Chapter 15
An Integrative Method for Decision-Making in EA Management

Dierk Jugel

Abstract Due to digitalization, constant technological progress and ever shorter product life cycles, enterprises are currently facing major challenges. In order to succeed in the market, business models have to be adapted more often and more quickly to changing market conditions than they used to be. Fast adaptability, also called agility, is a decisive competitive factor in today's world. Because of the ever-growing IT part of products and the fact that they are manufactured using IT, changing the business model has a major impact on the enterprise architecture (EA). However, developing EAs is a very complex task, because many stakeholders with conflicting interests are involved in the decision-making process. Therefore, a lot of collaboration is required. To support organizations in developing their EA, this article introduces a novel integrative method that systematically integrates stakeholder interests into decision-making activities. By using the method, collaboration between stakeholders involved is improved by identifying points of contact between them. Furthermore, standardized activities make decision-making more transparent and comparable without limiting creativity.

Keywords Enterprise architecture management · Decision support · Viewpoint · EA analytics

15.1 Introduction

Nowadays, organizations are confronted with major challenges [1]. Digitalization, constant technological progress, and ever shorter product life cycles are forcing organizations to adapt their business models more often and faster than in the past [1–3]. Agility is a decisive competitive factor to compete in the markets [4]. This is understood to mean the ability to adapt quickly business models and the organizational structures required to implement them [4]. This includes e.g., business processes, applications and technologies.

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Products and services offered by the enterprises are not only produced IT-supported, but they themselves have an increasing IT part [5]. As a result, changes in business models have a major impact on the enterprise architecture (EA) [2]. Traditional companies in particular face major challenges in terms of agility in comparison with startups that are increasingly entering the markets.

Historically developed EAs with a multitude of related elements make decision-making a complex task. Startups have the great advantage of being able to implement their business models on a greenfield site. Traditional companies, on the other hand, have to integrate the changed business models into their existing complex business architectures.

Enterprise Architecture Management (EAM) is a systematic approach to develop EAs [6]. The alignment of business and IT structures is a core task. A core characteristic of an EA is providing a holistic view of the enterprise [7]. As a result, an EA encompasses large parts of the enterprise. Due to the multitude of interrelated elements, many different stakeholders from different areas of the organization are involved in their further development [8]. In this context, a stakeholder is defined as a person or group of persons interested in the system of the enterprise [9].

The stakeholders involved in further development look at the EA from a special point of view (so-called viewpoints) due to their interests and responsibilities [9].

Due to many relationships between elements of an EA there are multiple dependencies between viewpoints that are relevant for stakeholders. Therefore, individual stakeholders are not able to change the architecture for their own and without involving other stakeholders that are affected by potential changes [7]. Instead, an integrative decision-making process is required, in which architectural changes are to be planned holistically and collaboratively under consideration of all dependent viewpoints of the stakeholders. In this context, the literature mentions collaboration, especially the conflicting interests of stakeholders, and inadequate tool support as major challenges in the further development of an EA [10].

In order to explore the problem described above, we use Design Science Research [11] and formulate the following research question, which are dealt with in this article:

> How can decision-making in EAM be supported methodically by taking into account the interests of involved stakeholders?

The remainder of this article is structured as follows: In Sect. 15.2, we go into the identification of deficiencies in practice and appropriate requirements. Afterwards, in Sect. 15.3 we revisit the state-of-the-art in decisions and decision processes in general as well as decision-making in EAM and decision modeling. In Sect. 15.4, we introduce the integrative method for decision-making. In Sect. 15.5, we focus on one method component in detail and demonstrate it using a case study in Sect. 15.6. Finally, we conclude with a summary in Sect. 15.7.

15.2 Deficiencies in Practice and Requirements

In order to support stakeholders in their decision-making, we have identified three key aspects through expert surveys and literature analyses:

Decision Process: According to the literature, a high degree of collaboration is required in decision-making due to the large number of stakeholders involved, some of whom have conflicting interests, and the complex corporate architecture [6, 12]. However, this collaboration is disturbed due to undefined decision processes and incomprehensible decision-making [13]. For this reason, we have taken a closer look at the decision-making processes through expert interviews. In addition to the question of what the decision-making processes look like and whether they are defined within the framework of governance, the methodological approach and the use of tools, e.g. automated techniques or visualizations, are of particular interest.

Visualizations: The basis for the further development of the EA is the analysis of the current state (actual architecture) [14]. Visualizations play an important role here as information providers [6]. In this context, our expert surveys provide information about the use of visualizations in decision-making.

Documenting decisions: According to Nakakawa et al. [13], an incomprehensible decision-making process is an obstacle to the collaboration required in the decision-making process. Furthermore, an architecture can only be understood if the reasons for decisions of the past are known [15, 16]. In practice, decisions are often not systematically documented [10, 12, 15]. Therefore, we wanted to investigate through the survey how architectural decisions are documented in practice.

As a result of the surveys and an additional case study to investigate tool support in terms of its visualization capabilities [17], we identified at least five deficiencies in practice that we describe in the following:

Decision processes are often not defined and run ad hoc. As a result, decision-making is almost exclusively a manual process. Support, for example through automated techniques, is difficult because it is unclear how the processes run, and which tools are needed. Furthermore, the processes are difficult to understand.

EAs encompass large parts of the enterprise. Therefore, **many stakeholders** are involved in changes that are affected by them. For this reason, decision-making requires a high degree of collaboration and communication between the stakeholders. The **often-conflicting interests** of the stakeholders arising from the various responsibilities further complicate the situation.

Visualizations are often used as information providers. In practice, the **visualizations are often static** and offer few interaction possibilities. In addition, the configuration of visualizations requires a good understanding of the underlying metamodel. Furthermore, the **configuration is often limited** or only possible by special users. Adaptation to changing information requirements during decision-making is therefore difficult to implement. For this reason, the visualizations offered by tools are usually only used as an entry point. Instead, partial models are exported and processed in spreadsheet programs.

Table 15.1 Identified deficiencies in practice and how we want to address them

Deficiency	Requirements
D1. Unclear and undefined decision-making processes	RQ 1. Decision-making activities that can be flexibly combined to form decision-making processes RQ 2. Integration of techniques into decision-making activities
D2. Many stakeholders with conflicting interests	RQ 3. Working environment to support collaboration and communication between stakeholders RQ 4. Parallel consideration of different aspects in order to be able to recognize relationships and dependencies
D3. Static and disconnected visualizations	RQ 5. Interactive visualizations for dynamic information demand during the decision-making process
D4. Loss of context due to sequentially considered aspects	RQ 4. Parallel consideration of different aspects in order to be able to recognize relationships and dependencies
D5. No systematic documentation of architectural decisions	RQ 6. Semi-automated documentation of architectural decisions and their rationale already during the decision-making process

The **sequential consideration of viewpoints** during the decision-making process, caused among other things by different interests of the stakeholders involved, presents them with major challenges. In this context, there is a lack of support in identifying dependencies between viewpoints.

In practice, **architectural decisions are often not documented systematically** and without rationales due to time-consuming ex post documentation. It is difficult to understand an architectural decision from the past without the corresponding justifications. To answer the question why an architecture is as it is, documented architectural decisions and their rationales are essential.

After identifying the deficiencies in practice, we derived appropriate requirements to solve them. Table 15.1 shows the result.

15.3 Related Work

The description of related work is divided into three parts. First, we will look at general decision theory with a focus on decisions and decision-making processes. Subsequently, we discuss approaches that also focus on decision-making but specifically on the domain EAM. In the end, we will discuss work that deals with modeling EA decisions.

15.3.1 Decisions and Decision Processes in General

There is general agreement in the literature on the description of decision-making processes. The processes described are very similar, although they differ in nuances. In the following we will therefore only show a small extract of them.

Dewey [18] first described the steps of solving the problem as "What is the problem?", "What are the alternatives?" and "Which alternative is the best? According to this, Simon [19] defines the decision-making and problem-solving process in three phases. In the first phase, the so-called Intelligence Activity, the environment is searched for situations or states that require action in the sense of a decision. In the second phase, called Design Activity, developing different solutions to solve the identified problem is in focus. Finally, the so-called Choice Activity aims to select the most suitable solution.

Mintzberg [20] defines a decision as a "commitment to action". According to him, a decision process is not merely the selection of a solution but starts with a stimulus that represents a recognized necessity to act and ends with the promise to realize a solution for the improvement of the situation. According to Mintzberg [20, 21], the organizational decision-making process consists of seven activities that can be assigned to the three phases according to Simon [19]. The process ends with the authorization of responsible decision-makers.

Due to the complexity of EAs and the stakeholders involved, decision-making today is no longer conceivable without appropriate tool support. Decision Support Systems (DSS) are specialized tools for this purpose. In the classical normative understanding of decision theory, DSS are suitable for recurring and highly formalized problems whose solution is already known in advance [22–24]. According to this understanding, the decision as a result of the decision process is determined by the DSS [24]. In contrast, a decision according to the understanding in computer supported collaborative work (CSCW) research is left to the user of the DSS and not determined by the system itself [24]. In this context, a DSS is seen as a computer-assisted system that assists people in carrying out semi-structured activities in the context of decision-making but does not take the decision [23].

DSS for groups are often used in combination with meeting support systems, which, in addition to supporting the decision-making process, focus on communication between the participants [24, 25]. The meetings take place in meeting rooms equipped with information technology, the so-called Electronic Meeting Rooms (EMS) [26]. Possible configurations are the Management Cockpit War Room [27] and the Management Cockpit [28]. Both approaches are based on equipping the room with several screens to view and analyze different perspectives on a particular situation in parallel.

15.3.2 Decision-Making in EA Management

There are different approaches that address decision-making in EAM. Although the evolution of an EA is based on a multitude of decisions within the architecture development cycle, TOGAF [14] as the standard work for EAM does not contain a decision-making process. The basic steps of the further development of an EA are however covered by the ADM cycle contained in TOGAF. This supports the collaboration between stakeholders, as the individual activities contain indications for the identification of relevant roles.

Best-Practice EAM [6] is an approach that provides concrete, practice-proven suggestions on how EAM can be established in an organization. The required steps for further development of an EA are described in detail and supported by tools in form of patterns and static visualizations. Although a decision process is not explicitly described, the method provides typical activities for further development of an EA and gives information about which roles and responsibilities there are and when these are to be included.

CEADA [29, 30] includes a collaborative and flexible decision-making process. However, the actual design of a target architecture is considered as a black box, which is carried out by experts. The focus of the method is on a collaborative understanding of the actual problem, a jointly developed solution sketch in the form of requirements and scenarios as well as on the subsequent collaborative selection. The authors consider the interests of the stakeholders and the views derived from them on the architecture as an important starting point for the collaborative decision-making process. However, the views and a systematic integration into the decision-making process, e.g., in the form of a conceptualization, will not be discussed in detail.

GEA [31] is an approach to make the interrelationships essential for organizations explicit and to control them. The defined perspectives allow the identification of stakeholders to be included in the further development of the EA. The explication of the interrelationships between the perspectives supports the stakeholders in the collaboration. Furthermore, the authors outline a process to move from a business problem to a holistic solution. This contains essential activities of decision-making in a very abstract way.

15.3.3 Modeling EA Decisions

ISO Standard 42010 [9] describes an approach for the systematic creation of architectural descriptions of systems based on the needs of corresponding stakeholders. In this context, it also provides modeling decisions. However, this is only rudimentary. A decision can be related to elements of the architecture description, e.g. views. But a decision cannot be related to elements of the architecture. Therefore, the effects of a decision are only very indirectly recognizable.

EA Anamnesis is an approach developed by Plataniotis et al. [32] for ex post modeling of decisions in EA management and decision-making itself. However, decision-making is not represented as a process, but as a strategy. This includes both the criteria on the basis of which potential alternatives are evaluated, their weighting and the evaluation itself. Essential parts of the decision-making process, such as the stakeholders involved in a decision and the findings gathered during the decision-making process, are not covered. The approach is designed for ex post documentation. However, a main reason why decisions are not systematically captured in practice is the time-consuming ex post documentation [33].

Multi-perspective Enterprise Modeling (MEMO) is a framework for enterprise modeling described by Frank [34]. The special feature of this approach is the modularization of different aspects of enterprise modeling into different modeling languages. MEMO addresses the perspectives strategy, organization and information systems. Bock [35] extends MEMO with an additional modeling language to describe decision processes in the organizational context. However, the modeling of individual activities within the decision-making process can only be implemented to a limited extent, since this is only possible by chaining processes. The metamodel consists of a multitude of different concepts, which leads to a high complexity. Similar to Plataniotis et al. [32], Bock also relies on a subsequent, manual modeling of the decision processes.

15.4 Integrative Method for EA Management

The idea of this work is to design a method that specifically address the demands of collaborative decision-making in EAM. The basis for the development of the method are the requirements (RQs) described in Sect. 15.2. The overview of related work presented in Sect. 15.3 did not identify an approach that fully meets all requirements. Therefore, a suitable solution has to be developed.

A key component of the method is a working environment supporting collaboration between stakeholders involved in decision-making (RQ 3), particularly by supporting discussion and providing all relevant information. For this purpose, the idea of the Management Cockpit [28] will be applied.

For method engineering we use the method definition of Goldkuhl et al. [36]. According to this, a method consists of method components for the modularization of decision-making activities, a framework as a ruleset for combining them and forms of cooperation. These forms define roles as well as the working environment in which the activities are carried out. The underlying concepts and relationships are defined by a metamodel. In the following the elements of the method are discussed in more detail. First, we introduce the Decisional Metamodel, which defines the basic mechanisms of the method. Subsequently the method components and the framework follow before we finally explain the cooperation forms.

15.4.1 Decisional Metamodel

The Decisional Model describes fundamental concepts and relationships of decision-making and additionally provides all relevant information for decision documentation (RQ 6). The basis of the metamodel is an extended conceptualization of the architecture description described in [37], which combines decision-making concepts based on related work and own considerations. The result illustrated in Fig. 15.1 is a novel approach to the description of decision-making. Orange colored concepts come from [20], yellow from [9] and blue from [32]. White colored concepts originate from own considerations.

The core concept is the *Decision Process*, which represents the decision-making process. Following [19, 20, 38] we define a *Decision Process* as a logical sequence of activities to solve one or more identified issues. The result of a *Decision Process* are one or more decisions to solve the identified problems taken by the responsible stakeholders.

The particular activities of the process are represented by the concept *Activity*. Since these *Activities* take place with human participation, at least one *Stakeholder* is assigned to an activity, who executes the respective activity. The *Stakeholder* concept is taken from ISO Standard 42010 [9].

In order to support *Stakeholders* in carrying out the respective *Activity*, visualizations (*Architecture Viewpoint*) and so-called *Techniques* can be used. Both concepts are part of the extended conceptualization of the architecture description [37]. *Architecture Viewpoints* are used to visually represent parts of the EA in a stakeholder-oriented way, while *Techniques* contain more detailed recommendations for action or algorithms for the automated execution of a specific task.

Based on CEADA [30], new information (*Process Data*) is created during the execution of an *Activity*. Such information represents the result of an *Activity*. These are, for example, newly identified or refined issues, arguments and discussion results

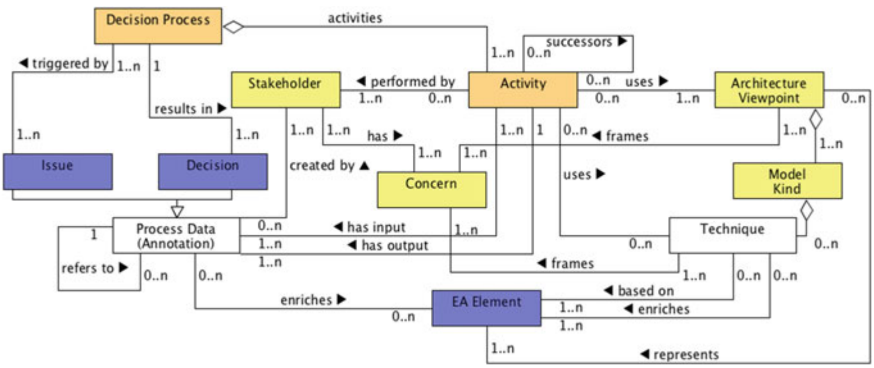

Fig. 15.1 Decisional metamodel

or a decision. In addition, the resulting information is the basis for subsequent *Activities*. Since this information refers frequently to particular elements of the EA, these can be set with one another in relation. These elements are represented by the *EA Element* concept, which also comes from [32].

Specializations of *Process Data* are *Issue* and *Decision*, which both have their origin in [32]. *Issues* represent problems and are the starting point of decision-making. These can be refined by new insights or can emerge during the analysis. The *Decision* in turn represents the result of the *Decision Process*.

The Decisional Metamodel shown is intentionally very abstract. The method components presented in the next section extend the metamodel. For each component there is a specialized *Activity* that defines what possible input and output information (*Process Data*) exists. In addition to *Issue* and *Decision*, there are other forms of the *Process Data* concept.

15.4.2 Method Components and Framework

According to Goldkuhl et al. [36], method components are used to modularize activities to be carried out. In this way, there is the advantage of a flexible sequence depending on the current situation (RQ 1). In order to prevent random combinations, the framework defines rules.

The decision process of Mintzberg [20] is used to identify the method components. This results in the components contained in Table 15.2.

The method components B to F correspond to decision-making activities from Mintzberg [20]. Component A is a special component, because it provides necessary steps to configure the method itself. The steps described there are not part of a decision-making process and are therefore not to be run through during the decision-making process.

In order to break down the complex decision-making into smaller tasks, a cyclical procedure similar to the ADM cycle [14] is possible. For this reason, for example, the successor of component C can be a new execution of the same component. The activities described there are not part of a decision-making process and are therefore not to be run through during the decision-making process.

Table 15.2 Method components and their possibilities of combination

Component	Predecessors	Successors
A: Configuration	–	B, C, D, E, F
B: Define Goals and Requirements	A	C, D
C: Analyze Situation	A, B	B, C, D
D: Develop Solution Candidates	A, B, C	B, C, D, E
E: Evaluate and Choose Solution Candidate	A, D	C, D, E, F
F: Authorize Solution Candidate	A, E	B, C, D

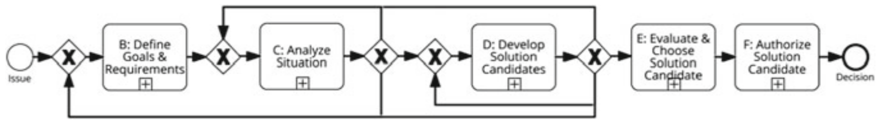

Fig. 15.2 Decision-making process based on the framework

Figure 15.2 illustrates an idealized decision-making process based on the framework's combination rules. We would like to emphasize that this process is not the only one possible. However, we have observed this in the application of the method with experts from practice.

The decision-making process is initiated by one or more identified issues. The process starts with the definition of goals and requirements. The next step is to analyze the current situation with the aim of sufficiently understanding the identified issues in order to be able to design solution candidates. The analysis takes place in an iterative way, which is why the corresponding method component can be applied several times in a row in order to be able to consider different aspects one after the other. By a better understanding of the issues or with the analysis of newly identified issues an adjustment of the goals and requirements could be necessary. This in turn triggers a new analysis. Then the iterative design of solution candidates takes place. For this the analysis and the design of solution candidates can be run through in combination several times and optionally a refinement of the goals and requirements can be inserted before.

After finishing the design of solution candidates, their evaluation and the selection of the candidate best suited to the goals and requirements takes place. Since this is an idealized process, no adjustments are necessary and one of the solution candidates adequately solve the issues. For this reason, no returns to the method components C and D are done at this point. The situation is similar with the authorization of the solution candidate. In case of a positive assessment by the responsible stakeholders, the previously selected solution candidate is authorized. The decision-making process ends at this point because the implementation of the solution is not part of the method.

15.4.3 Cooperation Forms

In order to complete the method on the basis of the method definition of Goldkuhl et al. [36], we finally describe the Cooperation Forms. These describe which roles are required for the application of a method, especially for performing the tasks contained in the method components, and how these should cooperate with each other.

The question which stakeholders are to be included in the particular method component depends very much on the issue at hand. EAM literature describes a multitude of different roles [6, 8]. Based on the role descriptions we identified the following three basic types and assigned the roles to them.

- *Domain Experts* have a profound domain knowledge and are experts in a part of the EA. They are responsible for preparing the decision-making process (components C to E). Typical Domain Experts are Business Architects or Process Owners.
- *Decision Makers* take the main responsibility and make final decisions (component F). Examples are the CIO or committees defined by an organization.
- Unlike domain specialists, *Moderators* work across domains. They guide through the decision-making process and are the mediator between different interest groups in order to reach a common consensus. The typical role of the moderator is the Enterprise Architect.

15.5 Method Component C in Detail

For limited space, we are concentrating on the method component C: Analyze Situation and describe them in detail. This method component is used for focused analysis of previously identified issues. The findings gathered are then used to develop possible solution candidates to solve the issue (method component D). The goals pursued by the analysis are defined by method component B: Determine Goals and Requirements.

According to Goldkuhl et al. [36], a method component consists of (1) a procedure that contains a step-by-step description of actions, (2) concepts for describing the underlying mechanisms and (3) a notation for representing the results. The concepts are used in the method components and specify what is possible. They correspond to the concepts of the Decisional Metamodel or specialize them. Figure 15.3 illustrates the necessary extensions.

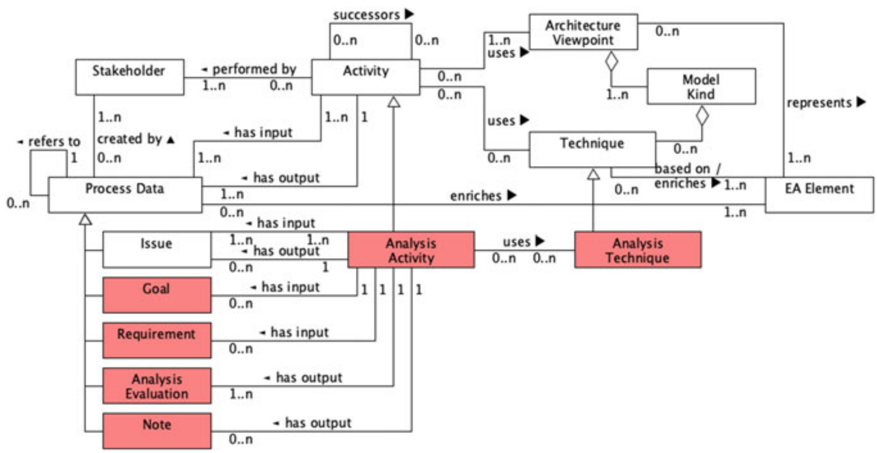

Fig. 15.3 Extended decisional metamodel based on method component C

For representing the analysis, the abstract *Activity* is specialized by the *Analysis Activity*. *Analysis Techniques*, which are a specialization of the abstract *Technique*, can be used to perform the analysis.

Addressed *Issues* are assigned to the *Analysis Activity* as input for the execution. The *Issue* is already included in the original Decisional Metamodel. Further inputs can be *Goals* and *Requirements*, on that basis the analysis is performed. The result of the analysis is so-called *Analysis Evaluations*, which represent the evaluation of results of executed *Analysis Techniques*. Furthermore, discussion results and further information can be documented in the form of *Notes*. New or refined *Issues* can also be the output of the analysis.

In the following, the procedure, which is the second part of a method component, is described. The notation as the third component of the method component is part of the viewpoints. These are based on a modeling language consisting of syntax, semantic, and notation (see [37]).

Step 1: Plan Analysis

This step is about setting up the analysis. For this the moderator is responsible. First of all, the aspect to be analyzed has to be defined. This is derived from goals and requirements of method component B. Stakeholders to be involved must then be identified. Once the stakeholders have been identified, the parts of the EA that are relevant to the analysis of the chosen aspect have to be defined. These parts are motivated by the stakeholder's interests and are represented by viewpoints that they use in their daily work as information providers. The creation of an appropriate viewpoint catalog is part of the configuration of the method (Component A).

Step 2: Analyze and Evaluate

First, the visualizations selected in step 1 have to be analyzed collaboratively. To support this, suitable analysis techniques can be selected and executed, which can run both automatically and manually. Analogous to viewpoints, there is also a catalog for this, which is created in component A. The catalog can be used as a basis for the analysis.

The analysis is based on interactions that can be performed in the selected and parallel visualizations. Some forms of interaction are shown in [39]. These are for example graphic highlighting and filtering as well as the representation of additional information to elements of the EA, which are represented by symbols. The execution of automated analysis techniques is also an interaction. With regard to the identification of dependencies between the viewpoints, dependency analyses can be used.

The results of the analysis have to be evaluated by the stakeholders. Furthermore, conclusions are to be deduced, which are to be documented graphically in the visualizations with the help of interactions. In addition, newly identified or refined issues could be a result of this evaluation. For the documentation of the results, a combination of graphical highlighting and annotation of the associated elements of the EA is used.

The viewpoints selected in step 1 provide the notation as the third component of a method component. In [37] we develop interactive visualizations (RQ 5) and show the interaction with analysis techniques (RQ 2). In [40] we describe which forms of interaction are generally possible. The novel feature of this method is that different visualizations can be viewed in parallel in an appropriately equipped electronic meeting room (RQ 4). Dependencies between the sections of the architecture represented by the visualizations can be made visible by analysis techniques.

15.6 Exemplifying the Approach

To demonstrate the method, we conducted a case study with an insurance company [41]. Insurance companies are exposed to a variety of risks through their core insurance and asset management activities. Including underwriting, operational, strategic but also credit, market, business, liquidity and reputational risks. Internal Governance Risk and Control (GRC) systems as means to actively govern and manage these risks are therefore prevalent in the insurance industry.

The insurance company has a holding structure with over 60 Operating Entities (OEs) represented in more than 70 countries and serving more than 100 million customers. The IT necessary to support the business of the OEs is partly operated by a captive shared service provider, while certain OEs with special situations reserve the right to maintain a local IT. In this context not only efficient and effective but also resilient and above all secure information processing is a key capability for the organization. These demands derived from the company's business model and regulatory requirements are translated into harmonized Global Architecture and Global Security Standards which are mandatory for all OEs and governed centrally in the holding.

In our case study, the CIO instructs the company's Enterprise Architect to improve the eight most important OEs based on predefined architectural indicators. One of these indicators is 'IT debt' that computes the distribution of IT Assets of Standard to non-standard technologies. The IT debt is expressed in the amount of money needed to migrate from non-standard technologies to their standard counterparts is considered the corresponding IT debt. The respective value of the indicator is based on an expert assessment together with the respective OE representatives.

The Enterprise Architect is the moderator and therefore responsible for improving the OEs. The case study takes place in the so-called Architecture Cockpit that is a combination of hardware and software and realizes the collaborative working environment (RQ 3). The hardware is based on the management cockpit concept [28] and includes nine different screens to display several viewpoints in parallel. In addition, in preparation of the case study we implement a software prototype met the support the designed method. In the following we describe the steps given by the method for carrying out the task. For space reasons, we are again focusing on the method component C: Analyze Situation.

Step 1: Plan Analysis

In step one of the method component C: Analyze Situation, the moderator's first task is to determine the aspect to be analyzed. This corresponds to the task assigned to him by the CIO. However, since not all indicators can be considered at the same time and different experts are required in each case, he first wants to analyze the eight most important OEs using the indicator 'IT debt'.

Next the relevant stakeholders have to be identified, their information needs for the present analysis queried and suitable viewpoints selected. Since domain experts are needed for the analysis because they have the necessary background knowledge, the Enterprise Architect involves the appropriate OE representatives who were involved in the expert assessment for the evaluation of the respective IT debt.

Figure 15.4 sketches the configuration of the Architecture Cockpit including the world map and a detail view for each OE.

The world map displayed on the center screen serves as entry point for user interactions. This viewpoint allows to highlight each OE according to a preselected indicator. In our case, all OEs are colored using the IT debt indicator. A legend at the bottom of the viewpoint reflects the category system of 'IT debt' ranging from 'very good' (dark green) to 'very bad' (red). The slider on the right represents an analysis technique that can be used to change the translation into the category system of a values determined by expert assessments. In this way, what-if analyses can be performed against changing global standards.

In contrast to the world map, which aims to provide an overview of the entire company, the detail views on the right and left side provide an overview of a selected OE. The viewpoint shows all existing indicators in the context of the OE. Therefore, there is an individual detail view for each OE. In order to assist users in planning

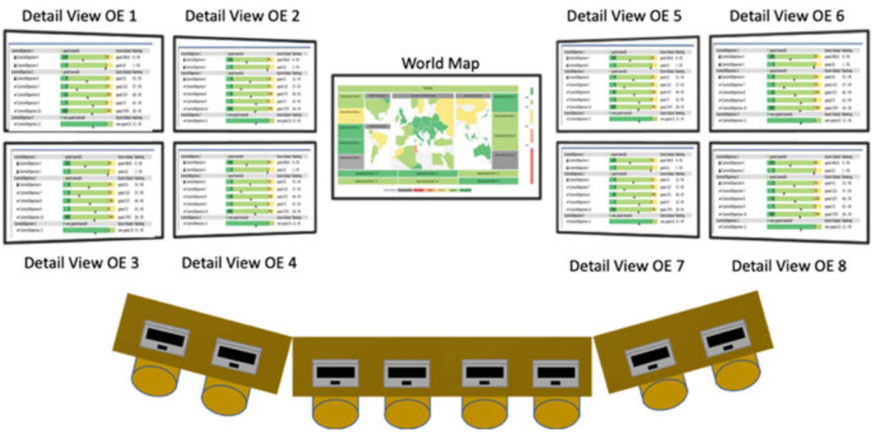

Fig. 15.4 Architecture Cockpit configuration including selected visualizations

standard changes, the exact location of each value within the determined category is shown. Hereby, the required effort to reach the next better category can be estimated.

Step 2: Analyze and Evaluate

Stakeholders first analyze the current situation with regard to 'IT debt'. All relevant OEs are in the good or very good range. In order to continuously improve the OEs, the objectives set for the OEs have to be increased over time. The participants see this potential and document this finding by an interaction on the world map. In this way, an *Analysis Evaluation* object is created in the background as an output of the current activity. This concept is a specialization of *Process Data* and represents findings during the analysis. In this way, semi-automated documentation of decision-making is made possible (RQ 6).

Subsequently, the stakeholders deal with changing the underlying parameters of 'IT debt'. They use a what-if analysis presented in step 1. By using the slider, effects on changed parameters can be analyzed. Since the viewpoints are related, changes made by the slider are displayed in all viewpoints. The indicator is recalculated in the background.

After testing some parameter changes, they choose one. They document this again with an interaction. All previously analyzed what-if scenarios are automatically documented in the background. In this way, you can later see what exactly was tried out and how the decision was made.

Figure 15.5 illustrates the semi-automatically created decision model of the current analysis that is an instantiation of the decisional metamodel (see Fig. 15.1). While activities performed and the *Architecture Viewpoints* and *Techniques* used are automatically documented by the tool. However, stakeholders are responsible for documenting the findings in the form of *Process Data* and the *Stakeholders* involved through interactions. For reasons of complexity, we will limit the decision model illustrated to two of the eight OEs and the first *Analysis Evaluation*, in which the *Stakeholders* have documented that the relevant OEs are in the good to very good range.

The concepts *Goals and Requirements Activity* and *Analysis Activity* are specializations of *Activity* and represent the method components B and C respectively. The *Analysis Technique* is also a specialization of the *Technique* with focus on analysis.

Further Activities

In the example shown, the stakeholders analyzed and planned changes in relation to the 'IT debt' indicator. Since there are further indicators, further iterations with other stakeholders and viewpoints have to be carried out. Each iteration corresponds to an execution of the method component. The individual iterations correspond to individual process steps, which are automatically brought into a sequence in the background.

After all indicators have been analyzed and planned, the aim is to react to the changed indicators (method component D). Actions are necessary so that the respective OEs are still in the good to very good range. For this, the EA have to be optimized. The solution candidates developed for this purpose must then be evaluated

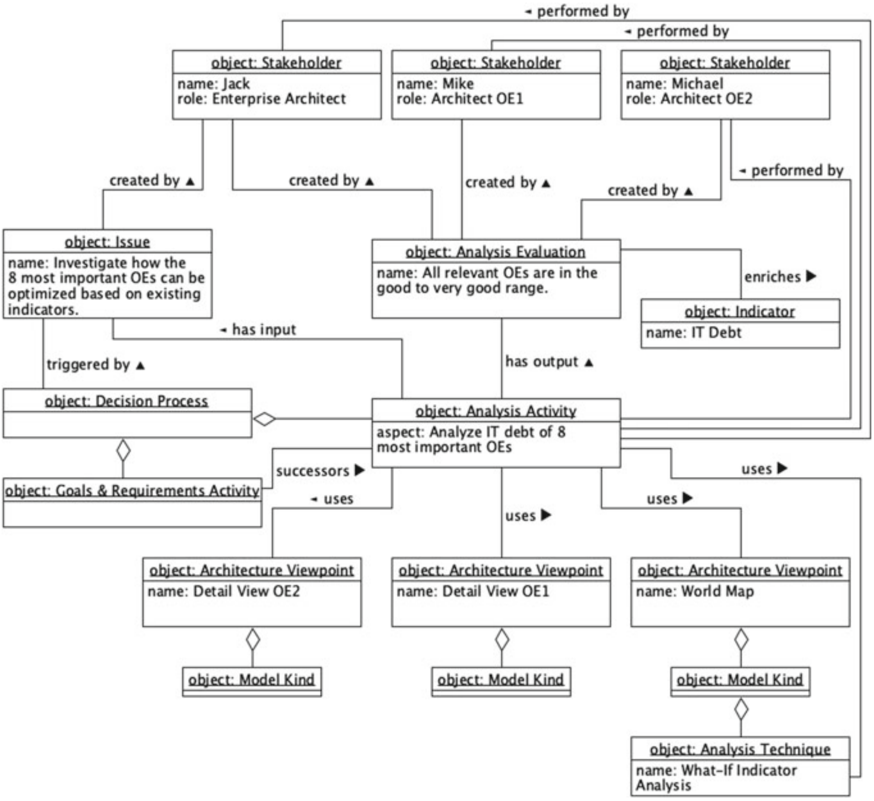

Fig. 15.5 Decision model created during the analysis

by performing method component E. At the end of the process, a decision is made as to which solution will be implemented (method component F).

15.7 Conclusion

The idea of this article is developing an integrative method to support the stakeholders involved in the decision-making process of EAM. The systematic integration of the stakeholders' interests by integrating the corresponding viewpoints on the corporate architecture into the decision-making activities gives the method its novel integrative character.

The interactive viewpoints enable executing manual and automated techniques specialized in the activities. In this way, stakeholders are supported in carrying out the activities.

Stakeholder collaboration is additionally supported by using an electronic meeting approach. This enables considering different viewpoints in parallel and to display dependencies between them. Specialized analysis techniques are used to identify these dependencies.

There are two limitations for the use of this method. On the one hand EAM must already be established in the enterprise, on the other hand an integrated EA model is required. Without an integrated model, automated analyzing techniques based on algorithms would not be possible.

In future work, we want to evaluate the developed method in other companies and further develop it on the basis of the resulting findings. Furthermore, we want to extend the Architecture Cockpit by integrating further techniques and visualization types.

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