Qualitative Comparison of Enterprise Architecture Model Maintenance Processes

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Abstract: Enterprise Architecture (EA) is no end in itself but has to provide central, important, and up-to-date information of the organization to its clients. So far, different researchers have elaborated on processes to ensure a (semi-)automated EA model maintenance. For practitioners this raises the question how the processes can be compared to each other. To answer this question, we identified a set of five quality criteria and asked EA researcher and practitioners to rate those for three processes.

Keywords: EA Model Maintenance; Comparative Study; Quality Assessment; Quantitative Study

1 Introduction

Information technology (IT) pervades organizations more and more and becomes further important for the business [VSM10]. Furthermore, the integration of business requirements with implemented IT functionality becomes more important. Consequently, the business-IT alignment has been most important for CIOs of different industries and different organization sizes for a long time [Lu05, LBZ10]. To promote the business-IT alignment, more and more information system (IS) change and development projects focus on the realization of technical solutions for local business needs. Enterprise Architecture (EA) is a widely accepted discipline to guide local IS endeavours through a holistic view on the fundamental structures, design, and evolution principles of the overall organization [BY06]. EA eases the alignment of IS projects with enterprise-wide objectives, which leads to reduced complexities as well as integration efforts in the overall corporate IS landscape [AW09, Pl07].

Since it beginnings in the 1980's [Ko16], EA has developed to an established discipline in industry and research. A widely accepted definition of the term architecture is given in the ISO 42010:2011, which defines architecture as the "fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution" [III11]. As this definition implies, the EA model, comprised by the elements and relationships of the organization, is one central artifact of EA. The model provides a holistic view on the organization and, therefore, eases the value creation for EA's stakeholder [NP13].

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EA is no end in itself but has to provide central, important, and up-to-date information of the organization (e.g., business processes, application and data architectures, or infrastructure components) to its clients, for instance, to all projects of an organization. There are a lot of different drivers for changes of the EA model [Fa12], which contribute to a continuous evolution of the EA. However, the input can be contradictory, for example, because the interaction between data providers and the EA is not coordinated systematically, leading to a state where EA model and the information offered by different data providers are not in sync, but inconsistent.

So far, different researchers have elaborated on processes to ensure a (semi-)automated EA model maintenance (see [FAW07, Mo09, HL18]). For practitioners this raises the question how the processes can be compared to each other. We focus on quality aspects and, accordingly, we wonder first:

What are important quality criteria of EA model maintenance processes?

After answering this question, we can move forward to our research question:

How differ certain EA model maintenance processes with respect to these quality criteria?

To answer this question, we identified five quality criteria and asked EA practitioners and EA researcher to rate three different EA model maintenance processes [FAW07, Mo09, HL18] based on this quality criteria.

The rest of this work is structured as follows: First, we present in Section 2 which quality criteria we like to test and their interrelation, as well as how the questionnaire is designed, and the way we collected the data. Section 3 presents the three processes, which should be assessed as well as how we prepared them for evaluation. The results are outlined and discussed in Section 4. Before we come to the conclusion, we present some related work.

2 Methodology

2.1 Tested Quality Criteria

Assessing the quality of a process is quite challenging. Especially, if the process cannot be applied in reality but has to be assessed based on its description only, as in our case. Therefore, we wanted to create a set of quality criteria, which captures a broad range of process facets. Additionally, the set should not be too big so that the participant can keep the different criteria in mind. First, we evaluated our own quality framework to rate EA models [Ti17]. Unfortunately, our framework assesses only the model quality and no deeper aspects of the process.

Next, we searched for a small set of quality criteria and ended up with the well-known eight dimensions of quality [Ga87]. However, those quality criteria are related to products

and, therefore, some criteria are hardly applicable to our issue. For example, aesthetics is a criterion, which does not really matter for processes.

Last, we evaluated quality criteria arising from the domain of software engineering [LL13, p. 66]. We reduced the extensive set of quality criteria by removing those, which does not suit the issue of rating process quality. For example, we neglect modularity, as we do not want to assess the reusability of the processes. Following, we present the five quality criteria, we use to compare the three processes to each other:

- **Comprehensibility** describes how easy the process model can be understood.
- **Effectiveness** relates to the capability of the process under inspection to keep an enterprise architecture model up-to-date. When something is deemed effective, it means it has an intended outcome.
- **Completeness** assesses if the process contains all the necessary process steps to maintain an enterprise architecture model.
- **Minimality** reflects if the process contains only those process steps that are necessary to maintain an enterprise architecture model.
- **Efficiency** presents to which degree the process is perceived –in terms of time– to maintain changes into an enterprise architecture model.

We expect that the beforehand introduced quality criteria are not completely independent from each other. First, we anticipate a strong mutual correlation between completeness and effectiveness. This is grounded in the fact that a process, which is not complete, can be hardly effective as if something is missing effectiveness cannot be guaranteed. Same holds vice versa, because if a process is not effective, it is likely that something is missing within the process. Nonetheless, –up to our mind– effectiveness and completeness are not the same. We argue that, for example, just small parts of the process could be missing which have a strong influence on the perceived effectiveness.

Second, we expect a mutual correlation between minimality and efficiency. If a process is minimal, there are no additional parts, which could slow down the process and, therefore, decrease its efficiency. Same holds vice versa, as the most efficient process does not contain unnecessary process steps. However, we do not expect the correlation between efficiency and minimiality as strong as between completeness and effectiveness, because efficiency of the whole process is strongly related to the efficiency of each process step, which is not the case for minimality. Last, we expect a positive correlation between minimality and comprehensibility, as we think that it is easier to understand a process which is minimal than a process which is not.

We will check our beforehand stated assumptions in Section 4.1 and if necessary, we will discard a criterion.

2.2 Questionnaire Design

To collect the necessary data, we created a seven-page questionnaire in German and English language. The first page introduces the research topic, and defines the targeted group of participants.

The second page explains the expectations towards the participant and introduces the five quality criteria to be assessed (cf. Section 2.1). Both pages have in common that they contain a not negligible amount of text to create a *high hurdle* [Re02]. Doing so, we want to sort out participants, which are not motivated to answer our questionnaire and reward the other participants as it is easier to capture the whole content on the following pages.

The next three pages present in each case one of the processes in a unified representation (see Figure 1, 2, and 3). Therefore, we sketched the processes in a "box-and-lines" notation, because we want the participant to focus on the process itself and not on notations. Additionally, we give a short description of the process' aim, followed by a characterization of all included roles. We unified also the role names and their description to ease the understanding of the different processes. Additionally, we provide an abstract of the process itself.

As the participant got all information she needs to assess process' quality, we ask her to rate every quality criterion on a five-point Likert-scale [Da08] to which degree the process suits the criterion from 1 (not) to 5 (perfect). If she is not able to assess a certain criterion, she can also indicate this. After rating the criteria, we offer the participant to give qualitative feedback on each process, too.

The sixth page is facilitated to collect demographic information on the EA experience of the participant and her organization. Further, she can also provide feedback on the questionnaire or give other comments.

On the last page, we ask the participant on her seriousness and consent to use her data. This is a common technique to exclude questionnaires which were not seriously filled [TW12, p. 114f].

To ensure usability of our questionnaire, we conducted a three-stage development. In the first step the first author created the questionnaire and the second author checked it for any flaws. In the second stage, the questionnaire was distributed within the research group of the authors to check for flaws and to determine the necessary time to answer it. In the last stage, the questionnaire was distributed throughout several EA practitioners for a last check.

2.3 Data Collection

We distributed the questionnaire among different channels to reach as many EA practitioners and researcher as possible. Therefore, we asked our industrial cooperation partners to answer

the questionnaire and to distribute it also to other EA practitioners. Additionally, we asked the participants of three regional EA related meetings to answer the questionnaire. To get responses of the scientific EA community, we send the questionnaire to our research network and distributed it through several EA related e-mail-lists.

In total, we received 123 questionnaires, which finished at least the questions related to the processes. First, we removed all questionnaires where the participant stated that she did not answered the questionnaire seriously ending up with 100 questionnaires. Second, we checked the demographic answers of the questionnaires where the participant did not answer the question regarding conscientiousness. As those answers seemed to be very randomly (e.g., 999 years of experience in EA or 1000 architects employed in a medium sized organization), we removed further 20 questionnaires.

The most of the left 80 participants are employed within the IT sector (27.5%), followed by the insurance sector (16.3%). 18.8% are working in an organization with more than 10,000 employees, followed by 15% working in an organization with 1,000 to 2,500 employees. However, the participants are likely distributed along all organization sizes and gained an experience of 3.8 years in average. The predominant part of the participants works as an employee without personnel responsibility (60%), followed by 16.7% working in the operational management (e.g., team or group leader). In average, the companies employed around 18 enterprise architects and the median is at 5. The companies have in average an EA initiative since 6.6 years in place.

3 EA Model Maintenance Processes

Following, we present the three processes we evaluate. We restrict us to three processes to stick in a period of maximum 15 minutes to answer the questionnaire. The first process [FAW07] focuses on the integration of information distributed in different systems and is highly cited. The second process [Mo09] focuses on the integration of information from different sources and is highly cited. The third process [HL18] is designed by the authors and focuses on integrating information generated by projects.

3.1 Process 1: A Federated Approach to EA Model Maintenance

The process presented at [FAW07] focuses on the integration of information distributed in different systems. Essentially, four different roles are assigned to the process:

- **EA Coordinator:** EA coordinator is part of the EA team and reports to the Chief Architect. Her main tasks include improving the EA meta-model, maintaining the EA model, and designing EA reports.

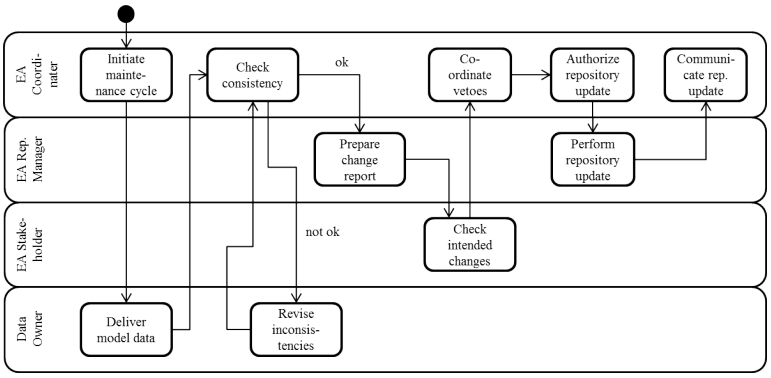

Fig. 1: A Federated Approach to EA Model Maintenance [FAW07].

- **EA Repository Manager:** The focus of the EA repository manager is more technical. She is responsible for user administration, software updates, and the repository update.
- **EA Stakeholders:** EA stakeholders are business and IT departments that use EA information, e.g., to implement the strategy or security management.
- **Data Owner:** A data owner is responsible for a system whose data is to be transferred to the central EA model.

The process (see Figure 1) starts with the EA coordinators wanting to update the EA model and, for that reason, requesting up-to-date information from the appropriate data owner. Once she has delivered the information, the EA coordinators check the information for consistency. If inconsistencies persist, the data owner is notified and revises the information accordingly.

If the consistency check was successful, all changes to the EA model are identified and made available to all affected stakeholders. They review the changes and, if vetoed by a stakeholder, the EA coordinators coordinate a discussion to resolve the differences between stakeholders and data owners. After everyone agrees to the changes, the EA model can be updated and the changes communicated.

3.2 Process 2: Process Patterns for EA Management

The process of Moser et al. [Mo09] focuses on the integration of information from different sources. Essentially, three different roles are assigned to the process:

- **Domain Expert:** Domain experts are a subset of EA's stakeholders. They formulate information requirements to the EA and are recipients of the information.

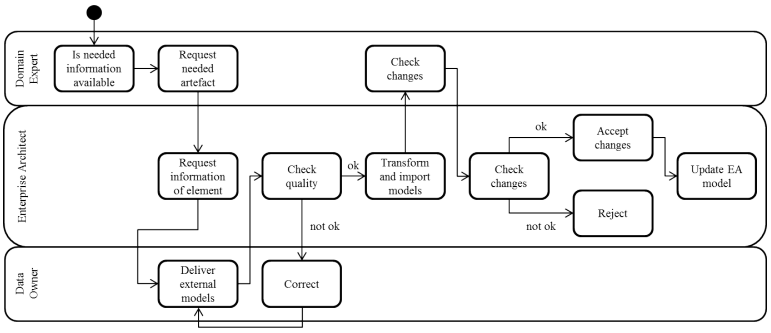

Fig. 2: Process Patterns for EA Management [Mo09].

- **Enterprise Architect:** Enterprise architects are responsible for maintaining and keeping the EA model up-to-date.
- **Data Owner:** A data owner is responsible for a system whose data is to be transferred to the central EA model.

The process (see Figure 2) starts when a domain expert notices that she does not have all the information she needs for a particular task. Therefore, she asks the enterprise architects for this information. These check the request and contact the data owner who holds the corresponding information. She provides the information to the enterprise architects, whereupon they check its quality. If the result of the check is negative, the data owner improves the information.

Once the quality check has been successfully completed, the information is transformed and prepared for import. Before that, the changes will be checked by domain experts and enterprise architects. If there is no objection from any side, the information is imported and the updated EA model is made available.

3.3 Process 3: A Roundtrip Based EA Model Evolution

The process presented in [HL18] focuses on integrating information generated by projects. However, the projects can also be replaced by any other source of information. Essentially, two different roles are assigned to the process:

- **Enterprise Architect:** Enterprise architects are responsible for maintaining and keeping the EA model up to date.
- **Solution Architect:** The solution architects develop a solution for the project that evolves the EA and, thus, the EA model. Therefore, these changes have to be included in the central model.

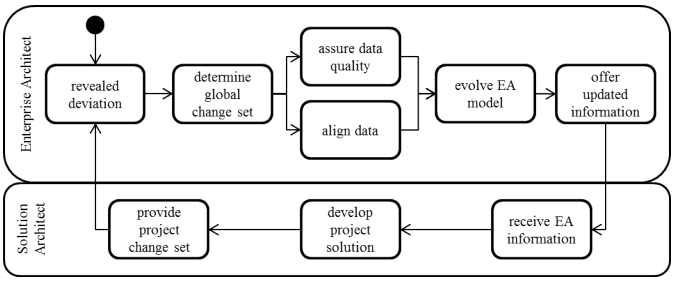

Fig. 3: An EA Model Evolution [HL18].

The process (see Figure 3) starts when enterprise architects identify changes in the EA and want to incorporate these changes into their core EA model. First, all changes that should be included in the next evolution of the EA model are captured. Subsequently, the data is quality-assured and aggregated to the necessary abstraction level of the EA model. Afterwards, the changes can be incorporated into the central EA model and the updated model distributed to the EA stakeholders.

For example, new projects receive this information and model the changes they make. These changes are then made available to enterprise architects and are the starting point for the next evolutionary step.

3.4 Preliminary Assumptions

Bringing the quality criteria and the processes together, we can formulate some assumptions how the processes are related to each other. First, we expect that process one and two are less comprehensible than process three as they include more process steps and roles. The plenty of process steps and roles in process one and two causes also our expectation that the third process gets the best rating for minimality.

As the third process includes no explicit negotiation between the different roles, we expect that the participants perceive this one as the most incomplete. Towards effectiveness and efficiency, we have no concrete expectations.

4 Results and Discussion

Following, we will present the results of our survey. As the participants could choose not to rate a certain criterion, we like to mention that only the comprehensibility was always rated. The efficiency of the processes was answered scarcest with a ratio of 93% (see Table 1).

Tab. 1: Descriptive Analysis of the Given Ratings.

	Comprehensibility			Effectiveness			Completeness			Minimality			Efficiency		
Answering Ratio	1.00			0.98			0.95			0.98			0.93		
Process	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Median	4	4	4	3	4	3	4	4	3	3	3	4	3	3	3
Mean	3.65	3.84	3.80	3.33	3.44	3.34	3.68	3.49	3.33	2.94	3.32	3.58	3.16	3.24	3.35
SD	0.85	0.74	0.71	0.77	0.76	0.75	0.70	0.83	0.85	0.74	0.71	0.79	0.89	0.79	0.70

4.1 Dependencies Between Quality Criteria

To test if our questionnaire might contain criteria, which are coupled too close to each other, we calculated ρ_T according to [Ch16]. Commonly, $\rho_T > 0.7$ means that the conducted items are in an acceptable matter linked to each other. As we calculate a value of 0.697, we can assume that we measure different concepts in our questionnaire. However, the value is close to 0.7 and, therefore, we calculate for each pair of our criteria ρ_T. As a result, we recognize for effectiveness and efficiency a value of 0.76. All other values are lower than 0.6.

To test the expected dependencies between our criteria, we calculated the Pearson correlation [Pe95] for each pair of criteria. We assume that an absolute value greater than 0.66 means a strong correlation and an absolute value between 0.66 and 0.33 a weak correlation. First, we can confirm a correlation between completeness and effectiveness. However, the correlation is not as strong as expected with a value of 0.42. Second, we found also a correlation between efficiency and minimality (0.39). Third, we could not uncover a correlation between minimality and comprehensibility (0.27).

Apart from the expected correlations, we notice a strong correlation between effectiveness and efficiency (0.62) and weak correlations between comprehensibility and effectiveness (0.34) as well as between completeness and efficiency (0.34). We assume that the correlation between effectiveness and efficiency can be explained by the fact that people often struggle to differentiate between both terms. This could also explain the unexpected correlations between completeness and efficiency as we expected a correlation between completeness and effectiveness. The correlation between comprehensibility and effectiveness can also be explained by the confusion of efficiency and effectiveness and a transitive relation along minimality.

4.2 Process Comparison

We show the results of the descriptive analysis of all responses in Table 1. Every quality criterion contains three values per measurement where the first value represents the first process, the second value represents the second process, and the third value represents the third process.

Following, we will discuss the insights we gathered from the survey:

- **Comprehensibility:** The comprehensibility is very likely perceived among all process models very likely. However, the first process achieved a smaller mean as the other processes as well as the standard deviation (SD) is higher, indicating a bigger uncertainty. On the one hand, this is surprising as the second process contains more process steps and more decisions. On the other hand, process one comprises the biggest set of roles. Therefore, we conclude that the amount of roles is more important for the perceived comprehensibility of a process model than the number of elements and decisions within a process.
  Additionally, we expected the third process to be most comprehensible as it is the simplest model. But, this is not the case. Consequently, a too abstract description – resulting in fewer process steps– does not necessarily lead to a better comprehensibility.
- **Effectiveness:** The participants perceived the effectiveness of the processes similarly according to the mean and SD. Only process two seems to be a little bit more effective as the median is higher than for the other processes. This may stem from the fact that process two lasts of the most process steps and, therefore, the participants assume that it is most effective.
- **Completeness:** In accordance to our expectations, the third process got the lowest scores for completeness, because it is the simplest process and the participants are missing certain steps (e.g., “The process is missing certain information”, “There are no binding criteria for reporting deviations or need for action.”, or “Does the enterprise architect get all needed information”). Additionally, the participants are very discordant about the completeness as the SD is 0.85, which is the second highest score in general.
- **Minimality:** The minimality scores are as expected. In accordance to our observations at comprehensibility, we can recognize that the plenty of roles in process one have a bigger effect on the minimality than the plenty of process steps and decisions in process two. Furthermore, we can appreciate a higher influence of this fact. The participants also stress this as they state that “the plenty of roles lead to a communicative overhead” and the necessity to coordinate vetoes every time is questioned.
- **Efficiency:** All processes have in common that they are not perceived as very efficient. Again, process one gains a lower score and the participants are very uncertain. The communication between the different roles seems to be the main driver for this low score. This is in line with the feedback of the participants as they think that “reconciliation with so many parties may lead to efficiency losses” and that “there are too many communication channels”.

Apart from the feedback directly related to the quality criteria, we can differentiate two divergent groups related to the complexity of the processes. The first group advocates for a “lean” maintenance process and claim a reduction of process steps and roles in processes one and two. The second group demands not only more roles and steps in process three but also further reconciliations in process two.

A further point, which should be considered, concerns all processes: Several participants remark a neglect of business stakeholder in the processes (e.g., “The maintenance of EA artifacts must also be handled by the business side”). They should not be “demoted to be only the auditor”, but “actively involved into the [EA model] maintenance”.

To summarize, if the organization tends to be more “agile” or “lean” the third process would be the best guess. If the organization tends to be more “classical” with strict hierarchies and lots of different stakeholders the second process suits best. The first process was never able to outperform the other processes in a significant manner.

5 Related Work

To the best of our knowledge, there was so far no study conducted to compare different EA model maintenance processes to each other. Therefore, we rely for related work on the assessment of business process quality and the comparison of business processes.

Different works have been published aiming the assessment of business process’ quality. For instance, Heravizadeh et al. [HMR09] assess the dimensions of business process quality by focusing on the gap between as-is and to-be process modeling. Heinrich and Paech [HP10] facilitate the body of knowledge in software engineering and develop a set of criteria to assess business process’ quality. Lohrmann and Reichert [LR13] build on the aforementioned results, take a management perspective, and propose a framework for business process quality. Additionally, they demonstrate their means with an illustrative case.

Apart from the quality of the business process itself, there have been also research conducted on the quality of business process models. For example, van der Aalst [va98] introduce the soundness of workflow nets, Rinderle et al. [Ri05] elaborate on quality issues with respect to a case-based capturing of knowledge, and Ly et al. [Ly11] propose a means to ensure compliance of business processes to global rules and regulations.

Research on the comparison of concrete business processes appears seldom. Mostly, comparative research in the domain of business processes is related to business process modeling techniques. However, there is some research around. Dijkman et al. [Di11] propose three metrics to compare the similarity of processes. Kunze et al. [KWW11] suggest a further metric relying on the behavioral similarity of processes. In contrast, Venkatraman and Ramanujam [VR86] focus on a classification scheme, which permits the classification of an exhaustive coverage of measurement approaches and provides a framework to discuss merits and demerits of processes.

6 Conclusion & Threats to Validity

Within this work, we wanted to compare different EA model maintenance processes based on their quality. To answer this question, we identified a set of five quality criteria and asked EA researchers and practitioners to rate those for each process. Facilitating the outcome of this questionnaire, we cannot answer the question which process is qualitatively best in general. In point of fact, the answer is related to the setting the process should be deployed: Process three suits best in an "agile" environment while process two suits better in a "classical" environment.

Our work offers insights for future EA model maintenance designs: All processes lacked the integration of the business side. The participants stressed that it is necessary to involve the business stakeholder actively into the maintenance. This would result in a shift from a central maintained EA model to a local maintained model.

Last, our survey incorporates some limitations. First, the 80 answered questionnaires are not representative for the complete population of all EA experts. Additionally, there is a selection bias as we asked mainly EA experts from Europe in general and German speaking countries in special. However, we believe that our questionnaire gives a good insight into the perception of maintenance process' quality. Second, we focused on a set of five quality criteria to keep the questionnaire lean. Obviously, there are other quality criteria, which could be assessed, too. Nonetheless, none of the participants remarked that an important criterion is missing.

Third, we neglected nearly one third of the questionnaires, because the questionnaires were either not answered seriously or we thought that the answers were filled randomly. This might be grounded in the fact that we distributed our questionnaire through several channels. Thus, a lot of people might want to have a look. This could also explain the relatively high standard deviations. Fourth, the participants seemed to be confused by the terms of efficiency and effectiveness. Hence, the results on these both criteria should be considered with caution.

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