

An Approach for Adaptive Enterprise Architecture

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Keywords: Adaptation, Agile Software Development, Dynamic Environments, Enterprise Architecture, Scrum.

Abstract: Given the fast emergence of new technologies and the highly changing business demands, enterprises are confronted with the need to keep up with the evolving transformation. This one is subject to internal and external factors which make it very often in the form of disruptive changes. As a consequence, various parts of companies' Enterprise Architecture are impacted. To address the new requirements of these increasingly dynamic environments, enterprises need to transition from heavy and document-centred Enterprise Architecture Frameworks to more agile and continuously adaptive approaches. On the other hand, Agile Software Development (ASD) are commonly used methods for IT development. They are mainly characterized by the high involvement of the requester and the rapid accommodation to development needs. This paper presents an Adaptive Enterprise Architecture model that is inspired from some ASD values. Thus, we begin with a brief summary of the criteria that we consider compulsory for Adaptive Enterprise Architecture. Then we present the related work and the connection between agile values and our criteria. Finally, we describe our model and illustrate it via a case study.

1 INTRODUCTION

Nowadays, enterprises are facing the disruptions caused by the digital transformation in a record time. So, they are taking actions in order to adapt to the current changes by improving their relationships with customers, their internal processes, their business models... As a result, the reaction to change impacts different parts of the business making it a major concern in enterprise architecture (The Open Group, 2011) and (Lankhorst, 2009). However, few Enterprise Architecture (EA) approaches provide modeling and analytics solutions to support rapidly changing environments. Indeed, the so-called traditional EA approaches are heavy, lack agility, and do not rely on well-defined concepts.

On the other hand, the adaptation ensures that the EA is consistent with the changes. It is a process of adjustment and continuous improvement that makes it possible to achieve an EA in harmony with its environment.

Consequently, a so-called adaptive enterprise can face unique challenges that it encounters with the specificities of each of them (cycles, recurrence, frequency, etc.). It recognizes the impact of change, detects obstacles and facilitates decision-making. It

takes into account the uncertainty of change and its diversity and responds effectively to it.

Thus, EA should focus on the methods and tools needed to move from an initial, detailed, complex, documentation-centred and prescriptive EA to an EA that focuses on principles of adaptation to expected changes and unforeseen ones. More importantly, EA should provide continuous improvement to proactively address development needs. As a result, several research questions arise: What are the criteria for identifying an adaptive Enterprise Architecture? How to model an adaptive EA? How to evaluate the implementation of this model?

In this paper, we propose a model that we consider meets the requirements of Adaptive Enterprise Architecture. It is structured as in the following. In Section 2, we summarize the results of a comparative study done in a previous work. Then, section 3 focuses on the values of agile methods and on the mapping between them and our criteria. In Section 4, we present some related works of integration of agile methods and Enterprise Architecture. The section 5 contains our model. Then, section 6 is a case study. Finally, in the last part, we conclude our work and present our perspectives.

2 CRITERIA OF ADAPTIVE ENTERPRISE ARCHITECTURE

In order to put into context our problematic, we tried to identify the limitations of some frameworks of Enterprise Architecture in relation with adaptation requirements. Then we discussed a definition of Adaptation: Adaptation ensures that the EA is consistent with the changes, to maintain its normal functioning. It is a process of adjustment and of continuous improvement to reach an EA in harmony with its environment. Then, based on this definition and on an analytical grid, we defined some evaluation criteria that we consider are compulsory elements for Adaptive Enterprise Architecture (Daoudi et al., 2018) and (Daoudi et al., 2020).

Multi-level of dynamics is the first criterion that we identified. In fact, disruptive change not only occurs at different layers but also impacts the relations between those layers and elements.

Then the second criterion is the **sensing of change** (Babar et al., 2015). In fact, having a continuous sensing part helps the scheduling of proactive actions.

Moreover the **process of adaptation** is the core of the adaptive enterprise architecture. Also, this process needs to have a low level of complexity. This leads us to another criterion: the **complexity of change management**. According to (Dietz, 2006), complexity management is the most dominant problem identified in scientific researches on enterprise management. Also, complexity (Chernobai et al., 2020) can be related to business diversification, geographic diversification and network interconnectedness and business complexity is a significant driver of operational risk.

The ability of **handling unforeseen changes** is another criterion. According to (Hinkelmann et al., 2016) the ability of keeping up with continuous and unexpected change is an essential quality of modern enterprises.

Also, to conduct each change, there are many properties, indicators, risks, etc. to deal with. Adaptive Enterprise Architecture needs to specify and assess adaptability properties of its different components. Thus, **the explicit management of adaptability trade-offs** is another criterion.

According to (Zhang, 2016), a most used maxim in the business world is the following: "If you can't measure it, you can't manage it." As such, the last criterion is the **evaluation of adaptation**.

3 ADAPTIVE ENTERPRISE ARCHITECTURE AND AGILE VALUES

Agile methods emerged in 2001 in computer development context, their main aim is to involve as much as possible the requester in the software design. According to the agile manifesto for software development (Beck et al., 2001), agile methods assume change is inevitable. The key values of the agile movement are: Individuals and interactions over processes and tools, Working software over comprehensive documentation, Customer collaboration over contract negotiation and Responding to change over following a plan.

Those methods do not spend effort and time on extensive design phases. So, they are based on the "design as you go" principle. Working with iterations, the designs and developments are improved after each increment. They provide continuous delivery to the requester. Finally, those methods are not document-centric although they lead to deliverables. In fact, as they assume changes occurs at a rapid pace, it makes no sense to produce a huge amount of documents that soon will be outdated, archived and difficult to manage.

As cited in (Yu et al., 2012), based on the precedent values of agile methods, we can already sense the convergence between the values of agile methods and the criteria that we selected for Adaptive Enterprise Architecture models. This can be explained as follow.

The **sensing of change** is inherent in agile methods. In fact, those methods have been proposed to deal with these rapidly changing circumstances. As mentioned before, they assume change is inevitable and they deal with it by creating new iterations.

Agile methods advocate to not 'waste' time on expensive planning and design activities early on, but to deliver something valuable to the requester as quickly as possible. They are lightweight methods that don't require complex documentation. Also, new or changed requirements trigger a new cycle and so on. This point converges with criterion related to **complexity of change management** in EA.

According to the comparison of Agile, project-planned and hybrid methods for multidisciplinary design made by (Guérineau et al., 2016), agile methods can deal with late/unexpected changes. This is done through high meeting frequencies and requester involvement. This characteristic meets the

criterion of **handling unforeseen changes** that we pulled over in the precedent part.

In its comparison (Dybå et al., 2008) between traditional development methods and agile development methods, the authors highlighted that the agile ones ensure a quality control via continuous testing and continuous control of requirements, design and solutions. This matches the **evaluation** criterion that we proposed for adaptive Enterprise Architecture.

The **process of adaptation** is the core of an agile method and is based on rapid feedback loops. Also, agile approaches strive for continuous improvement by speeding up the plan-do-check-act cycle introduced by Deming and Shewhart (Buckl et al., 2011).

Regarding **Multi-Level of dynamics and explicit management of adaptability trade-offs**, it is facilitated by the high interaction between different stakeholders in agile methods. They encourage collaboration to bridge understanding from both the problem-space and the solution-space. The aspect multi-level will depend on the model that we suggest for Adaptive Enterprise Architecture.

Since the year 2001, agile project management for the development of software, especially Scrum, are widely used in small, mid-sized enterprises, as well as big global software engineering companies (Taft, 2005). SCRUM is an agile method for project management. It is based on iterations called Sprints. We've chosen Scrum as a reference of agile methodologies due to the fact that it is one of the most popular approaches that are praised for coping with rapidly changing conditions (Anwer et al., 2017). It focuses on situations where it is difficult to plan ahead, with mechanisms for "empirical process control" where feedback loops constitute the core element (Schwaber, 1997).

The Scrum framework (Rubin, 2012) consists of a team with well defined roles, ceremonies and some artifacts. The team is formed with the aim of optimizing the value produced. There are three main Scrum Roles. First, the Scrum Master who helps the team apply Scrum and adapt it to the context. Second, the Product Owner is the product manager. Finally, the team is mainly responsible for actually implanting and testing the user stories.

The Scrum ceremonies are mainly related to the flow of the sprint: the "Sprint Planning", the "Daily Meetings" between the scrum master and the team and the "Sprint review" which marks the end of a Sprint. Finally, the "Retrospective" that examines

what has worked well and is a floor of discussion of process improvement.

Scrum requires two main artifacts. First, the "Product Backlog" that lists prioritized features and associated acceptance criteria. Secondly, the "Sprint Backlog" that lists all the tasks of a Sprint.

4 RELATED WORK

In (Buckl et al., 2011), the authors explored to which extent agile methods, namely Scrum, can be applied to EA management. They highlighted 4 challenges that EA is facing: the EA management endeavor has to be aligned with the stakeholders' interests expressed in a shared terminology, an EA management endeavor has to ensure an early and periodical delivery of concrete EA products, an EA management endeavor has to ensure commitment and involvement of all parties and an EA management endeavor has to continuously adapt to a volatile environment with changing criteria for goal fulfillment. To address those challenges, they propose a mapping between scrum concepts and their equivalents in EA management.

In (Rhubart, 2010), the authors showed that both the enterprise architecture and the agile development methodologies are decision-making frameworks. Thus they have the same foundations. They suggested an interview related to agile EA management but didn't propose any model for integrating agile techniques.

The paper (Armour et al., 2001) introduced an 'agile model driven development approach (AMDD) at the enterprise level'. The model starts with the creation of an architecture vision which is shared with the different stakeholders at the various layers. After having their feedbacks, the architecture is updated.

On (Ambler, 2003), the authors focused on the transition and implementation phases between an As-Is architecture and the To-Be architecture. They proposed a framework that uses an agile method in order to analyze the activities needed in the transition phase.

The work in (Pulkkinen et al., 2005) suggested a cyclic EA process that goes through all three decision making levels and reviews four enterprise architecture types. There is no description of the different phases explicitly.

In (Canat et al., 2018), the author did an evaluation through meetings and a pilot interview. The main findings highlighted were mainly that enterprise architecture and agile methods are

preferable on different levels not only on the lower levels (development and technology).

The authors in (Hanschke et al., 2015) runned interviews with different stakeholders in some firms in order to study the integration of Agile Software Development and Enterprise Architecture Management. They focused on Scrum and showed the necessary collaboration of empowered implementation teams with a central EA function

The authors in (Hensema, 2015) based on a literature review and an empirical study found specifically that there are similarities between waterfall methodology and current EA approaches. Moreover he highlighted the facts that agile practices will allow less EA challenges as they have the ability to deal with changing requirements and focusing on the essential.

In their position paper, (Proper et al., 2014) pointed out the success of agile methods and the trend of less detailed enterprise architecture. They claimed that those elements respond to the need for a more iterative approach.

In their paper (Aarnink et al., 2012), the authors conducted their study on a small population within non-for profit organization and focused on the use of agile software development method scrum. They concluded that organizations can apply an agile software development method in order to strive for business-IT alignment.

5 THE PROPOSED APPROACH

The core of our proposed model is inspired from Scrum and its sprint model in order to develop an adaptive Enterprise Architecture. First of all, our suggestion considers that during an enterprise lifecycle we move from an $E A_i$ ($i \in N^*$) to $E A_{i+1}$ ($i \in N^*$) (Elementary transition). So as to ensure those continuous transitions, we propose every elementary transition as a project with the main objective to close the gap between the As-Is and To-Be.

As shown in the diagram, we applied an inspired model from Scrum horizontally at business and application /IT layers. This allows us to inherit its characteristics and check positively some of the criteria of Adaptive Enterprise Architecture. As for, the multi-level dynamics and explicit management of adaptability trade-offs, thanks to the weekly meetings and the committee of owners, the flow of information goes top down and bottom up. This important point, allows the multi-level dynamics and

the discussion of adaptability alternatives and trade-offs.

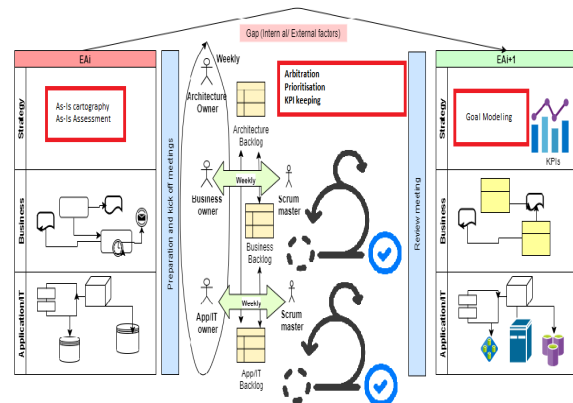


Figure 1: Simplified diagram of the proposed model.

In the following sections, we first focus on the strategy level and determine the formulation of strategy elements. Then, we present the overall approach and present its model and metamodel.

5.1 Focus on Strategy Layer

In the last decade, one of the main issues addressed by researchers in the context of EA and business strategy modelling is to integrate the business strategy to the systems requirements analysis.

According to (David, 2008), the process of strategy formulation consists of two main parts: strategic analysis and strategic choice. The first step consists of developing a vision and mission of the organization. The second step is generating alternative strategies to achieve the goals established in the first step.

According to (Simon et al., 1986) the process of problem-solving can be defined as a successful search for an action or a series of actions in order to transfer the given state of the system to a goal state

In the paper (Gavrilova et al., 2018), they identified methods and divided them into two large groups: generic and domain-specific. Generic ones are used for a wide variety of tasks from different areas; Domain-specific methods are mainly used only for managerial tasks. They suggested 5 groups of modelling methods from Informal description using natural language to objects and relations strictly defined.

According to (Kitsios et al., 2019) Although researchers have used plenty of enterprise modelling techniques to optimise the concepts above, the most frequently used methods are Archimate (14.5 %), i*framework (10.9%) and OWL(5.45%).

Focusing on i*, according to (Franch et al., 2016), goals can be formulated at different levels of abstraction, from strategic concerns to technical issues, and are less volatile than requirements. Goal-oriented methods allow analyzing consequences of decisions, making interrogative questions and exploring solutions.

We've chosen this modelling language for strategy formulation as it proposes a simple but relevant modeling perspective (Franch et al., 2016). The integration of i* in our model is in the Strategy level, it allows us to define a strategy map in the EAi and in EAi+1 in a formal way. The i* framework is a modelling technique which describes the modelling of strategic dependencies among business agents, goals, functions and resource (Doumi et al., 2011).

In addition, according to (Doumi et al., 2013), i* formalism is intentional, it lends itself well to strategic level modeling because it offers useful abstraction mechanisms when complex phenomena are represented.

The four central concepts of the i* formalism are: soft goal, hard goal, tactic and resource. First, a soft Goal that is a strategic goal that the actor wants to achieve. Second, a hard goal that is an operational goal whose satisfaction criteria are precisely defined. Third, a tactic that describes how to reach a goal (soft or hard). Fourth, resources that are the means that the company will make available to actors to achieve a goal.

To sum up, the method that we've chosen to formulate the To-Be Architecture is Goal modelling. As of the assessment of the As-Is architecture, we recommend the analysis of cartography and more informal strategy modelling such as SWOT.

5.2 Description of the Approach

So as to describe our approach at all levels, we will present the metamodel. Then, we will define the roles, ceremonies and the mandatory artifacts.

As in the Metamodel, each transition from an EAi to another one is a project that impacts all three layers (Strategy, Business and application/IT). Also, each project consists of iterations monitored by KPIs and metrics. At the Strategy level, we adopt i* concepts. So, we have soft goals linked to hard goals and other elements. We also introduce the pattern observer which allows the continuous listening of goals and ensures the correction of the shots whenever needed. The hard goals are related to the business processes. Finally, at business ad

Application/IT layers, we use the activity queues and items that allow the implementation of sprints.

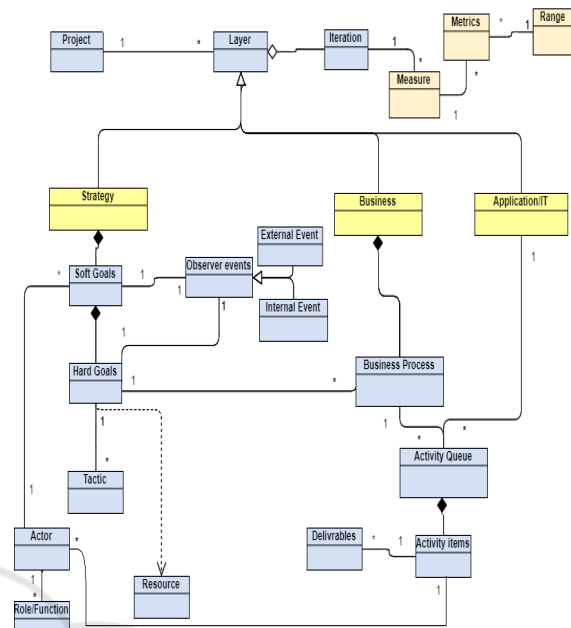


Figure 2: Approach Metamodel.

Regarding the roles, we suggest to have a committee of owners composed of an architecture owner, a business owner and an application owner. The business and the application/IT owners have each of them a team composed of a scrum master and members responsible of the development and the engineering of the solutions.

The architecture owner facilitates the top-down EA assets' information sharing. He is the architecture keeper vertically. He ensures the fluent discussion between the different other owners and consolidates their feedback. He will play the interface between the strategy from one side and the business and Application/IT levels from the other side. He knows the strategy needs and translates them into quantitative and qualitative goals for the other EA levels. He is in charge of defining and scheduling the architecture iterations. He also defines the acceptance criteria that are essential for a good understanding by the teams. He understands the non-functional needs and the exception stories. He maintains the architecture backlog and prioritizes tasks. Finally, he is the only one who can accept or reject the developed architecture. He defines and maintains the architecture metrics.

The business owner has an overview over all the business processes in the enterprise. He ensures their correct application in a daily basis. He optimizes the

business processes and prevents deadlocks. He is in charge of defining the impact of the stories in the architecture backlog on the business level. He works with his team to ensure the adaptation of business processes and to maximize the business value. He creates the business backlog and maintains it. He schedules and defines the iterations. Also, he is in charge of accepting or rejecting the implemented business adaptation. He gathers the exceptions and prioritizes tasks. He defines and maintains the business metrics.

The application/IT owner knows the applications landscape and the IT infrastructure. He determines the application/IT backlog. He collects the bug stories and non-technical needs from his team and adapts the backlog. He prioritizes tasks in the backlog. Also, he is in charge of accepting or declining the implemented solutions. He defines and maintains the Applications/IT metrics.

The scrum masters are responsible for implementing Scrum and for doing the follow up with the project teams. They facilitate the communication between the different stakeholders (their respective teams and owners).

The business and the application/IT teams are in charge of implementing their respective backlogs.

Regarding the Ceremonies, we suggest to keep Scrum Ceremonies for the business and the application/IT. Also, we propose to add four others at the architectural level: preparation meeting, kick off meeting, weekly meetings and review meeting.

The preparation meeting gives the opportunity to the different owners to know each other. The architecture owner then explains the proposed current analysis and To-Be architecture and shows his backlog. The business owner and the application/IT owner can challenge him regarding his proposition or agree immediately.

The Kick off meeting allows the team sharing the intermediate EA planning. Each of the members of the committee share their release planning, their backlogs, their KPIs and their sprints iterations. It marks the official start of the cycle.

The weekly meetings permit the synchronization between the three owners, the adaptation of backlogs and the review of the KPIs. It allows the correction of shots and the monitoring of the progress. Before those meetings, each owner (Business, Application/IT) has a weekly with his scrum master as a checkpoint.

Finally, the review of the EA is the final step of the work on an intermediate EA. The Team members have the opportunity to inspect and adapt their processes. They qualify what went right, what

could have gone better, and what can be made better in the next cycle.

Regarding the artifacts, scrum ones remains the same for business and Application/IT layer: "Business Backlog", "Application/IT Backlog", "Sprint Backlog" for Business and Application/IT layers. We add some other artifacts on the architecture level. First, a Strategy model As-Is and To-Be. Second, the chart of Key Performance Indicators to monitor the transition from the As-Is to the To-Be. Finally, the "Architecture Backlog" that lists prioritized features at the architecture level.

6 CASE STUDY

We present a case study to illustrate the proposed Adaptive Enterprise Architecture model.

XYZ is a large company with a B2B and a B2C channels. It is a manufacturing company with providers and distribution partners located in many countries. With the digital transformation trends, they envision to develop their online visibility in both channels. After analysing those elements, the enterprise would like to go from EA_i : Enterprise without online channel to EA_{i+1} : Enterprise with online channel. For the sake of simplicity we will only focus on one aspect of EA_{i+1} which is online selling in B2C. To describe the application of the model on the case studied, we will do it by steps.

In the beginning of the project, the architecture owner takes the lead; he checks the As-Is cartography of the current EA. Then, he runs the As-Is assessment. In our case, he used the SWOT matrix that summarizes as in the following. First, the **strengths** are: Well positioned in the market share, Strong customer relationship, Strong brand and business reputation, Successful marketing strategies, Strong organisation with well known processes. Second the **weaknesses** are: High costs due to storage in distributors stocks, Aged inventory, Classic channel only, No online marketing strategy. Then, the main **opportunities** are: Competitors products have less quality, High demand on products in many areas. Finally, the **threats** identified are: A lot of competitors with similar products, Online advertising campaign on B2C level by competitors.

After the identification of the main limitations and the study of the current architecture, he then uses i* concepts to formalise the To-Be architecture. For the sake of simplicity, we will display only one Soft Goal: Ensure online shopping deployment.

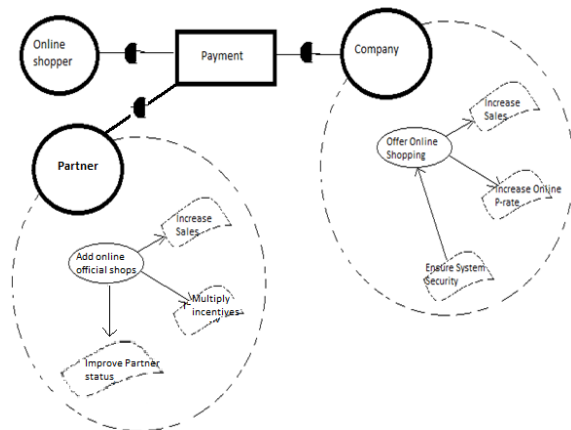


Figure 3: Goal modelling of the To-Be architecture.

Then, he creates his own backlog “Architecture backlog”: “As digital company, I have online shops”, “As a digital company, I can develop strategic alliances with online partners”.

Now, that the architecture owner has all the founding elements, he runs the preparation meeting to align with the two other owners. As he was not challenged by the Business Owner and Application/IT owner regarding the backlog content, they moved forward and did the Kick off meeting.

As a result, all the backlogs were created as follow. The elements presented are only the main ones.

- **Business Backlog:** “As member involved in online business, I have a business process with validation hierarchy that handles online payment”, “As marketing manager, I have a process of validation of online assets”, “As partner manager, I have a clear process of onboarding online partners”, “As member of management team, I can track online business “
- **Application/IT Backlog :** “As online buyer, I can authenticate”, “As online buyer, I can select items and add them to my bucket”, “As online buyer, the products displayed are the ones in stock”, “As online decision maker, I can know the most demanded elements and estimate the demand”, “As online decision maker, I can monitor the penetration rate per country.”, “As online partner, I can run the syndication at the frequency that I need.”.

Then the owners defined the KPIs and metrics that will help them assess their improvement: Number of online shops created on partners websites, Number of landing pages created on official websites, Penetration rate using online tools

over the testing period, Number of delays, errors after the implementation of the online process / internal complaints, Number of external complaints, Market share increase.

Finally, before starting the work with the respective teams, the business and the application/IT owners estimated with the scrum masters the number of iterations needed. During the weekly meetings, the owners assessed their improvement and resolved the new requirements. They also shared with the architecture owner the bottom up feedback from their teams.

7 CONCLUSIONS

In this paper we explored the usage of some of Agile Software Development (ASD) values in order to meet the criteria for Adaptive Enterprise Architecture: multilevel of dynamics, sensing and responding to change, handling unforeseen changes, process of adaptation, explicit management of adaptability trade-offs and the evaluation of adaptation. Then, we outlined our approach that uses some ASD values. Finally, we illustrated our method via a case study.

The main contribution in this paper is to stimulate discussion about the requirements and the methods of adaptation of EA to increasingly changing environments. In subsequent work, we aim to deep dive into the evaluation part by defining some standard KPIs and exploring the use of data driven analysis on To-Be architectures.

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