Analyzing the Evolution and Usage of Enterprise Architecture Management Patterns

Full paper

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Abstract

Enterprise Architecture Management (EAM) evolved to a powerful function to support organizations in strategic decision making and in the fulfillment of business requirements. The organization of an EAM function is not an easy task and demands for best practices that are suited to the specific needs of an organization. The pattern-based EAM approach constitutes a collection of such best practices, including detailed information on how to approach EAM activities in organizations. Recent research extended the original EAM pattern structure from 2008 with further concepts to provide more extensive patterns. We conducted an online survey with 31 EAM experts to identify current trends in this domain. We compare documented EAM patterns from 2008 with those identified in the conducted survey to evaluate changes of EAM best practices over the last years. Our research results reveal major changes of EAM needs and best practices, which evolved across several industries and point out clear trends.

Keywords

Enterprise architecture management, EAM pattern, EAM trends, EAM stakeholder

Introduction

Over the course of the last decade, the evolution of technology has led to new business opportunities and consequently to fundamental changes in operational business models of today's organizations (Malhotra 2001). The implementation of these opportunities results in new business requirements, such as after sales or online support activities. To fulfill these requirements, today's organizations undergo fundamental changes in in their EAM domain (Aier et al. 2011; Purchase et al. 2011; Rouse 2006).

The IEEE 1471/ISO 42010 standard defines enterprise architecture (EA) as the "continuous practice of describing the essential elements of a sociotechnical organization, their relationships to each other and to the environment, in order to understand complexity and manage change" (IEEE 1471/ISO 42010 2011). Managing an EA comprises all necessary activities for gathering and documenting the information of an EA in order to provide a better alignment of information technology (IT) and business functions while, at the same time, supporting decision makers with relevant information (Lux et al. 2008; Roth et al. 2013). Although established EAM standards, such as TOGAF or the Archimate standard by the Open Group, provide a collection of best practices to design, plan, implement, and maintain EAs, EAM practitioners face major challenges in EA projects (The Open Group 2011; The Open Group 2013). The main issue is that "no formal steps exist for defining, maintaining, and implementing EA and EA frameworks are not rigid enough in describing these steps" (Lucke et al. 2010).

Recurring EAM concerns can be observed in organizations from different industry sectors and most of them share the same patterns from different viewpoints. Based on this idea, Ernst (2008) suggested a pattern-based EAM approach, illustrating a "general, reusable solution to a common problem" (Buckl 2007). The EAM Pattern Catalog 2008 (EAMPC2008) provides a collection of EAM patterns to establish an EAM function within enterprises (Buckl 2008). Over the last seven years, the EAMPC2008 was cited over 100 times in research articles, illustrating the applicability of this approach. The EAMPC2008 considers four concepts in each pattern: concerns, methodologies, viewpoints, and information model patterns. Recent research extended the approach by adding further concepts: influence factors, stakeholders, architectural principles, and data collection patterns (Schneider and Matthes 2015).

We conducted an online survey with 31 EAM experts from Germany, the United Kingdom, Switzerland, Brazil, France, USA and Denmark, to identify new patterns in the EAM domain. All identified patterns are documented in the EAM Pattern Catalog V2 (EAMPC2015) (Aleatrati Khosroshahi et al. 2015). The purpose of this research is to examine how organizations operate their EAM function today by comparing the identified patterns from 2015 with those in 2008 and to interpret what kind of needs EAM stakeholders have today. The results can assist practitioners with evaluating their defined EAM governance and aligning it to current best practices. The identification of each stakeholder's information need helps to define the importance of data sources in practice. It also allows to better shape the role of IT- and business-related stakeholders in EAM. We investigate the EAM function of today's organizations by examining the following research questions (Q):

- *Q1: Which needs do EAM stakeholders have today?*
- *Q2: Considering the concepts of the pattern-based approach, how far did EAM practices change over the last years?*
- *Q3: Is the enlarged pattern structure accepted in the EAM practice?*

We first explain the pattern-based EAM approach, which provides a framework of our research results. After that, we illustrate our research approach and give an overview of our results, followed by a discussion and interpretation of the contribution. The paper ends with a conclusion and an outlook on future work.

Overview of the EAM pattern structure

According to the software engineering discipline, a design pattern is a recurring solution for common problems in the software design practice, or in other words, a template, including the kind of activities that have to be taken to solve a concrete and commonly known problem (Gamma et al. 1994). Ernst (2008) adopted this idea to the EAM domain: an EAM pattern follows the rule of three, meaning that a "documented pattern must provide reference to at least three known uses in practice to ensure the re-usability of the provided solution" (Buckl et al. 2013; Coplien 1996). Schneider and Matthes (2015) extended the EAM pattern structure with further concepts, illustrated in Figure 1. Each pattern consists of a number of connections between the concepts. The rows illustrate the included concepts of an EAM pattern. A box reflects one characteristic of the concern in the row. A colored arrow between two boxes means that the pattern includes these characteristics in its definition.

The extended EAM pattern structure includes the following concepts:

- **Influence factors / Maturity levels:** EAM has to be "organization-specific" and "compatible with the [...] embedding conditions" of the organization (Buckl et al 2011). This means that influence factors affect how organizations define their enterprise strategy, prioritize tasks, and operate their EAM.
- **Stakeholders:** The visualized EAM data is an information need of a concrete role in the organization. A stakeholder represents a role that is involved by such a need.
- **Concerns:** A concern is a "management objective", or in other words, an information need (Buckl et al. 2008).
- **Method patterns / Architecture principles:** "Methodologies describe steps to be taken to address a given concern" (Schneider and Matthes 2015). Method patterns provide guidance for using methodologies, including the addressed concerns. Architecture principles are design principles for an EA (Greefhorst and Proper 2011).

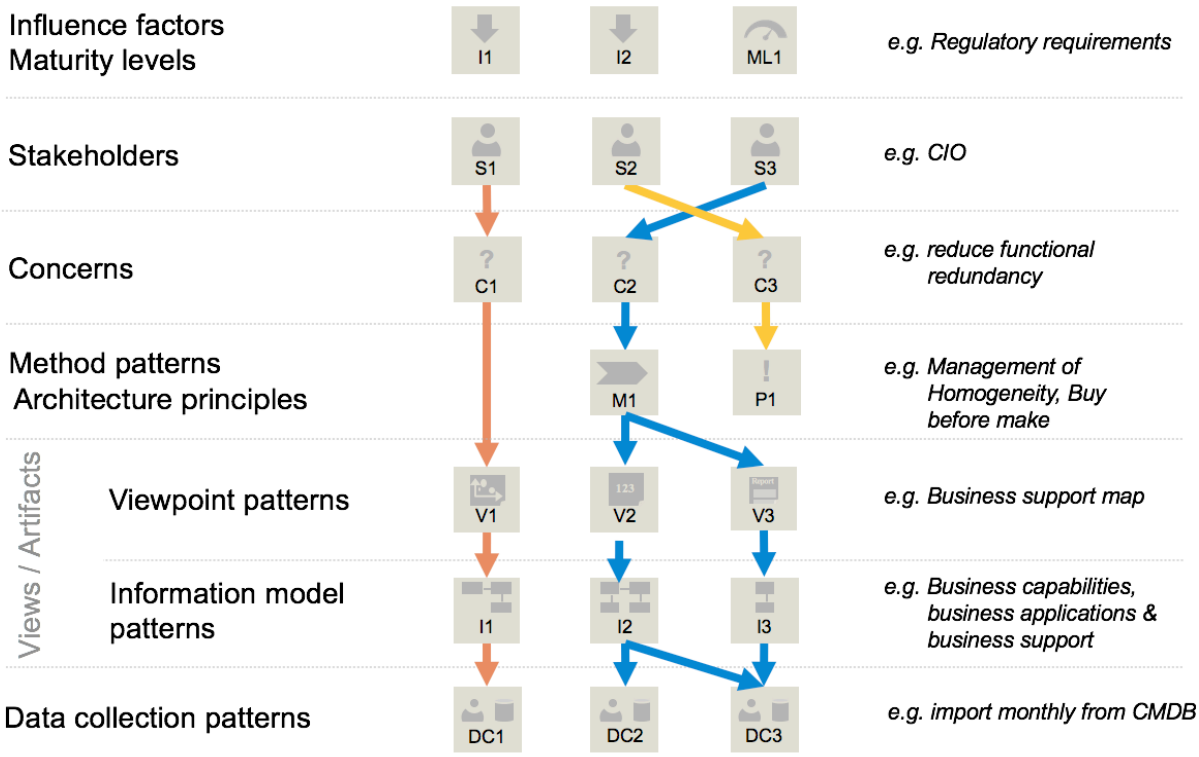

Figure 1: Overview of the extended EAM pattern structure (Schneider and Matthes 2015)

- **Viewpoint patterns:** A viewpoint is a visualization that illustrates the current status of a concern.
- **Information model patterns:** An information model pattern describes an underlying part of the EA model, including the needed information for the viewpoint.
- **Data collection patterns:** In order to provide a concrete viewpoint, enterprise architectures extract needed information from various data sources. Data collection patterns describe documentation standards for this activity, e.g., refresh frequencies or responsible persons.

Example (Blue arrows): Stakeholder 3 (S3) is interested in concern 2 (C2). C2 can be addressed with the method 1 (M1). The status of M1 can be visualized with viewpoint 2 or 3 (V2, V3). The needed information for the viewpoints are documented in information model 2 and 3 (I2, I3). The needed data of these information model are maintained with practices of data collection pattern 2 and 3 (DC2, DC3).

Research approach

We conducted an online survey to identify current practices of EAM. Figure 2 shows the timeline and conducted steps of the research methodology. We started in February 2015 with an analysis of 1.206 Powerpoint slides from 48 organizations from different industries to identify already named characteristics of the pattern concepts in the industry and derived 441 characteristics. The Powerpoint slides were gathered from past industry projects in our research group. The collected information was used for the design of the online survey. After that, we conducted data cleansing activities to remove duplicate data records. The cleaned up list includes 106 characteristics: 17 influence factors, 19 architecture principles, 24 stakeholders, 37 concerns, and 13 methodologies. Moreover, we developed a list of 45 EAM classes and asked for their refresh frequencies, roles in charge for maintenance activities, data sources, and data formats to identify data collection patterns. Practitioners had the possibility to explain their used viewpoints in a structured way. For each concern they could select the type of used visualization (e.g., bar charts) and up to three EAM classes for the visualization. Information model patterns are derived from the viewpoints.

Before starting the online survey, we performed a pretest with five experts from our research group to gather feedback about the survey design. Based on this feedback, we updated the survey and invited over 1.500 EAM research partners in academia and industry to participate. Industry partners that work for the same organizations should only provide one feedback. Moreover, we note that several research partners work as freelancers and do not have an EAM function. Overall we identified 500 organizations as potential participants. The completion of the survey takes approximately 3h. This is why we provided a feedback timeframe of four weeks – receiving answers via e-mail or anonymous upload. We received completely filled out surveys from 31 organizations. The majority of the participants operate in the financial sector (9 participants), followed by the IT and technology sector (6 participants). The majority of organizations (21 participants) operate on an international level and employ over 10.000 people (15 participants). 20 participants are enterprise architects, followed by technical architects (5 participants) and others.

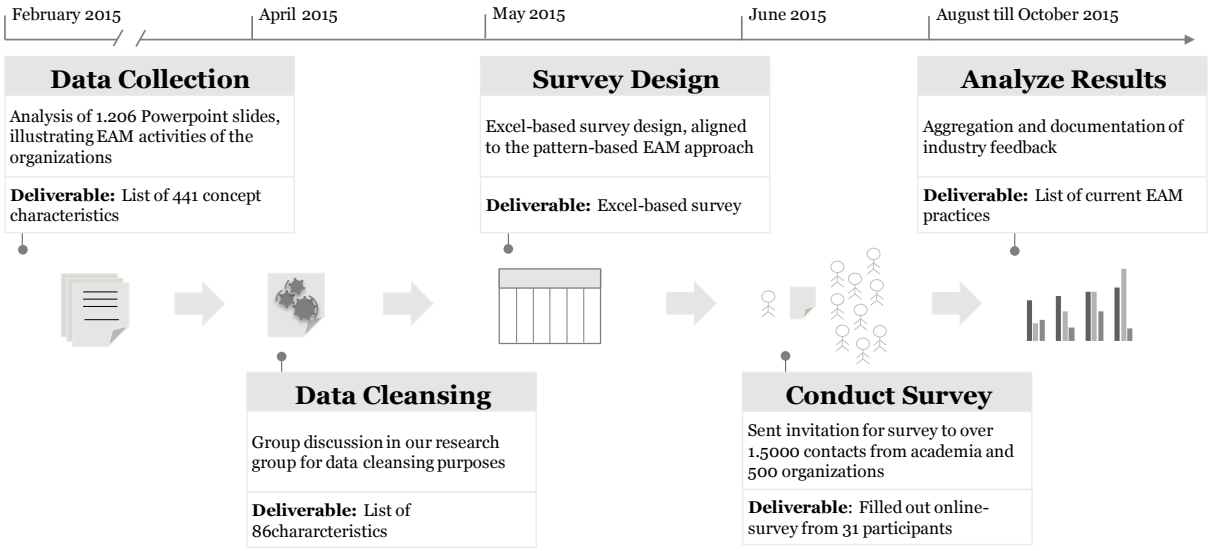

Figure 2: Research methodology

Identified stakeholders and their needs

We asked participants to assess what kind of concerns are relevant for their EAM. The online survey provides a list of the 37 identified concerns and the possibility to mark its relevance. Moreover, the online survey asked to allocate interested or affected stakeholders for each concern. To avoid wrong interpretations of the stated stakeholders, we provided a dropdown list, comprising a list of all 24 stakeholders (multiple choices possible). Table 1 provides an overview of the stated stakeholders (columns) and concerns (rows). Some concerns and stakeholders are only relevant for single participants (e.g.: Consultants; information demand for dependencies between business objects) and do not relate to important EAM stakeholders and information needs in general. We do not include these characteristics in the overview. Table 1 provides an overview of the top 27 concerns (out of 37) and 17 stakeholders (out of 24) and illustrates how many different concerns are addressed by a specific stakeholder (line 2). The cells in the middle of the table show how many times one concrete combination was mentioned by the participants. Each concern has a unique identification number (ID).

The results show that EAM spreads through the boundaries of IT departments and gains importance for business stakeholders (e.g.: CFO, corporate development / governance, business owner). The majority of the participants see architects in the lead (e.g. enterprise architect = 27 out of 27; domain / solution architect = 26 out 27 interesting concerns). The variety of concerns, provides a highly fragmented picture on present EAM: The survey results show that transparency (e.g. ID: 04, 07, 10, 12), project (e.g. ID: 13, 16, 25, 26) EA operation (e.g. ID: 03, 06, 08, 17), and EA strategy (e.g. ID: 02, 05, 07) related concerns find high attention in EAM. Also upper management roles are interested in non-strategy related concerns (e.g. CFO = ID: 01, 02, 04, 05). A complete list of the identified stakeholders and concerns and their relevance for the industry partners is documented in the EAMPC2015.

Analyzed trends, based on a pattern comparison from 2008 and 2015

Even though the extended EAM pattern structure includes further concepts, those of 2008 are still included. A comparison of the results from 2008 and 2015 provides further insights into how EAM best practices have changed over the last seven years.

Comparison of addressed concerns

Table 1 provides an overview of the top 27 relevant concerns, including whether the concerns were already addressed in 2008.

		Enterprise architect	Domain / Solution architect	CIO	Technical architect.	Head of Department IT	Head of Dep. Business	Project Manager IT	CFO	Business / Process architect	Application Owner	COO	Business Owner	Portfolio Manager (Business / IT)	Controller (Business or IT)	Project Manager Business	Corp. Development / Governance	IT Security & Compliance	**Addressed in EAMPC2008**
	Addressed concerns (out of top 27)	**27**	**26**	**25**	**23**	**24**	**23**	**18**	**14**	**14**	**12**	**18**	**11**	**9**	**6**	**6**	**4**	**4**	
ID	**Concerns**																		
01	Breached architectural blueprints	3	1	2	3	3	20	22	19		1	1	1			1			x
02	Definition of target application landscape	13	11	9	3	10	4	1				4	3			1	1		
03	Check to replace / keep used technologies	4	1	24	27	2													x
04	Map applications to business capabilities	13	7	5	1	4	4	1	3	6	2	2	3	1					
05	Alignment application landscape and business	10	6	6	1	5	5	2	2	4		3	3	1					
06	Detection of consolidation potentials	13	5	11	3	6	2		1			1		1	1	1			x
07	Long-term application landscape	12	6	8	2	7	4					2	1				1		x
08	Reduce application landscape complexity	13	3	9	4	7	2		1					1	1				
09	Merge two different application landscapes	11	10	5	3	3	2	3	1			1		1					
10	Supported applications by business processes	10	6	5		1	2	2		7		3	1						x
11	Shut-down impact of infrastructure component	6	5	3	14	3	2				3	1							x
12	Used infrastructure for applications	7	3	5	12	2	2				3	1							x
13	Define projects to increase standardization	6	5	5	6	4	2	1	1	1	2	1							x
14	Get transparency about IT costs	4		11		6	2		5			3			2		1		
15	Architectural assessment of change requests	6	8	3	4		1	4	1	1	2					2			x
16	Assign available IT budget to projects	8	1	7		3	2	1	3	1		1		3	2				x
17	Reduce operations and maintenance costs	4	3	7	1	7			4		2	2	1		2				x
18	Determine Interfaces of applications	8	8	1	2	1		3		2	4						1	1	x
19	Data flows (business objects and applications)	10	5	1	2		1	2	1	3	1		1					1	x
20	Align activities to modify application landscape	6	5	4		4	2	2	1	1		3	1	2					x
21	Dependencies between applications / projects	10	6	1	2	2		4			2			1		1			x
22	Dependencies between objects and interfaces	9	5		1		2	1		2	3		2		1			1	x
23	Communicate added value of EAM	10	4	2	3	4	2	1				1							x
24	Used applications by organizational units	10	6	2	1	1	1	3		1	2							1	x
25	Affected applications by projects	8	4		2	1	1	4		1				4					x
26	Outline projects to replace individual software	5	5	1	3	3	1		1	1		1	1			1			x
27	Remove monolithic applications	6	2	4	1	3	3	1		1		1							

Table 1: Top 17 EAM stakeholders and their architectural needs in 2015

- **Interpretation of results:** Supporting the daily business of organizations attracts less attention, indicated by the small amount of addressed stakeholders and the mentions of ID 16, 25, and 26. Information needs on EA operation (e.g. ID: 06, 10) constantly find attention. The strategic relevance of EAM is also emphasized by the amount of addressed stakeholders, illustrated by management roles from IT (e.g. CIO) and business (e.g. CFO). Most of the concerns are addressed by multiple stakeholders. Operating roles, e.g. software engineer or business analyst, are not addressed by concerns.

- **Interpretation of new concerns:** New concerns address transparency issues (ID: 04, 14), stronger alignment of EA to business (ID: 02, 05), and the reduction of EA size (ID: 08, 09, 27). The transparency related issues confirm our current observation in the industry; the definition of business capability maps and the allocation of applications to capabilities in organizations. The related concern (ID: 04) was not included in the EAMPC2008 and is an information demand for 13 out of 17 (~76%) stakeholders. This finding underlines the strategic relevance of business capability maps in organizations today, for both business and IT stakeholders. Similar results are observed for ID 05, the alignments of business and IT, showing an information demand for 12 out of 17 (~71%) stakeholders.

Changes in provided methodologies.

The EAMPC2008 references 20 methodologies, whereas the EAMPC2015 considers 12, revealing that today EAM concentrates on selected methodologies to address information demands. Table 2 illustrates the methodologies of the EAMPC2008 and EAMPC015. A closer look at Table 2 reveals that in 2008, EAM supported a wide range of demands, e.g. "Technology Homogeneity" (M-2 – M5), "Project Portfolio Management" and others (Buckl et al. 2008). In Section 4 we outline that EAM demands for information about EA operation (e.g. ID: 03, 06, 08, 09), but distances itself from documentation activities. The identified methodologies in 2015 align with strategic planning (e.g. M-29, 102, 112) and optimization tasks (e.g. M-69, 71), such as the definition of transformation roadmaps. Those tasks need data from the current EA model to explain the information needs of EAM, as illustrated in Table 1. This contrast between information needs and provided methodologies shapes the current role of EAM in organizations: enterprise architects have to analyze, plan and design the direction of EA on an abstract level and outsource operation tasks to other functions. They concentrate on optimization rather than documentation tasks. This result underpins the increasing importance of EAM as a strategic decision maker. However, recent research shows that EAM lacks appropriate methods and relies on only a few metrics to address optimization issues, e.g., complexity management (Beetz et al. 2010; Schneider et al. 2015).

Method	M-2 (Standard conformity application landscape)	M-3 (Management of Homogeneity)	M-4 (Blueprint conformity of the application landscape)	M-5 (Analysis of the enterprise knowledge)	M-6 (Process analysis)	M-10 (Analysis of standard vs. individual software)	M-13 (Analysis of the application landscape)	M-14 (Development of plan and target landscapes)	M-15 (Management of the application lifecycle)	M-18 (Horizontal and vertical integration)	M-19 (Management of business objects)	M-20 (Management of business services / domains)	M-21 (Management of interfaces)	M-22 (Service lifecycle management)	M-24 (Strategic conformance analysis of the project portfolio)	M-25 (Monitoring of the project portfolio)	M-26 (Decision for project approval)	M-29 (High level process support)	M-30 (Business process data flow analysis)	M-34 (Infrastructure failure impact analysis)	M-58 (Interpret KPIs to evaluate application landscape changes)	M-69 (Management of application landscape complexity)	M-71 (Elimination of functional redundancies)	M-87 (Interaction with other operational / management processes)	M-102 (Identification of core business capabilities)	M-112 (Definition of a transformation roadmap for the EA)	M-114 (Analyze which capability is supported by which application)	M-116 (Development of the planned and target EA models)	M-128 (Analysis of current annual IT costs (TCO) per capability)
2008	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x									
2015	x						x											x			x	x	x	x	x	x	x	x	x

Table 2: Considered methodologies in the EAMPC2008 and EAMPC2015

Evolution of the viewpoints and information models

When evaluating the gathered data from the online surveys, it turned out that only a number of viewpoints with mostly the same information and needs can be used to address different concerns, when changing one attribute. Consequently, we decided to change the viewpoint structure in the EAMPC015 and introduce variations as a sub-element of viewpoints (see Figure 3). These are also addressed by different methodologies and address different stakeholders, but use the same visualization type of the assigned viewpoint and add one further attribute to the viewpoint. The added attribute illustrates a business- or IT related status of one of the other two attributes. Example in Figure 3: attribute C illustrates the complexity (V107.1) or architectural fit to the target state (V107.2) of an application. However, comparing the amount of identified viewpoints in the EAMPC2008 and those in 2015, the results show a reduction of identified patterns (50 vs. 14+15). This indicates that over the last years designated viewpoints have proven their reliability and todays EAM concentrates on them in practice. This progression also decreases considered information models and maintained classes in EA models. A detailed list of the identified viewpoint, variation, information model patterns and maintained classes is documented in the EAMPC2015.

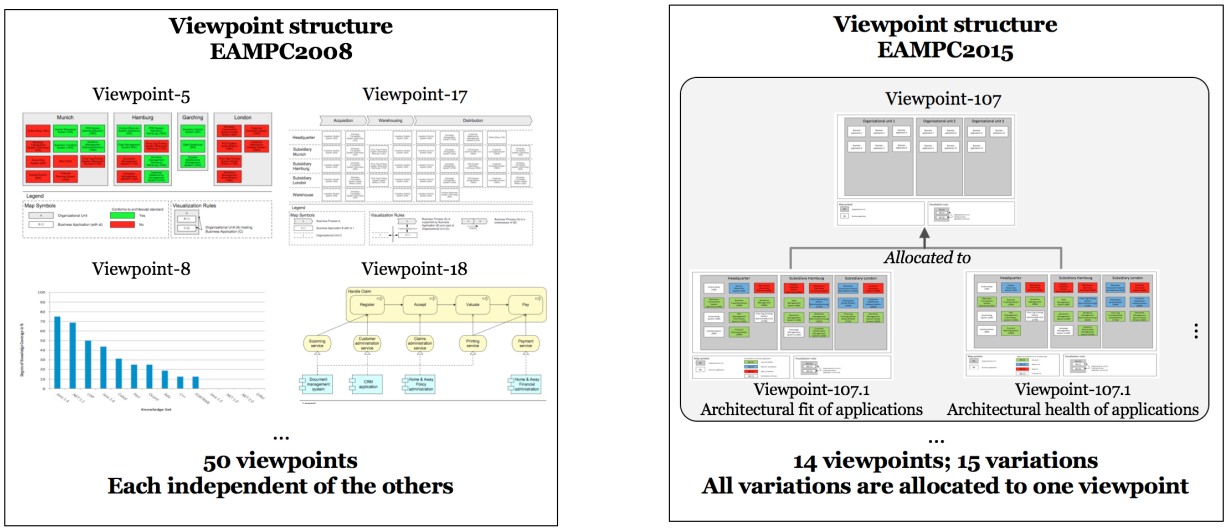

Figure 3: Transformation of the viewpoint structure

Meaningfulness of EAM pattern structure extension

The identification of addressed stakeholders by concerns illustrates a new concept in the EAM pattern structure and provide further insights on the strategic role of EAM in organizations. We received detailed information about the addressed stakeholders (see Table 1), indicating that today's organizations consider this connection in their EAM practices. However, the extension of the EAM pattern structure considers three further concepts: influence factors, architecture principles, and data collection patterns. The findings can help to shape the role of EAM practice in organizations.

- **Influence factors:** The participants assessed what kind of influence factors have an impact on their EAM. We consider two types of influence factors: external influence factors (6 factors) that are dominated from outside the organization, e.g. regulatory requirements, trends from the market, and internal influence factors (11 factors) that can be steered from the organization itself, e.g. cultural conflicts. The results show that external influence factors have a higher affect on EAM: Four out of the top five mentioned characteristics illustrate external influence factors. At least eight stated factors are internal influence factors. The top three mentioned factors are regulatory requirements, technical innovations, and cost-cutting initiatives. Based on the most important factors, EAM can support upper management in decision making by providing suitable viewpoints, addressing the status of the influence factors.

- **Architectural principles / Maturity levels:** We received 527 assessments for 19 influence factors (major, minor, planned, no relevance), including only 26 feedbacks with status planned (~5%). This finding reveals that EAM practitioners have a clear choice in their principles. Including this information in the EAM pattern structure supports organizations that recently started or restructuring an EAM function in the definition of their principles.
- **Data collection:** The EAMPC2015 provides 90 data collection patterns for over 19 EAM classes, including information about used data format, refresh frequency, data source, and maintenance responsibility. The large amount of identified patterns supports EAM practitioners as best practices for EAM repository tasks.

Discussion

In the introduction, we define three research questions to identify current practices of EAM, aligned to the extended EAM pattern structure: we evaluate the current stakeholders in EAM and their needs (Q1), derive how EAM has changed over the last years (Q2), and evaluate, whether the added concepts to the original EAM pattern structure are useful for practitioners.

Regarding Q1, identifying the needs of today's EAM stakeholders, the presented results in Section 3 reveal the increased significance of EAM in organizations. Apart from IT, also business-related stakeholders (e.g. CFO) have information demands to EAM. The presented 17 stakeholders in Table 1 contain mainly upper management stakeholders and no operative roles, revealing that todays EAM supports decision makers and acts as a strategic role in organizations. The identified concerns paint a fragmented picture that consists of EA strategy, operation, project, and transparency related information needs, indicating that there is no clear scope of information demands in practice. The fulfillment of the upcoming business- and regulatory requirements is a strongly data-driven task that asks for high transparency of the available information and its sources in the EA. Consequently, the management of EA demands high attention. Nowadays, business stakeholders are forced to have a clear picture of the available information in their organizations. They need this transparency in order to fulfill their data-driven requirements, e.g. risk reporting for regulatory requirements, which justifies the high attention of concerns by them.

With Q2, we aim to identify changes of EAM practices, using the concepts of the EAM pattern structure as an evaluation template. The presented results in Section 5 reveal changes of the addressed concerns, used methodologies, and viewpoints / information models in practice. One finding are the upcoming trends of business capability maps (ID: 04), not stated in 2008, which are underpinned by the amount of interested stakeholders (~76%), in line with Hossein and Danesh (2015). Although major concerns illustrate an information goal for architectural roles, the documentation of this information is methodically not handled by EAM, different from 2008, and shapes the role of enterprise architects in organizations. Our findings show that enterprise architects concentrate less on methodologies and outsource more operative activities to other departments. The changed structure of viewpoints shows that EAM focuses on a small number of established viewpoints in different variations to address information needs. This result shows the increased maturity of EAM that was reached over the last seven years. Organizations have discovered the potential of EAM, which they utilize to enable a strong alignment of IT- and business (e.g., the definition of business capabilities), rather than for operational activities (e.g. identification of data flows). The fixed definition of architecture principles shows that organizations have clearly captured the priorities within their EA. The highly fragmented number of both internal and external influence factors shows that successful EAM cannot be implemented without high efforts in communication and stakeholder-alignment.

Considering Q3, the extension of the EAM pattern structure has proven its worth: EAM practitioners take care of architecture principles, influence factors, and data collection practices. The identified patterns and trends serve further orientation for EAM practices and are helpful for the community. The evaluated patterns from the EAMPC2015 were identified with results of the conducted online survey, presented in Section 3. The EAMPC2008 followed a qualitative approach by conducting expert interviews and group discussions with practitioners.

Even though the Excel-based survey provided the opportunity to add unlimited data records and include screenshots, there might be further practices in industry that could be not presented in an online survey. Personal interviews provide an opportunity to sketch complex viewpoints on paper, unlike an online

survey, and thus are not communicated to us. The identification of further patterns asks for group discussions with practitioners. The survey includes feedback from 31 experts across various industries. The underpinning of the identified patterns and derived changes of EAM best practices requires further observations in industry.

Summarizing the results, we can state that

- EAM practices have changed over the last years (e.g. used viewpoints in practice, definition of Business Capability Maps)
- EAM has become a powerful tool to support both business- and IT requirements and attract high attention from various stakeholders in organizations,
- EAM has strongly increased its maturity level over the last years
- EAM patterns include a variety of concepts (stakeholders, methodologies, viewpoints, data collection, and other).

Conclusion and Outlook

We conducted an online survey with feedback from 31 EAM practitioners from various industries across several countries. The design of the online survey used the EAM pattern structure and is based on an analysis of over 1.200 Powerpoint slides from industry. Identified patterns were compared to those in the EAMPC2008. Our research results reveal that EAM practice has changed over the last years and the adaption of the EAM pattern structure so far received a positive echo from practitioners. The evaluation of how EAM practices have changed over the last years relies on the comparison of the identified patterns from 2008 and 2015. In 2015, we did not conduct the survey with the same participants as in 2008. A more precise evaluation of changed EAM practices demands for survey results from the same EAM experts. The conducted online survey lacks group discussions with the experts. There might be a risk of misunderstandings between the questions and the provided results.

The findings show clear trends in the EAM domain (e.g. increased interest for business capability maps). Further research might support the EAM community with methodology definitions for the identified trends. As defined in the introduction, today's EAM standards lack of formal steps in their methodologies. Our findings show the used EAM methodologies in practice (see Table 2). Further research can examine how to enrich EAM standards with regard to the revealed EAM methodologies.

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