INVESTIGATING THE STATE-OF-THE-ART IN ENTERPRISE ARCHITECTURE MANAGEMENT METHODS IN LITERATURE AND PRACTICE

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In recent years, enterprise architecture (EA) management has emerged to one of the major challenges for enterprises. When looking for guidance in this field companies can choose from a variety of EA management approaches, which have been developed by scientists, practitioners, and governmental organizations. However, these approaches differ significantly in a number of characteristics and especially when it comes to methods for the EA management function. There is neither a common understanding of the scope and content of the main activities an EA management function consists of nor has a commonly accepted reference method been developed.

This paper represents a first step towards a common understanding of the EA management function by investigating prominent approaches in literature on EA management methods. Based on the literature analysis hypotheses describing the state-of-the-art are derived. These hypotheses are tested for their relevance in practice in an online survey among enterprise architects. The paper discusses the findings and concludes by proposing future areas of research.

Keywords: Enteprise architecture management function, literature analysis, state-of-the-art in practice, empirical survey.

1 INTRODUCTION

Over the past decade a plurality of enterprise architecture (EA) management approaches with fairly different characteristics has been proposed by academia and practitioners. Some of these approaches can be described as frameworks (cf. The Open Group, 2009 and Zachmann, 1987), some propose modeling languages for EAs (cf. Frank, 2002 and Jonkers, 2004) and others delineate certain EA management activities (cf. Niemann, 2005 and Lankhorst, 2005). While some of the approaches suggest to conduct EA management in the course of an EA project (cf. The Open Group, 2009), which implies that there is a defined point of time when the project is completed, others regard an EA management as a continuous management function that needs to be established similar as other enterprise-level management functions (cf. Hafner and Winter, 2008). The latter perspective is the one, we pursue in the course of this paper as we regard EA management as an continuous and iterative management function. In many EA management approaches the method-related parts are described on a rather abstract level and have not yet reached the level of maturity that they deserve considering their contribution to the competitiveness of enterprises (Wegmann, 2003). The aim of this paper is to provide a detailed overview focusing on the method constituents of an EA management function, both from the perspective of prominent EA management approaches and as experienced in practice. Thus, the following research questions are answered by this paper:

- How are methods or activities of the EA management function described in literature?
- What are the characteristics of methods or activities of the EA management function in practice?
- How is the integration of the EA management function to other enterprise-level management processes realized?
- How is performance measurement of the EA management function implemented?

To answer these research questions a literature analysis focusing on the method-related parts of well-known EA management approaches is performed. Based on the analysis results an online survey is developed and conducted among EA practitioners, which aims at detecting the state-of-the-art.

In EA management literature a variety of definitions for EA management exists. On that account the notions of architecture, enterprise architecture, EA management, and method are defined and explained subsequently in order to provide a common terminology for the remainder of the paper. When it comes to defining EA most papers cite the ANSI/IEEE Std 1471-2000. Accordingly, architecture is defined as “the fundamental organization of a system embodied in its components, their relationships to each other, and to the environment, and the principles guiding its design and evolution” (IEEE, 2000). EA can then be defined as the coherent and holistic architecture of an enterprise, which comprises both IT (information technology) and business elements. It does not solely consist of elements such as the organizational structure, business processes, applications, and infrastructure elements, but also contains their relationships and crosscutting functions like strategies & objectives, requirements & projects, blueprints & patterns and KPIs & metrics (Wittenburg, 2007). As pointed out in the previous definition most EA frameworks distinguish several EA layers reaching down from business to IT infrastructure, but the number of layers varies. Fischer and Winter (2006) for example propose five layers whereas Niemann (2005) suggests only three layers. An EA description can be used in fairly different ways. On the one hand it might serve as a means for satisfying information needs of the various stakeholders while on the other hand it can also be used to perform analyses. In Aier et al. (2008) a number of usage scenarios for EA descriptions are depicted, e.g. IT/business alignment, business continuity management and compliance management. A further important term is EA management, which according to Buckl et.al. (2009) is “a continuous, iterative (and self maintaining) process seeking to improve the alignment of business and IT in an (virtual) enterprise. Based on a holistic perspective on the enterprise furnished with information from other enterprise level management processes it provides input to, exerts control over, and defines guidelines for other enterprise level management functions”. The goals of EA management are continually aligning business and IT (Matthes et al., 2008), creating and maintaining transparency, supporting agility, and preserving consistency of designs on the business and the IT-related EA layers (Hafner

and Winter, 2008). In general a method may be defined as "a systematic aid that guides the transformation of a system from an initial state to a target state" (Aier and Riege, 2009). It is unlikely that suitable EA methods exist for every possible problem situation and therefore it is recommended to adapt already existing methods or to combine dedicated method components or fragments. In the following section selected EA management approaches from literature are described in detail focusing on the method-related parts. Section 3 is concerned with analyzing the different EA management approaches and deriving hypotheses, which are subsequently falsified in an online questionnaire. Furthermore, the compilation of the survey for investigating the state-of-the art in EA management practice is depicted. Section 4 is then concerned with testing the hypothesis and analyzing the survey results. The concluding Section 5 summarizes the findings and gives an outlook on future research potential in the field of EA management methods.

2 EXISTING LITERATURE ON EA MANAGEMENT METHODS

Over the last years a multitude of EA management approaches have been developed both by scientists (Frank, 2002; Hafner and Winter, 2008; Lankhorst, 2005; Ross et al., 2006; Wegmann, 2003) and practitioners (Dern, 2006; Keller, 2006; Niemann, 2006; The Open Group, 2009; Schekkerman, 2008; Zachmann, 1987). The public sector has also contributed via the architecture frameworks DoDAF (Department of Defense, 2009) and FEAF (The Chief Information Officers Council, 1999). In the following, selected EA management approaches are described focusing on the EA management methods they contain.

The Open Group Architecture Framework (TOGAF) (The Open Group, 2009) is probably the most well-known framework for EA management. It is composed of seven parts of which one – the *Architecture Development Method (ADM)* – describes the EA management function from a method perspective. The ADM constitutes a step-by-step approach to developing an EA and delineates a cyclic process of continuous architecture definition and realization. The ADM cycle, which should be executed within a project, consists of different phases which are further divided into steps. The initialization of the ADM cycle is performed in course of the *preliminary Phase*. During this phase decisions about the scope of the management function, the EA team, and architectural principles are made. Moreover, the architecture framework tailored to the enterprise-specific requirements and architecture tools are implemented. During the *architecture vision* phase, which is the initial phase of the ADM cycle, the architecture project is set up, stakeholders are identified, and the scope is defined. Furthermore, architecture principles are confirmed and the architecture vision is created. The following three phases *business architecture*, *information systems architecture*, and *technology architecture* are concerned with investigating current architectures and developing target architectures on the respective layers. Gap analyses are performed between the current and the target architectures and based on the results a roadmap is compiled. Additionally, stakeholder reviews are performed and the respective architectures are documented in the architecture definition document. The phase *opportunities and solutions* addresses the initial implementation planning by identifying major work packages and transition architectures. In addition, the high-level implementation and migration strategy is formulated. During *migration planning* the different migration projects are prioritized and the transition architecture increments are confirmed. The implementation and migration plan as well as the architecture definition document are finalized. In the succeeding *implementation governance* phase deployment is monitored and post-implementation reviews are performed. The *architecture change management* phase is concerned with measuring performance and establishing procedures for managing change to the new architecture. The parallel activity of *requirements management* identifies and stores requirements and feeds them into the adequate phases of the ADM cycle.

According to Wegmann (2003) EA methodologies are largely based on experience and good practices, but they do not have theoretical foundations. The *Systemic Enterprise Architecture Methodology (SEAM)* therefore is based on the systemic paradigm, which regards an organization as a hierarchy of systems that span from business down to IT (Wegmann, 2007). The *SEAM Philosophy* explains the concepts used to model systems and the relation between these models and reality. Based on the constructivism principle SEAM assumes that no observer-independent descriptions of reality exist.

Hence different abstractions or viewpoints exist that specialists develop in order to simplify their understanding of the modeled systems. When actual enterprise models are developed the EA team has to choose between the different perceptions of reality and therefore experience plays an important role. In SEAM an EA team is conceived as a multidisciplinary team, which is composed of *specialists* and *architects*. Architects federate efforts of specialists to ensure the success of projects. Such a SEAM project is iterative as an enterprise being a complex system is subject to continuous evolution. As a result the specialists adapt the model to represent the changes. The *SEAM Method* suggests three different kinds of development activities, which may occur both sequentially or in parallel. During *multi-level modeling* new models are created or already existing enterprise models are modified. The specialists thereby define or modify the according organizational levels and thus describe their perception of goals, processes, and infrastructure. Identifying and resolving gaps is the goal of *multi-level design*. A gap is defined as the difference between what exists and what should exist. In order to bridge the gap the EA team has to develop the corresponding organizational levels to-be and deploy them. Thereby the EA team has to find adequate tradeoffs as usually multiple gaps exist that cannot be resolved independently of each other. The third activity is *multi-level deployment*, which is concerned with the transformation of what is described in the different organizational levels to-be into artifacts, e.g. executables, plans. Business and IT alignment with SEAM is delineated in detail in Wegmann (2007) by means of an example. The alignment is achieved by aligning the different views of the same system, i.e. ensuring the behavioral equivalence of the systems described in the views.

For developing, using, and maintaining an EA, Niemann (2005) proposes an iterative and stepwise process. This process is described in form of a cycle with the four cyclic phases of *document*, *analyze*, *plan*, *act*, and a parallel *check* phase. The *document* phase addresses collecting and structuring information about the current state of the EA. Thereby models are defined, implemented, and populated, which contributes to the communication of the EA. Niemann divides an EA into three layers: business architecture, application architecture, and system architecture. While modeling, the architects have to document the cross-references between these layers and also between the layers and the requirements. It is furthermore important to decide upon the appropriate levels of detail for the different stakeholder-specific views. Niemann explicates a multitude of views on each architecture layer and thus states *what* should be modeled. However, the approach does not explain *how* information can be collected, captured, and consolidated. On basis of the documentation of the preceding phase, the *analysis* phase is concerned with weak-point analyses. The results can be used to identify potential measures for maintenance, improvement, and renovation. Niemann describes different areas of analysis (e.g. complexity, heterogeneity, dependencies …) together with appropriate methods and visualizations of the results. Based on results from the previous phase new IT development plans are derived in the *plan* phase. They address the application landscape as well as the underlying infrastructure and are a supplement to the portfolio management. Thus, it is ensured that besides fulfilling the demands of the business side, the stability and long-term integrity of the application landscape are also taken into account. For obtaining an IT development plan at first different scenarios are developed, which characterize possible future states of the EA. Those scenarios are subsequently assed with respect to their impact on business and IT goals, costs, and risks. Niemann presents several visualizations (e.g. kiviat diagram, process support map), which support the assessment process. In a further step the gaps between the current state and possible future states are analyzed and finally the IT development plan is derived. This plan is put into practice during the *act* phase. According to Niemann (2005) it is essential to set up appropriate organizational structures and processes for EA management. At first, the processes of strategic and operational architecture management have to be introduced together with corresponding tools and methods. Moreover, goals and standards have to be set and the different architectural roles need to be defined. Secondly, EA management has to be located in the organizational structure. Depending on the size and complexity of the IT organization different forms of occurrence exist. EA management can be central or decentral, it has either staff or line function and strategic and operational architecture management can be separated or not. The parallel *check* phase is concerned with measuring and monitoring the performance of the four cyclic phases. For this purpose key performance indicators are defined and Niemann suggests utilizing an EA management scorecard with the perspectives of efficiency, safety, EA process, and effectiveness.

Winter and Hafner explicate in Hafner and Winter (2008) a process model for application architecture management, which was derived from three case-specific process models from the insurance and banking sector. This consolidated process model can be used as a reference for establishing company-specific EA management functions. However, it must be kept in mind that the process model is restricted to enterprise application management. Hafner and Winter introduce four phases with a given order and a feedback loop: *architecture planning, architecture development, architecture communication*, and *architecture lobbying*. During the architecture planning phase strategic requirements from IT as well as from the entire enterprise are identified and explicitly addressed. Furthermore, the existing current, planned and target architectures are assessed and adaption requirements are thus identified. In doing so architecture principles are derived, defined, and updated. In the successive architecture development phase further strategic and also operational requirements are captured, consolidated, and also prioritized. On the basis of these requirements, architecture artifacts are piloted and subsequently developed and integrated into the entirety of architectural artifacts. The architecture communication phase is at first concerned with the identification of target groups. In a further step the previously developed architectural artifacts are communicated to the respective target groups. The last phase of architecture lobbying can be seen as a part of the communication function of EA management. Strategic and operational assistance is provided for target group projects, which ranges from mere consulting to direct collaboration in the project. Standardized tool and method components are made available to the projects and finally projects are also assessed. Feedback from these communication activities reveals the diffusion and effectiveness of the architecture and influences the next architecture planning phase by means of a feedback loop.

In Dern (2006) describes an architecture pyramid with layers reaching from strategy and business architecture down to infrastructure architecture. The pyramid is supplemented with several architecture processes of which IT architecture management is regarded as the central process. Dern here differentiates coarsely the phases of *architecture planning* and *architecture development*. For each of the phases three detailed workflows are defined. Architecture planning is concerned with analyzing and assessing the current IS (information system) portfolio and thus derives the target portfolio. Moreover, requirements are recorded and analyzed with respect to their impact on existing architectures. Finally, management decides which requirements will be implemented during the succeeding phase of architecture development. In this phase the focus is on the iterative development of the conceptual, logical, and physical layers of IT architectures. At first, success criteria are defined and requirements and scenarios are consolidated. In a further step, the appropriate scenario is selected and the architecture is drafted, refined, and validated. Dern propagates close relationships between architecture planning and IT project portfolio management as well as between architecture development and the process of software development. Dern describes in (Dern, 2006) a way to introduce architecture management. At the beginning, the current state is analyzed and the target state is defined. Then a roadmap is developed and mechanisms for controlling the deployment are defined. Thereby, it is important to define roles (e.g. IT architect, service manager) and boards (e.g. architecture board, application board) as well as integrating these into the organizational structure.

Lankhorst et al. unlike many other approaches do not propose an own process model but explicate in detail certain topics relevant in an EA management process model. In Lankhorst et al. (2005) focus on communicating, modeling, visualizing, and analyzing EAs. These EA activities are supported by the EA description language *ArchiMate*, which has been introduced in Jonkers (2004). For *communication* at first a theoretical introduction is provided. Actors communicate for the purpose of creating, furthering, and disseminating knowledge. For communicating EAs different conversation strategies exist and are selected and applied according to the given situational factors (availability of resources, complexity, and uncertainty). Architectural conversations may have different knowledge goals, such as introduction, agreement, and commitment to knowledge. Depending on these goals conversation techniques listed in Lankhorst (2005) are chosen. For the topic of *modeling* Lankhorst first describes the basic modeling activities and types of modeling actions from a theoretical perspective. Afterwards a multitude of concise modeling guidelines is delineated. For *visualizing* again a theoretical introduction is provided spanning from the origin of viewpoints, via architecture viewpoint frameworks to the interrelations between models, views, and visualizations. Subsequently, the general phases an architectural viewpoint will pass through are described. Firstly, one or more appropriate

viewpoints are selected and scoped. After selecting the actual content for the viewpoint, it is validated and stakeholders are informed of the results. In the following, an extensive listing of different viewpoints is provided. In the field of *analysis* the different dimensions of analysis are presented. First of all, analysis techniques can be distinguished with respect to the types of inputs and results that can be of functional or quantitative nature. Secondly, a distinction can be made between analytical techniques and simulation. Based on the descriptions of the different EA management approaches in this section, a survey is compiled in the following section.

3 FINDINGS FROM THE LITERATURE ANALYSIS

In order to answer the above stated research questions the EA management methods currently described in literature and employed in practice need to be investigated. Therefore, the performed EA management activities need to be determined and characteristics how they are performed, e.g. when or how often the EA management activities are performed. Furthermore, the relationships of the EA management function to other enterprise-level management functions established at a respective company are subject to investigation. Similarly, whether and how the performance of the EA management function is measured should be analyzed. Based on the descriptions of EA management methods depicted in the previous section, a literature analysis is performed and respective hypothesis for the survey are derived in the following.

During literature analysis it became evident that the investigated EA management approaches vary widely in respect to their extent and granularity. TOGAF, for instance, is described in a document comprising over 700 pages and the ADM as a part of TOGAF is described on about 160 pages. On the contrary the reference method of Hafner and Winter (2008) is delineated on only ten pages. When it comes to granularity, Dern (2006) proposes detailed workflows with interdependencies for the different EA activities whereas Niemann (2005) describes these activities on a fairly coarse granular level. Furthermore, some of the approaches, as for instance The Open Group (2009), Hafner and Winter (2008), and Niemann (2005), contain a process model with phases or activities in a defined order. Others like Lankhorst (2005) detail on certain EA topics without defining a sequence of activities. The same is true for Wegmann (2003) who states that the described activities may occur both sequentially and in parallel. This leads to *hypothesis 1: The EA management function consists of different activities, which are reiterated at defined points in time.*

A further finding of the literature analysis is that roles, responsibilities, capabilities, and the placement of the EA department in the organizational structure are described in TOGAF's architecture capability framework (The Open Group, 2009), in the *act* phase of Niemann (2005), and in Dern (2006). Here it becomes evident that practitioners emphasize on this organizational topic whereas the approaches of scientific origin seem to neglect it. *Hypothesis 2* was derived as follows: *Defining roles and responsibilities in the field of EA management is important.*

The definition of the scope and goals of the EA management function is mentioned in most of the investigated approaches. However, defining and updating architecture principles is only considered explicitly in Hafner and Winter (2008) and The Open Group (2009). Therefore, *hypothesis 3* is derived: *Scope, goals, and architectural principles of EA management are defined and updated.*

While analyzing EA management literature, it became apparent that adapting an approach to company-specific needs is neglected in all investigated EA management approaches except TOGAF, which only states that the ADM should be adapted without specifying how. Hence *hypothesis 4* is: *Adapting the EA management approach to company-specific needs is of low importance.*

The usage of EA management tools is recommended by all of the investigated EA management approaches. SEAM even proposes its own specialized tool named SEAMCad. Thus, *hypthesis 5 is* worded: *EA management tool(s) are used for capturing and visualizing EA information.*

A further difference found in the investigated EA management approaches are different perceptions of the time dimension of an EA description. TOGAF for instance differentiates between baseline architecture, target architecture and architecture vision while SEAM (Wegmann, 2003) only makes a

distinction between as-is and to-be. Hence there are some approaches which distinguish between current, middle-term, and long-term states of the EA and others only consider current and future states. This leads to *hypothesis 6*: *While documenting and developing future states of the EA, there is a distinction made between planned (middle-term) states and target (long-term) states of the EA.*

Another important aspect of EA management, which is uncared-for in most approaches is gathering and maintaining EA information. The EA management approaches delineated in the previous section mostly describe what is to be documented or modeled. The different ways, in which this information can be gathered and kept up-to-date, is only described in Fischer et al. (2007). For this topic two hypotheses were formulated. *Hypothesis 7*: *EA information is collected and maintained centrally by the EA department. Hypothesis 8*: *For obtaining EA information, data from dedicated sources is remodeled manually.*

In addition, it was investigated that analyzing the EA is mentioned in nearly all approaches. Although most of the investigated approaches state what should be analyzed, only (Niemann, 2005; Lankhorst, 2005) depict applicable analysis techniques. *Hypothesis 9* therefore reads as follows: *EA descriptions are analyzed with different analysis techniques (expert assessment, computational simulation…). Hypothesis 10*: *Analysis techniques used for analyzing EA descriptions are rather informal.*

In most of the investigated EA management approaches evidence for a collaboration of EA management with other enterprise-level management functions can be found. The Open Group (2009) and Dern (2006) consider this topic in more detail than other approaches. TOGAF (The Open Group, 2009) suggests relationships between portfolio/project management, operations management, business planning, solution development, and EA management. Dern (2006) proposes close relationships between IT project portfolio management, software development, and EA management. Thus, *hypothesis 11* is formulated as follows: *There is a close collaboration between EA management and other enterprise-level management functions.*

A further finding is that the communication challenge is referred to in only two of the above mentioned approaches (Hafner and Winter, 2008; Lankhorst, 2005). Most of the other approaches, as for instance Niemann (2005), assume that documenting the EA fosters the communication of the EA, the communication activity itself however is not considered explicitly. Hence, *hypothesis 12* is: *Communicating EA descriptions is of low importance.*

Measuring the performance of the EA function is considered in TOGAF (The Open Group, 2009), Niemann (2005) and to some extent in Hafner and Winter (2008). The Open Group (2009) and Niemann, (2005) suggest defining and measuring key performance indicators whereas Hafner and Winter (2008) state on a very abstract level that diffusion and effectiveness are to be measured. As only two approaches consider this topic in detail, *hypothesis 13* is: *The performance of the EA management function typically is not measured.*

A questionnaire was developed according to the above information requirements and the structure of the survey and the according questions was elaborated. Therein, each hypothesis was operationalized to one or more questions. In its final version the survey consists of seven parts with a total of 46 questions. The introductory part contained screening questions in order to obtain eligibility criteria for evaluating the survey results. The second part comprises questions concerning general characteristics of the enterprise-specific approaches used at the respondent's company. The third to fifth part of the survey considered the EA management activities of documenting, analyzing, and communicating the EA. The sixth part contained questions aiming at detecting relationships of EA management to other enterprise-level management functions and the concluding part was concerned with performance measurement of the EA management function. The online survey was active for 16 days and invitations were publicized in dedicated groups on XING, LINKEDIN, and Google. In total there were 121 responses of which 56 records were completed, leading to a *dropout rate* of 53.7%. For the analyses in the following section the 56 completed records are used.

4 STATE-OF-THE-ART IN EA MANAGEMENT PRACTICE

In this section the survey results are analyzed and the hypotheses, which were derived in the previous section, are tested. The introductory part of the online survey yielded that the majority of the survey respondents come from Germany (53.6%) and the USA (10.7%) and are predominantly employed in financing (30.4%), manufacturing (12.5%) and governmental organizations (8.9%). 64.3% describe their current occupation as being an enterprise architect, followed by the IT architects with 19.6%. Respondents with a tenure of less than one year make up a share of 8.9% and are excluded from the subsequent analyses.

EA management literature of practitioners attaches more importance to the definition of roles and responsibilities than literature of scientific origin. However, only 39.2% of the respondents' approaches have detailed EA role descriptions and 49.0% state that it is defined which architectural role is responsible for which EA specific tasks. Thus, *hypothesis 2* has to be rejected.

As next, goals of EA management are investigated in respect to their importance in the company-specific approaches. The respondents were asked to rate typical goals of EA management on a five-level Likert scale. For analysis purposes the two categories on the positive side of the five-level Likert scale were aggregated as well as the two categories on the negative side. Figure 1 shows the goals of EA management ordered according to their share in the top-2 categories with business-IT alignment and providing transparency being the most important goals.

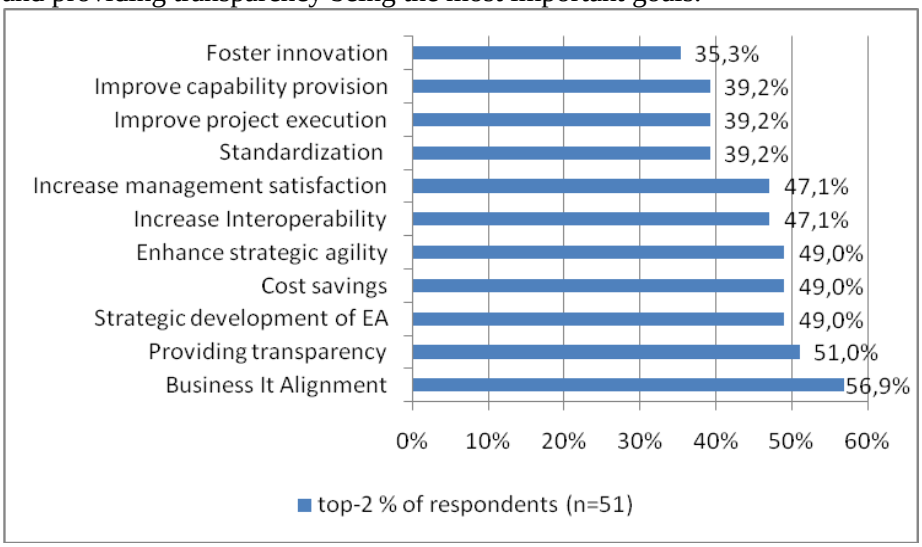

Figure 1. Importance of EA management goals

Furthermore, 58.8% percent of the respondents state that the goals of their company's EA management approach are documented. Besides defining goals also the scope and architectural principles are specified according to 66.7%. Hence *hypothesis 3* can be accepted.

The disregard of adapting the EA management approach to company-specific needs in literature led to *hypothesis 4*, which has to be rejected on examining the practitioners' responses to this topic. According to 82.1%, their approach uses company-specific terminology and 73.2% declare that the EA artifacts were tailored to the company's and stakeholders' needs.

The next point in the evaluation is concerned with the use of EA management tools, which are according to 66.7% of the informants employed for capturing EA information. Creating visualizations and reports as well as communicating EA information is affirmed by 70.6% of the survey respondents. Thus, *hypothesis 5* can be approved.

Different states of the EA can be documented and the respondents' companies document different combinations of these states as shown in Figure 2. For hypothesis 6 only the proportions of approaches documenting current & planned & target (15.7%) and planned & target (2.0%) are relevant. These two

figures add up to 17.7%, i.e. only 17.7% of the informants' EA management approaches distinguish between middle and long-term states of the EA. As a consequence, *hypothesis 6* is rejected.

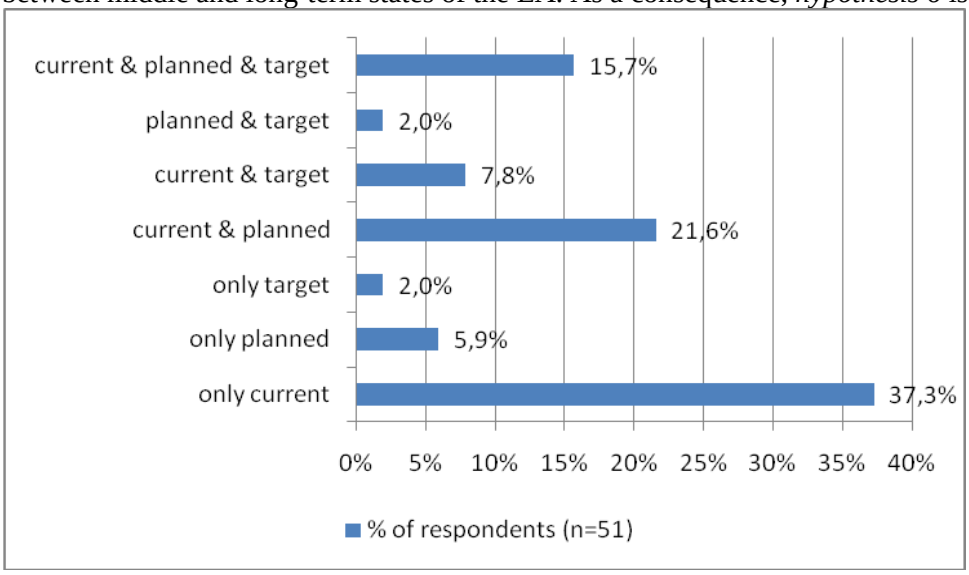

Figure 2. States of the EA documented

There are different ways, in which EA information can be gathered and maintained. 29.4% of the respondents state that collecting and maintaining EA data is done centrally and solely by the EA department. Exactly the same proportion of informants affirms that these activities are conducted exclusively and locally by the respective divisions. A combined approach of gathering and keeping EA information up-to-date is employed in 31.4% of the informants' companies. As a consequence *hypothesis 7* is rejected. According to 45.1% of the respondents the collection and maintenance of EA data is done manually only, whereas a semi-automated way is employed by 21.6% of the respondents' enterprises. A combination of manual and semi-automated techniques is used by 21.6% and finally 5.9% of the informants' companies have established a combination of manual, semi-automated, and automated modes for collecting and maintaining EA information. When considering the overall use of the manual mode with 72.6% it becomes evident that *hypothesis 8* has to be approved.

Documenting the EA is either updated in defined time intervals or triggered by an event. These time intervals and triggers vary for the three different states of the EA (cf. Figure 3). For updating the current state, the top three are "on demand" (59.5%), "when the person in charge triggers is" (52.4%) and "when a project is finished" (35.7%). "When a change in the project portfolio demands it" (47.8%), "annually" (43.5%), and "when the person in charge triggers it" (21.7%) are the top three triggers for updating the planned state. The top three for updating the target state are "when the person in charge triggers it" (57.1%), "when the circumstances or goals change" (42.9%), and "annually" (28.6%). Hence *hypothesis 1* can be approved as far as documenting and maintaining is concerned.

Hypothesis 9 and 10 are concerned with the different ways of analyzing EA descriptions. For analyzing functional aspects of the EA, as for instance dependencies or business process support, the analysis technique mostly used is individual expert assessment. As can be seen in Figure 3 this is the case for all of the three different states of the EA. The group expert assessment and the pattern-based way complete the top three techniques for analyzing functional aspects of the EA. For analyzing non-

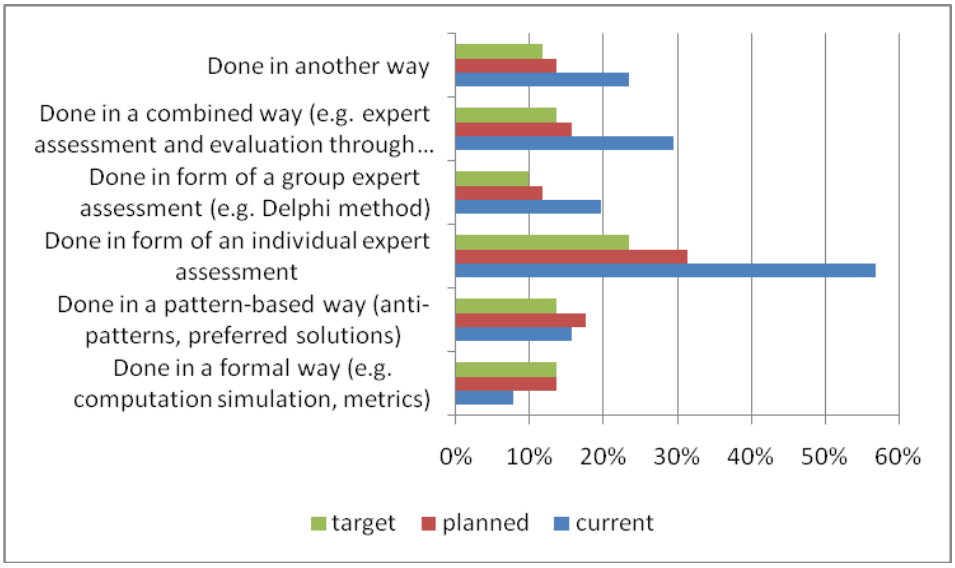

Figure 3. Analysis techniques used for analyzing functional aspects

functional aspects such as workload, the analysis technique mostly used over all states of the EA is again individual expert assessment. Figure 4 shows that for analyzing the target state of the EA the pattern-based way makes up the largest proportion with 49.0%.

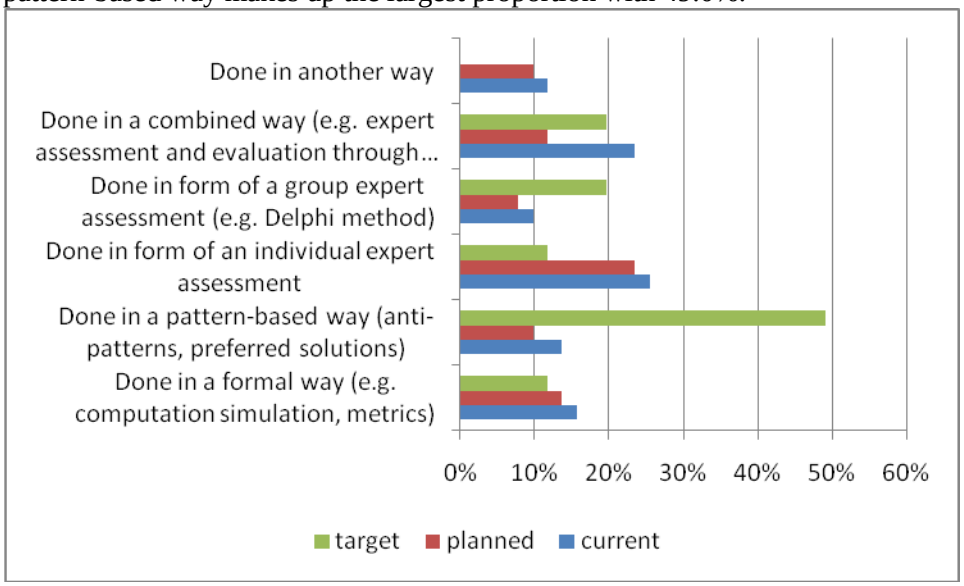

Figure 4. Analysis techniques used for analyzing non-functional aspects

Besides the analysis of functional and non-functional aspects, gap analyses between different planned states, between a current and a planned state, between a current and a target state and between a planned and a target state were examined. Individual expert assessment and the combined way were again the top two analysis techniques for all suggested combination of the different states. As individual expert assessments and also the combined techniques can be rated as rather informal, *hypothesis 10* is be accepted. The different analyses techniques listed in the questions seem to be applied in practice and thus also *hypothesis 9* can be approved.

Hypothesis 11 considers the association of EA management with other enterprise-level management functions. Strategy & goals management (58.8%), project portfolio management (52.9%) and project management (51.0%) are considered to have a rather strong association with EA management. Only 17.7% of the survey respondents stated that demand management has a strong association to EA management. Other enterprise-level management processes listed by the informants are release management, change management, business process management, and infrastructure management. As

a result *hypothesis 11* can be approved. Different means for realizing the association of EA management to other processes exist. Quality gates (43.1%), consultancy by enterprise architects (70.6%), higher project budget if enterprise architect is a project member (5.88%), and handover of prefilled documents for completion (23.5%) were stated. Only consultancy by enterprise architects received a higher proportion for yes than for no and can thus be considered as a means of integrating EA management to other enterprise-level management functions.

Communicating EA is neglected in many approaches found in EA management literature and therefore hypothesis 12 was formulated. In practice however, communication of the EA is not practiced in only 23.5% of the respondents' companies. In 11.8% the distribution of EA information is even considered to be well-defined and practiced according to the definition. In 27.5% of the informants' enterprises the distribution is well-defined, but not practiced as defined and in 37.3% communication is practiced in a satisfactory manner although it is not defined. Consequently, *hypothesis 12* is rejected. EA information is usually distributed via different communication channels. The top five channels identified in this survey are presentations (86.3%), intranet (78.4%), contacting colleagues directly (74.5%), enterprise architect as consultant in projects (68.6%), and email (64.7%). In the context of communicating EA information different techniques exist, which ensure that information, as for instance new architectural principles and plans, are noticed and are followed by the recipients. Quality gates are employed in 58.8% of the respondents' firms, whereas request for prompt feedback and acknowledgement are only used in 31.4% and 19.6% respectively.

For detecting how performance measurement is achieved in practice the survey respondents were provided with a number of statements on performance indicators such as stakeholder participation and acceptance or diffusion of the EA. However, the proportion of participants who answered no is significantly higher than the share of those who do measure these performance indicators. Besides the statements on performance indicators, the informants were also asked whether in their company's approach lessons learned during EA management are documented and communicated (yes: 37.5%). A list of best practices for EA management is compiled and extended in 41.2%. A balanced scorecard for EA management is not used according to a 82.4% proportion of the informants. Furthermore, only 15.7% of the survey respondents' enterprises use the results of performance measurement for enhancing the EA management function in the future. As a consequence *hypothesis 13* is accepted.

5 CONCLUSION AND OUTLOOK

This article aims at identifying and analyzing the state-of-the-art in EA management literature as well as in practice. Thereby, at first existing literature in the context of EA management is examined with a focus on the methods comprised in the various EA management approaches. Subsequently, a detailed literature analysis is provided elaborating the different characteristics and shortcomings of the described approaches. Based on the analysis results, an online survey is compiled and conducted in order to investigate the state-of-the-art in practice. In a further step the survey results are analyzed and evaluated. One key finding of the survey is that adapting the EA management approach to company-specific needs is important in practice although EA management literature implies the contrary. A further finding is that the communication of EA is not neglected and the majority of respondents states that the distribution of EA information is done in a satisfactory and often even in a defined way. Additionally it was found that the performance of the EA management function is rarely measured in practice even though this constitutes a valuable starting point for improvement.

A possibility to consolidate and validate the findings of the online survey is to conduct an interviewer administered survey either in form of a telephone interview or a face-to-face interview. Results from such a survey could provide a deeper insight into practitioners' EA management methods. Further research potential lies in developing an approach to EA management, which considers the enterprise-specificity of the topic. Although the company-specific adaption of an EA management approach is widely used in practice, little guidance is found in literature. In this line a future research possibility is the development of adaption mechanisms and guidelines for this task. In this context situational method engineering approaches might be helpful.

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