Enterprise Architecture: What Aspects is Current Research Targeting?

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Abstract

Enterprise architecture is an approach to aligning business and IT within a company. In this paper we present the state of the art in enterprise architecture (EA) research, our survey is based on an analysis of the publicly available publications.

Our research methodology defines the analysis criteria. These criteria are: the distribution of the papers over time, their topics, authors, reference disciplines and their dispersion over the lifecycle activities, which will be defined. The evaluation included 80 papers (all referencing explicitly the term "enterprise architecture").

The results of our survey are: EA is a young discipline, but the interest in it is growing. Although a wide range of topics is covered, the discipline is lacking basic research. The main contributers to EA are consulting companies and academics. But academics do not contribute very much to the basic research in EA. Furthermore, very few other disciplines are used to enhance enterprise architecture. In addition enterprise architecture is a new discipline and it will not mature unless substantial basic research will be made.

Keywords: enterprise architecture, survey, SEAM, business IT alignment

1   Introduction

Enterprise Architecture (EA) can be defined as [1]: the "blueprint that documents all the information systems within the enterprise, their relationships, and how they interact to fulfil the enterprises mission."

In 1987, Zachman introduced the Framework for Information Systems Architecture [2], which is commonly accepted as the first approach towards the discipline of EA. EA is characterized by the use of frameworks that support the analysis of the enterprise from the business-level down to the IT-level. Zachman, in his paper, actually defined the first framework. Five years later, in 1992, Zachman, in collaboration with Sowa, enhanced his framework [3]. The term enterprise architecture was not used in 1987, or even in 1992; instead they referred to information systems architecture. In 1996, the Clinger-Cohen Act [4] (formerly know as the Information Technology Management Reform Act) of the U.S. government directed federal agencies to implement a holistic approach to align information technology to their business goals. According to Raphael Malveau [5], this led to the creation of the term enterprise architecture. Since then, the amount of interest devoted to EA has increased [6]. Today EA is well-known as a hierarchical approach to aligning Business and IT. And one of the most popular frameworks, inspired by the Zachman framework, is The Open Group Architecture Framework (TOGAF) [7].

This paper presents, based on selected EA literature, the state of the research that is conducted in this discipline. Section two presents the research method, section three presents the findings, section four discusses them and section five concludes the paper. In the Appendix the list of the identified publications is given.

2   Research Method

In 2.1 we briefly analyse the discipline EA. From this, we derive a framework that we use to evaluate the papers. For the evaluation, we identified 80 papers referencing explicitly the term "enterprise architecture". In section 2.2 we will outline the selection criteria that led to them.

2.1   Definining the Analysis Method

The model in Figure 1 illustrates our analysis framework. The model is a SEAM model. SEAM is an EA method that supports the hierarchical analysis and design of markets, companies and IT systems [8].
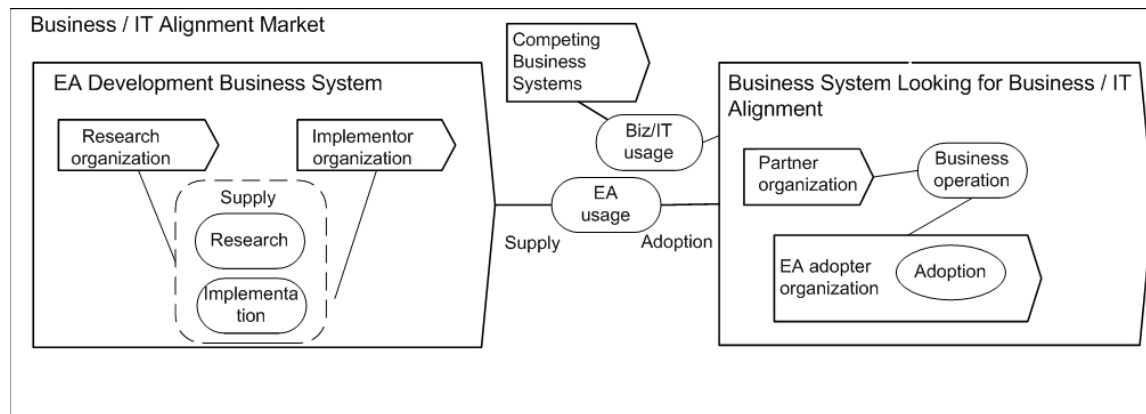

Figure 1: SEAM Model of the business/IT alignment market

As our goal with this survey is not to present SEAM, we limit our discussion about SEAM to the description of the model on which our analysis criteria are based. The model represents markets in which supplier business systems compete to provide a value to an adopter business system. All these organizational entities are represented using Porter's arrow [9]. A business system is a group of companies who share a common interest. In our case, we are in the market of business / IT alignment. In this market we have a business system composed of companies that are conducting their business operations (for example by making a better integration of their supply chain or by reducing their operating costs). For them business/IT alignment is not their main concern, it is just a tool. In Figure 1, this business system is represented on the right side. On the other side, we have the EA Development Business System. This business system is composed of organizations that care mainly about EA. They do (basic) research in EA and then make this research applicable by implementing products, processes and consulting. All these people collaborate for the development of the EA discipline. It is worth mentioning the

existence of competing business systems that also seek to provide business / IT alignment solutions (but not labeled as EA). In this paper we will limit ourselves to a few names of the competing approaches as the survey's scope is strictly EA. In the diagram, behavioural entities, actions, are represented either by rounded rectangles or ellipses. The diagram is read in the following way: the companies in the EA business system and the companies in the adopter business system collaborate through an action called EA Usage. The role of the companies in the EA business system is to supply EA. The role of the companies in the adopter business system is to adopt EA. The supply role in the EA business system can be broken down into two main actions: research and implementation. The adoption action is mainly the responsibility of the company that drives the improvement of the business process. To foster EA development, we need research organizations. This research is then extended or made practical by implementers. At the end, EA is adopted by companies who have a need for business / integration. We call these three actions: research, implementation, and adoption, the EA lifecycle activities. So our survey analyzes:

- **Communities:** Who is involved in EA (and in particular research organizations, implementer organizations and adopter organizations)?

- **Lifecycle activities:** What is published in terms of basic research issues, implementation issues and adoption issues?

We also analyze:

- **Distribution in Time:** From the dates of the papers we derived a timeline to identify the evolution of the discipline.

- **Topics:** Each paper is categorized in terms of topics. The list of topics was first established by identifying clusters of papers targeting similar issues.

- **Reference Disciplines:** To get a better idea about the disciplines influencing EA, we examined the disciplines referenced in each paper.

2.2   Paper Identification

As mentioned in the introduction, EA refers to Business-and-IT-Alignment. To keep the focus of our paper, we limited our search to papers that were explicitly related to the term "enterprise architecture" either in the title or in the body of the papers. Thus, in general, papers addressing the issue Business-and-IT-Alignment are not captured in our survey. There are some exceptions, such as the paper referring to the original Zachman framework [2], which, as we stated in the introduction, uses the term *information systems architecture* instead of *EA*.

In addition, we only included papers that were written in English. Thus we did not search for papers referring to terms like "urbanisation des systèmes d'information" (French) or "Unternehmensarchitektur" (German).

We obtained the papers from searching the World Wide Web. The sources were: digital libraries (roughly 40 papers), the EA community web site (approx. 20 papers) and individual web sites. The types of papers were: journal papers [2], conference proceedings [10], white papers [11] or reports [12].

Many communities other than academics participate in EA. In order to cover the broad range of the EA discipline and with respect to its practical relevance, we did not limit the range of the papers to scientific publications, submitted by academics. Instead, the backgrounds of the authors are diverse. They cover diverse communities, including academics [8], consulting companies [13] or tool vendors [14].

3   Results

Having applied the analysis framework on 80 papers within the defined scope, we found the following results:

3.1   Distribution in Time

Table 1 shows the distribution in time of the surveyed papers. Most of the papers were published in 2003 and 2004.

Table 1. Distribution of the surveyed papers in time

Year	Surveyed Papers (one or more categories for each paper)	#
Not known	[15], [16], [17]	3
Before 1996	[18], [19], [20], [2], [3]	5
1996	[21], [22], [23], [24]	4
1997	[25], [26]	2
1998	[27], [28], [29], [30], [31]	5
1999	[14], [11], [32], [33], [34], [35], [36]	7
2000	[37], [38]	2
2001	[39], [40], [41], [42], [43], [44]	6
2002	[45], [46], [47], [48], [49], [50], [51], [52], [10], [1]	10
2003	[53], [54], [13], [55], [56], [57], [58], [59], [12], [60], [61], [62], [63], [64], [65], [66], [67], [68], [69], [70], [71], [72], [8], [73]	24
2004 (Jan - Apr)	[74], [75], [76], [77], [78], [79], [80], [81], [82], [83], [84], [85]	12

3.2 Topics

By analyzing the topics covered by the papers, we found five main categories: o*verview, usage, modelling, framework* and *design principles.* Table 2 details the number of papers per category and their distribution within each category. The categories are defined as following:

Overview applies to all papers that present EA from a high-level-perspective or summarize the goals and the means of the discipline; *usage* applies to all papers that relate to the application of EA. For papers that are more research oriented, we found two main categories: one uses modelling techniques to graphically represent the architecture of an enterprise. The corresponding category is *modelling*. EA is based on the use of frameworks, such as Zachman's; hence we do have a *framework* category. Last, we have identified a category on *design principles*. Papers that did not fit into any of those categories are grouped into the category *others*.

Table 2. Topics of the surveyed papers

Topics	Surveyed Papers (one or more categories for each paper)	#
Usage	[60], [57], [56], [30], [20], [59], [66], [67], [27], [25], [35], [75], [83], [15], [26], [33], [49], [34], [42], [19], [63], [82], [74], [37], [71], [53], [78], [43], [47], [45], [86], [72], [46], [55], [52], [41], [68], [54], [40], [10]	40
Framework	[2], [3], [11], [84], [58], [16], [17], [31], [65], [80], [79], [64] , [85], [38]	14
Modelling	[1], [8], [14], [47] , [48], [73], [23], [28], [62], [76], [84], [61]	12
Overview	[13], [12], [32], [24], [81], [70], [22], [77], [50]	9
Design Principles	[51], [11]	2
Others	[21], [36], [44], [18], [86]	5

The majority of the papers focus on the usage category, followed by papers on the framework (14), the modelling (12) and overview papers (9). Two papers address the design principles.

All papers refer to EA; however, some papers do not contribute to the discipline of EA itself, but rather to other disciplines. These papers are classified in Usage. For example, a paper on a framework for knowledge management based on the Zachman framework would appear in "Usage" and not in "Framework".

Each paper is in one or more categories. Within the categories we evaluated the topics on the papers more closely. They were:

- **Usage**: The topics targeting the usage of EA are divided in three groups. The first group of papers addresses the importance of EA and listes reasons why EA should be applied (e.g. [15, 30, 40]). They often include a general review of EA. The second group describes experiences with EA – mainly from case studies (e.g. [19, 26]). The third group uses EA in order to enhance other disciplines. This is the largest group. For example, EA is used in Knowledge Management [35], in E-government [45] or for Information System Design [25] They all address EA mainly from a business perspective.

- **Framework:** The majority of the papers target or adapt the Zachman framework [2, 3, 11, 16, 17, 31, 80]. Most of these papers were written by Zachman himself. The other frameworks were: Meta Group´s EA Process and OMG´s MDA [48], the "Census" framework [64] and other approaches [79, 84, 85].

- **Modelling:** Many papers emphasize the importance of a common modelling technique that allows for modelling the processes in every level of the EA blueprint the same way. This would help to bridge the gap between people from different disciplines (e.g. business and IT) [14, 23, 61]. The most referenced modelling technique is the Unified Modelling Language (UML) [1, 28, 47, 61]. In addition, systemic modelling [8, 73] and conceptual modelling is used. Another contribution is to use the integration of existing modelling tools using an integration platform [62].

- **Overview:** Most papers including an overview of EA narrow their focus to a specific topic. Thus they are likely to be found in another category as well [12, 32]. An overview of EA typically consists of reasons for the use of EA, and a summary of existing frameworks and views [13, 24].

- **Design Principles:** Two papers target the issue design principles. [51] suggests eight principles on how to prepare an enterprise to be ready for changes in the environment. [11] introduces a process that has to be applied to integrate technologies within EA. It builds upon the Zachman framework.

- **Other:** These papers mostly cover topics that relate to EA in a wider sense. One paper discusses a misuse in the EA community of the terms *Framework* and *Architecture* [44]. According to the author's understanding, the Zachman Framework could be better called Zachman Architecture. Another paper targets the issue of architectural thinking [21], referring to the Architecture Planning Group (AGP). The AGP is a group to incorporate architectural standards.

3.3   Communities

From the various backgrounds of the authors, we derived seven categories – each representing a community that is involved in EA: academics, consulting companies, research agencies, software houses (such as platform or tool vendors), adopter companies, governmental players and other players (Table 3).
Most papers are written by people working in consulting companies. Most of them are small to mid-size companies, like *Metagroup* [48] or *Cutter Consortium* [60], which have defined their marketing strategy around EA. The second largest community is the academics.

Table 3. Communities that contributed the papers

Communities	Surveyed Papers (each paper was written by players from one or several communities)	#
Consulting Companies	[54], [13], [48], [39], [40], [75], [57], [59], [12], [60], [76], [28], [77], [78], [24], [20], [51], [15], [80], [66], [67], [68], [69], [81], [83], [72], [43], [85], [16], [17], [30], [31]	32
Academics	[47], [32], [33], [27], [55], [49], [38], [18], [39], [41], [22], [35], [19], [23], [36], [79], [25], [52], [26], [86], [10], [8], [73], [44]	24
Governmental Agencies	[4], [45], [46], [53], [32], [33], [74], [37], [56], [34], [64], [29], [65]	13
Software Houses	[14], [11], [58], [63], [50], [42], [1], [2], [3]	9
Research Agencies	[61], [62], [70], [82], [71], [84]	6
Other	[25], [39]	2

3.4   Reference disciplines

As Table 3 illustrates, the surveyed papers reference very few disciplines beside business and IT. Although the vast majority of the papers focus on EA from a business perspective (55), still many papers are influenced from IT (33). Some papers reference other disciplines than business and IT; the disciplines referenced are analyzed in Section 4.

Table 4. Reference disciplines used by the surveyed papers

Reference Disciplines	Surveyed Papers (one or more reference disciplines for each paper)	#
Business	[13], [60], [57], [8], [1], [32], [56], [23], [81], [22] [2], [73], [24], [11], [16], [17], [36], [30], [31], [20], [39], [59], [66], [67], [80], [27], [75], [83], [15], [33], [49], [34], [42], [19], [63], [82], [70], [79], [37], [71], [64], [53], [78], [43], [61], [45], [12], [29], [86], [77], [46], [55], [50], [68], [40]	55
IT	[1], [32], [48], [2], [73], [58], [11], [16], [36], [51], [39], [65], [80], [27], [72], [25], [23], [28], [26], [18], [62], [74], [71], [84], [47], [35], [38], [3],	30

	[54], [14]	
Business and IT	[1], [32], [2], [73], [11], [16], [36], [39], [80], [27], [23], [71],	**12**
Other	[8], [21], [2], [73], [23], [52], [3]	**7**

3.5   Distribution of Research regarding the Lifecycle Activities

In section 2.1 we identified the three lifecycle activities that are vital for any disciplines and for EA in particular: *research*, *implementation* and *adoption*. Most of the papers contribute to adoption, some to implementation and only a few to research (Table 5).

Table 5. Lifecycle Activities

Lifecycle Activities	Surveyed Papers (each paper corresponds to one action)	#
Adoption	[57], [32], [56], [17], [30], [65], [59], [66], [67], [27], [25], [75], [83], [15], [26], [34], [42], [19], [74], [37], [78], [43], [22], [35], [10], [85], [45], [12], [29], [86], [46], [55], [38], [50], [68], [40], [31], [64], [24], [79]	40
Implementation	[13], [60], [51], [20], [39], [72], [81], [33], [49], [63], [82], [70], [71], [84], [53], [47], [77], [41], [54], [14], [58], [16], [36], [44], [80], [11], [61],	27
Research	[8], [1], [48], [2], [73], [23], [28], [18], [62], [76], [52], [3], [21]	13

4   Discussion

From our results we derived the state of the art in EA as following:

Importance of EA: Since 1996, EA has been gaining recognition (Table 1). The impressive increase of the number of publications between 2003 and 2004 demonstrates that EA is gaining momentum. We assume, that the internet hype is at least partly responsible for the stagnation of EA until 2001. However, with approx. 25 papers in 2003 and possibly 60 papers in 2004, we still observe limited interest in the field.

Publication Topics in EA: The analysis of the topics (Table 2), shows:

- A significant amount of papers focus on *usage*. Analyzing the papers that address usage reveals other adopter business systems which are interested in EA. An example of these are the business systems dealing with knowledge management in which people reference the Zachman framework.

- Within the category framework, most papers refer to the Zachman framework, even more, they were written by Zachman himself. To us it was very surprising, that the Togaf [7] framework was not addressed. It only occurred within some papers that focus on an overview of EA.

- For EA modelling UML is used, as well as other modelling techniques. In general, most papers outline the need for an overall modelling technique across EA. Unfortunately, so far there is no technique that is capable of this.

According to Gene Leganza [87], EA has developed into two major approaches: a top-down approach that assumes comprehensive scope and strictly follows a formal process, and a bottom-up approach that starts with infrastructure technology standardization and then moves up the food chain to target high-priority problem areas and eventually influence business architecture. Amazingly, the surveyed papers exclusively followed the top-down approach.

From the lifecycle analysis (Table 5), we notice:

- There is an unbalanced distribution among the lifecycle activities: 50% of the papers target adoption, while still 34% of the surveyed papers focus the implementation issue of EA. Only 16% of the surveyed papers deal with research issues related to EA.

  EA is a discipline in which more interest is devoted to its adoption than to its further development. This point is even strengthened when related to the dispersion of the papers within the timeline (Table 1): This field only beginning to exist in 1996. The research efforts increased in 2002. From this data, EA is still an immature discipline. Furthermore, a recognized definition of what EA is, has yet to be achieved. So far there is no framework or methodology that allows for completely structuring and cross-

referencing all systems in a company – aligned to its mission.

As of today the communities within EA rely on a few frameworks and methodologies. And still little basic research is done despite, for example, that many papers recommend the development of an overall modelling technique for EA (note that such techniques exist or might exist but they do not use the term "enterprise architecture" in their publications so they are not included in this survey).

Reference Disciplines in EA: Most papers reference Business and IT (Table 4). Some of them even refer to both disciplines. To us it was surprising that very few papers used the value of other disciplines to build up their theories. This finding is in close relation with the few basic research efforts in EA. The reference disciplines used were architecture [21], philosophy [73] and system science [8]. But no paper referred disciplines such as social sciences. Other disciplines might be relevant such as information system engineering, requirement engineering, system engineering, sociotech approaches, etc…

With respect to the lack of basic research in EA the little use of reference disciplines is important to outline. Referencing other disciplines would generate new ideas and could thus lead to new frameworks or methodologies for EA.

Communities in EA: The majority of the papers are written by consulting companies, which are small and medium size (Table 3). This was in line with our expectations because most adopter companies rely on the support of consulting companies for the implementation of an EA framework. But surprisingly, the major consulting companies, such as Accenture or McKinsey, don´t seem to act much within the discipline.

As expected, the second largest contribution came from the academic world. Nevertheless, the interest of academics on basic research within EA is very low: Only 5 out of 24 of their papers deal with basic research within EA (Table 3, Table 5). Most academic papers focus on issues of other disciplines, using EA to enhance their fields. The low contribution by academics to EA itself is likely one reason for the general lack of basic EA approaches.

Keeping in mind the effect of the Clinger-Cohen-Act in 1996 (see Introduction), it is not surprising that we found governmental agencies as the third biggest stakeholder group: Roughly one out of six papers is written by them. Apparently, the Clinger-Cohen-Act did not affect governmental agencies in countries other than the U.S. All the governmental contributions come from the U.S.

Amazingly, even if most publications are about the adoption of EA (Table 5), adopter companies are absent as authors (Table 3). Examples of adopter companies are large banks, or large manufacturers. This could be a reason for the lack of papers targeting the bottom –up approach of EA.

In terms of publication sources, it is interesting to highlight that roughly 15 of the surveyed papers were published on the EA community web site. It appears that this web site is quite active and represents the professional association interested in this discipline.

Future work: For further work based on this research, we see an extended survey covering papers that do not explicitly name the term EA. There are probably approaches in basic research that target the EA discipline, but they do not explicitly name the term enterprise architecture. As stated in 2.2., we only included research articles that explicitly refer to the key words enterprise architecture, rather than the alignment of Business and IT.

Additionally, a future survey could include papers written in languages other than English.

Furthermore, for the identification of the EA community it would be important to name the term enterprise architecture in future research papers.

5   Conclusion

We have evaluated the state of the art in EA as follows:

The interest in EA is growing, but focusing mostly on the adoption. If adopter companies would publish their experience, EA could gain even more recognition.

From the dispersion of the publications over time, we can conclude the immaturity of the discipline.

Immature disciplines rely on basic research in order to progress. Given this lack, the increased attention from the academic world would be beneficial. In addition, EA can draw from other disciplines.

6   Acknowledgements

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