An Empirical Evaluation of Design Decision Concepts in Enterprise Architecture

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Abstract. Enterprise Architecture (EA) languages describe the design of an enterprise holistically, typically linking products and services to supporting business processes and, in turn, business processes to their supporting IT systems. In earlier work, we introduced EA Anamnesis, which provides an approach and corresponding meta-model for rationalizing architectural designs. EA Anamnesis captures the motivations of design decisions in enterprise architecture, alternative designs, design criteria, observed impacts of a design decision, and more. We argued that EA Anamnesis nicely complements current architectural languages by providing the capability to learn from past decision making.
In this paper, we provide a first empirical grounding for the practical usefulness of EA Anamnesis. Using a survey amongst 35 enterprise architecture practitioners, we test the perceived usefulness of EA Anamnesis concepts, and compare this to their current uptake in practice. Results indicate that while many EA Anamnesis concepts are perceived as useful, the current uptake in practice is limited to a few concepts - prominently 'rationale' and 'layer'. Our results go on and show that architects currently rationalize architectural decisions in an ad hoc manner, forgoing structured templates such as provided by EA Anamnesis. Finally, we interpret the survey results discussing for example possible reasons for the gap between perceived usefulness and uptake of architectural rationalization.

Key words: Enterprise Architecture, Design Rationale, Design Decision concepts, Evaluation, Survey

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1 Introduction

Enterprise Architecture (EA) modeling languages, such as the Open Group standard language ArchiMate [1], connect an organization's IT infrastructure and applications to the business processes they support and the products/services that are in turn realized by the business processes. Such a holistic perspective on an enterprise helps to clarify the business advantages of IT, analyze cost structures and more [2].

While EA modeling languages allow for modeling an enterprise holistically, the design decisions behind the resulting models are often left implicit.

As discussed in our earlier work [3], the resulting lack of transparency on design decisions can cause design integrity issues when architects want to maintain or change the current design [4]. This means that due to a lacking insight of the rationale, new designs are constructed in an adhoc manner, without taking into consideration constraints implied by past design decisions. Also, according to a survey for software architecture design rationale [5], a large majority of architects (85,1%) admitted the importance of design rationalization in order to justify designs.

Furthermore, anecdotal evidence from six exploratory interviews we conducted with senior enterprise architects suggests that enterprise architects are often external consultants. This situation increases the architectural knowledge gap of the Enterprise Architecture, since without rationalization architects lack insights into design decision making in an organization that is new to them.

In earlier work [3, 6, 7], we introduced an approach for the rationalization of enterprise architectures by capturing EA design decision details. We refer to this approach as EA Anamnesis, from the ancient Greek word $\alpha\nu\acute{\alpha}\mu\nu\eta\sigma\iota\varsigma$ (/ˌænæmˈniːsɪs/), which denotes memory and repair of forgetfulness. The EA Anamnesis meta-model is grounded in similar approaches from the software engineering domain, prominently in the Decision Representation Language (DRL) [8]. At this stage, EA Anamnesis complements the ArchiMate modeling language [1] by conceptualizing decision details (alternatives, criteria, impacts) and by grouping EA decisions in three different enterprise architecture layers (Business, Application, Technology) in accordance with the ArchiMate specification.

In this paper we evaluate empirically the design decision concepts from the EA Anamnesis meta-model by means of a survey amongst enterprise architecture practitioners. On the one hand, our study shows that a majority of EA practitioners deem EA Anamnesis's concepts, such as "motivation" and "observed impact", as useful, in that these concepts help them with the maintenance and justification of enterprise architectures. On the other hand, however, our study shows a limited uptake of rationalization in practice. For one, while many architects capture a decision's motivations, there is less attention for capturing the observed impacts of decisions. Finally we find that, currently, there is little reliance on a structured rationalization approach, such as provided by EA Anamnesis. Rather, rationalization of decisions (if any) is done in an ad hoc manner, relying on unstructured tools such as MS Word or Powerpoint.

Also, we speculate that the distinction between perceived usefulness and uptake in practice is, at least partially, due to a lacking awareness of rationalization, and potential usefulness it has for architectural practice.

This paper is structured as follows. Sect. 2 presents the EA Anamnesis concepts and a short illustration of them. Sect. 3 presents the evaluation setup, while Sect. 4 presents the results of our study. Subsequently, in Sect. 5 we discuss the survey results. Sect. 6 concludes.

2 Background

To make the paper self contained, this section presents the design rationale concepts of the EA Anamnesis approach that were confronted to practitioners during our study (in Sect. 2.1), accompanied by an illustration of our approach with a case study from the insurance sector (in Sect. 2.2).

2.1 EA Anamnesis Design Decision Concepts

In this paper we focus on decision detail concepts that provide qualitative rationalization information for design decisions. According to [4], architectural rationale can be discriminated in three different types: qualitative design rationale, quantitative design rationale and alternative architecture rationale.

The meta-model of the EA Anamnesis approach is depicted in Fig. 1. To limit survey length we focus our study on a set of key concepts. Concepts of the meta-model that provide additional details, such as title (a descriptive name of a decision), are not discussed.

Below we provide a brief description of the concepts used in our survey.

Rationale: The reason(s) that leads an architect to choose a specific decision among the alternatives. According to Kruchten [9] a rationale answers the "why" question for each decision.

Alternative: This concept illustrates the EA decisions that were rejected (alternatives) in order to address a specific EA issue [10, 11].

Layer: In line with the ArchiMate language [1], an enterprise is specified in three layers: *Business, Application and Technology*. Using these three layers, we express an enterprise *holistically*, showing not only applications and physical IT infrastructure (expressed through the application and technology layers), but also how an enterprise's IT impacts/is impacted by an enterprise's products and services and its business strategy and processes.

Observed impact: The observed impact concept signifies an *unanticipated* consequence of an already made decision to an EA artifact. This is opposed to antici-

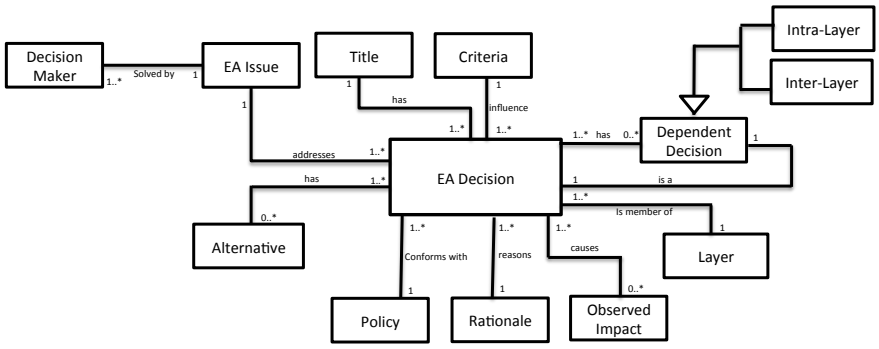

Fig. 1. The EA Anamnesis meta-model

pated consequences, such as signified by decision impact relationships (discussed next). Observed impacts can be positive or negative consequences.

In current everyday practice, architects model *anticipated* consequences using what-if-scenarios [2]. Unfortunately, not every possible impact of made EA decisions can be predicted. This is especially true for enterprise architecture, where one considers impacts across the enterprise rather than in one specific (e.g. technical) part. Some of the consequences of EA decisions are revealed during the implementation phase, or during the maintenance of the existing architecture design [12]. These unanticipated consequences are exactly captured by the concept of an observed impact.

For us the main usefulness of capturing observed impacts is that they can be used by architects to avoid decisions with negative consequences in future designs of the architecture.

Impact (Decision traceability): the "Impact" concept makes explicit relationships between EA decisions. For example, how an IT decision affects a business process level decision or vice versa.

2.2 Illustrative example

We now briefly illustrate how the concepts of our approach can be used to express architectural design rationale, using a fictitious insurance case presented in our previous work [3].

ArchiSurance is an insurance company that sells car insurance products using a direct-to-customer sales model. The architectural design of this sales model, created in the EA modeling language ArchiMate, is depicted in Fig. 2.

Two business services support the sales model of ArchiSurance: "Car insurance registration service" and "Car insurance service". ArchiMate helps us to understand the dependencies between different perspectives on an enterprise. For example, in Fig. 2 we see that the business service "Car insurance registration service" is realized by a business process "Register customer profile". In turn,

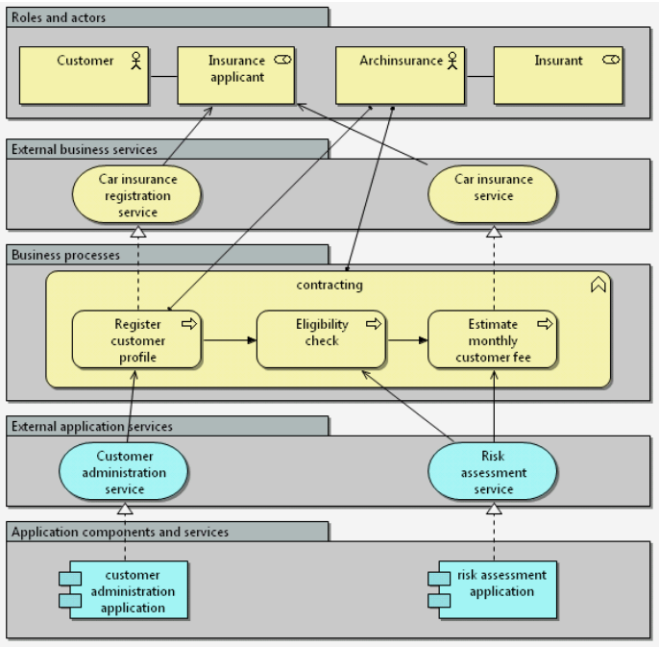

Fig. 2. ArchiSurance direct-to-customer EA model

we also see that this business process is supported by the application service "Customer administration service".

Although disintermediation reduces operational costs, it also increases the risk of adverse risk profiles [13], incomplete or faulty risk profiles of customers. These adverse profiles lead insurance companies to calculate unsuitable premiums or, even worse, to wrongfully issue insurances to customers. As a response, ArchiSurance decides to use intermediaries to sell its insurance products. After all, compiling accurate risk profiles is part of the core business of an intermediary [13].

In our example scenario, an external architect called *John* is hired by ArchiSurance to help guide the change to an intermediary sales model. John uses ArchiMate to capture the impacts that selling insurance via an intermediary has in terms of business processes, IT infrastructure and more. For illustration purposes we will focus on the translation of the new business process "Customer profile registration" to EA artifacts in the application layer. The resulting ArchiMate model is depicted in Fig. 3.

In Fig. 3 we see for example how a (new) business process "customer profile registration", owned by the insurance broker (ownership being indicated by a line between the broker and the business process), is supported by the IT applications "customer administration service intermediary" and "customer administration service ArchiSurance".

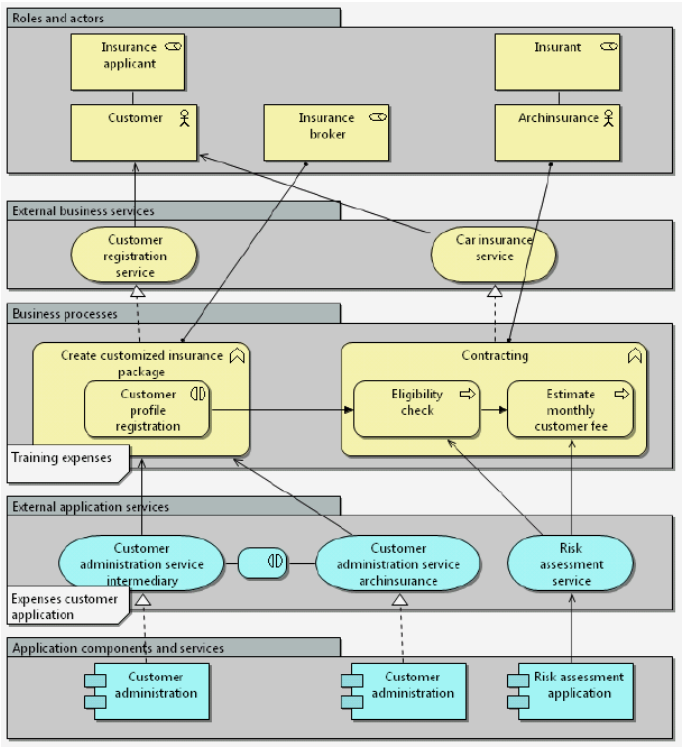

Fig. 3. ArchiSurance intermediary EA model

For this simplified scenario, 13 architectural design decisions were taken. These design decisions, in terms of our design decision concepts, were captured with EA Anamnesis by John during the transformation process.

Let us assume that a newly hired Enterprise Architect, Bob, wants to know the rationale behind the architectural design that supports the new business process of Archisurance. To this end, he relies on decision rationales captured by John. Table 1 shows one such rationalized decision: design decision 13, for the IT application "customer administration service intermediary".

As can be observed, design decision 13 regards the acquisition of the Commercial off-the-shelf (COTS) application B. Bob can determine the **alternatives**, "COTS application A" and "upgrade of the existing IT application". Furthermore, Bob determines that John's **rationale** for the selection of COTS application B was that COTS application B was more scalable.

Next, let us assume that Bob is interested in reviewing the relationship of this individual decision with other decisions. Firstly, he can identify by examining the **Layer** field that this decision is an application Layer decision. Moreover, by examining the **Impact relationship** field, he can understand that this decision

Table 1. EA decision 13 details

Title:	Acquisition of COTS application B
EA issue:	Current version of customer administration application is not capable to support maintenance and customers administration of intermediaries application service
Layer:	Application
Impact relationships:	Business: Decision 07 Application: Decision 10
Alternatives:	COTS application A Upgrade existing application (in-house)
Rationale:	Scalability: Application is ready to support new application services
Observed Impact:	Reduced performance of customer registration service business process

is related with 2 other decisions, decision 07 (a business layer decision) and decision 10 (an application layer decision).

Last but not least, Bob can inspect the possible unanticipated outcomes of this decision. By examining the **Observed impact** field, he is aware of an issue that arose in the customer profile registration business process because of the unfamiliarity of clerks with the new application interface.

For a more detailed illustration of EA Anamnesis approach, how the different concepts are interrelated and how this rationalization information is visualized, see earlier work [7].

3 Evaluation

In this section we describe the objectives of our study, the evaluation method for the validation of our decision design concepts, and limitations and considerations of the evaluation.

3.1 Objectives

The main objective of this study is to identify the usefulness of design rationale approaches in the context of Enterprise Architecture. As we mentioned in the introduction, anecdotal interviews with EA practitioners gave us a first insight regarding the perceived usefulness of design rationale approaches in EA. In particular, we aim at identifying the perception of EA practitioners regarding our design rationale concepts.

For our study we address three research questions:

Question 1:
Do enterprise architecture practitioners perceive EA Anamnesis's concepts as useful for the justification and maintenance of EA Designs?

Question 2:
To what extent do EA practitioners currently capture EA Anamnesis's concepts?

Question 3:
If rationalization information is captured, to what extent are structured templates used? (such as provided by EA Anamnesis)

3.2 Study setup

Participants: Participants were gathered during a professional event on enterprise architecture organized by the Netherlands Architecture Forum (NAF). NAF is a leading Dutch (digital) architecture organization, concerned with the professionalization of Enterprise and IT Architecture. A total of 65 people started the survey, 35 out of which actively finished the study. Given the different focus of the individuals, the number of participants for each individual part of the survey fluctuated between 33 and 35. The majority of the participants were of Dutch nationality, had at least several years of professional experience in enterprise architecture, and were fluent in the language the survey was taken in (English).
Materials: The questions and input used for this survey derived from previous research and professional workshops on the use and creation of architecture principles in Dutch knowledge management and enterprise modeling organizations. The data analyzed and used for this study derives from a subset of the total survey, which contained additional sections dealing with other, related, factors of architecture principle creation and use. All questions were presented in English because non-Dutch speakers were expected. Furthermore, the survey was planned to be extended to other European countries afterwards.
Method: The survey consisted mostly of structured and closed questions. The participants were given the context that the questions dealt with the larger area of architecture principles, specifically introducing them to the fact that principles provide a foundation for EA decisions, and what factors are important for such decisions.

To investigate to what extent the concepts of EA Anamnesis are grounded in reality, we queried for each concept (a short explanation of each concept was provided) whether participants considered them to 1) help with the maintenance of an enterprise architecture, 2) help them to justify an enterprise architecture, and 3) be currently actively documented in the participant's organization or professional experience.

For each of these dimensions participants could answer whether they disagreed, agreed, or strongly agreed with the dimension applied to the given concept. The format of the answers was adopted from a bigger survey, which was

executed by an outside party. The outside party had already structured the questions' format of this survey and as such we adopted the same answering formats in order to reduce any potential confusion as much as possible. To follow up on the current practical state of design decisions, we then enquired whether any standardized approaches or processes existed for the capturing of EA design decisions.

Participants were given the choice of either stating that, for their organization, such approaches exist, do not exist, or that they were uncertain of their existence. In the case of nonexistence of documentation approaches, participants had the possibility to expose the reasons for this through a hybrid structure with predefined answers as well as free text comments.

Data analysis: The data resulting from the main questions (whether our use case concepts help in the maintenance and justification of an EA and whether they are documented) were quantified by assuming "strongly agree" implied "agree", and that such answers could be treated as "agrees". Based on this, we calculated the total amount of "agree" and "disagree" answers for each of our concepts as they pertained to the investigated dimensions. Of course, questions that were not filled in were disregarded in our calculation. While the size of these groups did not differ much (resp. 33, 34 and 35 participants), and comparison between them should thus be a valid endeavor, care should also be taken not to assume they represent a breakdown of opinions in the exact same group. The data resulting from the question regarding the use of standardized templates for documenting EA design decisions were analyzed in a straightforward way, calculating the percentages of yes, no and uncertain answers for the group (n=35) of participants who answered this question.

3.3 Survey limitations

The main difficulty in executing this study was that our questions had to be integrated into a larger study, of which the structure and answer formats were already determined. Unfortunately, the opportunity to conduct a dedicated survey regarding design rationale with such a number of participants was quite limited due to time unavailability of practitioners. Therefore, we had a limitation regarding the number of questions we could incorporate into this larger study.

Thus, in order to ensure that participants would not feel confused by radically different question and answering formats, we had to deal with a suboptimal set of answers for our first question. Ideally, the question of whether certain concepts apply to a given dimension, would be done on a Likert scale, with equal amounts of negative and positive answers. However, as the goal of the wider survey was to elicit as much (strong) opinions as possible from practitioners, it was chosen to use answer structures which contained no neutral grounds and thus forced people to make a polarized choice.

We will take these issues into account during the analysis of our data, and attempt to account for the possible loss of nuance.

4 Results

Tables 2, 3, 4 show the survey results on to what extent EA Anamnesis's concepts help the EA practitioner to (1) maintain the architecture, (2) justify the architecture, by which we mean that the EA Anamnesis concepts can aid in motivating design decisions, and (3) to what extent EA practitioners document EA Anamnesis concepts in current practice.

For each question, we provide a division into "positive" and "negative", and a subsequent division of "positive" into "agree" and "strongly agree". We do this for the sake of transparency: on the one hand, we want to show aggregate results on positive reactions to a concept, but on the other hand we do not want to hide that the questions were posed in a possibly biased manner (as discussed in Sect. 3.3).

Furthermore, Table 5 shows us to what extent practitioners use standardized templates to capture EA design rationales. In case practitioners forego the use of standardized templates, Table 6 shows why this is so, by means of closed answers (such as "no time/budget") and open answers, whereby the architects could provide a plaintext description (such as "Enterprise Architecture is not mature enough").

Table 2. To what extent study participants (n=35) find that EA Anamnesis's concepts help with the maintenance of the enterprise architecture.

	Helps with the maintenance of EA			
Concept	Negative	Positive	Positive-Agree	Positive-Strongly agree
Rationale	9%	91%	42%	49%
Rejected Alternatives	26%	74%	43%	31%
EA Layer	9%	91%	46%	45%
Observed Impact	23%	77%	43%	34%
Decision Impact	14%	86%	40%	46%

5 Discussion

Generally, the results from Tables 2, 3 indicate that EA practitioners perceive that the EA Anamnesis concepts will help them with the maintenance and justification of Enterprise Architecture designs. This can be concluded from the fact that, for each concept, a majority of architects agrees with its usefulness for both maintenance and justification. Yet, the results from Table 4 indicate that while the design rationale concepts are considered useful, the majority of them is not documented by practitioners. While many EA practitioners capture the

Table 3. To what extent study participants (n=35) find that EA Anamnesis's concepts help with the justification of the enterprise architecture.

	Helps with the justification of EA			
Concept	Negative	Positive	Positive-Agree	Positive-Strongly agree
Rationale	18%	82%	29%	53%
Rejected Alternatives	29%	71%	44%	27%
EA Layer	38%	62%	38%	24%
Observed Impact	18%	82%	50%	32%
Decision Impact	26%	74%	44%	29%

Table 4. To what extent study participants (n=33) currently document the EA Anamnesis concepts.

	Current documentation practice			
Concept	Negative	Positive	Positive-Agree	Positive-Strongly agree
Rationale	30%	70%	55%	15%
Rejected Alternatives	73%	27%	27%	0%
EA Layer	21%	79%	40%	39%
Observed Impact	73%	27%	24%	3%
Decision Impact	58%	42%	36%	6%

Table 5. To what extent study participants (n=35) use a standardized template for documenting EA design decisions.

Question	Uncertain	Yes	No
Does your organization use a standardized template for documenting EA design decisions?	23%	40%	37%

Table 6. The proportions of the reasons that practitioners (n=33) do not use standardized templates for documenting EA design decisions.

Not useful	30%
No time/budget	3%
No suitable tool	9%
Other comments:	58%
Design decisions are documented inside PSA/PEA (Word or Powerpoint)	
Depends mostly on the client	
EA is not mature enough	
Our organization is not mature enough when it comes to EA	
General immaturity of EA departments	
We use several templates, but they are not exactly the same	
Company standard is the TOGAF template	

rationale for a decision (70%) and the EA layer (79%), a majority of them does not capture either the observed impact, decision impact or rejected alternatives.

Moreover, in cases where practitioners document decisions, 40% of them use standardized templates for documentation, while 23% of them is not aware of the existence of such templates. The remaining 37% of practitioners, that do not use standardized templates, finds that standardized templates are not useful (30%), or that there are no available resources in terms of time/budget (3%), or that there no suitable tool for this (9%). Furthermore 58% of the EA practitioners do not use standardized templates because they feel covered by documenting design decisions inside MS Word/Powerpoint. Others insist the Enterprise Architecture is not a mature practice in the organization.

A possible reason for the currently limited rationalization of Enterprise Architecture designs is that practitioners are insufficiently *aware* of the potential usefulness of design rationale techniques. This may be caused by the relative immaturity of the Enterprise Architecture field compared to areas in which decision rationalization and their tool support is well established, such as the field of Software Architecture.

Let us now discuss our findings per concept:

Rationale: The Rationale concept, which captures why a decision is taken, is considered an important concept for the majority of practitioners. Specifically 91% believe that this concept helps with the maintenance of the EA, and 82% believe that it helps to justify existing Enterprise Architectures. Interestingly however, as opposed to capturing other concepts, the current practice of documenting rationale of decisions is quite high (70%). We argue that this happens, because architects usually have to justify their design decisions to other stakeholders and the management of the organization.

Rejected alternatives: The majority of practitioners (74%) acknowledges that captured rejected alternatives information assists them with the maintenance of the enterprise architecture and (71%) of them that they are helped with the justification of the enterprise architecture. Practitioners seem to understand that this information provides a better insight into the rationalization process. We speculate that rejected alternatives, in combination with selection criteria, provide them with additional rationalization information by indicating the desired qualities which were not satisfied by these alternatives.

However Table 4 indicates that only (27%) of the EA practitioners capture rejected alternatives. We reason that the capturing effort of rejected alternatives in combination with the ignorance of the potential usefulness of this information do not motivate practitioners to document this concept. Even if this information is documented, the added value it provides is not so high because of the lack of structured documentation. However when rejected alternatives are combined with other rationalization concepts (such as criteria) it does allow one to better trace the decision making process, as is commonly done in structured rational-

ization templates for software architecture (see e.g. [11]).

Layer: 91% of the practitioners agree that the concept of layer helps them with the maintenance of an enterprise architecture. The proportion of practitioners that agree that this concept helps them to justify enterprise architectures is 62%. Although the proportion itself is quite supportive, we can observe quite a big variation compared with the question on "helps with maintenance". We argue that this is because the Layer concept is not a justification concept in itself, but when it is combined with the other design rationale concepts it can actually contribute to justification. For example, design decisions that belong to the business layer can impact decisions in the application layer.

Observed impact: A majority of Enterprise Architects (77%) recognize that the explicit information of observed impacts helps them with the maintenance of the enterprise architecture. We speculate that practitioners, while they maintain existing architectures, are expected to use information of the unanticipated outcomes of past decisions in the enterprise to avoid past mistakes. Furthermore 82% of Enterprise Architects agree that the observed impact concept helps them with the justification of the EA.

Interestingly however, despite the fact that practitioners recognize the usefulness of capturing the observed impact, only the 23% of them has a standard practice to document this concept. We believe that when an unanticipated outcome of a design decision is observed, practitioners are focused on immediately solving this issue. From a short term perspective, the documentation of this observed impact is a minor issue for them. However, in the long term, the awareness of observed impacts raises awareness of unanticipated outcomes. Another reason could be the lack of a structured environment for architectural rationalization, which would allow architects to relate observed impacts to decisions, layers (impacts on a business process or IT level), and more.

Impact (Decision traceability): A majority of the practitioners (86%) find that the impact concept can assist them with the maintenance of the enterprise architecture. Moreover, 74% indicate that this concept helps them with the justification of the enterprise architecture. Our approach provides impact (decision traceability) information by making explicit how design decisions are related to each other. The different types of decision relationships, described by decision relationships concept, provide different types of impact traceability. Regarding the documentation practice, some of the practitioners (42%) capture this concept but still the majority of them (58%) does not document it. In our view this indicates a tendency of practitioners to interrelate their design decisions and EA artifacts. However, on the other hand, we think that the capturing of decision impacts is still limited since architects lack structured ways to capture design decisions, as we can see in Table 6.

6 Conclusion

In this paper, we reported on a first empirical evaluation of the EA Anamnesis approach for architectural rationalization. Using data from a survey amongst enterprise architecture practitioners, we found that EA Anamnesis concepts are largely perceived as useful to architectural practice. Yet, we also found that the uptake of rationalization in practice is currently limited to only a few concepts, prominently "rationale". Furthermore, these few concepts are captured in an ad hoc manner, thereby forgoing structured rationalization approaches such as EA Anamnesis.

Finally, we speculated on (1) the distinction between perceived usefulness of rationalization concepts on the one hand, and the uptake in practice on the other, and (2) the seeming current limited use of a structured template for rationalization. A possible explanation is the relative immaturity of the field of Enterprise Architecture, compared to fields where rationalization is well accepted, such as Software Architecture. Such immaturity manifests itself in a lack of awareness of rationalization, including recognizing its potential usefulness for tracing design decisions, as well as in a lack of structured templates for documenting design decisions in enterprise architecture.

However, as we test only the *perceived* usefulness of EA Anamnesis concepts, we should use a single in depth case study to further investigate the claims made in this article. For one, the difference between perceived usefulness and uptake may also be caused by the effort that it takes to capture rationalization information, in addition to a lack of structured templates and usefulness awareness.

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