Enterprise Architecture and Agility: A Systematic Mapping Study

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Abstract. This article presents a systematic mapping study of published scientific papers on Enterprise Architecture (EA) and agility. More specifically, we reviewed studies on applying agile practices to EA and applying EA to the organization's agility. A categorical structure is proposed for classifying the research results based on the extracted topics discussed. The categories include agile traits (i.e., principles and practices), EA practices, and organizational contexts. By mapping the published works and analyzing them, the article also highlights some trends and indicates some obstacles and needs for future research and practice.

Keywords: Enterprise architecture · EA · Agility · Systematic mapping study

1 Introduction

In the field of Enterprise Architecture (EA), there is an ongoing discussion about the relationship between EA and Agility. On the one hand, EA was considered as an effective tool to bring agility to organizations [1, 2], and organizations are increasingly relying on the agility to "cope with rapid, relentless, and uncertain changes and thrive in a competitive environment of continually and unpredictably changing opportunities" [3]. On the other hand, researchers advocated that EA by itself should be agile [4, 5], as traditional frameworks-based EA is often "too rigid, and full-scale use requires quite a lot resources" [6] and "in some cases benefits of EA are unclear" [6].

Despite that some existing studies have also paid attention to these two perspectives [7, 8], there is no integrated and widely agreed understanding about how EA could be agile, and how EA could contribute to organizations' agility. This motivated present research. In this article, we use the definition of EA as "the fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution" [8] where an enterprise is viewed as a "system" [8]. We refer to an extended view of EA in this article. While a narrow view of EA is "specifically concerned with the level of an entire organization

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where business aspects are included," an extended view of EA also includes various architectural domains that EA (a narrow view) depends on such as Information Systems (IS) architecture and Information Technology (IT) architecture [9]. The main Research Questions (RQs) are:

RQ1: What has been studied to make EA agile?
RQ2: What has been studied to leverage EA to help organizations be agile?

2 Systematic Mapping Study Design

We used a **systematic mapping** method [10, 11] for the present study to provide a categorical structure and classify published scientific papers and results that have been published and indexed until December 2020. There are very few review studies relevant to the research questions [12–14], which are not systematic reviews and did not provide a full literature list. The most relevant study (i.e., [12]) is eight years ago and only covers agile EA management.

2.1 Searching and Screening

We searched one primary scientific database: SCOPUS, which claims to be the largest database of abstracts and citations [15]. Our keywords included "enterprise architecture" and "agile" or "agility." The overall searching string was as follows:

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( TITLE-ABS-KEY ( agile OR agility ) AND TITLE-ABS-KEY ( "enterprise architecture" ) )
AND ( LIMIT-TO ( SRCTYPE,"p" ) OR LIMIT-TO ( SRCTYPE,"j" ) ) AND ( LIMIT-TO (
LANGUAGE,"English" ) ) AND ( EXCLUDE ( DOCTYPE,"cr" ) )
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The screening process for inclusion was performed in several rounds. ***First***, we excluded studies that are not published in peer-reviewed conferences or journals and not written in English. ***Second***, based on abstracts, we filtered out all publications that were not related to the research questions. ***Third***, based on the full text, we excluded those with no full text or did not contain comprehensive descriptions and clear propositions about the relations and implementations of the relations. Finally, we had **53** papers as primary studies to analyze.

2.2 Categorizing Scheme

To extract data, map existing studies, and answer the research questions, we performed a concept-centric review focusing on categories relevant to the research subjects. We considered the following categories [10] to classify included studies: Agile traits, EA practices, Organizational context.

With regard to the categorization of **the agile traits,** we first surveyed the existing conceptual and literature-review publications on agile (not included in the reviewed papers). However, we discovered that there was not a commonly agreed classification of agile traits. The most relevant framework might be [16]. But it was used to evaluate the degree of agility of software development methods, and thus too concrete and

qualitative for our classification purpose for the agility of EA and organizations. We further examined two notable frameworks, which were mostly referred to: Dynamic System Development Method (DSDM) [17] and Manifesto for Agile Software Development (ASD) [18]. While the latter is generally recognized as the starting point for rising interest in agile methods, the former covers the entire project lifecycle (not only software development) and is thought to have helped formulate the Manifesto. Both theories define agile traits at two levels of abstraction.

To map the mentioning of agile traits in the EA studies, we used a *two-level framework* similar to the Manifesto and the DSDM. The first level summarizes higher-level, more abstract requirements and goals, referred to as *agile principles a*s shown in Table 1 (with a prefix of "APri-"). In the second level, we enumerate more concrete *agile practices* (with a prefix of "APra-", as shown in Table 1) which in some way help fulfill the principles. As the two frameworks have different naming for similar practices, we combined those with similar meanings. As a result, we extracted 19 agile practices.

Table 1. Agile traits (principles and practices)

Principles	Practices
APri-1: Deliver *pragmatic* value (valuable and evaluable)	APra-1: Deliver valuable (products) APra-2: Deliver working (products) APra-3: Deliver early APra-4: Deliver frequently APra-5: User feedback
APri-2: Be lean (*reduce waste and cost* without compromising on *quality*)	APra-6: Never compromise quality APra-7: Simplicity APra-8: Reuse (building blocks) APra-9: Align projects to business goals APra-10: Develop iteratively APra-11: Build incrementally from firm foundations APra-12: Regularly reflects and adjusts APra-13: Demonstrate control APra-14: Maintain a constant pace indefinitely APra-15: Sustainable development
APri-3: Respond to *changes* (iteration and autonomy)	APra-16: Build projects around motivated individuals APra-17: Communicate continuously and clearly APra-18: Collaborate APra-19: Self-organizing teams

In order to categorize **EA practices**, we used the framework proposed in [9] where three main categories of EA research were defined. *EA Understanding* refers to architectural content, including key concepts like architectural building blocks, ther interdependencies, views and viewpoints, and reference architectures. *EA Modelling* refers

to activities related to architectural models such as EA modelling languages, modeling tools, and modelling deliverables. *EA Management* refers to how EA is applied and managed including key concepts like development and implementation of architectures, their lifecycles and EA governance.

2.3 Data Analysis

The analysis of the included 53 studies started by mapping them to three groups according to their research focus, as shown in Table 2. For the group of "Agile EA" (left part of Table 2), the studies are focusing on how to make EA agile (RQ1). For the group of "EA for Agility" (right part of Table 2), the studies are focusing on how to leverage EA to make an organization agile (RQ2). For the group of "Agile EA for Agility," the studies covered both efforts. As a result, 16, 15, and 22 studies are included in these groups.

Table 2. Categorization of the studies by their focus on agility.

Agile EA (16)	Agile EA for agility (15)	EA for agility (22)
[6, 19–33]	[7, 34–47]	[2, 48–68]

3 Mapping Study Results

To demonstrate the timeliness of the 53 papers included in our study, we show the distribution of the papers by year of publication (see Fig. 1). Evidently, the majority of the articles are published in the recent six years.

Fig. 1. The distribution of included papers by the year of publication.

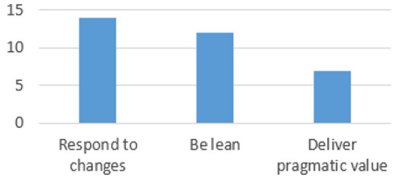

Fig. 2. (Agile EA) Mapping to agile principles.

3.1 Agile EA (RQ1: What has been Studied to Make EA Agile?)

For RQ1, we analyzed which *agile* traits (*i.e., principles and practices*) and which *EA practices* have been linked to making EA agile. As Fig. 2 shows, the most referred agile principle which is claimed to make EA agile is "Responding to changes," which was also recognized as the main trait of organizational agility [69]. The changes might arise from different channels such as development needs [20], requirements [28, 70], market

demands [30], and circumstances [22]. In Fig. 3, we report the coverage of the agile practices among the included papers. Evidently, Alignment to business goals is the top category, which might need to be "end to end" [29] or bridging the gap between strategy and implementation [23]. The second most popular category is "Iterative development".

In Fig. 4, we see that more papers about EA understanding and management have been found than those about EA modeling. This indicates that issues relevant for EA are more social and organizational than technical.

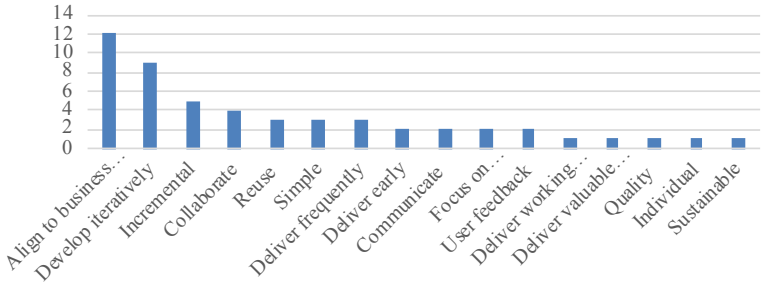

Fig. 3. (Agile EA) Mapping to agile practices.

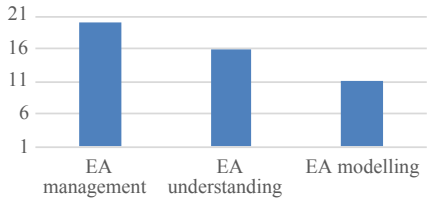

Fig. 4. (Agile EA) Mapping to EA practices.

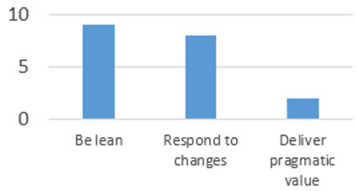

Fig. 5. (EA for Agility) Mapping to agile principles.

3.2 EA for Agility (RQ2: What has been Studied to Leverage EA to Help Organizations be Agile?)

For RQ2, we investigated "According to which *agile traits (principles and practices)*, have EA application contributed to making an organization agile?", "Which *EA practices* have been applied for this contribution?" and "What *organizational contexts* are relevant to the EA application?".

Regarding the agility traits employed by EA to contribute to organizational agility, most studies point out that EA helps organizations be lean and respond to change (See Fig. 5). A more detailed mapping (See Fig. 6) shows that most studies recognized that alignment is far the most important use of EA for improving organizational agility, often referred to as "business-IT alignment" [55]. But actually, alignment can be used to indicate more general relations between higher-level and lower-level components. While higher-level components can include strategies [49, 50, 59, 71], goals [52], or business [52, 62], lower-level components include executions [71], projects [50], (information)

systems [59, 62] or IT [49, 52]. As described in [64], EA provides "the insight and overview necessary to guide the lower level agility in the right overall direction."

Similar to the papers in the Agile EA category, Fig. 7 shows that there are more studies discussing EA management and understanding than EA modeling. However, modeling aspects such as formal models [61] and how to model an enterprise ontology [60] were also thought of as important and raised.

As shown in Fig. 8, a number of studies addressed how to make EA work in an agile environment [7, 45, 52, 53], e.g., by using Scrum [54], large-scale agile development environment [40, 50, 51] and geographically distributed agile development [34]. In addition, several studies also discussed how EA could work with different architecture styles like SOA [23, 62, 63, 65, 66] and microservice[38, 39] to contribute to agility together.

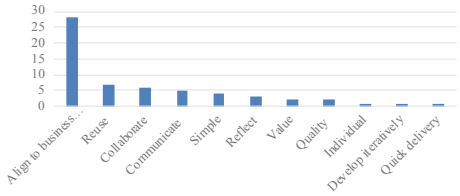

Fig. 6. (EA for Agility) Mapping to agile practices.

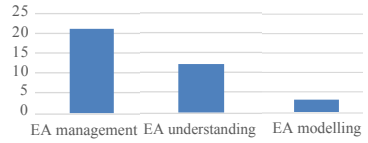

Fig. 7. (EA for Agility) Mapping to EA practices.

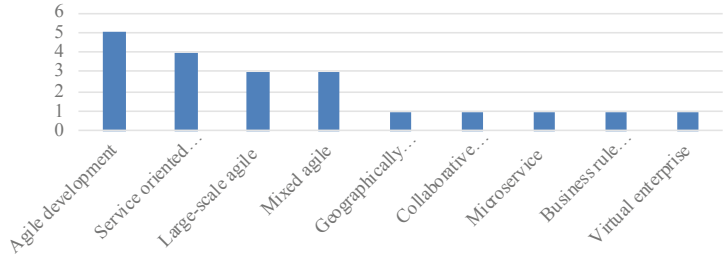

Fig. 8. (EA for Agility) Mapping to organizational contexts.

4 Discussion

According to the results, we see that over the past fifteen years, academia has continuously paid attention to the relation between EA and agility. We found the division between the questions of making EA agile and agility arising from the use of EA quite balanced in terms of contributions (16, 22, and 15 papers in each category).

What is most intriguing in our findings is the focus of the papers. The importance of both "Responding to change" and "Being lean" scored high when talking about *how to make EA agile* and *leveraging EA to achieve organizational agility*. This means that while EA helps organizations to respond to change (discussed in 8 papers) and being lean (discussed in 9 papers), it is important to improve EA processes themselves to better

react to changes (discussed in 14 papers) and be leaner (discussed in 12 papers). The latter does confirm the heavy-weight reputation of EA processes.

A more detailed analysis shows that the majority of reviewed studies regarded alignment as the most significant value of EA in helping organizations become agile. We also see some recent **trends** indicating EA is required to be applied in an existing agile environment (small or large scale or mixed) and co-work with architectural styles like SOA and microservice. Another interesting finding is that EA practices relevant to management and understanding (social and organizational aspects) have drawn more attention than modeling (technical aspects). Finally, we identified several research **gaps**. According to the agile spirit, users' feedback is crucial as it is the key to receiving changes and knowing what value should be delivered. But few studies have addressed relevant traits such as "deliver pragmatic value," "deliver working (products)," "deliver early," and "deliver frequently" when considering how to make EA agile. Besides, alignment is commonly agreed to as the most important benefit EA brings to organizations to improve agility. But few studies clarified what alignment includes and how to achieve a cost-efficient alignment without compromising the necessary quality.

5 Conclusion

The goal of the present research is to review the directions and tendencies of existing studies on applying agile practices to EA and the role of EA in organizational agility. By performing a systematic mapping and analyzing the results, we identified some trends as well as gaps. One limitation of the review is that we only included highly relevant papers. We did not examine other *databases* than Scopus and did not employ *snowballing* to exhaustively include all relevant papers. Therefore, we plan to do a more inclusive review and synthesize relevant information extracted to construct more concrete and prescriptive guidelines to help companies achieve organizational agility by leveraging a more agile EA.

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