, application systems and organizational units. At the same time there is no coherent architecture covering the majority of problems. [1, 28, 45]

Enterprise Architecture (EA) is the formal declaration of the basic structures of an organization, its components and relations, as well as the processes used for development. [2, 3, 4, 10, 12, 45] The specific implementation of EA is derived from a rich set of framework models and the economic and organizational situation of the specific enterprise. Caused by industrial changes like automatization, standardization and innovation, enterprises began to focus on software products and IT. In the past, IT focused architectures failed to integrate other layers and functions of the enterprise. The complexity of integrating different layers like business processes, applications and technologies should be controlled to get long-lasting opportunities of action. [6] “It is such a complex topic that easy and general solutions are unlikely to appear.” [18, p. 268] Therefore, EAM is getting more and more important, but is still mostly unexplored and rarely used, especially in context of SME. However, the terms EA and EAM are used inconsistently. This is in part a result of different authors focusing on specific parts of companies. [6, cp. p. 234]

The objective of this paper is to identify the current research state of EAM, its terminology and its applicability for SMEs. The research approach is described in section 2, followed by the design of the systematic review. Some approaches from the selected papers are compared based on the aptitude for use in SME, after the research questions have been answered in section 4. The paper ends with a summary.

2 Research Approach

The research approach used by this paper is a methodological review of research results. The approach aims to be transparent, conclusive, and repeatable for the audience. The purpose of this paper is to summarize knowledge on EAM, to distinguish it from other terms of management disciplines, and finally to identify its applicability for SMEs.

We have conducted a systematic literature review based on the guidelines of Kitchenham et al. [25] A preliminary overview has shown a limited amount of existing conference submissions with relevance to this topic. Therefore we decided to shift our focus and cover journals and book series and modified the search process for literature due to limited availability and access.

The research proceeded in the following steps are recommended by B.Kitchenham:

1. Formulation of the research questions to define the important topics and relevant research fields.
2. Identification of literature sources covering EAM
3. Selection of papers for inclusion in the analysis
4. Data extraction from selected papers
5. Presentation of results
6. Interpretation of results

The remaining part of paper is organized by following these analysis steps.

3 Systematic Review Design

To develop the role of EAM in research and practice, as well as in the context of SMEs, a literature selection was conducted and the result analyzed. This section describes the different steps of the systematic literature analysis.

3.1 Research Questions

The research questions (RQ) and expectations for answers addressed by this paper are:

1. How can Enterprise Architecture Management be classified? This question aims to clarify the tasks of EAM. It tries to illustrate the importance of several parts of an organization in accordance to the management methodology.
2. Are SMEs a target group of the EAM research? Are there any articles addressing EAM directly in the context of SME?

3. What are the different research approaches? Are they using literature analysis, surveys, case studies or other kinds of research methods?
4. What are the limitations of this research with regard to the covered literature?

3.2 Identification of Literature Sources

The initial search for appropriated literature sources itself was performed using the internet services Citeseer and Google Scholar and sorted by common ranking evaluation. Search terms like “enterprise architecture” and “enterprise architecture management”, as well as the corresponding German terms were used for the initial literature identification process. Based on the abstracts and reference lists of the initial matches the list of search terms was refined (e.g. “enterprise models) and additional journals as candidates for inclusion identified.

Overall we found ten journals covering the topic more than once; individual articles were not considered in the latter analysis. Furthermore, we selected journals based on the rank and the number of potentially relevant articles supplemented by two book series. The first one is *Xpert.press*, a book series following the popular journal with the same title. The second one, called *Business Engineering*, offers a whole book on the topic. Both of them are published in German.

The ranking was approached from the perspective of Information Systems Research and not of Business Economics. The *HMD* journal for example only got a “D” in the business oriented JOURQUAL [39], but a “B” in the “WI-Journalliste 2008“ [43]. German and English sources were included without specific preference.

The journals *Wirtschaftsinformatik* and *HMD* were chosen because of their classification as popular journals of the Oldenbourg-Verlag by the Encyclopaedia of Information Systems Research. [21] *Knowledge and Information Systems* was chosen because of the SCImago Country and Journal Rank. [35] Due to availability and the iteration of search terms, both book series and *Information Systems Frontiers* were chosen. The journal *Wirtschaftsinformatik*, published in both German and English, is released six times a year. The magazine publishes innovative and quality assured research results as well as trend-setting and other kinds of interesting practical ideas in the field of Information Systems. [42] *HMD - Praxis der Wirtschaftsinformatik* is issued six times a year. The German magazine points out solutions for problems of IT experts and managers, presents implementation possibilities and informs about news on Information Systems Research. [20] The English journal *Knowledge and Information Systems* “provides an international forum for researchers and professionals to share their knowledge and report new advances on all topics related to knowledge systems and advanced information systems.” [43] *Information System Frontiers*, also an English journal, is about Business Information Systems, its management and systems theory and control. It is issued four to five times a year. [38]

Business Engineering is in contrast to other selected journals and book series not restricted to business, but also includes articles of the cultural and political implications. [36] The book series *Xpert.press* offers actual and qualified knowledge to professionals of software development, internet technology and IT Management. It is mainly focused on technologies and applications of modern Information Technologies. [37]

All editorial and scientific articles of the chosen sources are subject to a profound quality assurance including peer review. Except for the *HMD*, all sources are published via SpringerLink.

3.3 Paper Selection

As period of time we used the last six years, ranging from 2006 till 2012. The majority of potentially relevant articles is from 2004 till 2012 and increases over the years. We curtailed the timeframe to analyze enough articles, while remaining up to date. Furthermore, we used a two-pronged approach to look for relevant papers.

Selection path A means selecting paper by matching with the primary keywords like “enterprise architecture”, “enterprise architecture management” and the corresponding German terms within the abstracts and bodies. These papers were directly selected. Selection path B includes all papers with several models of architecture and management disciplines. This is deeply rooted in the fact that EAM includes management disciplines like IT and Business Management. In the second phase papers were chosen, if they contained at least two different secondary keywords like “architecture” and “SME” and were not already selected as part of Selection A. The selection was reduced based on a cursory reading of the abstracts.

We found the majority of papers (> 300) in the *Information System Frontiers*. Nevertheless we just left five articles within our literature selection, which cover enterprise management disciplines and particularly SME. The search within the *Wirtschaftsinformatik* journal led to the smallest number of hits (17).

As a conclusion we started with 418 papers in the first iteration of literature sources. This was extended by 176 papers in the second iteration (section 3.2). Ultimately 35 papers were selected for this evaluation. Overall this constitutes 5,9% of our starting pool of 594 papers after the second iteration.

4 Data Analysis

RQ1: How can Enterprise Architecture Management be classified?

Different classifications of EAM are possible. [22, cp. p. 65] introduces EA as a management instrument, because the EA has to be part of the classic management processes in every organization. By comparison, [27] defines EAM as a discipline of the IT Management. The majority considers EAM a combination of different management disciplines working together for an integrated enterprise view.

The design and reorganization of architectures is consolidated as Architecture Management. Furthermore it defines roles and responsibilities as well as the guidance of participating employees. [10]

[3, cp. p. 189] divides Enterprise Architecture into two parts: the Organization Architecture and the IT Architecture. The first one contains organizational structure and business processes. The IT Architecture is influenced by the Information System Architecture. Often the IT governance follows the business governance. [32]

EAM is divided into different layers by [12, p. 169]. He describes four layers with its functions: the strategy layer, the organization layer, the IT and Business Alignment layer and finally the IT layer. In contrast to this, the paper by [19, cp. p. 104] lists business architecture, process architecture, application architecture and IT architecture as the aspects to manage.

It is essential to manage and arrange the different aspects. Otherwise the enterprise will not reach the reuse of models and a homogeneous archetype of matching components. To build an EAM it is necessary to know the layers, where an architecture takes effects. [6] Without managing the overall context it is difficult for enterprises to satisfy their customers, to extend their market shares and to react to society changes." Nowadays the IT management is the backbone of many enterprises." [31, p. 52]

[14, p. 67 ff.] concentrates his research on the Architecture Management of information systems. The management of information systems is divided into three layers: the strategic one, the administrative one and the operative one. Information Management concentrates as part of the Business Management with the identification and best conversion of the IT potentials in solutions. [14, 15] The orientation of EAM is mentioned to consider the same three levels of management: strategic, tactical and operational. The strategic level is focused on the enterprise future and consequently covers a long time horizon. The tactical level implements the future by the creation of concrete plans and has a medium time horizon. The last one, the operational management, includes the detailed planning and realization. [13, cp. p. 71]

RQ2: Are SMEs as a target group of the Enterprise Architecture Management considered?

At first it is remarkable, that there is no paper addressing EAM directly to SME. Most of the examples in the articles are mentioned for large enterprises like the Credit Suisse [18], T-Com [16] and Volkswagen [11]. EAM is a necessary factor of target-oriented controlling and governance of medium and large enterprises. Implementing EAM and documenting it is a complex and expensive undertaking. The implementation is specific to each company and has to be supported by a matching communication policy. The expense of such a project is justified even for SME, because defining all elements of an EA is less work and provides other synergy effects. [27, 30]

According to [31, cp. p. 55] the European Commission defines enterprises up to 250 employees with a yearly business volume of up to 50 million Euro or a balance sheet total of up to 43 million Euro as SME. All others are considered large enterprises. The management of SME is characterized as less comprehensive. As a result corporative and operative planning are less formal and often do not exist in written form. Furthermore SME are predestined for flexibility due to their flat hierarchies, less bureaucratic structures as well as the direct inclusion of decision-makers. To make an enterprise-wide management possible the enterprise units have to be involved in strategic decisions and several management disciplines have to be differed. SME often operate in specialized markets where each product is highly customized for this specific customer. SME are more sensitive to investment decisions and often require more directly visible Return of Investment. As a consequence many SME has heterogeneous, historically grown IT structures. [30].

These facts lead into different conclusions, why an EAM might be challenging in SME, apart from not having a multitude of elements and a number of dependencies, which is ment as a main reason for implementing EAM. [6] Nevertheless even SME have to respond to changes forced by rough environments and IT developments. [31]

Firstly, SME are not interested in EAM because of the complexity and price for the design and management of EA. [41] Even the expenses to introduce methods, tools, customizations and trainings might not be justifiable in SME. [12, 18] Furthermore they are aware of temporary and commercial restrictions influencing their business operations. Typically, SME need more time to compensate changes and losses than large enterprises because of their limited possibilities of evasion. [6]

Secondly, models (e.g. maturity degree model) and tools have to be reduced to core concepts to be usable by SME. [24] Thirdly, small enterprises have few employees with necessary technological skills. The loss of expert knowledge is a high risk for smaller enterprises. [8] Fourthly, the success of EAM is rarely detectable by data because causes and effects cannot be linked as well as most effects cannot be measured (e.g. by quantities) so easily. [6]

Despite all these challenges, there are reasons for using EAM in SME. Firstly, the distinction of management disciplines and its need is a subjective decision. Secondly, security, availability and performance are aimed by every enterprise independently of its size or industrial sector. The usage of EAM can take these goals forward. [10] Thirdly, the main reason, different applications and requirements have to be integrated in a homogenous system in general. Otherwise the maintainability and transparency of an enterprise gets lost. This can even result in a loss of customers. [3, 19, 26]

To summarize, the size of an enterprise does not determine whether it has a complex structure or not. In general “all industry enterprises, whose markets are affected by a high complexity of value creation, are concerned.” [45, p. 187]

RQ3: What research approaches are being used?

After describing the topics investigated by the papers in the field of EAM in research question two, we sorted all papers of our research into the following categories.

1. Case study: Analysis of a specific use case with regard to this topic.
2. Survey: It is a research source, answering a research field, by questioning some stakeholders.
3. Theoretical work: Analysis of a research topic in a methodological way, possibly proving a solution problem, without direct application or experiments.

The emergence of research approaches is offers a lack of surveys (1). The majority of sources are of theoretical nature (24). Additionally some of these theoretical works were titled as analysis, but did not include literature reviews by definition. The second highest amount are case studies (10). They are mostly related to large enterprises.

RQ4: What are the limitations of this research?

The search was done using Google Scholar and Citeseer. Based on earlier studies it was assumed that the full-text search provided by SpringerLink and the homepage of HMD automatically searches for both British and American spelling. Derived from the guidelines of Kitchenham et al. [25] the search was organized as a manual search.

In difference to the guideline, the analysis is based on journals and book series instead of conference proceedings. Thus, we are aware that there is a possibility missing some relevant sources. Articles published in languages others than English and German were not considered for lack of understanding. It is our believe, that the language selection provides a comprehensive overview. Papers not directly using the terms Enterprise Architecture or Enterprise Architecture Management might have been disregarded. The list of search terms was refined by the initial research (section 3.2), but this may not be exhaustive. Additional iterations of wordings for the search term list might be useful.

Thus, our results apply only to national German journals, highly ranked English journals and two additional book series to get more information. We focused on Information System and Business Engineering focused magazines. Individual articles were not considered in the analysis. As a result the decision may be biased. The classification of articles into main topics and management disciplines is not unique as formulations in the papers are often not clear enough. The timeframe was chosen to balance the number of potential papers and the currentness. Choosing a different timeframe affects both factors.

5 Comparison of selected approaches

In this section four selected approaches (section 5.1) are compared in different aspects to highlight the similarities and differences. We want to identify a consistent understanding of EAM and its applicability for SME.

5.1 Selection Process

We selected four approaches from the 35 literature sources of this paper. They are chosen because they used the terms “enterprise”, “architecture” and “management” in the paper title. Two of these four papers, published by the Information System Frontiers, belong together. [22] introduces and refers the paper of [13]. The special case of architectures for extended enterprises of these papers is left out.

5.2 Comparison

Table 1 compares the different approaches in selected categories. Cells labelled with numbers from “1” to “3” indicate the allocation of papers to specific categories. “1” means, the category is named directly. “2” implies, that the category is indirectly named, for example by circumscription. A cell marked by “3” signals, that the content is not mentioned.

The categories are derived from questions like: Which approaches are compared? What are they about? What is the intention of writing? What is their understanding of EAM?

Table 1. Comparison of Selected Approaches

Approach	[6]	[13, 22]	[27]
Journal	Business Engineering	Information System Frontiers	HMD - Praxis der Wirtschaftsinformatik
Initial research interest	<ul style="list-style-type: none"> • Internal development of architectures as fundament of EA 	<ul style="list-style-type: none"> • Integrated view of business and IT is missing 	<ul style="list-style-type: none"> • Complex relations of IT landscapes • Collection & analysis of information about supporting IT by processes
Focus of approach	Realization of architecture mgmt.	Framework for EAM	Development of procedures for EAM
Reasons for EAM	<ul style="list-style-type: none"> • Merging of business & IT units to change from business process oriented to enterprise-wide management 	<ul style="list-style-type: none"> • Changes of strategy and business goals of companies have enterprise-wide consequences • Agile, integrated and aligned enterprises 	<ul style="list-style-type: none"> • Introduction of EAM caused by the integrated approach is difficult
Relation of EA and EAM	<ul style="list-style-type: none"> • Coordination of EA with other business processes to address organizational changes 	<ul style="list-style-type: none"> • EA is a tool of organizational management and blueprint • Architecturing got more attention than managing EA 	<ul style="list-style-type: none"> • EAM has to provide integrated and transparent documentation for the EA to manage the included elements and processes
Differentiation of model states	Actual and target state architecture	Starting and end state	-
Usage of EAM	IT strategy & derived initiatives have to be aligned with business strategy	Integration of IT and business	Integrated usage of EA
Understanding of EAM	<ul style="list-style-type: none"> • Managing of EA models, regarding processes and gets value by different views and focuses 	<ul style="list-style-type: none"> • EA is a management instrument • EAM includes different models and methods 	<ul style="list-style-type: none"> • Discipline of IT Management
Stakeholder of EAM	<ul style="list-style-type: none"> • From management to operators and users • Specific information & services 	<ul style="list-style-type: none"> • From management to software engineers • Outside and within the company • Specific information 	<ul style="list-style-type: none"> • Initially IT internal stakeholders, later business extended
Layers of EAM	<ul style="list-style-type: none"> • Might be derived from the integrated architectures 	<ul style="list-style-type: none"> • Various (e.g. business process layer, data management layer, software systems layer) 	<ul style="list-style-type: none"> • Strategy layer
Orientation of EAM	Directly/Indirectly	Directly	Indirectly
strategic	1	1	2

tactical	2	1	3
operational	2	1	3
Tool support of EAM	<ul style="list-style-type: none"> • EA models • Portfolio mgmt. 	<ul style="list-style-type: none"> • EA frameworks • management tools 	<ul style="list-style-type: none"> • specific management tools (e.g. for outsourcing)
Implementation by ...	<ul style="list-style-type: none"> • Chief architect • Architecture office 	<ul style="list-style-type: none"> • All parts of the enterprise (first business, second IT) 	<ul style="list-style-type: none"> • Continuous positions • Organizational units
Recommended for ...	<ul style="list-style-type: none"> • Historical grown application landscape 	<ul style="list-style-type: none"> • Large organizations • Large systems • Complex systems 	<ul style="list-style-type: none"> • Medium and large IT organizations

The three compared approaches are published in different journals. Their intention of research in the field of EAM is caused by several reasons. [6] and [27] underline their approaches and topics of interest by examples. The paper by [6] points out that EAM is necessary, if the enterprise is characterized by a complex system or a historical grown application landscape with applications used in different environments. The article of [27] is focused on the development of procedures for implementing EAM. EAM is described as a discipline of IT Management; EA as a management tool. [13, 22] concentrate on a framework for EAM, including models, principles and methods. [6] names the alignment of strategies and derives initiatives with the business strategy as a main goal, which is connected to several sub goals, mainly caused by the complexity of enterprises, the costs to control it and the risk to lose it. Even [13, 22] state “changes in a company’s strategy and business goals” [22, p. 63] as necessary preconditions of an enterprise-wide alignment of measures and actions. [6] and [13, 22] are using models to formulate the EAM. [6] directly names actual and target states of architecture, whereas the paper of the *Information System Frontiers* indirectly mentions them in the context of the development of enterprises. The third approach does not mention states for its procedures.

The approaches agree that the stakeholder of EAM are various in number and profession and can be inside or outside of the company. The importance of the results for target groups is different. [13, 22] write about three different orientations of EAM: strategic, tactical and operational. These levels do not have to be implemented directly by the enterprise, but rather has to be the core of working and acting. The strategic level has a long time horizon (five years), is vague by nature and defines the mission, vision and principles. Its implementation includes the creation of more concrete plans in the medium-termed (1-2 years) tactical level. The different projects are structured, fitting the EA. At the operational, short-termed level the detailed planning is made to turn the projects into reality.

All of the approaches include different architectures in their approach. The architectures defined by [6] were adopted as subcategories. All approaches agree that the EAM has to be controlled and implemented by assigned persons or even instances. The EAM can be supported by several tools.

In summary, it is obvious that the focus of research in the field of EAM varies widely. All approaches mainly focus on large enterprises as they are used in examples, as well as indirect proofs like naming complex systems. Nevertheless we believe that all of them can be applied to medium-sized enterprises and all except for [27] are possible to implement for small ones. [27] is too much focused on procedures for very complex or even extended enterprises. If small enterprises are structured as organizational units, EAM could be implemented as described in [13, 22]. It is

understood to imply that an integrated management is only helpful if complex structures, dependencies and processes exist. EAM has to integrate all units of an enterprise to control and govern it as a whole. It covers several management disciplines and can be supported by a number of tools. The specific tasks, a commonly accepted definition of the term and the applicability to SME have to be scientifically developed.

6 Summary

The majority of research on EAM is done in theoretical work and case studies. All in all the discussion and usage of EAM is focused on IT in practice, although there is knowledge about the importance of processes, strategies and organizational aspects as well. Reasons are the continuous attention, cost, less experiences and expenses to integrate such an EAM model. There is not much work on implementing EAM in smaller enterprises, although some approaches would fit SMEs also. The connection between just business-focused and IT-focused managing has to be established in consideration to the dynamic environment, forcing for adaption and changing of enterprises. The different management disciplines are neither defined, nor used in a consistent manner. It is not clear, what the tasks and members of the management of an enterprise are. Management methods are not supposed to apply to specific company sizes, sectors or organizational units; they are supposed to be adaptable to different circumstances. For that reason companies have to be organized to provide a coherent, satisfying experience. To achieve this, processes and organizational structures have to be aligned, covering all elements, relationships and dependencies in every part of a company.

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