FAKULTÄT FÜR INFORMATIK

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Master's thesis in Information Systems

Evaluation of Governance and Process Structures of the federated Enterprise Architecture Model Management

Pouya Aleatrati Khosroshahi

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Evaluierung von Governance- und Prozessstrukturen des föderierten Unternehmensarchitektur Modell Managements

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I assure the single handed composition of this master thesis is only supported by declared resources.

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Abstract

In today's environment, Enterprise Architecture Management (EAM) is facing the problem of separated departments within an organization. Each department works as an autonomous community with separated Information Technology (IT) applications, role allocations and data models. To integrate these separated data models to a holistic Enterprise Architecture (EA) model, standards and policies are needed. The initiation and maintenance of this enterprise wide framework is aggregated under the aspect of federated Enterprise Architecture Model Management (EAMM). Fischer et al. [FAW07] and Roth [Ro14] defined concepts of a federated approach to EA model maintenance and analyze technical aspects within the community. Governance-specific aspects of federated EAMM were not analyzed in research yet. The management of a holistic EA model might be very complex due to several factors – for instance the company size, the established processes and further quantitative aspects. To ensure controlled and traceable processes within a federated EAMM, the definition of governance structures is advisable. Thus, this thesis focuses on the evaluation of governance-specific aspects of federated EAMM, such as:

- Involved roles and responsibilities
- Governance-specific processes
- Relevant standards and policies

This thesis intends to identify best practices within a federated EAMM, focusing on its influence on the IT governance of an organization. Furthermore, the insights can have an impact on the definition of new standards – for instance process definitions and the general role allocation – in context of federated EAMM. The empirical research includes 11 expert interviews with participants from different industries to discover common best practices of managing a federated EA model. Moreover, the results of the expert interviews are evaluated by an online survey.

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Abbreviations

ADM	Architecture Development Tool
CIO	Chief Information Officer
CSV	Comma Separated Values
COBIT	Control Objectives for Information and Related Technology
DQ	Data Quality
DWH	Data Warehouse
EA	Enterprise Architecture
EAM	Enterprise Architecture Management
EAMM	Enterprise Architecture Model Management
FS-RI	Financial Services - Reinsurance
HP	Hewlett Packard
IBM	International Business Machines Corporation
IFRS	International Financial Report Standards
IEEE	Institute of Electrical and Electronics Engineers
IT	Information Technology
ITIL	Information Technology Infrastructure Library
KC	Key Characteristics
OLAP	Online Analytical Processing
OLTP	Online Transaction Processing
OWL	Web Ontology Language
ROI	Return on Investment
TOGAF	The Open Group Architecture Framework
TRM	TOGAF Reference Models
TUM	Technische Universität München
SEAM	Semantic Enterprise Architecture Management

Outline of the Thesis

CHAPTER 1: INTRODUCTION

In the introduction, we illustrate the motivation, the research problem and the desired goals, we want to achieve. Furthermore, we describe the used research approach to identify findings and to define artifacts.

CHAPTER 2: FOUNDATION OF EA AND EAM

Before getting specific in federated EAMM, we give an overview of EA and EAM theory and provides a definition of common terms regarding acEA and EAM.

CHAPTER 3: DESIGN OF A FEDERATED EA MODEL MANAGEMENT

In this chapter, we give an overview about current methods and practices within research relating to federated EAMM. Furthermore, we highlight the specific use cases and characteristics, we want to analysis with the research activities. Moreover, this chapter elaborates the adaptation of common EAM frameworks to federated EAMM.

CHAPTER 4: EVALUATION OF THE EXPERT INTERVIEWS

In this evaluation part, we give a clear overview of the defined research approach and describe all single steps in detail. We describe the research findings in an aggregated way and present the created artifacts, based on the conducted expert interviews.

CHAPTER 5: EVALUATION OF THE ONLINE SURVEY

The research results retrieved from the expert interviews are evaluated by an online survey. This chapter illustrates the feedback of the online survey participants in an aggregated way.

CHAPTER 6: RECONDILIATION OF EVALUATION RESULTS AND ALREADY CONDUCTED RESEARCH

The feedback from the online survey participants are used to define a holistic artifact that includes all necessary activities, when initializing, designing and maintaining a federated EAMM. This chapter describes the holistic artifact and provides a reconciliation between the findings of this thesis and research results of already conducted research.

CHAPTER 7: CONCLUSION, DISCUSSION AND FURTHER WORK

In the last chapter, we recap the the quintessence of this thesis and give a valuation of the federated EAMM regarding usefulness and missing characteristics. We also discuss the research findings from different viewpoints and state further steps that are necessary in re-

1. Introduction

This chapter we gives a short overview about the research topic by motivating the current status of EA documentation in today's organization and by explaining the problem that we address. Furthermore, we give an overview of the performed research approach.

1.1. Motivation

In today's business world, companies are facing the problem of changing organization structures [Dr88], rising complexity of business products [FAW07] and a spate of regulatory requirements by several supervisors [Ko07, Eu06]. To handle these requirements, information technology is a crucial resource. Recent research [Ke02] shows that the IT of today's enterprises has increased over several years: Companies make use of several computing systems, mainframes, sever-client systems and web systems, customized for a specific use. Furthermore, the IT landscapes of large companies take off quite fast, but very heterogenous [Ge05, Ca95, MHR00, Br96], which leads to further efforts regarding consolidation and maintenance of the IT systems. Other components within companies also developed in a heterogenous way such as the used applications to fulfill the specific business requirements, the defined processes for the established business transactions and the developed meta and data models. To summarize these characteristics, it can be stated that autonomous organization units – in our case called *communities* – emerged. However, a company is operating as one organization within a specific market and the single communities are forced to work collaboratively. All generated profits and efforts will be allocated to a whole company.

As a consequence, also IT components within the organization have to be considered in a holistic manner to provide an integrated IT controlling or to fulfill requirements that refer to the company as a whole – for instance the regulatory requirements. However, as aforementioned, communities operate independent of other communities to fulfill their specific business requirements. The communities implement and maintain their IT autonomously as well. As a consequence, we suggest that the majority of significant EA information is stored within the single communities. We also suppose that the implemented meta models in the communities does not only provide information regarding the defined EA entities; rather, they also provide concrete instances for each entity. To have an integrative and complete view on the current IT landscape across all communities, the respective organizations have to conduct various documentation activities regarding EA information.

Recent research by Roth et al. [Ro13a] show that EA documentation activities are mainly performed manually by a central EAM team. Figure 1.1 illustrates the results of a conducted online survey by Roth et al. [Ro13a] that illustrates, how the data collection is organized in today's organizations.

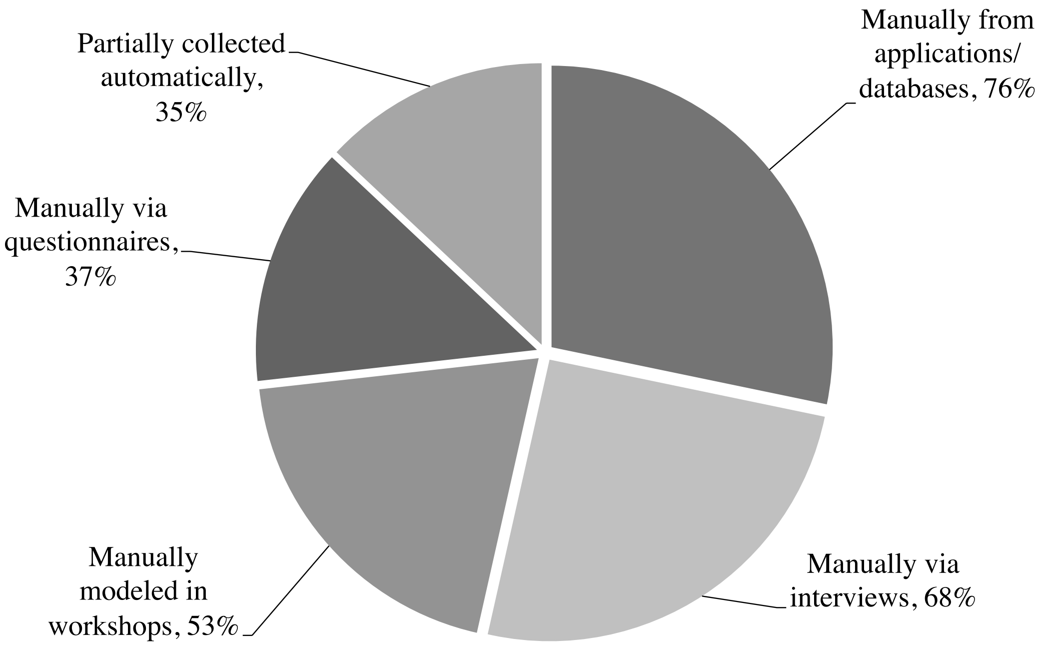


Figure 1.1.: Type of EA data collection approach in today's organizations (adopted by [Ro13a])

As illustrated in figure 1.1, only 35% of the participants mentioned that their respective organization conducts information collection activities partially automated. Most of the activities are performed manually. The survey also reveals that EA documentation activities are very time consuming. Also, dedicated and specified process descriptions for the data collection have not been established yet by 71% [Ro13a] of the participants.

Table 1.1 illustrates the mentioned challenges regarding EA documentation activities.

Various obstacles hinder efficient EA documentation initiatives in today's organizations. Especially the consuming time to collect the necessary data leads to suspect efforts. Further implementation of automated solutions might decrease the demanded effort and suppress the majority of the mentioned obstacles in table 1.1.

The extraction of the EA information from the respective communities and the aggregation of these information to a holistic and integrated EA model might be an appropriate solution to have a comprehensive EA documentation overview.

Fischer et al. [FAW07] and Roth [Ro14] suggest an approach called *Federated Enterprise Architecture Model Management*, which provides methods to document the present EA across the company by aggregating EA information of the respective communities in a holistic and integrated EA model.

Triggering Events	n	% of all
It is very time consuming to collect the data	87	62%
Information is difficult to acquire	69	49%
Sufficient EA model actuality is not achieved	62	44%
Information is not available	56	40%
It is difficult to get hold of the right stakeholders as data providers	54	39%
The information is too fine grained	43	31%
Real world EA changes too quickly to synchronize EA model	38	27%
It creates inconsistencies in the model	34	24%
Other	14	6%
No specific problems	6	4%

Table 1.1.: EA documentation challenges of organizations [Ro13a]

1.2. Problem

Recent research by Roth [Ro13a], Hauder et al. [HMR12] and Farwick et al.[Fa14] show that EA documentation is a challenging and costly task for today's organizations. Beside the mentioned challenges by Roth [Ro13a] in table 1.1, today's organizations have to put major efforts in terms of conflict resolution and data cleansing activities and have to deal with an obvious disinterest by non-IT stakeholder in EA documentation activities. The participation by all respective communities that host relevant EA information and further parties – for instance Data Owner – is mandatory. The problem is that – especially business stakeholders – rarely participate in EAM activities [Ro03]. Due to the heterogenous IT landscapes between the federated communities, major transformation and mapping activities of the provided data from these communities are required. Moreover, it can be advocated in line with Farwick et al. [Fa11] that information systems, which are used by more than one community, result in overlaps between the respective meta or data models. These overlaps might bring up semantic conflicts between the respective EA information, whereby conflict resolution activities need to be conducted. Beside these barriers, it can be distinguished between the transfer of new instances to the EA model and major changes referring to meta model modifications within a respective community.

To manage the listed obstacles, clear governance structures in terms of process definition and role allocation are required. Hence, this thesis strives to answer the following research questions:

$\boldsymbol{Q}_1$: Which governance-specific processes need to be established to implement and maintain a federated EAMM?

$\boldsymbol{Q}_2$: Which roles need to be considered when operating a federated EAMM?

$\boldsymbol{Q}_3$: What further items need to be considered when implementing a federated EAMM?

Further characteristics – for instance automated vs. manual documentation or supervisory pressure – have also an impact on the governance definitions. These characteristics are also considered in this thesis.

Technical issues like tool development or the technical definition of interfaces for data transfer activities, will not be approached. Kirschner [Ki14] addresses technical use cases that refer to the federated EAMM within his master thesis.

1.3. Research Approach

It can be distinguished between behavioral science [MS95] and design science [He04] in terms of information systems research.

Behavioral science originated from the natural science, which *includes traditional research in physical, biological, social, and behavioral domains* [MS95]. It seeks to understand the reality by defining higher order constructions like concepts, theories and languages. To provide and prove the stability of the marked claims, behavioral science consists of two activities: Discovery and Justification. Further information can be obtained at [MS95].

Design science has its roots in engineering and the science of the artificial [Si69] and *seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts* [He04]. The design science focuses on the development of new products, called *artifacts*. In terms of information systems an artifact is defined as a construct, model, method and instance [He04]. These new artifacts should help to solve organizational problems.

This thesis aims to create artifacts that describe the governance aspects of the federated EAMM. Thus, the design science approach is the most preferable research approach. Figure 1.2 illustrates a conceptual framework for understanding, executing, and evaluating information system research. The environment and the knowledge base affect the research. In the case of EAM, the present environment is represented by the employees (*People*), the defined IT strategy and governance setup (*Organizations*) and the current IT landscape (*Technology*). The knowledge base is represented by related work – for instance [Ro08, RHM13, Ro13a]. Further information about the design science framework can be obtained at [He04].

It can be assumed that intensive discussions with experts from the industry are necessary, to assess the theory of federated EAMM. Furthermore, this thesis aim to observe challenges and strategies from these companies and to identify further aspects that should be considered when managing an EA model across several communities. In line with Meuser/Nagel [MN91], persons, who already have profound expertise in terms of EA, are considered as experts. Thus, quantitative research methods are not used to define a first draft of the artifacts. To justify the theories referring to the governance structures of federated EAMM, qualitative research methods are used. Semi-structured interviews with experts from the industry are the most preferable method. To justify the correctness of the designed artifacts, an online survey will be conducted. Figure 1.3 illustrates the performed research approach in detail.

Identify problem: In line with Marsall/Rossmann [MR95], *real world observations* were considered for the research field. There are several possibilities of research in terms of federated EAMM: Process management, tool development for visualization or conflict resolution, definition of required role allocation, etc. This research focuses on social aspects of the federated EAMM, basically the required role allocation and the process design for the major use cases.

Literature research: Based on the defined scope, already publicized literature referring

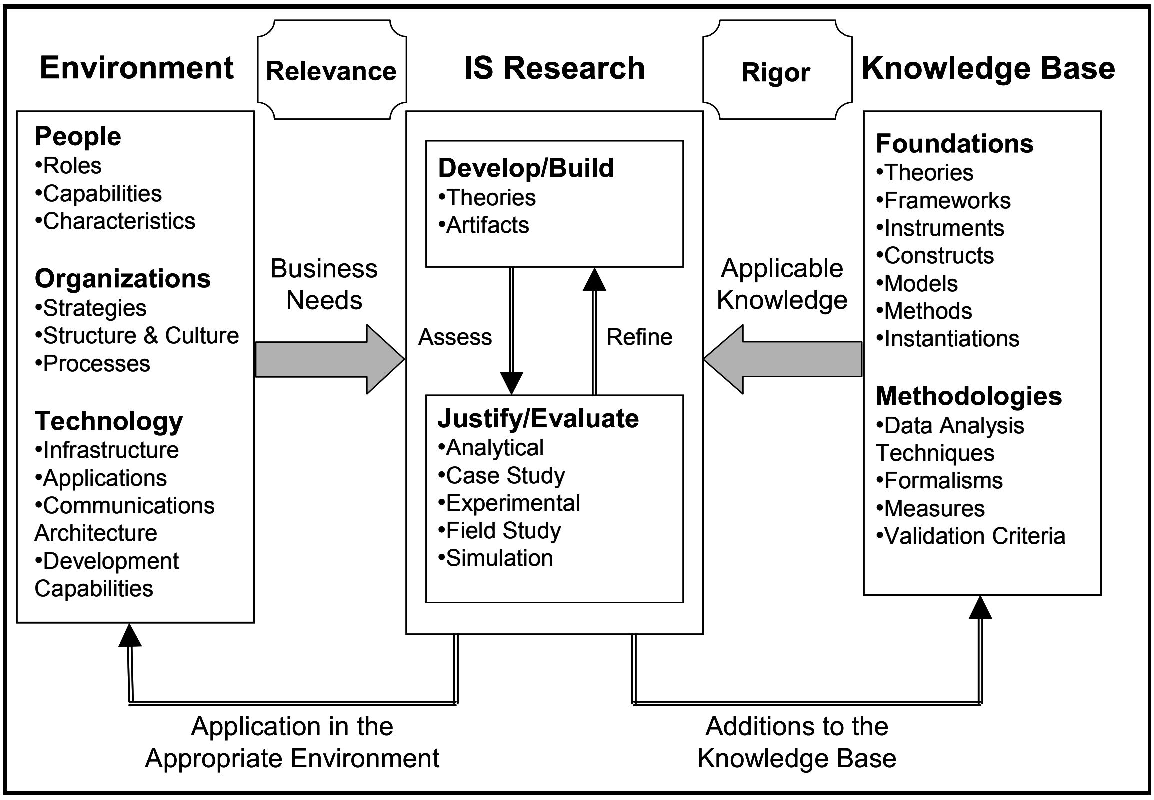


Figure 1.2.: Information systems research framework [He04]

to federated EAMM and governance structures when managing information systems within an organization were analyzed.

Interview guideline: Based on the already publicized literature, open topics will be identified when managing a federated EAMM. When developing the interview guideline, we followed specific principles, described by Stigler/Reicher [SR05].

Conduct interview: As described by Mayring [Ma02] and Wiedemann [Wi86], narrative interviews were performed. These kind of interviews are characterized by the fact that the procedure of the interview is not standardized strongly. The interview guideline serves only for orientation purposes. 11 semi-structured interviews with different stakeholders were performed. Each interview took about 60 minutes.

Evaluate findings: In line with Marsall/Rossmann [MR95], an attempt has been made to search for general statements about relationships among categories of data, filter out the unusual information and generate categories, themes and patterns related to performed strategies for the federated EAMM.

Perform survey: To test the stability of the artifacts, an online survey with 48 participants has been performed. All participants were experts in context of EA. As mentioned by Chelius et al. [CDV12], survey questions may designed in scales, closed questions and open ended questions. The designed survey mainly includes closed questions and scales.

Nevertheless, also open ended questions were included to get further information regarding the root cause for the choices. The results are aggregated to categories to identify further patterns.

Finalize artifacts: The results of the survey give advice regarding the stability of the developed artifacts and give further information regarding missing elements and fundamental errors. The results of the online survey were used to perform further adjustments of the artifacts.

1.4. Related Work

Referring to EA documentation and federated EAMM, only little in-depth research has been conducted yet.

Fischer et al. [FAW07] discuss the concept of a federated EAMM from a general perspective. Fischer et al provide a comprehensive role allocation definition regarding the federated EAMM and highlight that this approach can be a powerful tool among all EA stakeholder. Moreover, the research paper provides information about existing approaches to EA model maintenance and presents the federated EAMM approach at a large financial service provider.

Hauder et al. [HMR12] discuss challenges for automated EA documentation by presenting a practical example from a global acting enterprise of the German fashion industry and by conducting an online survey. The conducted online survey showed that practitioners from the industry face major Data Quality (DQ) issues and missing tool support hinders automization initiatives. Furthermore, organizations face non-technical challenges – for instance missing upper management support, language gaps between several stakeholder and a low return on investment.

Roth et al. [Ro13a] conducted an online survey among >100 EA experts and identified that Enterprise Architects are facing the issue of data collection efforts and lack of DQ in the collected data. Furthermore, they state that *federated teams perform better in keeping the quality of EA models high* and an adequate tool support is mandatory for EA documentation. The online survey also show that theEAM faces the challenge of manual data collection with major efforts, data collection process are not defined yet.

Referring to conflict resolution strategies, Roth et al. [Ro13b] suggest a process definition for the conflict resolution in a federated EA model and provide an interactive visualization solution for it by providing a prototype of the conflict resolution process and evaluating the process definition with expert interviews. Moreover, Roth et al. provide a prototype for the conflict resolution visualization regarding automated EA documentation.

Farwick et al. [Fa13] conducted an online survey and illustrate further issues that hinder EA documentation in today's organizations – for instance the abstraction gap between the collected data and the EA model. Another finding is that in most cases only information within lower technical layers can be documented in an EA model. Moreover, Farwick et al.

highlight that the majority of EA experts conduct data collection activities manually, due to missing automization mechanisms.

Referring to conflict resolution activities Lippe presents an operation-based merge algorithm that detect conflicts between models [Li92]. Further information about conflict resolution can be obtained at [CW98] and [IN04].

Furthermore, a scientific paper by Buschle et al. [Bu12b] evaluated the coverage of EA information within source systems for an automated EA documentation by investigating an enterprise service bus in a fashion industry company. The research results show that EA documentation highly benefits from an automated collection of information from productive information systems. Moreover, Buschle et al. highlight that the use of an enterprise service bus for automated EA documentation reduce costs and leads to higher quality of data.

Moreover, Diefenthaler/Bauer [DB13] suggest an ontology based approach – called Semantic Enterprise Architecture Management (SEAM) – to provide a federated EAMM. The approach is based on semantic web technologies.

However, holistic aspects – for instance the governance setup or incentives for business stakeholder to participate in preparatory actions referring to federated EAMM – are not discussed in current research. Moreover, research do not provide process definitions for meta and data model changes with a clear role allocation for each activity. Further activities and general parameters are necessary to establish a federated EAMM and will be discussed within chapter 4.

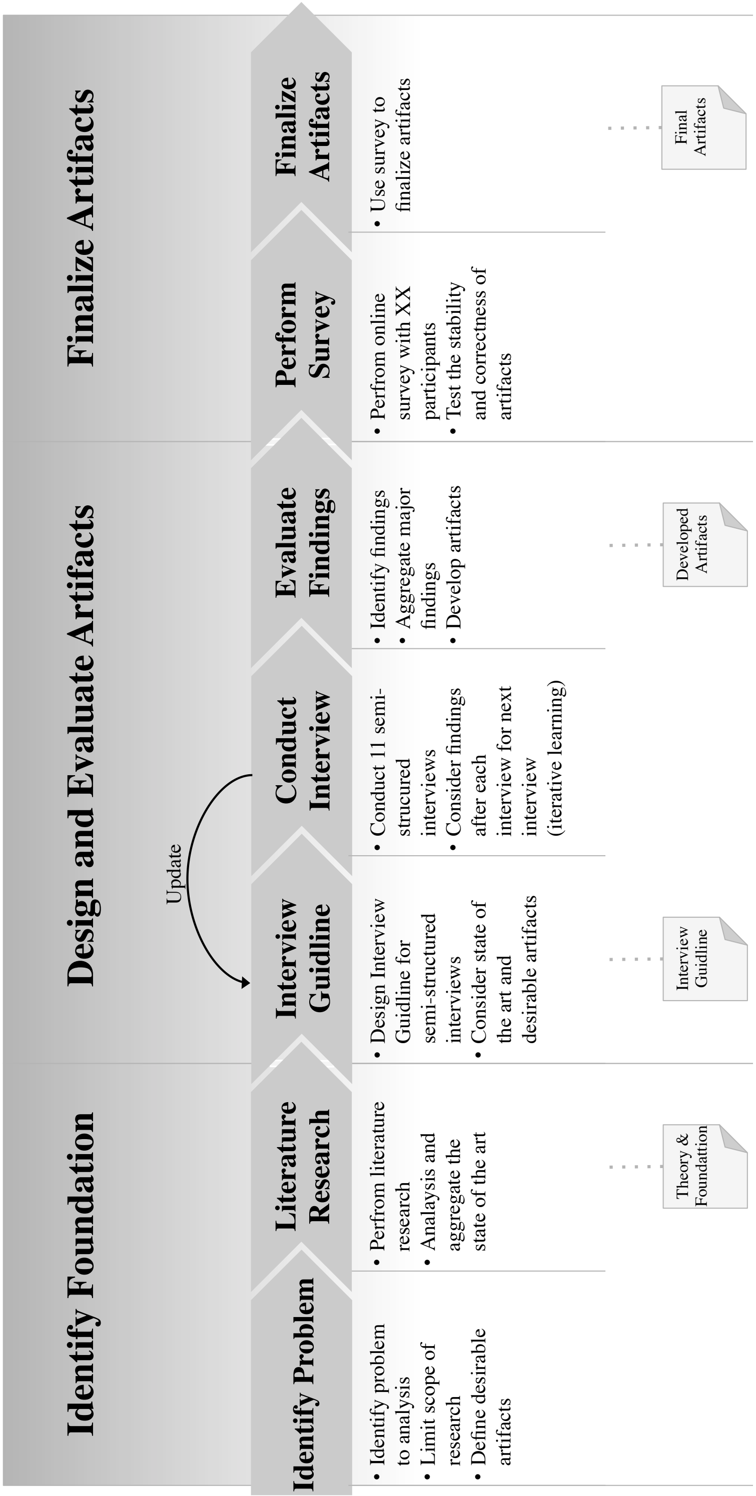


Figure 1.3.: Overview of the performed research approach

2. Foundation of EA and EAM

Before diving deeper into the theory of federated EAMM, this chapter gives a general understanding about external influences that affect organizations behavior and explain the conceptional basis of EA and EAM. Furthermore, common governance aspects that are found in today's organizations as well as the structures that are used to manage IT and its alignment to the corporate strategy are highlighted.

2.1. Organization 2.0

In this section, characteristics and influences that affect the strategic decision making and the planned activities of today's organizations are mentioned. The role of information in general and the rising complexity of IT as a whole are focused. Furthermore, this section highlights the fact of grown heterogeneous communities in larger companies.

In addition to that, it is explained how far EA plays a role in these characteristics and what kind of actions are necessary in future.

2.1.1. Information as a Key Success Factor

In the 1960s, Price identified an exponential increase of knowledge [Kö01]. He specifies that each 15 years the amount of knowledge and information doubles. Toffler defines the term *Information Overload* in the 1970s, which illustrates the fact that nowadays people have to deal with the problem of making decisions, caused by the presence of too much information [To70]. Social network platforms like Facebook, Twitter or Google+ also generate mass of information, which value should not be underestimated by today's companies regarding desires and attitudes of current and potential customers. But to go one step further, the role of information technology regarding the *Information Overload* should also be considered: Porter/Millar [PM85] highlight the terms of *Lowering Cost*, *Enhancing Differentiation*, *Substitution* and *Buyer Power*. All these terms categorize specific situations, in which information technology helps to gather, analyze and structure consumers information in an economic and efficient way – for instance browsing the web for product information or make use of respective IT systems to analyze customers behavior in casinos and develop specific rating systems for it. Drucker states that *information transforms a budget exercise into an analysis of policy* [Dr88]. This statement reveals the fact that information needs to be analyzed thoroughly to achieve competitive advantages.

However, a structured and efficient analysis and management of bulky mass of information, requires a properly positioned IT landscape. The identification of all information systems that provide information input from the environment and a clear definition of data flows across the present IT landscape is mandatory. Otherwise there is the risk that not all information is used comprehensively. As a consequence, valuable information is not used for further strategic decisions.

Furthermore, companies – especially financial service providers – have to cope with upcoming regulatory requirements [FAW07] like Solvency II [Ko07], Basel II [Eu06] and International Financial Report Standards (IFRS) 4 Phase 2, which also require compelling support by information technology: Most of the named regulatory requirements call for broadly capital, risk and reporting requirements, whereas most of the necessary information is stored in distributed information systems across the organization. However, these regulatory requirements do not relate to a competitive advantage or other kind of optional activity. Regulatory requirements are mandatory for specific companies and are statutorily regulated.

Figure 2.1 illustrates the dependencies of *Information*, *EA Landscape* and *Mandatories* – for instance regulatory requirements – as a cycle.

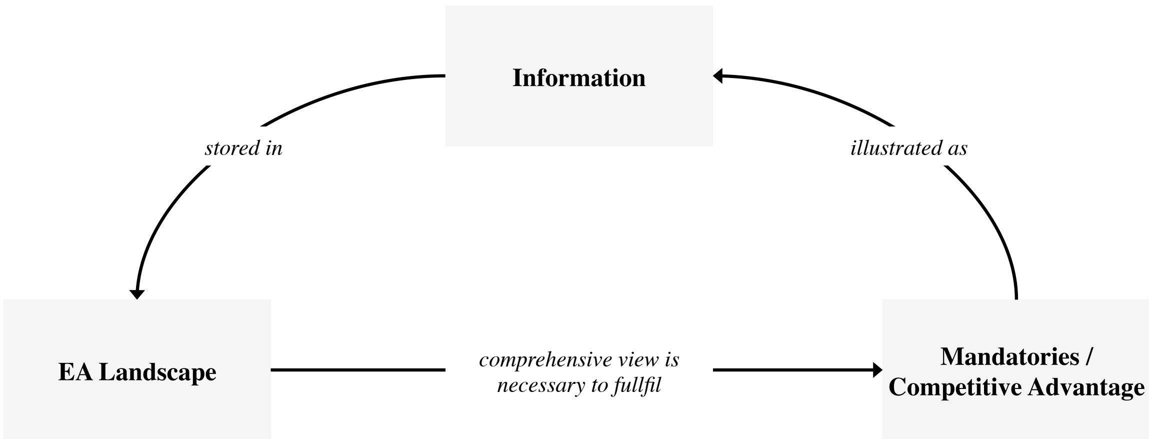


Figure 2.1.: Cycle of EA, information and mandatories/consumer behavior

Regulatory requirements and input regarding consumer behavior are illustrated as information. This information is stored in the organizations EA landscape. Hence, organizations need a comprehensive view on the EA landscape to identify usable information to fulfill the mandatories or to achieve competitive advantage.

2.1.2. Rising Complexity and Dependency on Information Technology

In line with Hanschke [Ha11], it can be advocated that the complexity of information technology is rising. Companies have to face the problem of costly legacy systems [Bl14], complex mainframes, huge amount of custom interfaces etc. These various types of complex IT systems might lead to show stoppers within the daily IT activities – and as a consequence for the daily business – and to unplanned efforts. For instance: 49% of the Fortune 500 companies spend over 1.6 hours a week [Ma14a] for downtime activities. A report by International

Business Machines Corporation (IBM) states that *the average revenue cost of an unplanned application outage was estimated to be nearly 2.8 million dollars per hour* [OCMT14]. Fischer et al. [FAW07] highlight that an increasing complexity of business transactions due to customized products and services is a major challenge for today's companies and IT is an enabler to handle these issues [Da93, Ve94].

Figure 2.2 gives a comprehensive overview, how IT transforms the running business of today's organizations.

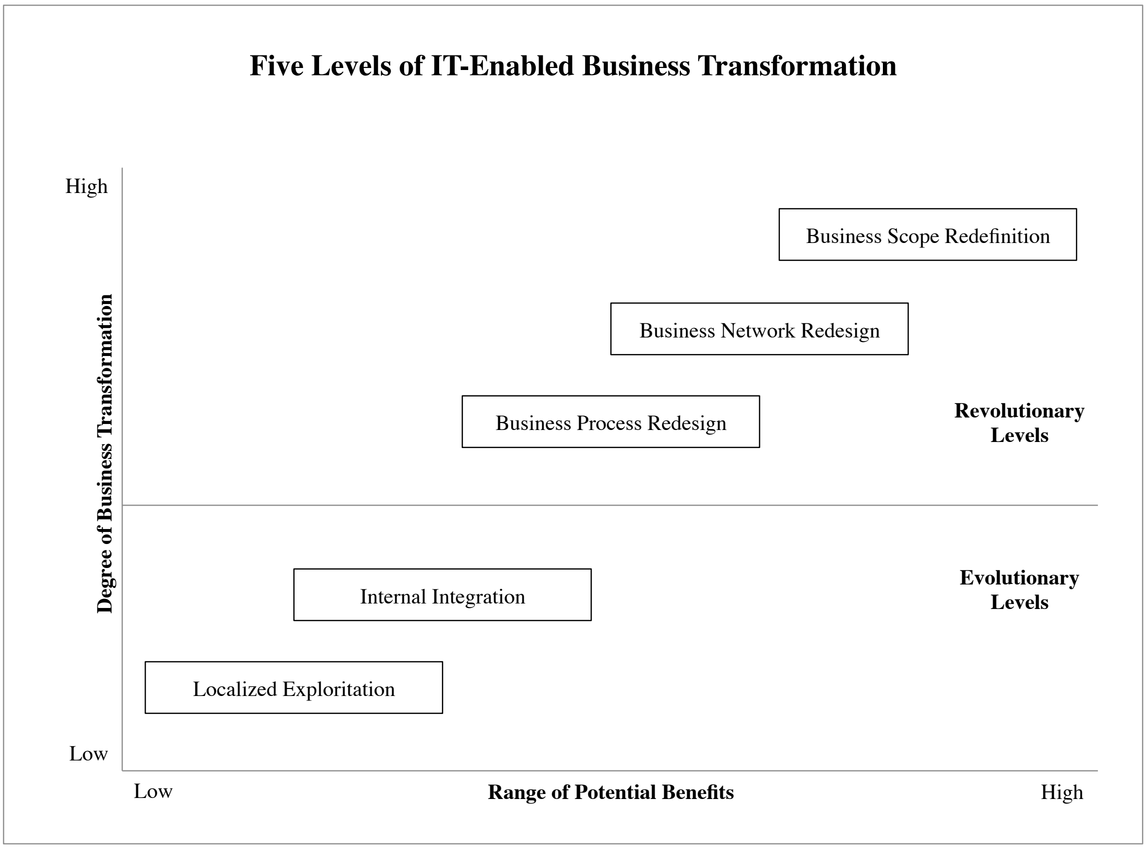


Figure 2.2.: Business transformation stages by IT (adopted from [Ve94])

Figure 2.2 shows that IT influences the business process design or the complete business scope of today's organizations. IT is mandatory to fulfill today's requirements and keep the business running. As a consequence, EA issues should also be managed correctly. Further information can be obtained at Davenport [Da93] and Venkatraman [Ve94].

2.1.3. Establishment of Autonomous Communities

In context of organizational structures Thommen/Achleitner [TA12] and Krcmar [Kr05] define an organizational unit – in our case called community – as an aggregation of roles, which aims to fulfill specific tasks in a collaborative way. Stahlknecht/Hasenkamp [SH13] also describe that the structure of a community depends on organizational, spacial and further characteristics. To fulfill their tasks, these communities define their own business processes, implement and run customized IT applications and establish own data models (see section 3.1.2). Nevertheless, these autonomous communities take only tasks in their responsibility that refer to their organizational unit. However, the single tasks of each community refer to a group project that requires the commitment of more than one community. Collaboration is mandatory to finalize a project successfully.

The problem is that the IT landscape of today's companies developed heterogeneously over the past years. In line with George,[Ge05], Carey et al. [Ca95], March et al. [MHR00] and Brancheau [Br96], it can be assumed that nowadays organizations have a major issue with heterogeneous information systems and the development of autonomous communities over the past years. An adequate communication between these systems is only possible with major efforts [Ze14].

2.2. Conceptional Basis

2.2.1. EA and EAM

The term architecture: There are various definitions and use cases, where the term architecture becomes important. Depending on the specific environment, it has a slightly different meaning. The term is used for instance in IT, process management, naval engineering, landscapes, the classical construction of buildings and houses and various other topics. Vitruv [Kr04] defines three principles of architecture that can be related to every type of architecture: Stability *(Firmitas)*, Utility *(Utilitas)* and daintiness *(Venustas)*. As already mentioned, the term architecture changes its meaning, depending on the specific domain, but these three principles illustrate indicators, which gives a clear statement about the quality of a specific architecture. Furthermore, an architecture should deliver a better understanding about how solutions should be built [Go10]. Referring to IT, the definition, provided by the Institute of Electrical and Electronics Engineers (IEEE)[1] Computer Society [So00] is used:

> **Architecture:** 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 [So00].

The definition illustrates that architecture focuses on the single components (for instance databases, applications and platforms), their relationships (interfaces and data flows) and principles (standards and frameworks).
To get more granular, different types of established architectures, which illustrate the used

[1]IEEE: Professional association that is dedicated to advance technological innovation and excellence.

components and relationships in a different manner – for instance business architecture or application architecture has to be distinguished. Information from these different architecture domains define an EA. Aier et al. [Ai08] explain that *Enterprise Architecture is Broad an Aggregate* and objects, *which only focus on implementation details of one object and which are only relevant for this object, should not be considered part of EA*. Aier et al. focus on general objects within an organization – for instance enterprise services, processes, markets – but this statement can also be mapped to EA. In line with Aier et al. [Ai08] it can be expected – as illustrated in figure 2.3 – that broad and aggregate information is relevant for EA. Each domain deal with enterprise information in a different manner. For instance: The *Business Architecture* is *a blueprint of the enterprise that provides a common understanding of the organization and is used to align strategic objectives and tactical demands* [Th]. A business architecture describes the architecture of the business – for instance relations between specific products. There are rarely relationships between objects of different architectures on a granular level. However, on a more aggregate level, different architectures provide relationships and interdependencies that have an impact on the EA of the respective organization. For instance: A specific application within the application architecture, runs on a specific platform within the platform architecture. These kind of relationships matter to EA and need to be identified, documented, analyzed and optimized by EAM.

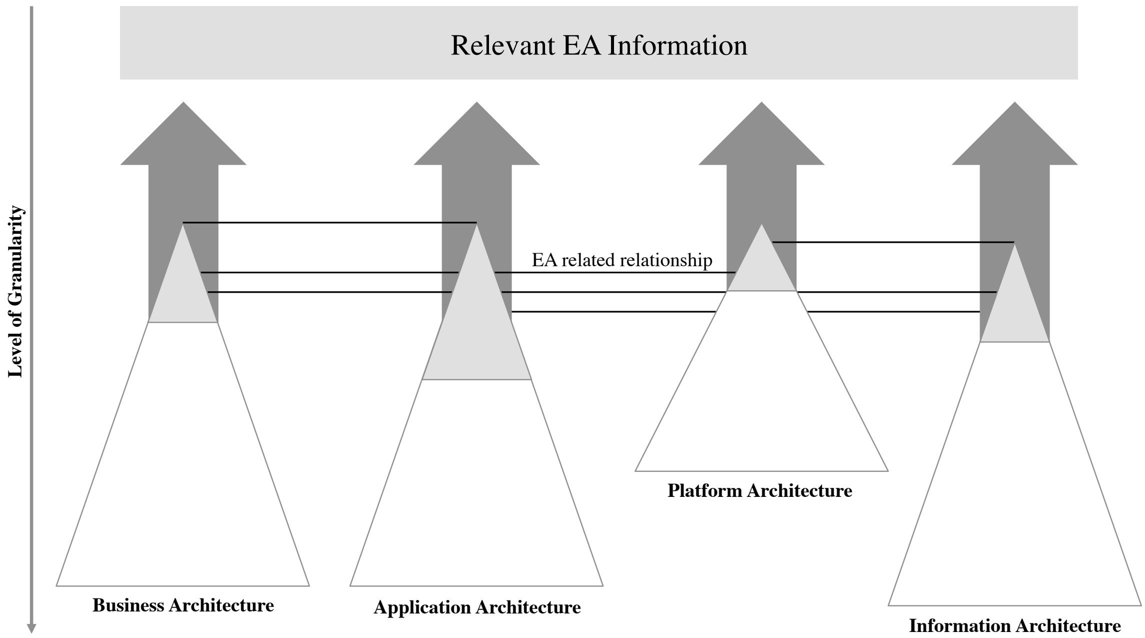


Figure 2.3.: EA relevant information from various architecture domains – adopted from Aier et al. [Ai08]

Gern [De09] describes the art of EA by showing plenty of analogies between EA referring to IT and classical architecture in terms of buildings and houses. Table 2.1 shows analogies between city planning and strategic IT planning.

City planning	Strategic IT planning
Further development of city	Strategic development of the IT landscape
Middle and long term vision	Middle- and long term vision
Guidelines to achieve goals	IT principles to achieve vision

Table 2.1.: Analogies between IT and city planning [Ma14b]

Depending on the focus and assumed objectives of EA, the definitions in research show slightly different emphasis of EA. Ross et al. [RWR06] focus on the business support functionality by EA:

> *"The enterprise architecture is the organizing logic for business processes and IT infrastructure, reflecting the integration and standardization requirements of the company's operating model. The enterprise architecture provides a long-term view of a company's processes, systems, and technologies so that individual projects can build capabilities - not just fulfill immediate needs."* [RWR06]

Another definition is provided by Lankenhorst [La05], who does not focus on the significance of the business, but more on comprehensive topics – for instance organizational structures and information systems:

> *"Enterprise architecture: a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organizational structure, business processes, information systems, and infrastructure."* [La05]

The definitions by Ross et al. [RWR06] and by Lankenhorst [La05] have different views on EA, which shows that there is not one correct definition of EA. However, the following definition for EA is assumed:

> **Enterprise Architecture:** EA represents the present status of the used business, technical, personal and further organizational objects – and its relationships to other domains – which affect the IT landscape of an organization.

Further definitions of EA, can be obtained at [JK06, FAW07, Ro05, Ri07].

Referring to **EAM** a definition by Technische Universität München (TUM) can be used:

> **Enterprise Architecture Management:** EAM is a continuous and self maintaining management function 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 functions it provides input to, exerts control over, and defines guidelines for these enterprise-level management functions. The EAM function consists of the activities envision EA, document EA, analyze EA, plan EA, and enforce EA [Te14].

According to the definition given by TUM, EAM is defined as a *management function seeking to improve the alignment of business and IT* and *furnished with information from other enterprise level management functions*. These two statements reveal that EAM is connected with other management functions within an organization and seeks to support business activities. TUM also states that EAM acts as *Glue* between other management functions, as illustrated in figure 2.4 [Te14].

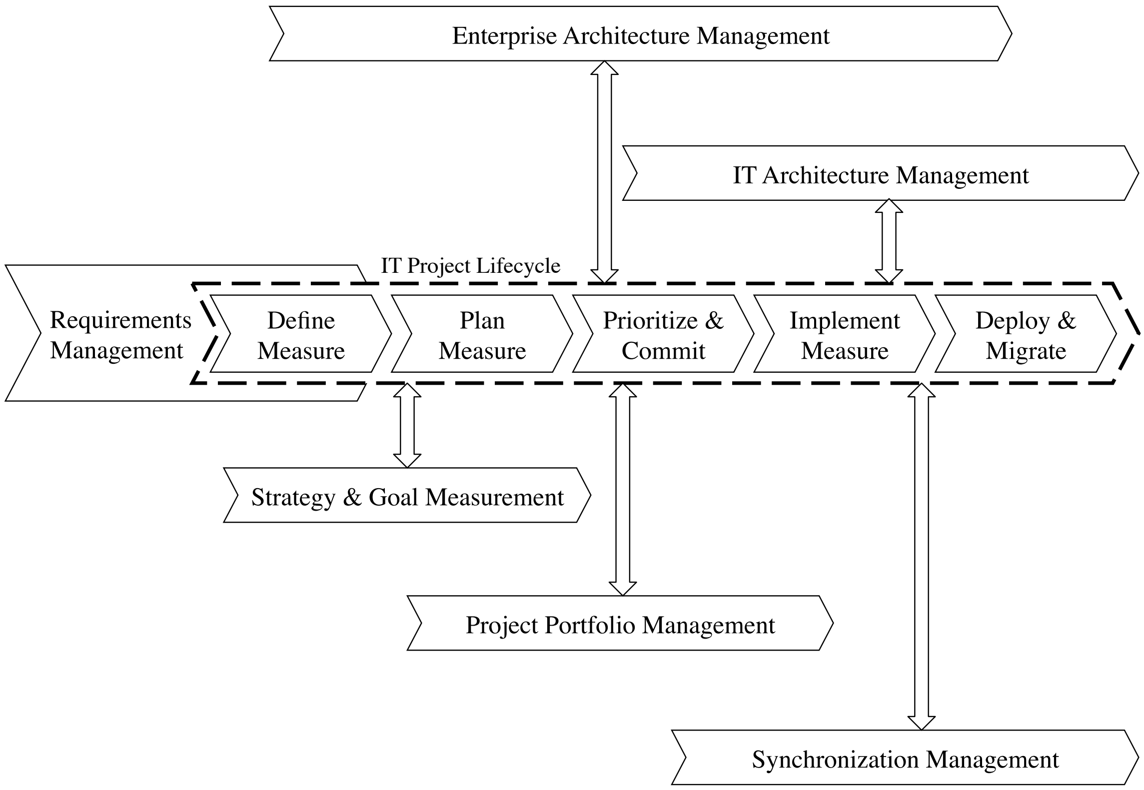


Figure 2.4.: Glue functionality of EAM (adopted from [Te14])

3. Design of a Federated EA Model Management

In this chapter, an overview of the federated EAMM approach is given. The general setup of the landscape – for instance the establishment of several communities and one model – and characteristics of the single layers in this landscape are presented. Furthermore, an overview of the defined roles that are involved within the management of the federated EA model is given, the roles are allocated to the specific layers of the landscape and specific assignments are assigned to these roles. In addition to the defined roles, the use cases – also called processes – that take place within the federated EAMM are presented. Moreover, this chapter provides a briefly analysis of EAM frameworks towards its capability of federated EAMM.

3.1. Approach of the Framework

To facilitate the comprehensive structure and setup of a federated EAMM, this chapter defines the term of *model* regarding EA and illustrates a brief overview of the assumed landscape within the model maintenance organization. The meaning and the role of the multiple communities is highlighted and the levels of the model update process are described briefly.

3.1.1. The Model Term in Context of Federated EA Model Management

There are several definitions of the model term by Rivetts [Ri72], Zeigler et al. [ZPK00], Kotiadis/Robinson [KR08] etc. According to Stachowiak [St73] a model is defined as an artifact, illustrating specific aspects of the reality. He also defines three Key Characteristics (KC) that represent the nature of an model. Figure 3.1 illustrates these characteristics:

Figure 3.1 illustrates the data flow of specific values exemplarily trough four information systems, for instance the claim reserve[1] calculation within an insurance company. The originated claim serves as input and is entered within System A . This system is responsible for the calculation of insurance-specific values. Depending on the location – for instance Europe or Asia – various other systems are responsible for the second calculation step, in this case System BA and System B2. The third calculation is conducted by the integrative System C. This system finally provides the claim reserves information.

[1] Claim reserve: Calculated reserve value in insurance sector

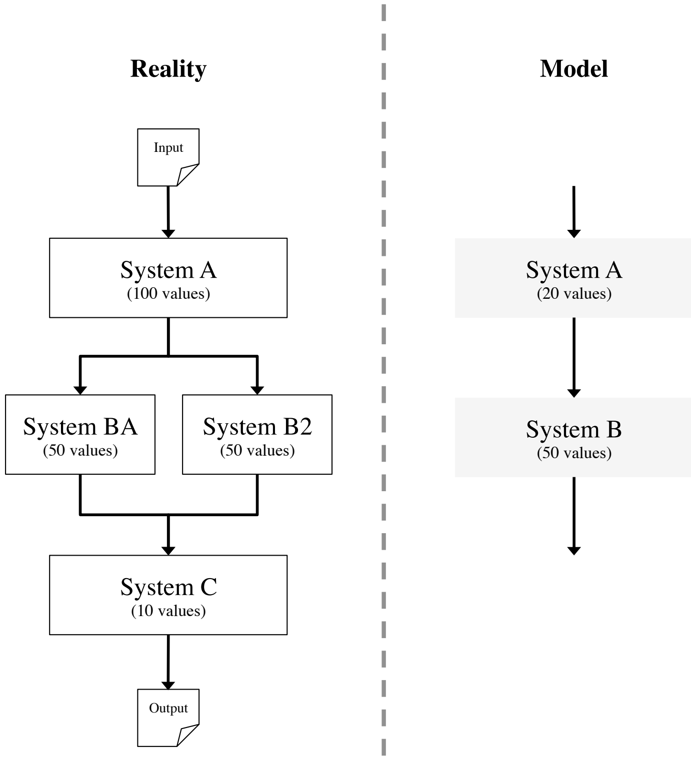


Figure 3.1.: Key characteristics of a model

The provided example illustrates the case within the reality. Let us assume that the EA governance of the insurance company is interested in specific elements and dependencies of the claim reserve calculation, which should be provided in a model. The model represents the claim reserve case from the reality. But as already mentioned there are three KC within the model theory of Stachowiak [St73]:

1. KC: Mapping: Models always represent an element from the reality – or another model. *Example:* The model illustrates the original claim reserves calculation.

2. KC: Abstraction: Models do not capture all attributes, entities and elements of the original case. *Example:* The model includes only system A, system B and it's interfaces. The input file, system C and the output are not included within the model. Furthermore, not all attributes from the systems within the reality are captured within the systems of the model.

2. KC: Pragmatics: Models do not always represent the allocated reality. They only illustrate their originals for certain subjects, time intervals and for specific operations. *Example:* As aforementioned, the second calculation step depends on the location of the claim. As a consequence, the reality includes two different types of information systems for the second calculation step. But the model, represents only one calculation tool representing the information system for the claims in Europe. Thus, system B within the model does not represent the original system with all attributes from the reality.

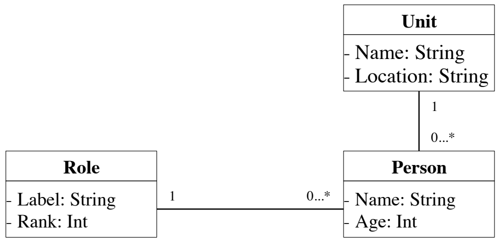
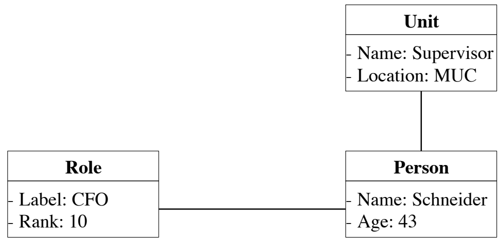
Meta Model	Data Model
	
• Schema, concept or semantic construction of the model • Defines the entities of the model • Defines the attributes of the entities • Defines the association between objects • Does not provide specific content	• Represents the instances of the model • Semantic structure algin to the meta model

Table 3.1.: Example of a meta model and a data model

Beside the KC of a model by Stachowiak [St73], a distinction between meta models and data models can be made. Table 3.1 illustrates the differences between these concepts: On the one hand, the meta model of the illustrated example includes an entity PERSON with the attributes NAME and AGE, whereas on the other hand, the data model includes instances of the entity PERSON, for instance MR. SCHNEIDER, 43.

In context of EA, the meta model defines the semantic structure of the IT landscape with the defined entities, attributes and associations. To be more specific, the following definition is used for meta model term in case of federated EAMM:

> **Meta Model:** A meta model of an federated EAMM defines the different types of IT elements within the IT landscape of the organization and the associations between these elements. The meta model only defines the structure of the landscape and does not include specific instances.

As already mentioned within table 3.1, the data model includes specific instances and content of the IT landscape. Hence, the following definition of data model will be used in context of federated EAMM:

> **Data Model:** A data model of an federated EAMM illustrates the present status of

Sub-architecture domain	Required core artifacts
Strategic plans	Concept overview diagram
Business activities	High level diagram
Data	High level logical data model
Applications	Application interface diagram
Infrastructure	High level network diagram
Security	Control list

Table 3.2.: Artifacts of the sub-architecture domains

> an EA. It includes specific instances of the allocated meta model and provides the final information about the current EA.

There are further classification of model types by Heimbigner/McLeod [HM85], Sheth/Larson [SL90] and Haslhofer/Neuhold [HN11]. These classifications provide further information about the differences of local schemas, import schemas, export schemas, etc. The mentioned literature can be considered as the foundation for further references.

3.1.2. Involvement of Multiple Communities with Customized Elements

One major challenge within the federated EAMM approach is the consideration of several autonomous communities when maintaining an EA model. As already described in 1.1, today's companies have to deal with the challenge of heterogeneous information systems and autonomous communities within their organization. The Executive Office of the President of the United States [Ex12] defines five sub-architecture domains that can be considered within each line of business – in our case community. An adequate meta and data model in terms of EA should provide information about the defined domains in table 3.2.

Each community has its own infrastructure – such as server and network services – and runs customized applications to support the specific business activities and keep the used data on a certain quality level and up to date. Furthermore, the alignment of these applications with the defined strategic plans is of importance. Each community defines customized security activities for assurance purposes. The defined artifacts can be seen as the core EA information, which documents the present condition of the IT landscape for each community. This information can be reported to the governance or give an authoritative statement whether defined principles, methods, standards, etc. are getting used by the community or not. Figure 3.2 illustrates a comprehensive overview of the defined sub-architectures and further principles and activities, which are affected by these sub-architectures.

As already highlighted in section 2.1.1, information can be seen as a key success factor in today's economy. EAM requests to have a holistic and integrated view of the present EA

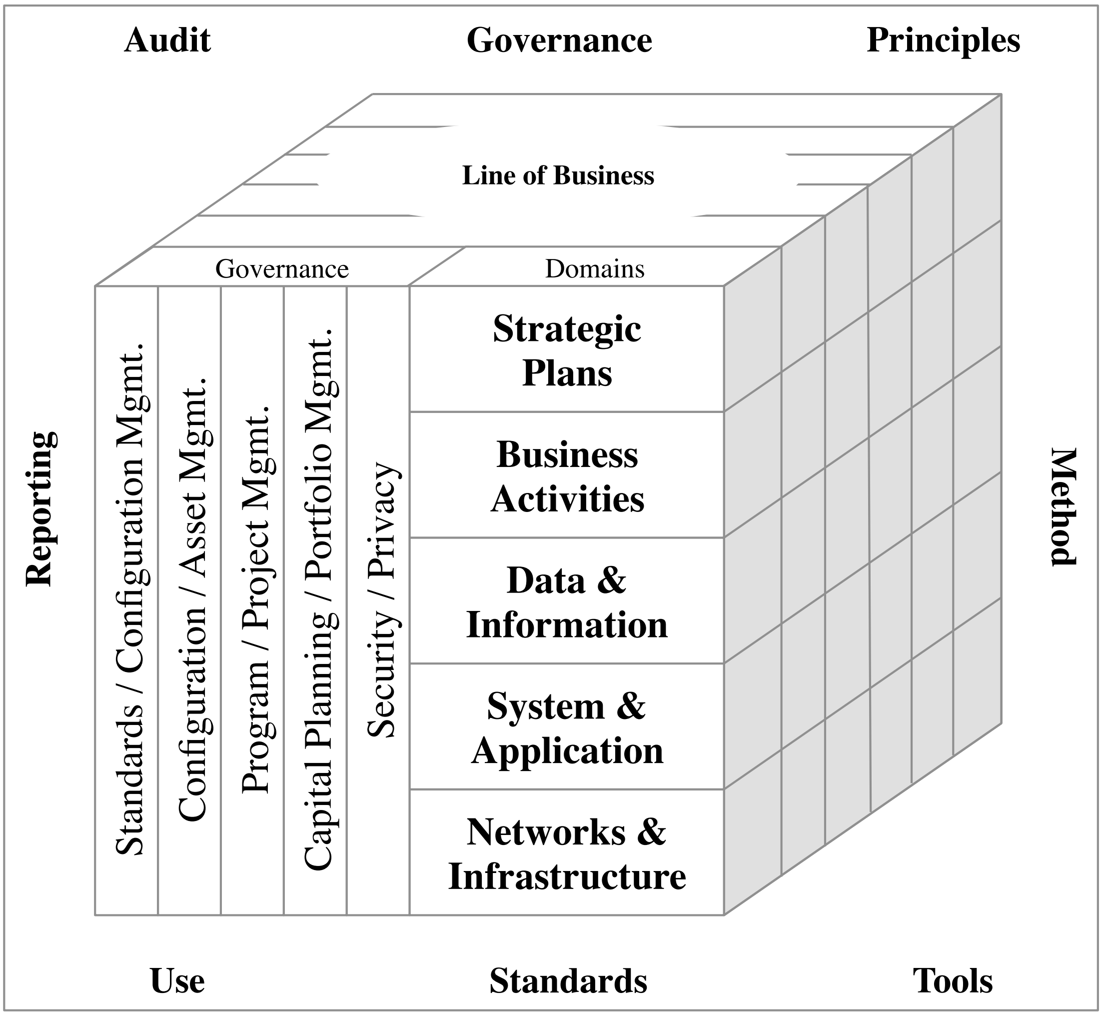


Figure 3.2.: Illustration of a federated organization (adopted from [Ex12])

status within the organization across all communities. The defined artifacts within table 3.2 could provide information about the present EA status in terms of used data, applications, etc. But to illustrate interdependencies, interactions and further interesting information, these artifacts should be aggregated within one meta model (see section 3.1.1).

The construction and maintenance of such a comprehensive EA model across all communities in an integrated way is the objective of the federated EAMM. The general landscape of the maintenance process is described within section 3.1.3. Detailed definition of the processes are provided in section 3.3.

3.1.3. Layers of the Federated EA Model Management

The federated EAMM approach aims to create and maintain a holistic EA model, which provides integrative information about the present EA status across all communities within the organization. The required EA information is stored within each community and needs to be extracted, validated and imported to an EA model. The information passes a bunch of operations until the information is getting integrated into an EA model. Thus, a multi-tiered architecture with an *community level*, a *staging level* and a *enterprise level* is defined. Figure 3.3 illustrates the defined landscape.

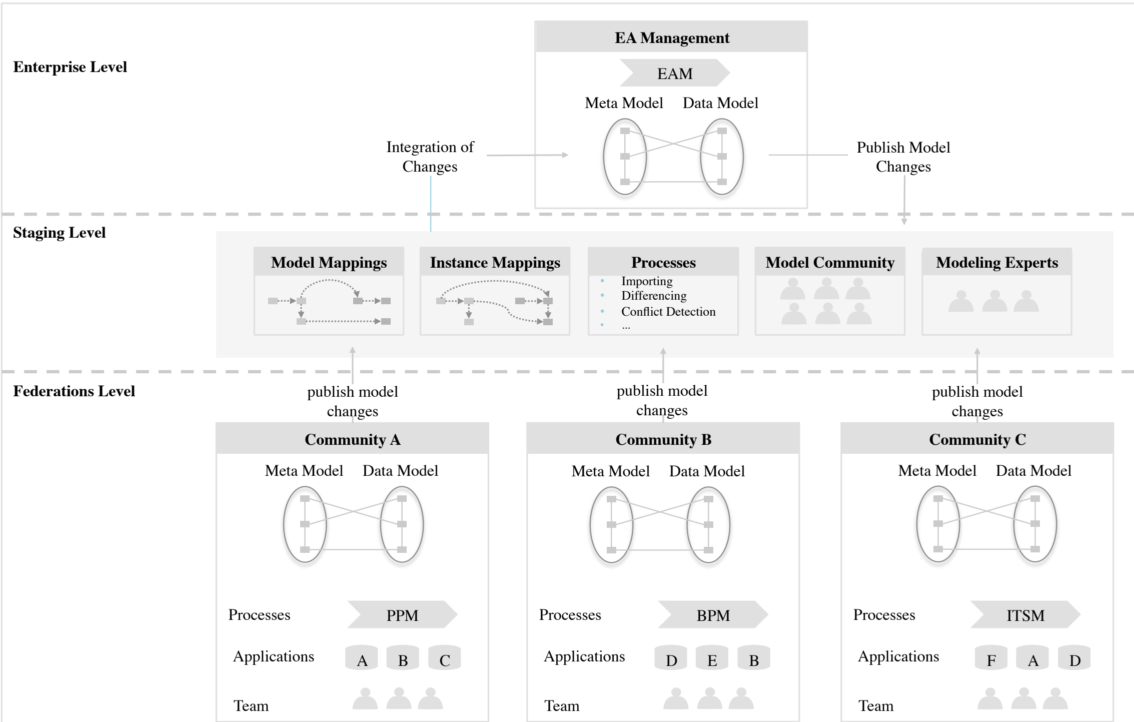


Figure 3.3.: Illustration of the federated EAMM layers

Community level: As already mentioned in section 3.1.2, each community operates as an autonomous organization with own applications, own processes, meta and data models, etc. The community level represents these communities. The information for the federated EA model are stored in these communities and needs to be extracted to the staging level.

Staging level: Malinowski/Zimanyi [MZ09] and Turban et al. [Tu10] highlight issues of different technologies used by source systems and DQ, when extracting information from these systems to a Data Warehouse (DWH). Further data cleansing operations have to be performed when integrating data from different sources to a target system [KR02]. Berson/Dubov [BD07] also illustrate the issue of DQ in case of master data management and provide a possible classification of root causes.

Furthermore, Roth et al. [Ro13b] refer to conflicts between EA elements that might appear during EA documentation activities. These conflicts relate to issues between the meta or data models of the communities.

Due to DQ issues, differences of technologies, model conflicts and internal data structure, data cleansing, data transformation and mapping operations are necessary before importing the extracted information from the the single communities to the EA model. These operations will be performed in the staging level. Defined roles – for instance developer or modeling Experts – conduct these activities. A detailed overview of DQ issues and different types of conflicts is provided in section 3.3.2.

Enterprise level: After performing several activities related to extracting, transforming and mapping the data, the required EA information from the communities, is ready to get mapped to an EA model. This EA model should include all EA related information across all communities of the organization in a holistic and integrative way. The EAM team, which is located at the enterprise level, manages this model. Depending on defined processes, the EAM team can change elements within the EA model and publish them to the single communities. The methods of unidirectional or bidirectional data transfer will be elaborated in section 4.3.10.

3.2. Role Allocations

This section addresses the allocation of roles within the federated EAMM. The term of *role* in case of EAMM is defined and a short overview of the roles within research is given. Furthermore, the defined roles within the federated EAMM are presented and allocated to specific layers of the federated EAMM.

3.2.1. Role Allocation in Terms of Federated EA Model Management

Opitz [Op09] and Blessin [BW13] define a role as a cluster of expectations that have to be fulfilled by a specific person. In terms of governance structures, the Control Objectives for Information and Related Technology (COBIT) standard provides a structural element that defines, who is involved in the governance, how they are involved, what they do and how they interact within the scope of any governance system [CO112]. To attribute importance to the various definitions of a role within a federated EAMM approach, an overarching definition is specified as follows:

> **Role:** A role represents a party with specific interests, responsibilities, allocated activities and a specific position that is involved within the management of the federated EA model.

Further characteristics of a role are:

- A role can be staffed by more than one person. Furthermore, one person can staff more then one role.

- The involved role does not have to be member of a community or the EAM team. For instance the supervisory or IT governance members could also have interests and responsibilities within the federated EAMM, although they do not belong to a specific community or the EAM team and do not have operative responsibility.

3.2.2. Defined Roles in Research

In line with Fischer et al. [FAW07], it can be advocated that a clear allocation of responsibilities for each activity is mandatory. A detailed description allocation for each use case will be provided in section 3.3. In this section, an overview of the involved roles within the setup and the maintenance of a federated EAMM and a description of the major characteristics of the roles is given. Beside the common EAM frameworks like The Open Group Architecture Framework (TOGAF) [Gr11], there are different established definitions of the Enterprise Architect role in research. Hanschke [Ha13a] defines the Enterprise Architect as the dominant role, who is responsible for all EA management processes. Hanschke also mentioned that depending on further indicators – for instance the size of the company or the organizational structure – further roles for the master data management, the process management or for the correct implementation of the business requirements can be defined as well. Sessions [Se14] argues that *the relationship between the complexity and planning for buildings and cities is similar for information systems* and further roles like a Database Architect, a Solutions Architect, an Infrastructure Architect, a Business Architect and an Enterprise Architect are mandatory elements. Niemann [Ni06] defines the role of the IT Architect in context of EAM as a person, whoever *applies methods, deploys tools and heuristic techniques, communicates with the IT units clines, as well as with other units, including applications development, infrastructure, acceptance and deployment and system operations.*

There is a further definition from Fischer et al. [FAW07], which focus on the role allocation regarding the federated EAMM. Due to the fact that this definition does not give a general definition of roles for EAM, but focuses more on the community characteristic and explicits the collaborative model management across these communities, the defined roles within this scientific paper are evaluated.

It can be differentiated between business oriented (*EA Coordinator*) and technology oriented (*EA Repository Manager*) roles, in order to ensure an adequate model update process. In addition, *EA Stakeholders* and *Data Owners* are defined. The EA Coordinator is responsible for the complete update process. Fischer et al. also define the role of the *Chief Enterprise Architect*. This role is mostly similar to the role of the EA Coordinator. Most of the industry experts do not distinguish between these different types of role and thus this role will not be considered for the planned interviews.

The roles conduct the following activities and are responsible for the following management disciplines:

EA Coordinator: The EA Coordinator is integrated in all performed activities: He manages the complete update process, initiates the maintenance cycle and is accountable for the final data consistency check. Furthermore, he authorizes repository updates and informs the supervisory in case of performed repository updates. In case of inconsistencies, he consults the operative team.

Enterprise Architect: Hanschke [Ha13a], Niemann [Ni06] and Rosen [Ro08] provide different definitions of an Enterprise Architect. It can be assumed that the responsibility and the role of the Enterprise Architect depends on further characteristics of the organizations landscape, culture, goals, etc. In case of the federated EAMM, Enterprise Architect is defined as an overarching role within the model update process that supports numerous activities across the update lifecycle. He supports within the strategic planning of the IT landscape, defines next updates processes, consults in arisen conflicts, etc.

EA Repository Manager: The EA Repository Manager manages technical issues related to the EA repository. He is some kind the *Administrator* of the EA model and performs activities like software updates, backup procedures, conducts the correct loading of the updated EA model to the repository, etc. He also supports the data transformation within the staging area and the process of conflict resolutions.

EA Stakeholder: Each community provides a contact person that coordinates the communication between the specific community and the EAM team. This task is assigned to the EA Stakeholder. To ensure the correct mapping of the provided objects from his allocated community to the EA model, the EA Stakeholder is responsible for the intended changes that refer to information from his unit and gets informed in case of planned repository updates.

Data Owner: The Data Owner is a specialist for specific applications, platforms, information systems, etc. and has profound knowledge about the particular meta model. He consults the EAM team in case of requested data that refer to his unit and assists within the specification and maintenance of the interface between his data source and the EA model.

In addition to these defined roles by Fischer et al. [FAW07], special attention is also paid to to further roles – defined by Roth [Ro14] – that may contribute further support to the management of the federated EA model:

Modeling Expert: It is advisable to involve a role within collaborative model management that only addresses tasks that relate to modeling issues. The Modeling Expert has profound knowledge in modeling theory and focuses on the integration of the different models of the communities [Ro14]. He also deals with the development of conflict resolution strategies that refer to modeling issues.

Data Steward: Buckl et al. [Bu12a] define a Data Steward as a role that is responsible for *specific business objects and provide information on their relations to other business objects*. The Data Steward belongs to a specific Data Owner or an EA Stakeholder and has the operative responsibility to provide the required information for the modeling update process from his Data Owners information source.

Decision Maker: A performed model update process produces new information about the current IT landscape of the organization. The Decision Maker uses this new information for further management decisions. He does not has an operative role within the model update process.

3.2.3. Allocation of Roles to the Stages

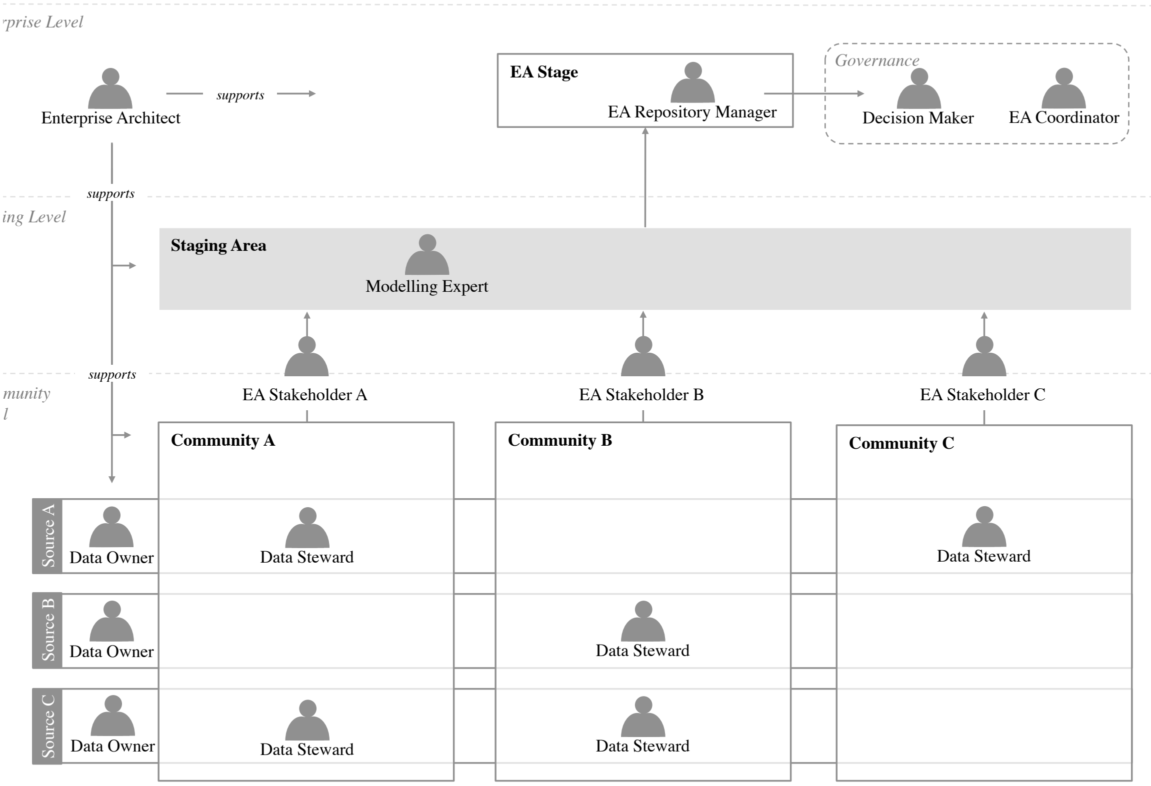


Figure 3.4.: Allocation of roles to the single stages

As illustrated within Figure 3.2.3, the landscape of the organization is splitted into three level: The community level, the staging level and the enterprise level. As described within the definition of roles on page 26, the Data Owner is responsible for a specific application, platform etc. – here substituted as *Source*. Figure also shows that a source can be used by several communities. Each source is illustrated as a cross section trough all communities. Depending on whether or not an application is used within a specific community, there should be a Data Steward, responsible to provide the required information from the specific data source.

The EA Stakeholder acts as a mediator between the staging area and the communities. Hence, the EA Stakeholder for each community are placed in both levels; the community and the staging level.

The Modeling Expert deals only with modeling specific tasks, issues and conflicts. All these activities have a quality assurance characteristic. So the Modeling Expert is only placed within the staging area.

The EA Repository Manager is responsible for technical issues of the EA repository, which is located within the EA stage. Thus, the EA Repository Manager is located within the enterprise level.

The Enterprise Architect is also located within the enterprise level, but supports the comprehensive update process on all levels. The EA Coordinator and the Decision Maker represent the governance of the federated EAMM, which is also located on the enterprise level.

3.3. Specific Use Cases and Further Characteristics

Within this section, a conceptional overview of the relevant use cases when maintaining a federated EAMM is provided. Further requirements – for instance necessary software solutions, data flows, governance processes – build upon the use cases.

Roth [Ro14] suggest a granular segmentation of the use cases. This thesis focuses on governance and process specific elements of the federated EAMM, with the result that such a segmentation is not appropriate – for instance the definition of an own use case for *View Differences*. However, the definition of the use cases is provided by Roth [Ro14]. The planned activities in terms of maintaining a federated EAMM are aggregated in three use cases:

- **Model Mapping:** The meta and data models of the communities is stored within the source systems of the respective community. In case of changes in the meta or data model within a specific community, the modification of the meta or data model will be performed within the local models in the source systems. As a consequence of these locally performed operations, the changes have to be communicated accordingly to the EA model. This use case treats the data extraction from the communities.
- **Staging Area:** The extracted information from the communities can be seen as raw data and require follow-on activities – for instance data transformation or perform data cleansing activities. Furthermore, there is the risk of rising conflicts between data of different communities – for instance in case of overlapping models. These obstacles need to be resolved before transferring the new information to the EA model, which is the purpose of this use case.
- **Model Merge:** After the data cleansing activities within the staging level, the information is ready to be merged to the EA model. This merging procedure will be conducted within the *Model Merge* use case, whereby the merging activity depends on the defined process: There is the possibility of an automated transfer of information to the EA model or the manual implementation of the information into the EA model.

Furthermore, other characteristics, which need to be considered when designing a federated EAMM, are illustrated. Although these further characteristics do not represent specific use cases, they have a major impact on the functionality of the federated EAMM and its use cases.

Cockburn [Co01] defines and discusses different ways of defining use cases in a standardized format. One of the options he described – called *Fully Dressed Template* – includes general information about the use case (name, context, scope, level, actor, etc.), main success scenario information, extensions, technology/data variations list and related information. To describe the as aforementioned use cases a slightly different template as Cockburn's *Fully*

Dressed Template is used. The aspects of*Level* and *Extensions* are not considered within the use case definitions. Moreover, the use cases are described in a narrative mode.

3.3.1. Model Mapping

As already mentioned in section 3.1.2, each community established its own meta and data model. These models contain the necessary EA information, whereby the meta and data models of the communities are stored on source systems, which are located within a community. The following definition for information sources is used in terms of federated EAMM:

> **Information Source:** An information source represents an information system within a community, which includes information about the present EA status of the community or the meta and data model.

This use case deals with the process of transferring and mapping model information from a single community to the overall EA model. There are two different strategies of transferring the information to the EA model: Automated or manual. Roth et al. [Ro13a] perform a survey among 140 participants from several industries. As mentioned in section 1.1 only 35% of the participants consider automated data collection mechanism at the present time. Roth et al. [Ro13a] differentiate between the following options of manual data collection:

- Manually from applications/databases
- Manually via interviews
- Manually modeled in workshops
- Manually via questionnaires
- Partial automatically

The survey also reveals that 46% of the data collection is conducted by an EAM team and 42% by the EAM team in corporation with the communities.

A low number of the participants (19%) confirmed that their respective organizations implemented some form of automated update mechanism within their respective EA tool. The majority of the participants make use of Excel imports, relational database imports and Comma Separated Values (CSV) imports.

As a consequence, it can be said that nowadays most of the data collection and transfer is performed manually and by less sophisticated tools.

A slightly different automated approach to transfer EA information from a single community to the EA model is provided by Bergamaschi [BCV99]. He suggests not to transfer information from a community model to the EA model, but rather to establish semantic links between the EA objects. As illustrated by Bergamaschi, this type of automated data collection requires the definition of a standardized dictionary of terminological relationships, called *Common Thesaurus*. Furthermore, a shared terminology has to be established and used across all communities. Recent research by Dreyfus [Dr07] illustrates that there is a clear *language gap* between business and IT departments Further information can be obtained at Bergamaschi [BCV99] and Dreyfus [Dr07].

Figure 3.5 illustrates the role allocation, when transferring EA information from a specific community to the holistic EA model.

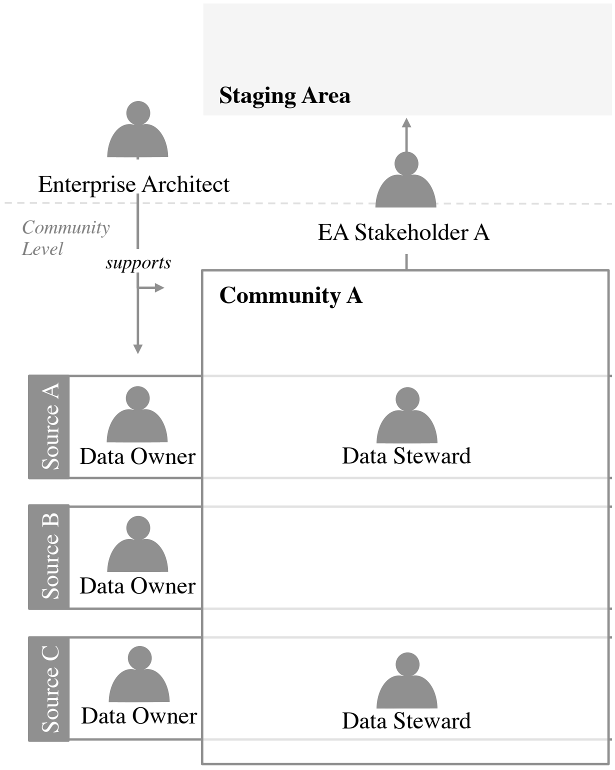


Figure 3.5.: Involved roles for use case model mapping

- **Data Owner/Data Steward:** As already mentioned, organizations can decide, whether they make use of automated or manual information transfer. Nevertheless, the data has to be provided by the Data Owner and the Data Stewards. As aforementioned, the Data Owner is a specialist within its allocated source and is located within a specific community. The Data Owner knows what kind of information needs to be provided for the next data transformation, whether the Data Steward performs the operative activities – for instance the extraction of the present data and the preparation of the information for the transfer.
- **EA Stakeholder:** The EA Stakeholder constitutes an intermediary role between a specific community and the staging level. Commonly the EA Stakeholder mediates the requirements of the EAM team to the communities and acts as a contact person between a community and the staging level. Communication, requirement and quality issues will be handled by the EA Stakeholder, whether the interests of the EAM team

and the community will be considered in activities.

- **Enterprise Architect:** The Enterprise Architect is not allocated to specific activities. He supports the complete mapping process and has to ensure that the process operates correctly and all required information is provided by the communities.

Use Case	**Model Mapping**
Context of Use	Transfer meta or data model information of a community to the EA model
Scope	Federated EA model management
Primary Actor	Data Owner
Stakeholder & Interests	• **Data Owner:** Intends to share EA information to develop and maintain an EA model across all communities. • **Data Steward:** Operative employee that aims at performing his activities correctly. • **EA Stakeholder:** Desire to align with corporate standards to increase the planning effectiveness of the IT landscape within his community. • **Enterprise Architect:** Wants to have a consistent and integrative view of present EA status, which require to consider all meta and data model for mapping purposes from all communities that contain EA information. • **EA Coordinator:** Wants to have a consistent and integrative view of the EA status quo. The consideration of the meta and data models from the single communities that provide EA information is mandatory.
Preconditions	Information sources, which contain necessary meta and data model with EA information have been identified.
Minimal Guarantees	The imported data occurs a conflict on meta or data model level.
Success Guarantees	The imported data contains further EA information. The EA model does change.
Trigger	The EA information within a specific meta or data model of a community changes.

Main Success Scenario	• **Step 1:** The EA Coordinator identifies a new meta or data model object within a community. • **Step 2:** The Data Owner specifies an export model. • **Step 3:** The EA Modeling Expert ensures the quality of the defined model. • **Step 4:** The EA Repository Manager manipulates the meta or data model of the EA repository. • **Step 5:** The Data Owner, the EA Modeling Expert and the EA Repository Manager altogether define the transfer of the information. • **Step 6:** The EA Modeling Expert and the EA Repository Manager collaborate to refine the conflict resolution strategy. • **Step 7:** The EA Repository Manager synchronizes the information within the EA model.

3.3.2. Staging Level

As already mentioned in section 3.1.3, the information has to be transformed in a defined format and further mapping activities have to be performed before uploading the information to the EA model. Roth [Ro14] suggests a merge of the imported information and the current EA model, whereby the information can be transferred automatically or manually to the EA model. Nevertheless, there is the risk of DQ issues and arising conflicts that require either manual or automated resolving before the uploading activities of new information of the communities to the holistic EA model can be performed.

Section 3.1.3 mentioned that heterogeneous IT landscapes of communities and DQ issues within the source systems of the communities have a major impact on the model mapping activities and lead to further efforts. Redman [Re98] described that DQ issues account 8% – 12% of enterprises revenues in today's organization. Juran defines the term DQ as *fitness for use* [JS05]. Depending on the specific context, research reveals that there are heterogeneous definitions in research [Iv74, Re97, Ev05, PLW02]. Malinowski/Zimanyi [MZ09], Turban et al. [Tu10] and Roth et al.[Ro13a] provide a more precise overview of DQ issues referring to information systems. Nevertheless, the differentiation of DQ issues is kept more simple and the various dimension of DQ are aggregated in line with Hauder et al. [HMR12] to *Correctness*, *Completeness*, *Actuality* and *Granularity*.

- **Correctness:** Wang et al. [WSF95] differentiate between *semantic correctness* and *syntactic correctness* of data, whereas this thesis focus on to the *semantic* perspective. A lack of semantic correctness of data occurs, when an imported instance by a community does not fit to the current information in reality. An example is, when the imported instance refers to an *SAP*[2] *Application* with a *Release* attribute and the value of this attribute does not match to the present value of this instance in reality.

- **Completeness:** Batini/Scannapieca [BS06] define the *Completeness* dimension of DQ as the *Degree to which values are present in a data collection.* In terms of EA documentation, the imported information by the communities has to provide a minimum set of information for each instance of meta model information. Consider there is an entity *Platform* in the EA model with two attributes *Name* and *Environment* and a community provides a *Platform* instance, where the *Environment* information is missing. In this case the provided data is not complete and consequently this issue is allocated to a lack of *Completeness* referring to DQ.
- **Actuality:** The discipline of DWH and data mining distinguish between Online Transaction Processing (OLTP) and Online Analytical Processing (OLAP) paradigm of data transfer [GGP09]. Information that will be transferred by the OLTP principle, will be transferred immediately and regularly, whereas the OLAP paradigm will be used for complex information, that does not change often and will be updated to the DWH to run analytical activities. The same construct can be assumed for the transfer of EA data from the communities to the EA model: A community will not release new applications n short time slots and hence instances that refer to new applications will be reported rarely by the communities to the EA model. But objects that change often in short times periods – for instance virtual machines – will be reported to the EA model quite often in short time periods. The problem with data that will be reported to the EA model often and in short time slots is the risk of obsolete information. Consider the virtual machines example: One community changes twice a day the present status of the productive virtual machines and reports the current portfolio to the EA model in accurately defined time slots automatically. In this case, the respective community has to ensure the correctness of the present portfolio when the data will be transferred to the EA model. In case of a delay, old information will be transferred to the EA model and we meet a lack of *Actuality.*
- **Granularity:** Consider the meta model of the EA model has defined an entity *Person* with the attribute *Joined the Company* with datatype *Date* (dd.mm.yyyy). A single community reports a new employee as a *Person* instance to the EA model, but provides only information regarding the month the employee joined the company, namely in November, although the EA model requires a more granular information. Hence, we are facing a lack of *Completeness.*

Further data challenges in regard of EA documentation, can be obtained at Farwick et al. [Fa11] and Buschle et al. [Bu12b].

Beside the DQ issues and the upcoming data cleansing activities, there is another issue, which lead to further effort and activities before implementing the imported information by a community to the EA model: Consider two different communities that maintain information regarding the same application instance, but completely decoupled and each community can define the content of the application instance independently. Hence, there is the risk of different values for overlapping data model objects. This event is named as **conflict**. There

[2]SAP: Business Software Corporation

are several different types of conflicts that might occur when merging meta or data models from heterogenous communities to an EA model. The following definition of conflict will be assumed in case of federated EAMM.

> **Conflict:** A conflict illustrates discrepancies between data model or meta model elements of one (or more) communities, which lead to integrative and semantic issues within the holistic EA model. We distinguish between the following conflict situations:
>
> - **Meta model vs. meta model:** The meta models of two different communities disagree syntactic referring to the same meta model component.
> - **Meta model vs. data model:** The provided data model information by a specific community does not align with the definition of the respective meta model element.
> - **Data model vs. data model:** The provided information by two (or more) communities for the same instance disagree (on attribute, data type or another dimension).

Conrad [Co97] suggests a classification of conflicts in terms of federated databases. The classification segments the conflicts in five classes.

- **Semantic conflicts:** Consider two different data models in two different communities. There is the possibility that these data models overlap in specific objects – e.g. the same *SAP* system runs in both communities. It can be hypothesized that the objects include the same information – for instance the same defined attributes with the same instances. Nevertheless, the saved objects could also differ regarding their content. One community could report that the specific *SAP* instance runs on a specific server, whereas the other community reports that the same *SAP* instance runs on another server.

- **Descriptive conflicts:** There could be also the possibility of differences in naming: Consider the same *SAP Application* in two different data models. An example for a descriptive conflict is, when community A names the object *SAP System* and community B names the object *SAP Application*, or specific attributes that represents the same value, but are named differently. Differences in the defined domains for the same attribute are also subsumed to descriptive conflicts.

- **Heterogeneity conflicts:** Database systems can be established in an object-oriented or relational scheme. Conrad [Co97] referrs to the fact that relational database schemes provide less modeling concepts compared to object-oriented databases. This fact could lead to major structural differences between the models, which might lead to structural conflicts, when integrating these models to a holistic model.

- **Structural conflicts:** Object-oriented schemes provide several modeling approaches for the same issue.

  Example: Community A models an *Application* entity with the attribute *Person* *in charge*, who is responsible for maintenance issues of the respective application instance. However, community A models the same issue slightly different and defined an association to another entity person in charge. The respective application instance receive the necessary responsibility information from instances of this entity.

As the example illustrates, the same issue has been modeled in completely different ways. This fact might lead to heterogeneity conflicts, when merging these two data models to a holistic model.

Kim/Seo [KS91] segment each type of conflict in further sections. Further information regarding granular conflict classification can be obtained at Kim/Seo [KS91].

Kirschner/Roth[KR14] provide a different classification approach when referring to model conflicts, whereas this classification explicit refers to conflicts in case of collaborative model merging between different communities.

Figure 3.6 illustrates a classification matrix (illustrated in own developed tool).

	object update	object delete	object create	object move	object use	attribute update	attribute delete	attribute create	attribute move	attribute use	value update	value delete	value create	value move	value use
object update	conflict														
object delete	approve	none													
object create	none	none	conflict												
object move	validate	approve	none	conflict											
object use	validate	approve	none	validate	none										
attribute update	none	approve	none	validate	validate	conflict									
attribute delete	none	none	none	none	validate	approve	none								
attribute create	none	approve	none	validate	validate	conflict	none	conflict							
attribute move	none	none	none	none	none	none	none	none	none						
attribute use	none	none	none	none	none	none	none	none	none	none					
value update	validate	approve	none	validate	validate	none	approve	none	none	none	conflict				
value delete	none	none	none	none	validate	none	none	none	none	none	none	none			
value create	none	approve	none	validate	validate	validate	none	none	none	none	none	none	none		
value move	none	none	none	none	none	none	none	none	none	none	none	none	none	none	
value use	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none

Figure 3.6.: Conflict classification matrix

Each line represents activities, which can be performed by one specific community and each column specifies the activities, which can be performed by another community. Depending on the combination of performed activities by the communities (on the same object) there is the possibility of a conflict.

Example: In line one (*object update*) and column one (*object update*), two different communities try to update the same data object. Thus, the EA model receives two different values from two different communities, which leads to a conflict.

Potential conflict scenarios between two communities are:

- create object / create object
- update object / delete object
- move object / create attribute
- create value / update attribute

- update object / update attribute

Before transferring the received information to the EA model, these conflicts have to be resolved. In line with Roth [Ro14], a collaborative resolution strategy is preferable. Roth[Ro14] suggests to involve for instance an Enterprise Architect, the respective Data Owner and the EA Stakeholder. Depending on the conflict nature, it advisable to perform workshops for respective conflicts with all concerned parties. The assumed resolution strategy is summarized within the following use case description:

Use Case	**Conflict Resolution Strategy**
Context of Use	Resolve meta or data model conflicts within the staging level
Scope	Data Cleansing
Primary Actor	Enterprise Architect
Stakeholder & Interests	• **Enterprise Architect:** Ensures the consistency and correctness of the EA model. • **Data Owner:** Asks, which kind of information does not fit the EA model to provide information with higher quality next time. • **EA Stakeholder:** Mediator between the Enterprise Architect and the Data Owner.
Preconditions	Information has been transferred from a community and conflict or conflicts arise.
Minimal Guarantees	Conflict will not be solved and profound activities have to be planned.
Success Guarantees	Conflict or conflicts have been resolved.
Trigger	Report new EA information from a community to the EA model.

Main Success Scenario	• **Step 1:** The Enterprise Architect (or another party within the Staging Level) recognizes a conflict. • **Step 2:** The conflict will be analyzed by the respective party. • **Step 3:** A resolution strategy and next steps – for instance a workshop initiation – will be defined by the Enterprise Architect. • **Step 4:** All concerned parties will be informed about the conflict and the next steps. • **Step 5:** All concerned parties perform one (or more) workshops until the conflict is resolved. • **Step 6:** The root cause of the conflict and the resolution strategy will be documented by the Enterprise Architect.

Roth et al. [Ro13b] provide a more comprehensive process definition, which includes the participation of further parties – for instance the EA Repository Manager. The complete process is illustrated in figure 3.7.

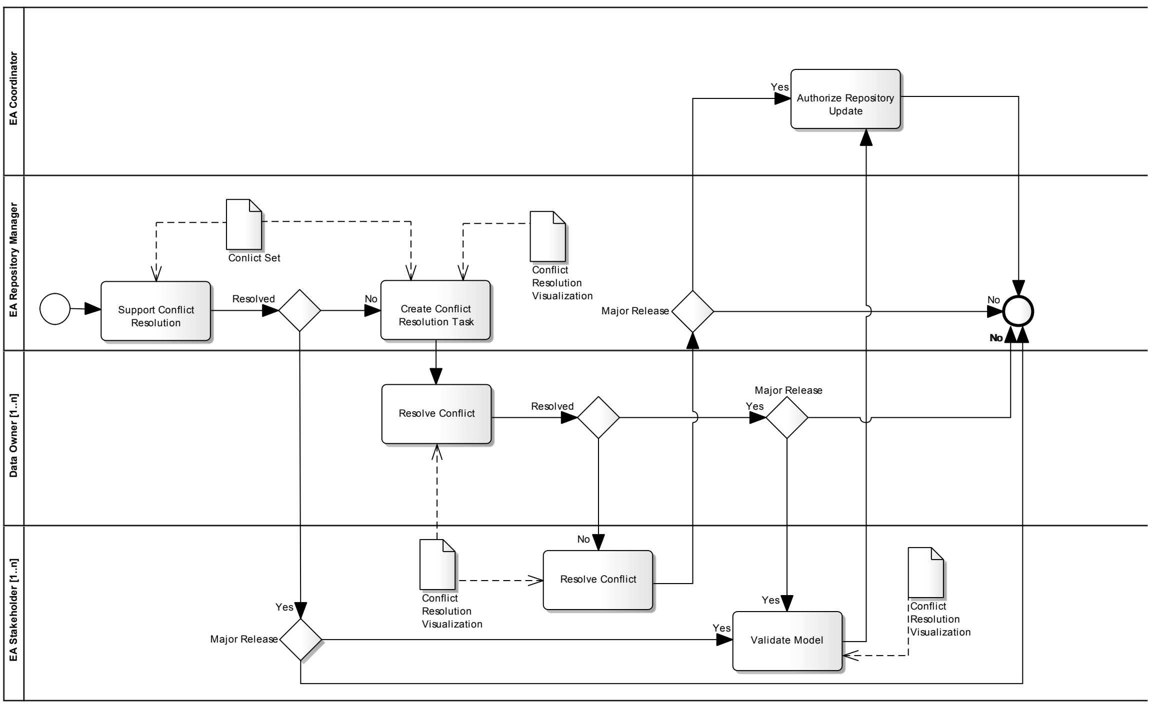


Figure 3.7.: Comprehensive process of conflict resolution

Figure 3.7 highlights that this type of conflict resolution strategy also includes the participation of the EA Coordinator and the EA Repository Manager. The *EA Coordinator* only conducts the final sign-off of major releases, whereas the EA Repository Manager has a more important role (active conflict resolution support and task allocation).

It can be assumed that the design of the conflict resolution process depends on further characteristics, e.g. company size, corporate culture, etc.

Roth [Ro14] also defines a use case called *Assign Task*, where conflicts will be forwarded to a responsible person by creating and sending a task to the respective responsibility. The task assignment is triggered by the EA Repository Manager. Such a task includes a description, which explains the issue. A description of the issue, but also further information about the task should be considered as well. The suggested items are oriented to the Information Technology Infrastructure Library (ITIL) v3 Standard that takes into consideration service transition and change management [Eb08].

Use Case	**Assign Task**
ID	Each task should be assigned with an unique ID.
Name	Short name for the task.
Date	When the task was created.
Current Status	The current status of the task, e.g. *open*, *ready for testing*, *ready for review*, *closed*.
Deadline	When the task should be closed. The deadlines should be observed strictly. Otherwise there is the risk of a huge amount of open tasks that should already be closed.
Description	Detailed description of the issue and it's effect on the EA model or respective IT systems.
Person in Charge	Person responsible for the elimination of the issue.
Priority of Change	Depending on the issue, the daily EA model maintenance process can be obscured by the issue. The priority illustrates the urgency of the issue e.g *low*, *middle*, *high*.
Risk Assessment	Short description of possible events, when the task will not be resolved in time.
Test Status	Current test phase.
Test Results	Short description, whether the test results illustrate a positive result or if further activities are necessary.

Review Result	Review results after sign-off by person in charge.
Sign-Off	Final sign-off by supervisory instance.

A current overview of the tasks should be published within the intranet of the organization or within a respective service system – *Hewlett Packard (HP) Quality Center* [3]. Furthermore, a change advisory board, EA Board, EA Coordinator or another authority should monitor and track the current status of open tasks.

Depending on the root cause of the conflict, Roth[Ro14] also suggests a use case referring to conflict resolution within the information source of a community. This use case simply suggests a task assignment by the Enterprise Architect to the respective Data Owner, which includes the task, to run specific changes within the meta or data model of the information source. Detailed information about this use case, can be obtained at Roth[Ro14].

After all DQ issues and conflicts have been resolved, the new information can be imported to the EA model. This activity is described within specific use case, which is provided in section 3.3.3.

3.3.3. Model Merge

After all conflicts and EA issues have been resolved, the information is ready, to get merged to the current EA model. As mentioned in section 3.2.2, the EA Repository Manager can be seen as a kind of *Administrator* of the EA repository and the EA model. The main responsibility of the merging activities are allocated to the EA Repository Manager. However, the Enterprise Architect has already been involved as a active supporter in the process of data extraction (use case *Model Mapping* and in the quality assurance activities (use case *Staging Level*). The Enterprise Architect has a comprehensive knowledge about the history of the data, that should be merged with the EA model and supports the EA Repository Manager in the merging process.

Use Case	**Model Merge**
Context of Use	Import the new meta or data model information to the EA model.
Scope	Merging new model information the EA model
Primary Actor	EA Repository Manager

[3]HP Quality Center: Quality management software by the company HP

Stakeholder & Interests	• **Enterprise Architect:** Ensures the correct import of the new information to the EA model. • **EA Repository Manager:** Keeps the correctness of the EA model.
Preconditions	Information that should be merged to the EA model align with the defined syntax of the EA model and does not cause conflicts within the EA model.
Minimal Guarantees	The information still does not align with the requirements of the EA model, whereby further assurance activities have to be performed.
Success Guarantees	The information were imported correctly to the EA model.
Trigger	The Enterprise Architect reports new model information to the EA Repository Manager.
Main Success Scenario	• **Step 1:** The Enterprise Architect reports new model information to the EA Repository Manager. • **Step 2:** The EA Repository Manager analyzes the received information regarding the required syntax of the EA model. • **Step 3:** The EA Repository Manager implements the new information within the EA model in a test environment and provides the first draft of the new EA model to the Enterprise Architect. • **Step 4:** The Enterprise Architect assesses the new EA model by analyzing the differences between the provided draft of the EA Repository Manager and a target model. • **Step 5:** The Enterprise Architect provides his final sign-off for the merge. • **Step 6:** The EA Repository Manager implements the changes within the productive EA repository and documents the change.

Depending on occurred differences between the first draft of the EA model and the target model or failed syntax requirements, the involvement of the EA Stakeholder from the respective community should also be considered.

Use Case	Primary Actor
Model Mapping	Data Owner
Staging Level	Enterprise Architect
Model Merge	EA Repository Manager

Table 3.7.: Allocation of primary actors to the respective use case

3.3.4. Further Characteristics

Collaboration as Mandatory

Every defined use case has an allocated *Primary Actor*. The primary actor is defined as the person in charge for the respective use case. Table 3.7 illustrates the defined primary actors for each use case.

Further roles that also support the use cases are defined in section 3.2.2. Moreover, the primary actors can support other use cases – for instance the Enterprise Architect supports in all use cases – and use cases can be conducted by more than just the primary actor. Mens [Me02] and Edwards [Ed97] point out that collaboration is mandatory for software engineering projects and Roth et al. [RHM13] state that collaboration is an essential element in case of model conflict resolution.

As a consequence, a communication and working platform, which supports, controls and documents the collaborated activities, but is also connected to the present EA model have to be provided. The implementation of a groupware solution – defined as a software solution that may help a group of parties to work in a collaborative way [EGR91] – is a possible solution. Figure 3.8 illustrates the concept of a collaborative platform.

Unidirectional vs. Bidirectional Data Flow

Communities provide the requested information to the EA model. This data provision – also called data flow – is mandatory to provide all necessary information across the communities within one EA model. However, the organization should define, whether the EAM team can also communicate information to the communities. Figure 3.9 illustrates the possible types of the data flow.

Czarnecki/Helsen [CH03] define the directionality in case of model transformation, whereas the definition also matches for the management of a federated EA model: *Unidirectional transformation can be executed in one direction only, in which a target model is computed – or updated – based on a source model.* In case of the federated EAMM, the target model matches the EA model and the source model matches the single sources within the communities. In simple terms: The communities provide the requested information to the enterprise level, whereas the EAM team cannot communicate information to the communities.

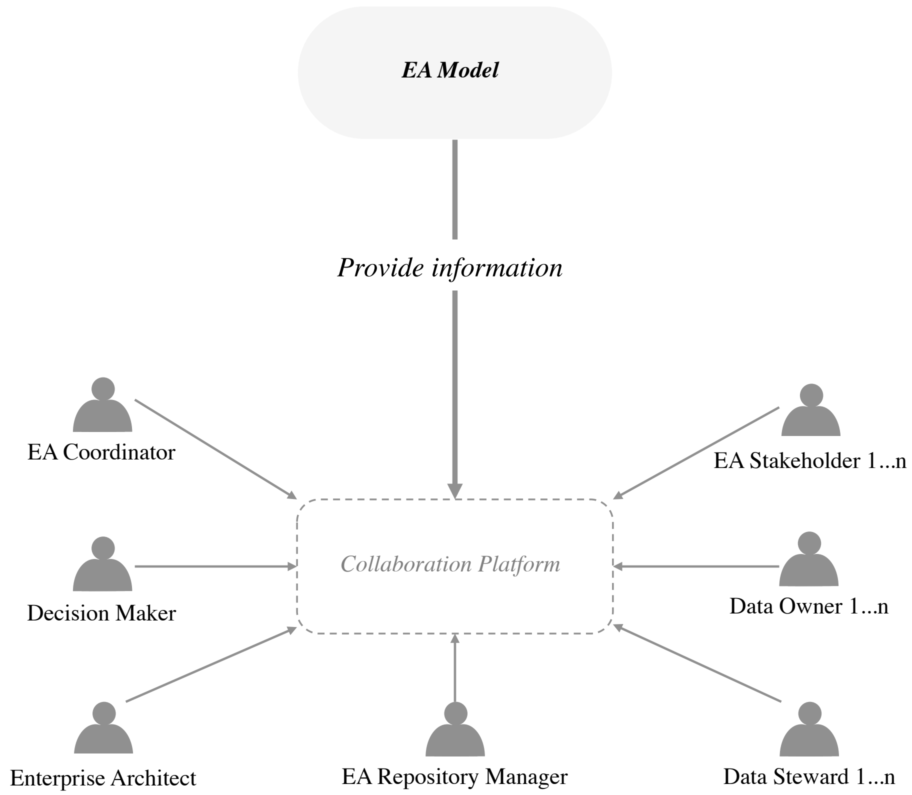


Figure 3.8.: Concept of connected collaboration platform

In case of bidirectional communication the EAM team also communicates information to the communities. Bidirectional communication makes sense when the EAM team changes elements within the federated EA model – for instance for standardization issues – which were provided by a community. It would be advisable to contact the community about the standardization activities and the following changes of the provided information. The community could adapt their running landscape to the change, whereby further effort of transformation could be saved. However, there are two different types of communication:

- **Interpersonal communication:** The EAM team communicates changes of the EA model to the employees or contact persons of the communities. They only inform the communities about the changes and do not change any elements within the landscape of them.
- **Machine to machine communication:** In this type of communication, the EAM team customizes elements of the communities, for instance naming conventions of the meta model.

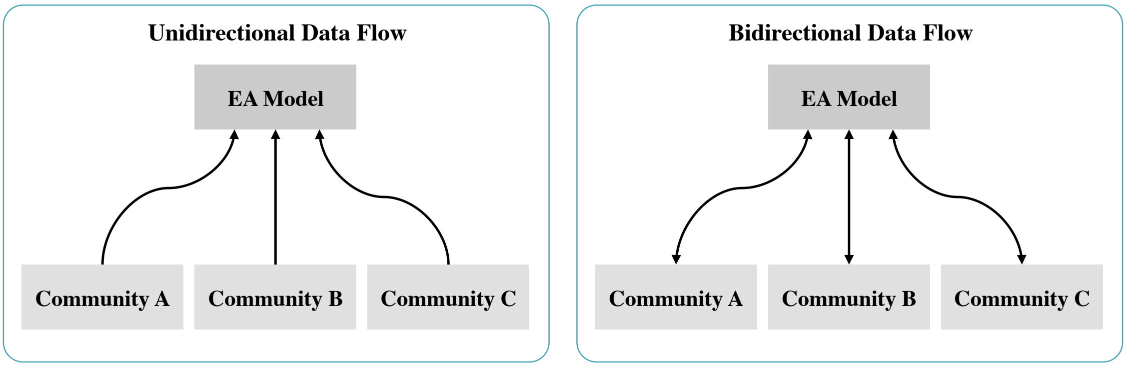


Figure 3.9.: Unidirectional vs. bidirectional data flow

Corporate Culture Towards EA

The term culture is highlighted by several researchers [KK52, LK06]. Schein defines culture as a *pattern of shared basic assumptions that was learned by a group as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems* [Sc06].

To get more specific in an information systems context, only a bunch of components that influences the culture of IT are considered. Figure 3.10 highlights the considered components [LK06].

- **IT Issues:** IT issues represent possible conflict areas. Figure 3.10 shows that not only the management affects the culture towards IT within an organization, but also *Values Embedded in IT* and general *IT Values* influence the culture. Furthermore, IT specific processes towards development, which might be different across the organization, affect the culture of IT.
- **Organizational Values:** Organizational values define the general embedded values within the organization – for instance the thinking towards teamwork or competitiveness between employees.
- **National Values:** In line with Shore et al. [SV96], it can be hypothesized that the environment of the organization influences the culture of IT. Depending on typical comprehensive cultural themes there might be a tremendous impact on the organizational thinking and attitude towards quality standards, role and provided budget for IT within the organization. But also external elements – for instance regulatory requirements in specific areas – have an impact on the IT.

Recent Research by Hauder et al. [Ha13b] also outline external influences that affect the EAM of today's organizations. For instance: The results illustrated that large organizations pay more attention to IT activities rather than small organizations. Further factors that were evaluated within their research are the region, industry sector, size of the company, years of experience, EA framework, modeled state of EA and team organization. Further

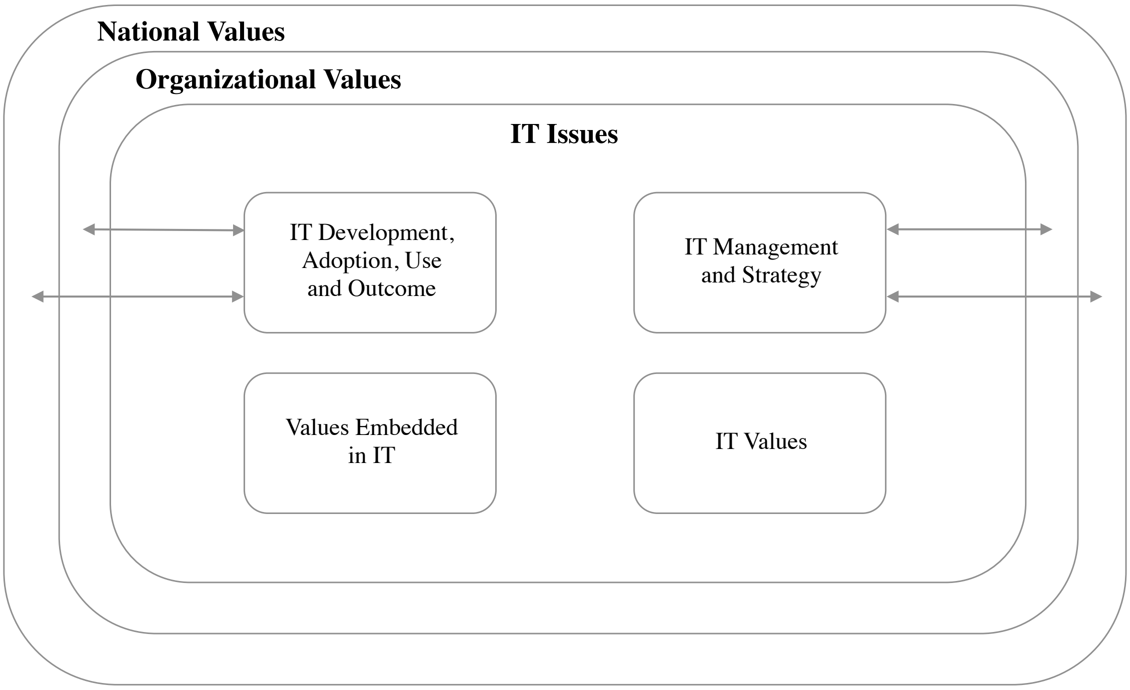


Figure 3.10.: Summary of IT culture influences [LK06]

information can be obtained at [Ha13b].

Further – more specific and not comprehensive – themes that might influence the IT within an organization from a cultural and employee attitude perspective, can be obtained at Scholz [Sc87], Deeks [De93] and Pacey [Pa83].

EAM is an interplay between several stakeholders within an organization. In line with [Yi06], it can be assumed that the commitment of several stakeholders is advisable. For instance: the commitment of Enterprise Architects, Business Architects and Data Owners is necessary to develop and maintain the EA within an organization and as a consequence a federated EAMM. Ross already mentioned [Ro03] that business stakeholder rarely participate in EAM activities and in developing and maintaining a federated EA model. Non-EA stakeholder do not see the value of a federated EAMM, because their running business will not change or getting more efficient by putting efforts in the setup of such a model. We meet a lack of interest; each member has different interests and beliefs [MR72] and may affect the quality of the federated EA model. The illustrated themes in figure 3.10 have a major impact on the rarely interest in EA activities. Especially the IT values and the values embedded in IT play a significant role: The publications by Ross [Ro03] and Marschak [MR72] point out that the values embedded in IT and the IT values do not include enough attention for EAM.

This challenge is also illustrated within the empirical study of this thesis, by focusing the present status of EA within today's organization and what kind of values can be created – not only for the EA management – but also for business stakeholders by establishing a federated EAMM. The results are documented in chapter 4.

Use of Ontologies

When extracting information from the communities – whether performed automatically or manually – section 3.3.2 already mentioned that further quality assurance activities like conflict resolution activities are necessary before transferring the information to the EA model. The gaps can be identified automatically or manually. With regard to semantic gap identification, ontologies provide an automated opportunity. Ontologies relate to semantic web technologies, which can be used to integrate heterogeneous data sets to a formalized structure [SHBL06]. Furthermore, ontologies provide the advantage of machine readability – referring to the semantic purpose of the data – by using a semantic reasoner. Gruber [Gr93] provided the following definition of an ontology:

> **Ontology:** An ontology is as a standardized concept with a shared vocabulary, including formal definitions of classes, relations, functions, instances, rules, axioms, etc.

In case of the federated EAMM, the following components should be defined within an ontology:

- **Class:** Classes are defined as extensible templates for creating objects [Br02]. They provide the initial structure – called body – of an object including attributes and methods, whereby the definition of methods is irrelevant within the federated EAMM. In case of federated EAMM a class might be *Application* or *IT-Service*.
- **Attribute:** Attributes are allocated objects to a specific class and define the semantic and syntax of a class. Examples for – referring to a class application – might be: *Name*, *Release* and *Status*.
- **Relations:** Relations provide information about how classes are related to each other. To refer to the mentioned example: Consider a defined class *Environment* with specific attributes. An application runs within a specific environment. Thus, the definition of a relation between the application class and the environment class – e.g. *runs in* – is mandatory.
- **Individuals:** Individuals – or called objects – represent concrete instances of a class. In case of the application class, concrete instances of that class might be *SAP FS-RI*[4], *Archi*[5] or *Steria Mummert*[6] *SOLVARA*[7].

Figure 3.11 elaborates the term *strict* in a comprehensive way.

Ontologies are at the highest peak of formalization. The complete language, all relations, attributes, etc. are defined very strictly. As a consequence, modeling structures are stated

[4]SAP FS-RI: Reinsurance specific SAP module
[5]Archi: A modeling tool, provided by the company ArchiMate
[6]Steria Mummert: Information technology services company
[7]Steria Mummert SOLVARA: Solvency II software solution by the company Steria Mummert

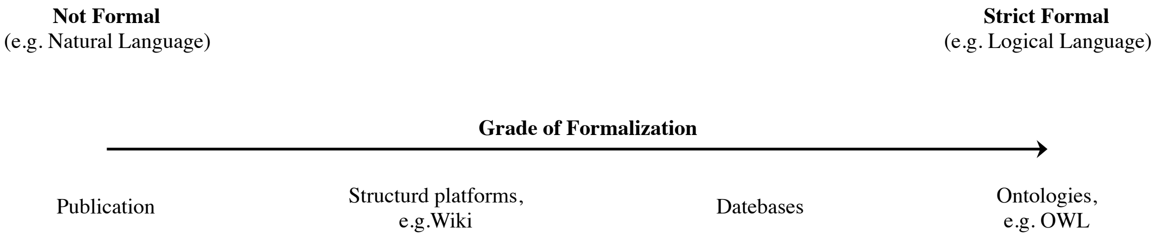


Figure 3.11.: Placement of ontologies in a formalization scale

precisely and semantic consequences can be inferred in a accurate way. These consequences will be performed by the semantic reasoner.

There are several different ontology languages – for instance the Web Ontology Language (OWL). The different languages define ontologies slightly different. Figure 3.12 highlights the functionality of ontologies in terms of federated EAMM. Figure 3.13 represents the same example, but in the OWL language.

Consider a defined ontology, which includes a definition for the class Application and it attributes name, release and env with allocated data types. Figure 3.12 shows that the attribute env has a complex data type Environment. Environment is an enumeration within the defined ontology. As a consequence, an application instance always runs in one of the defined environments. Furthermore, there is a defined class Tool, which is based on the application class. All instances of the tool class have a defined constraint: Each instance has the value Tool Environment for the env attribute.

All information and defined data types are mandatory and have to be provided by the communities in the defined way.

Community A introduces an new tool called claim_calc. A specific software solution – or extraction tool – on the EAM level exports the information for the new application to update the federated EA model. Before implementing the new tool to the EA model, the extraction tool runs semantic checks to ensure the semantic correctness of the provided information. Figure 3.12 shows that the tool instance does not include any information regarding the env attribute. However, the semantic reasoner infers the logical consequence that the imported information can only run within the tool environment. Thus, no further activities are necessary and the missing information can be submitted to the instance automatically.

The OWL code of the tool example is illustrated in figure 3.13. The allocations for possible values and the structure of the code is strict. The example shows that possible ranges and domains for the object properties are defined closely and that all tools, have the value tool environment for the property environment. As already mentioned, ontologies can be parsed mechanically. The semantic reasoner will use this constraint for logical inferences.

Diefenthaler/Bauer [DB13] suggest an approach, called *SEAM*, to identify gaps within a federated EA model. The SEAM approach makes use of the ontology concept. SEAM defines one meta model of one of the data sources as the *global model*, whereby other data

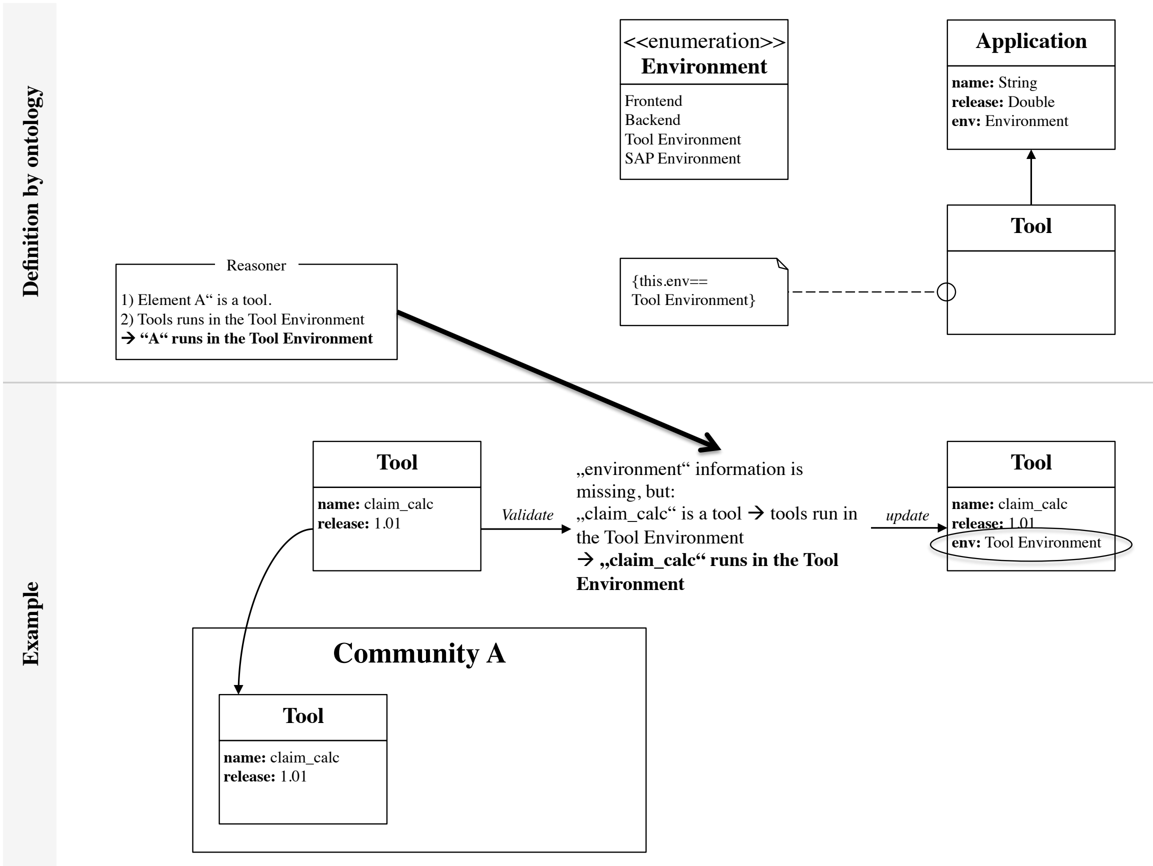


Figure 3.12.: Functionality of ontologies in terms of federated EAMM

sources have to map their elements to the global model. Thus, the single community can keep their own meta models – without manipulating their internal meta model structure – and only have to map their EA information to the global model. Detailed information about the SEAM approach, can be obtained at Diefenthaler/Bauer [DB13].

sectionShort Analysis of EAM Frameworks Depending on the domain – for instance software engineering or information systems – frameworks have slight differences within their definitions. Referring to software engineering, Johnson [Jo97] defines a framework as a *reusable design of all or part of a system that is represented by a set of abstract classes and the way their instances interact.* EAM does not refer to the software engineering domain within the EA and as a consequence, abstract classes are not considered when focusing on EAM frameworks. But the term *reusable design* by Johnson is an universally valid characteristic, which apply to frameworks in general. Frameworks provide patterns, principles and practices to develop artifacts and design products and do not supply completely realized products or sub products.

Röwekamp [Rö10] defines an EAM framework as a guarding rail, which need to be customized to the specific organization.

The Open Group defines an architecture framework more precisely and the provided definition of EAM frameworks will be assumed for further research:

> **EAM Framework**: An architecture framework is a foundational structure, or set of structures, which can be used for developing a broad range of different architectures. It should describe a method for designing a target state of the enterprise in terms of a set of building blocks, and for showing how the building blocks fit together. It should contain a set of tools and provide a common vocabulary. It should also include a list of recommended standards and compliant products that can be used to implement the building blocks [Gr11].

Well known EAM frameworks are the *Zachmann framework* by John Zachmann [Za14] – a *Dinosaur* of the EAM frameworks [Rö10] – and *TOGAF* by the Open Group [Gr11] – one of the most promising [Bu09] and influencing EAM frameworks. These two frameworks and their capability towards federated EAMM are described briefly.

3.3.5. TOGAF

As mentioned in section 3.3.4, TOGAF is published by the Open Group. The current version of TOGAF – version 9.1 – consists of the following components:

- Architecture Development Tool (ADM)
- ADM Guidelines and Techniques
- Architecture Content Framework
- Enterprise Continuum and Tools
- TOGAF Reference Models (TRM)
- Architecture Capability Framework

The Open Group titles the ADM – a step by step approach to develop an EA – as *the core of TOGAF* [Gr11]. However, referring to federated EAMM the TRM element will be focused for further analysis. The TRM includes a

- **Taxonomy:** Defines a terminology and description for the components.
- **TRM graphic:** Provides a visual representation of the taxonomy.

The TRM defines applications, platforms and communication infrastructure elements within a model. These elements are connected via interfaces with each other. Figure 3.14 illustrates the elements in an expanded way:

TRM knows *Infrastructure Applications* and *Business Applications*, which is a quite rugged definition of applications. Further application entities – e.g. environment – are not defined within the TRM. The *Communications Infrastructure* provides basic services to interconnect systems and enable the transfer of data. Furthermore, TRM gives a granular list of possible platform service entities – the vertical boxes in Figure 3.14.

However, the complete TRM elements of TOGAF are not described and further information can be obtained at [Gr11]. When adapting the TRM to establish and maintain a federatedEAMM the following issues occur:

- It is not defined how to establish a standardized taxonomy.
- The provided entities by TRM are not granular enough – e.g. missing entity of employee.
- There are no processes defined for maintaining the EA model or upload new instances to the EA model.
- There is no dedicated role definition and allocation within TRM.
- Conflict resolution strategies are not defined in TRM.
- Community notion is not considered within the TRM.

The problem is that TRM just illustrates a high level overview of a meta model or gives a thought-provoking impulse of how a meta model could look like. Detailed practices or useful hints that refer to typical problems – when working with several communities on one EA model – are not described.

3.3.6. Zachmann

As mentioned in the beginning of this chapter, the Zachmann framework is one of the first EAM frameworks. It is defined by John Zachmann in 1987 within a publication called *A framework for information systems architecture* [Za87]. The Zachmann framework does not suggest a methodology or a process model like the ADM of TOGAF. The focus of the Zachmann framework is to provide a comprehensive view on the enterprise landscape and allocate defined roles within an organization – which are responsible for specific artifacts – to different views on these artifacts. Figure 3.15 illustrates the framework in a matrix format, including exemplary artifacts.

The framework provides specific roles, which are responsible for defined artifacts. A role definition and artifact allocation becomes also important within the federated EAMM approach (see section 3.2). The framework also considers further important characteristics of an artifact – for instance the consideration of a process definition – which also need to be performed, when managing a federated EA model. The Zachmann framework provides some useful guidance for the establishment and maintenance of a federated EAMM. However, obstacles – for instance the rare EA management participation by business stakeholder [Ro03] or the practices for collaborative working across all companies – are not considered in this framework.

3.3.7. Adaption of EAM Frameworks for Federated EA Model Management

It turns out that EAM frameworks differ in their orientation and pursue different objectives: In line with Röwekamp [Rö10], it can be hypothesized that TOGAF has an orientation towards enterprise transformation activities, whereby Zachmann focuses on the management and maintenance of an IT landscape. However, specific obstacles within the federated EAMM do not attract attention within present EAM frameworks. As a consequence, the development of customized processes and management structures might be more effective and only minor orientation to chosen EAM frameworks is suggestive.

```
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:owl="http://www.w3.org/2002/07/owl#"

  <owl:Ontology rdf:about=""/>

  <owl:Class rdf:ID=„Environment“>
  <owl:oneOf rdf:about=„Collection“>
      <owl:Thing rdf:about="#Frontend“/>
      <owl:Thing rdf:about="#Backend“/>
      <owl:Thing rdf:about="#Tool Environment“/>
      <owl:Thing rdf:about="#SAP Environment“/>
  </owl:oneOf>
  </owl:Class>

  <owl:Class rdf:ID=„Application“/>
  <owl:Class rdf:ID=„Tool“>
    <rdfs:subClassOf rdf:resource="Application“/>
    <owl:equivalentClass>
      <owl:Restriction>
        <owl:onProperty rdf:resource="environment“/>
        <owl:hasValue rdf:resource="#Tool Environment“
rdf:type="Environment“/>
      </owl:Restriction>
    </owl:equivalentClass>
  </owl:Class>


  <owl:ObjectProperty rdf:ID=„platform“
     rdf:type="http://www.w3.org/2002/07/owl#FunctionalProperty">
    <rdfs:range rdf:resource="#Platform“/>
    <rdfs:domain rdf:resource="#Application“/>
  </owl:ObjectProperty>
  <owl:DatatypeProperty rdf:ID="name"
     rdf:type="http://www.w3.org/2002/07/owl#FunctionalProperty">
    <rdfs:range rdf:resource=http://www.w3.org/TR/xmlschema-2/#string/>
    <rdfs:domain rdf:resource="#Application“/>
  </owl:DatatypeProperty>
  <owl:DatatypeProperty rdf:ID="release“
     rdf:type="http://www.w3.org/2002/07/owl#FunctionalProperty">
    <rdfs:range rdf:resource="http://www.w3.org/TR/xmlschema-2/#double"/>
    <rdfs:domain rdf:resource="#Application“/>
  </owl:DatatypeProperty>

  <Tool rdf:ID="claim_calc“ name="Claim Calculation“ release="1.01“>
    <Platform rdf:resource=„#backend“/>
  </Tool>
</rdf:RDF>
```

Figure 3.13.: Defined ontology in OWL language

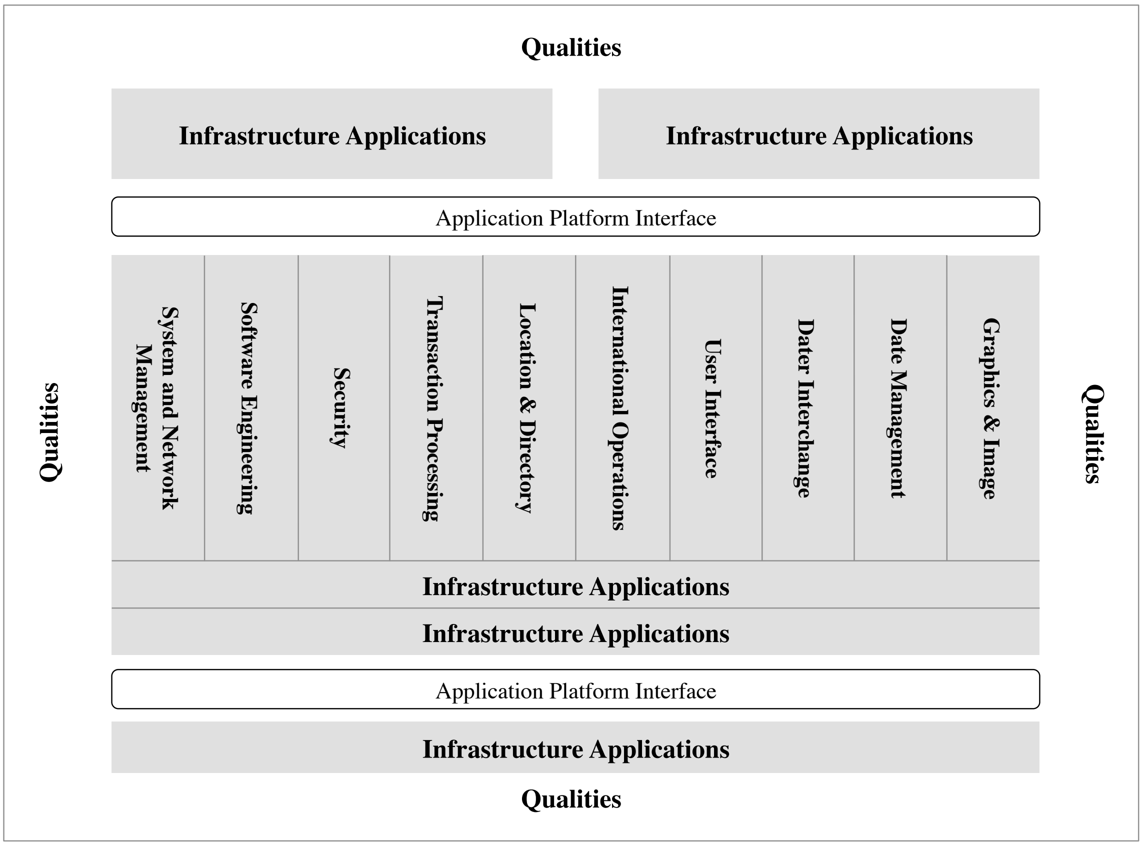


Figure 3.14.: Detailed technical reference model (adopted from [Gr11])

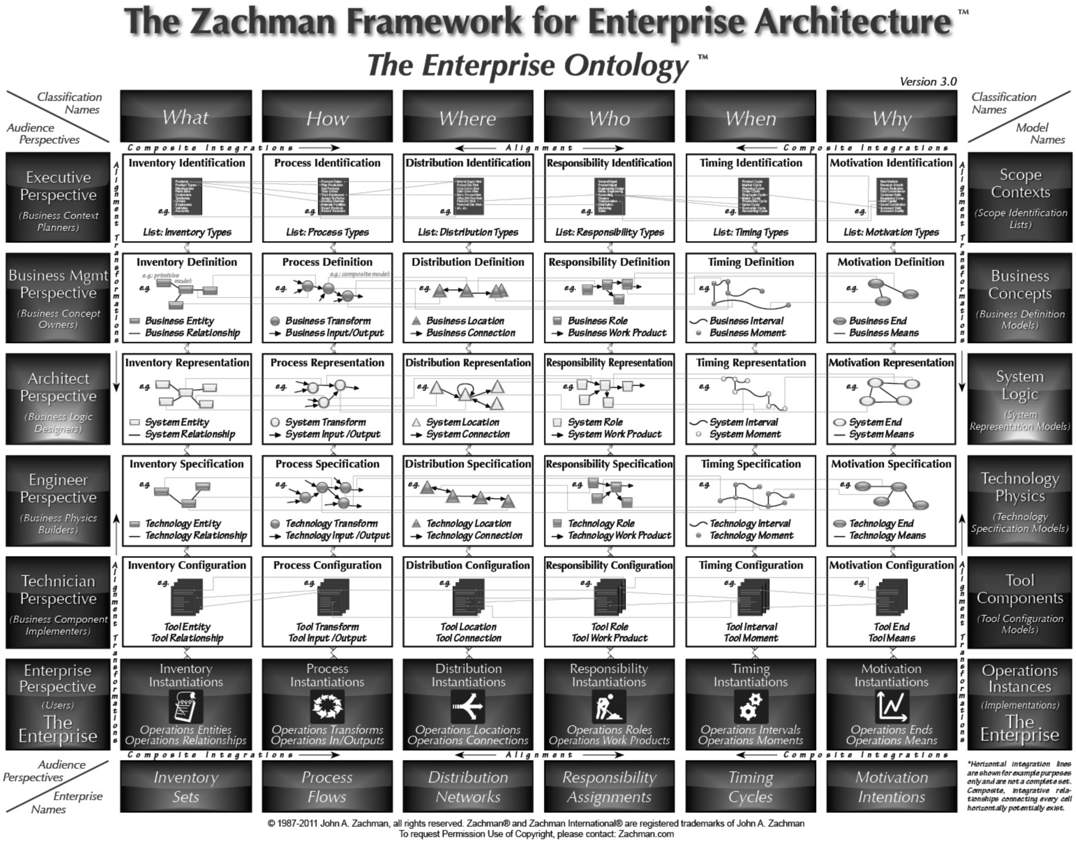


Figure 3.15.: Zachmann framework [Gr11]

4. Evaluation of the Expert Interviews

This chapter presents the results of the research. A detailed overview of the conducted steps within our research approach is given. Furthermore, the results of the semi-structured interviews – the first draft of the developed artifacts – are presented.

4.1. Goal of the Expert Interviews

The conducted interviews with expert within industry aim to achieve the following goals:

- Verify the current status of EA documentation and EAMM
- Validate the suggested EA documentation best practices within literature by [Ro14, Ro13b, Ro13a, Fa14, HMR12]
- Identify common cases that benefit from a federated EAMM
- Identify common obstacles when designing a federated EAMM
- Develop governance structures and design processes to maintain a federated EAMM

To achieve the research goals, a set of questions for each objective were defined. Furthermore, the questionnaire was adjusted, depending on the current situation of the interview and the provided knowledge by the EA experts.

4.2. Interview Approach

There are two fundamental different approaches, when performing expert interviews within research: Structured questionnaires and semi-structured interviews. A structured questionnaire includes the same questions for all participants. Thus, the research results would be more measurable and comparable to each other. However, the expert interviews were performed in a semi-structured way, to make use of the outlined advantage by Barriball/While [BW94]: *They are well suited for the exploration of the perceptions and opinions of respondents regarding complex and sometimes sensitive issues and enable probing for more information and clarification of answers.* In simple terms, a standardized questionnaire limits the creativity of the interviewed EA experts. For instance: A provision of various use cases for the federated EAMM – such as IT controlling and regulatory requirements – would limit the answers of the interviewed experts. The EA experts would not provide further use cases referring to federated EAMM. Furthermore, semi-structured interviews should be used in more pragmatic research topics, as mentioned by Mayring [Ma02]: The federated

EAMM is not a longstanding discussed topic in research. The approach has a strong linkage to current industry challenges and experts from the industry should narrate unbiased about their relation and opinion towards this approach.

Figure 4.1 illustrates the conducted interview approach.

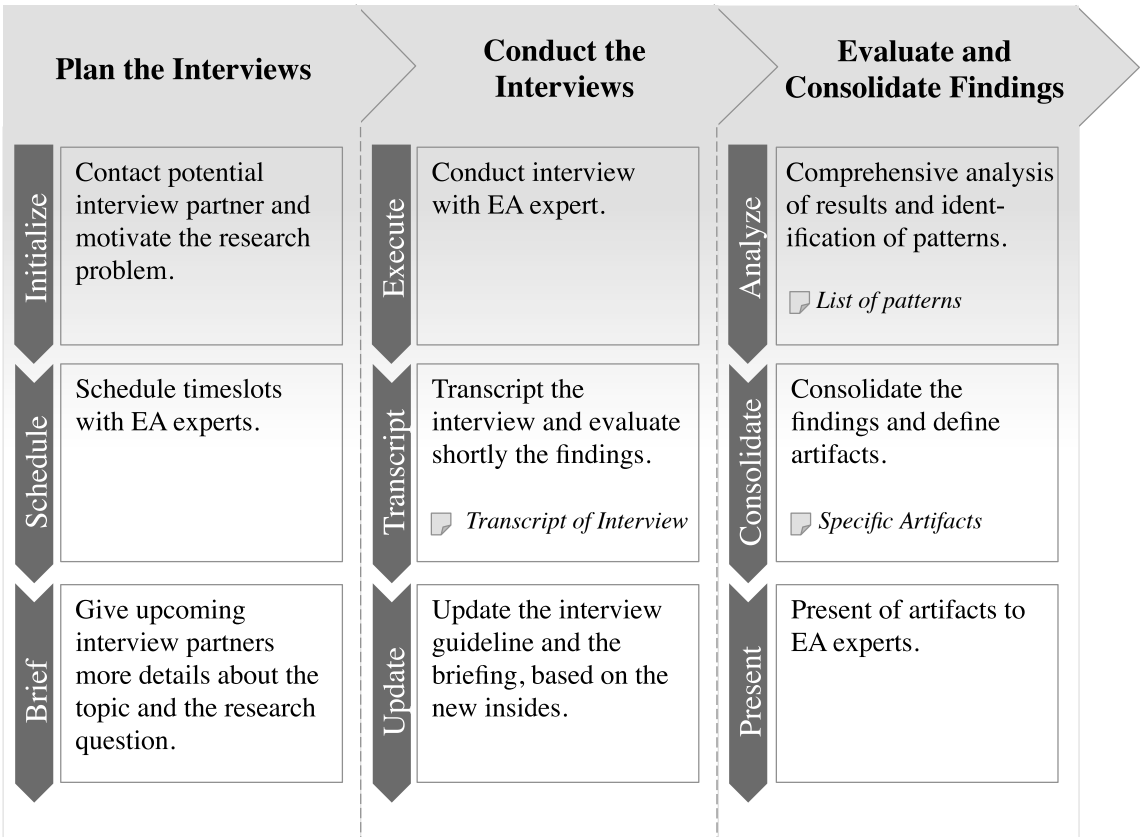


Figure 4.1.: Conducted interview approach

Plan the Interviews

After the definition of the research goal, the information and a general overview of the topic were summarized in a presentation deck. Furthermore, potential EA experts were contacted and asked for their participation in an expert interview – called the *Initialize* phase. While the EA experts were asked for their participation, general information about the topic were also provided. All EA experts that express their willingness to participate in an expert interview, receive the summarized presentation deck about the topic. After that, single time slots with the EA experts were *scheduled*. Group interviews were not performed, because of the following reasons:

- >10 experts expressed their commitment for an expert interview. It would be difficult, to find one time slot, in which all participants have time for an expert interview.

Participant	Position	Industry	No. of Employees	Operating Countries	Duration
#1	Enterprise Architect	Insurance	3.000	International	76 min
#2	Enterprise Architect	Manufacturer	47.000	International	54 min
#3	IT Architect	Manufacturer	175.000	International	56 min
#4	Enterprise Architect	Insurance	9.000	National	65 min
#5	Senior Manager	Service Provider	156.000	International	61 min
#6	Enterprise Architect	Public Sector	ns	National	120 min
#7	Senior Consultant	Service Provider	400	International	90 min
#8	Executive Assistant	Insurance	23.000	International	23 min
#9	IT Architect	Insurance	10.000	International	76 min
#10	Enterprise Architect	Insurance	60.000	International	66 min
#11	Professor	Research Institute	100	International	58 min

Table 4.1.: Overview of interview participants

- When starting with the first interviews, further information from industry experts were provided that were not considered within the first interviews. This further input can be used to update the interview guideline and consider these new questions in the next expert interviews.
- The information from the expert interviews are threaten anonymously. When conducting group interviews, we face a lack of anonymity.
- Group interviews might affect the opinion of the participants towards specific characteristics.

Table 4.1 gives an overview of the EA experts that participated in an interview.

Experts from different industries, organizations and company size were considered within the expert interviews. These parameters have an impact on the EA model complexity within the organization and on the necessary governance activities. Organization with a less employees – for instance participant #1 – could pursue a more pragmatic approach, while companies with a high number of employees – for instance participant #3 – have a more complex IT landscape and thus need to define more complex governance structures towards EAMM.

When scheduling the single interviews with the EA experts, we also try to build up a first personal relationship to the EA expert and gather first information about the general situation towards EAMM within the respective organization. This information can be used to prepare the upcoming interview more individually. Furthermore, this information can be used to prioritize the sequence of the interviews: EA experts with profound expertise towards EAMM or EA documentation give more significant input to these topics. Thus, these experts are considered as first participants. The input can be used to consider the profound information in interviews with EA experts that have less experience in these topics.

After each interview, the interview guideline and the presentation deck were updated with the gathered information of the respective interview. Before starting the next interview, the respective participants get an updated presentation deck, an updated interview guideline and a profound *Briefing* about the topic.

Conduct the Interviews

The interviews were *Executed* mainly by phone calls and WebEx [1] sessions. Most of the interviewees are located in different cities and countries. Traveling to all interviewees were economically not possible. However, a minority of the EA experts is located nearly. In this case, the interviews with the participants were performed personally. The interviews were scheduled for 60 minutes and recorded – in the case of an agreement by the respective EA expert. The recordings were used to perform the *Transcription* activities of the interviews.

The transcription of the EA experts were performed by creating comprehensive protocols, outlined by Mayring[Ma02]. Only essential information that refer to EA documentation and EAMM was documented. The information is documented within the interview guideline, which is illustrated in appendix A.1. The qualitative content analysis method were used to draw conclusions while transcribing the interviews. The *Indicator-Concept Model*, defined by Strauss [St87] were used for the analysis.

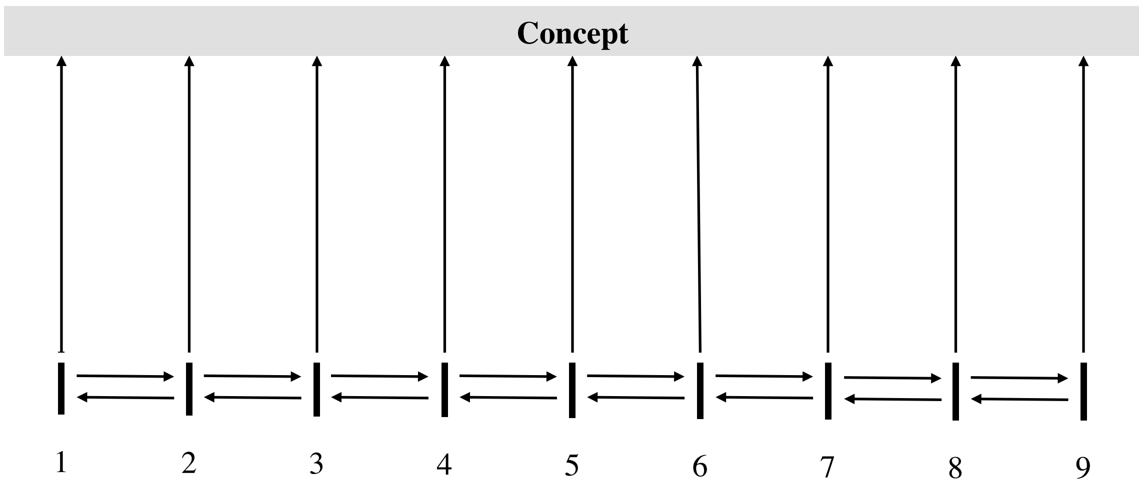


Figure 4.2.: Indicator-concept model (adopted by Strauss [St87])

The indicator-concept model compares each indicator with other indicators. Indicators are defined as *behavioral actions/events* [St87] – in case of federated EAMM for instance opinions and decisions towards unidirectional vs. bidirectional data transfer. The comparison of indicators leads to the identification of similarities and differences – or in simple terms – patterns. These patterns helped to draw conclusions and to define a generalized concept referring to a specific manner. Further information about indicator-concept model, can be obtained at [St87].

After the transcription, the interview guideline and the presentation deck get *Updated* with the recent research results and further questions to the new insides.

[1] WebEx: Online meeting solution by Cisco Systems Inc.

Evaluate and Consolidate the Findings

After all interviews have been conducted, the comprehensive findings were *Analyzed* regarding patterns. The *Indicator-Concept Model* by Strauss [St87] is a significant method, used in this phase. Moreover, a comprehensive matching between the recent research by [Ro13a, RHM13, HMR12, Fa14] with the results of the conducted interviews were performed. By conducting this activity, differences between current research and the research results of this thesis were identified.

After the final research results have been identified an documented, the results were *consolidated* to specific artifacts. These artifacts refer to clear process definitions – for instance meta model changes – and role allocations within the management of a federated EA model.

In the last step, the artifacts were documented within the presentation deck and *presented* to the participants of the expert interviews.

4.3. Results of the Expert Interviews

As mentioned in section 3.3 it can be distinguished between three main use cases: *Model Mapping*, *Staging Level* and the *Model Merge*. Moreover, it can be distinguished between meta and data model information – see section 3.1.1.

While performing the semi-structured interviews, it turned out that the experts from the industry do not distinguish between specific use cases, but between different types of information – meta or data model information. To get more specific, experts within industry prefer an integrative process for *meta model changes* and *data model changes*. As a consequence, the defined artifacts were aligned to these types of processes. Figure 4.3 illustrates the developed artifacts after the performance of the semi-structured interviews and the placement of the explained use cases in section 3.3 within these artifacts.

As illustrated in figure 4.3, the following artifacts are provided:

- Process for meta model changes
- Process for data model changes
- Process of conflict resolution

Beside these artifacts, an aggregated project view that consider the complete implementation process of a federated EAMM is provided in section 6. An overview of further impacts from a management perspective – for instance incentives to participate in the federated EAMM – and technical impacts – such as unidirectional vs. bidirectional data flow – is also afforded.

4.3.1. General Acceptance of EAM

Most of the participants indicated that EAM is identified as an asset within their company, whereby only IT departments and the supervisory think that EAM can increase the efficiency of the running business. The problem is, that business departments do not recognize any

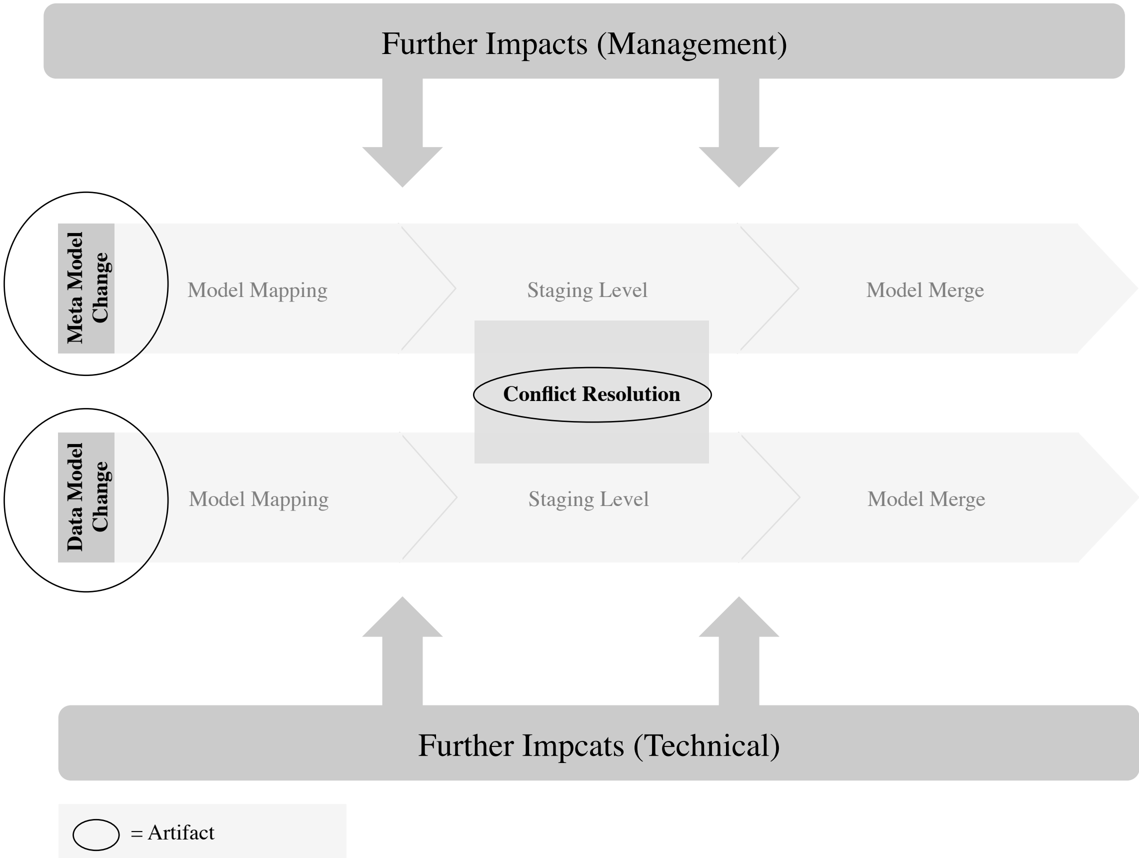


Figure 4.3.: Overview of the developed artifacts

benefit in EAM. Their running business would not change and they have further efforts to provide the required information, considering changes in their IT landscape.

Nonetheless, there is a clear trend of board definitions within organizations that focus on activities referring to EAM. Depending on the size of the company, the present status of EAM and the culture towards EAM within the company, the board is called weekly or monthly. Typical topics are the planning of next steps, reconciliations regarding new technologies and changes of the EA model.

4.3.2. Performed Activities Regarding EA Model Management

It turns out that the significance of EA documentation is realized by today's companies and activities regarding EAMM – or familiar EA documentation approaches – already take place. However, the activities are limited to general reflections, the standardization of the terminology or federated EA documentation in a small scale. Comprehensive federated EAMM activities – or federated EA documentation activities – are not established in industry.

Another group of EA experts mentioned that the respective organization they work for, does not consider structured EA documentation or EAMM activities. Reasons are missing management support or the allocation of a low priority: The *daily business* and other challenges – such as regulatory requirements – have a higher priority.

4.3.3. Identified Cases for Federated EA Model Management

IT Controlling

There are various approaches to allocate overhead to specific products within an organization – e.g. the planned overhead cost calculation or the marginal planned cost accounting [Fr08]. Nonetheless, before starting to allocate costs to specific cost drivers or products, all IT products within the organization that generate the costs need to be identified. Brun et al. [BHK06] highlight that IT costs represent a non-transparent overhead in today's companies: Especially groups have to handle several hundreds of information systems, IT processes, data flows etc. As a consequence, there is a lack of transparency regarding these IT elements.

During the performance of the semi-structured interviews it turned out, that IT controlling is one of the most pursued cases as part of the implementation of a federated EAMM. Figure 4.4 illustrates a typical IT controlling issue that might be identified by using a federated EA model.

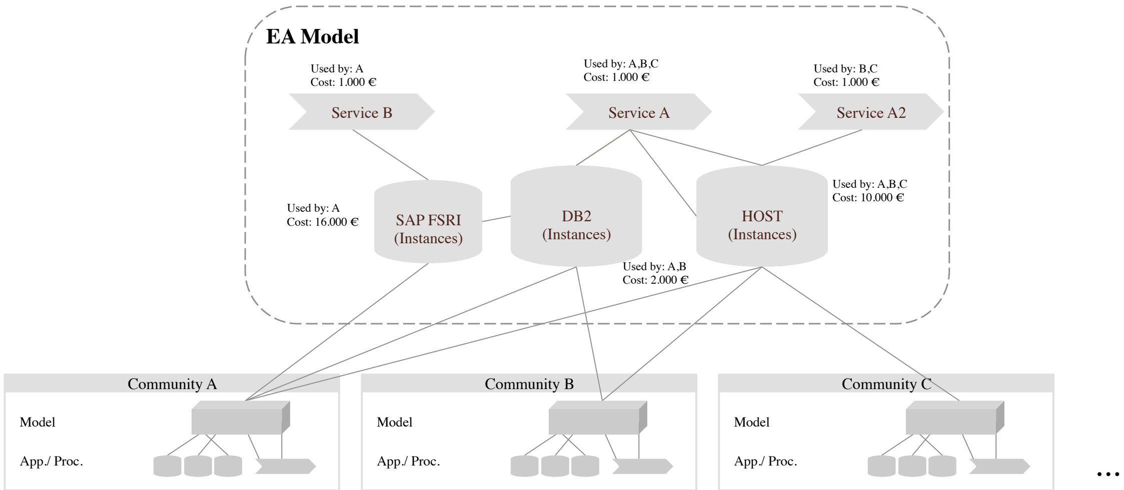


Figure 4.4.: IT controlling case in terms of a federated EAMM

Three communities implemented their own applications and processes. The EA information is stored within the specific meta and data model of the communities. Due to the representation of all services and applications – and furthermore their associations to each other – the company is able to identify inefficient cost drivers within the company. In this case: SAP Financial Services - Reinsurance (FS-RI) is only used by Community A. SAP FS-RI is to expensive and powerful for this little amount of reinsurance business transactions. It is advisable to substitute SAP FS-RI with less complex system. This action leads to cost savings and increase the efficiency of the IT.

Trends and Forecasting

A further case that were presented by a majority of the participants, is the identification of trends and forecasting issues: Business transactions, process outputs, employee information etc. are all stored in specific databases, whereas these databases have only limited storage space. By having an up-to-date EA model with present information about the single EA products, Enterprise Architects are able to run forecasts about the development of specific EA products. These forecasts can be used to plan the next steps of the EA landscape development or to identify bottle necks within the IT infrastructure. Figure 4.5 represents an exemplary case.

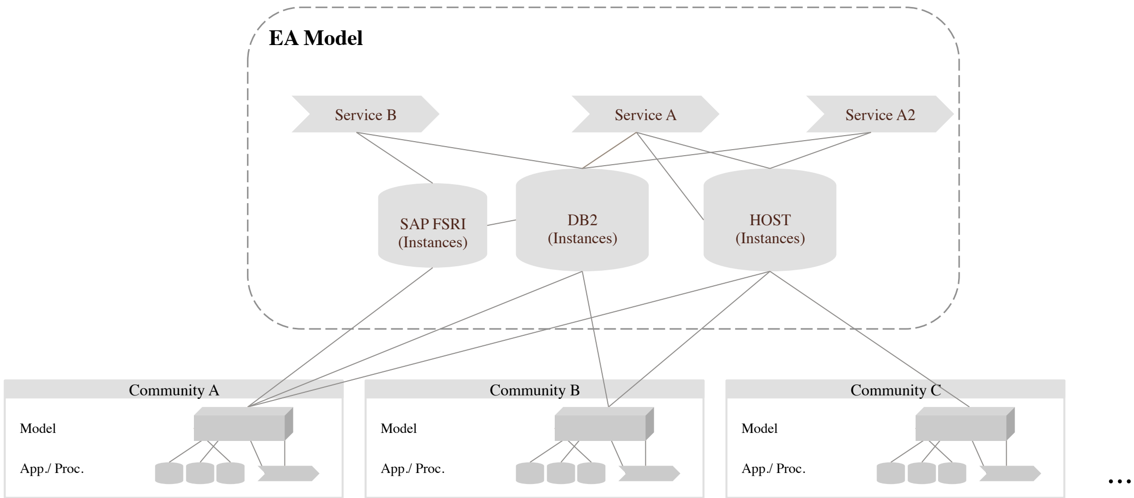


Figure 4.5.: Trends and forecasting by using a holistic EA model

All Services make use of the IBM DB2[2] database. The Enterprise Architects forecast an increase use of services over the last 12 months. As a consequence, a further increase of service uses can be assumed with the consequence that the IBM DB2 database would not provide enough capacity, to handle the upcoming information. The Enterprise Architects suggest to implement a further IBM DB2 instance.

Further long period trend identifications referring to the comprehensive IT landscape – for instance the establishment of necessary applications or specific technologies – are also possible with an comprehensive EA model.

[2]IBM DB2: Database solution by the company IBM

General Control and Planning Future IT Landscape

The heterogeneous IT landscape and the sum of implemented information systems across large organizations represent obstacles for the general control of the IT landscape and thus, for the effective planning of the future IT landscape. A comprehensive EA model provides a certain overview of the present EA status. One participant from the reinsurance sector mentioned that the reinsurance company he works for, is currently running over 150 productive IT systems. Due to the fact that a huge amount of these systems were developed by single persons, freelancers, etc., documentations about these systems are missing or are not traceable for the employees within the company. A federated EA Model with participation of the major communities helps organizations to get an overview of the whole IT landscape and also serves some kind of documentation about the current IT landscape.

Regulatory Requirements, Transformation Projects and Further Cases

Beside the most popular assets described in section 4.3.3, 4.3.3 and 4.3.3 the semi-structured interviews also provide cases for the EAMM, which do not fit to all organizations – for instance regulatory requirements for the financial service sector. The following cases were mentioned by single EA experts:

- **Regulatory requirements:** As aforementioned in section 1.1, regulatory requirements – for instance Solvency II and IFRS 4 Phase 2 in the insurance sector – represent a challenging mandatory for today's companies. Supervisors expect various quantitative information and adequate risk management activities that also need to be reported. Almost all information are stored within distributed information systems. As a consequence, companies have to put much effort to identify the demanded information and implemented data flows between these information systems. An holistic EA model could help to identify these data flows and also provide a clear overview of the IT landscape. This would facilitate the process of information identification.
- **Chief Information Officer (CIO) reporting:** The single IT departments within a company are encouraged to report the present status of the IT landscape with meaningful facts – such as costs of the single information systems or planned updates in the next period – to the CIO of the company. An federated EA model would provide enough information to facilitate this reporting.
- **Transformation projects:** Companies realized over the past years that much effort is necessary to manage heterogeneous IT landscapes. To increase the efficiency of the present IT landscapes, complex and comprehensive IT transformation projects have to be initiated. A clear overview of the current IT landscape is the foundation and the starting point of each IT transformation project. An holistic EA model provides exactly this overview.
- **Benchmarking between communities:** Communities within an organization implemented own applications and stores their information on customized databases, but do also make use of company wide information systems – for instance a host [3] system.

[3]Host: Central information system in large companies

Also IT processes – for instance change management process – can be defined as a company wide service and can be utilized by the single communities. One EA expert mentioned the use case of running benchmarks between the communities. The respective organization wants to measure the IT demand of each community and the added value of the respective community. With these two items, the IT governance would be able to calculate the efficiency of each community and match these communities to each other.

4.3.4. Defined Roles in Industry

In section 3.2 an overview of the defined roles in research, when referring to the federated EAMM is given. Notwithstanding, experts from the industry follow a more pragmatic approach. Figure 4.6 illustrates the results of the semi-structured interviews.

	Participants										
Enterprise Architect	x	x		x	x	x	x	x	x	x	8 / 10
EA Coordinator											0 / 10
Modelling Expert											0 / 10
EA Repository Manager											0 / 10
Data Owner		x		x							2 / 10
Data Stewart											0 / 10
EA Stakeholder											0 / 10
Decision Maker											0 / 10
Business Architect		x				x		x			3 / 10
Domain Architect	x	x	x	x	x	x	x	x	x	x	9 / 10
Security Architect									x		1 / 10

Figure 4.6.: Allocated roles for federated EAMM within industry

All participants mentioned to involve a Domain Architect, when managing a federated EAMM. A Domain Architect is defined as an expert for a specific technology – for instance for a specific SAP system or all IBM DB2 instances within an organization. Moreover, most of the EA experts would involve Enterprise Architects within the model management. Enterprise Architects have an overarching role and are responsible for the complete model management process. In addition to that, they support in various model management activities and act as a general contact person in case of problems and upcoming issues. Depending on the considered information – for instance some business information might also be interesting for the EA model – Business Architects might also be involved. Specific roles – like the Modeling Expert or the acEA Repository Manager – are not involved or defined by the EA experts: As aforementioned in the beginning of this chapter, most of the experts within industry deal with EA documentation issues more pragmatic. The documentation and model maintenance can be done by using modern EA tools – for instance *Archi* or *Iteraplan*[4] – which do not require profound modeling expertise. One EA expert also mentioned that the involvement of too many roles would bring up a lot of different opinions regarding the next steps. As a consequence and in line with Gloger [Gl10], the involvement of roles should be hold on a minimum level.

4.3.5. Alignment of the Terminology

As mentioned in section 3.3.2, various types of conflicts might occur between extracted information from communities. One mentioned conflict type is the semantic conflict. An example would be:

Community A: SAP is a productive platform in our environment.
Community B: SAP is a productive application in our environment.

Both communities talk about a SAP instance. One community classifies SAP as a platform, whereas the other as an application. As a consequence, the SAP instance would be allocated to the application entity within the EA model and to the platform entity. This problem has its root cause in the used terminology within the specific communities. It is mandatory to define a shared EA terminology across all communities to avoid such conflicts.

After conducting the interviews with the EA experts, it turned out that the terminology alignment process is a significant and risky process, which requires the participation of all communities and the strict observance of the process. Figure 4.7 illustrates the alignment process.

The alignment process suggests to involve the *EA Board* – or a similar authority –, *Enterprise Architects* and all *Communities*, which host EA model relevant information. The planned activities are clustered in three parts:

- **General setup activities:** The EA board defines a general *Strategy and scope.* This artifact describes the intention of of the planned activities, the requirements that have to be fulfilled, the scope of the alignment process and provide further project management information concerning planned budget and the suggested timeline. Based on the defined strategy and the general parameters, the Enterprise Architects define the operative activities and *strict governance principles* to fulfill the requirements of the EA board. The term *strict* is chosen deliberately: One EA expert stated that the participation of all members – following the defined approach – is mandatory. Otherwise, there is the risk that obstacles – for instance missing information of a community or wrong format of the delivered data – might occur and the alignment process ends in a show stopper. After the EA board gives the *sign-off* for these defined principles, the

[4] Iteraplan: Open source tool for EAM activities, provided by the company Iteratec

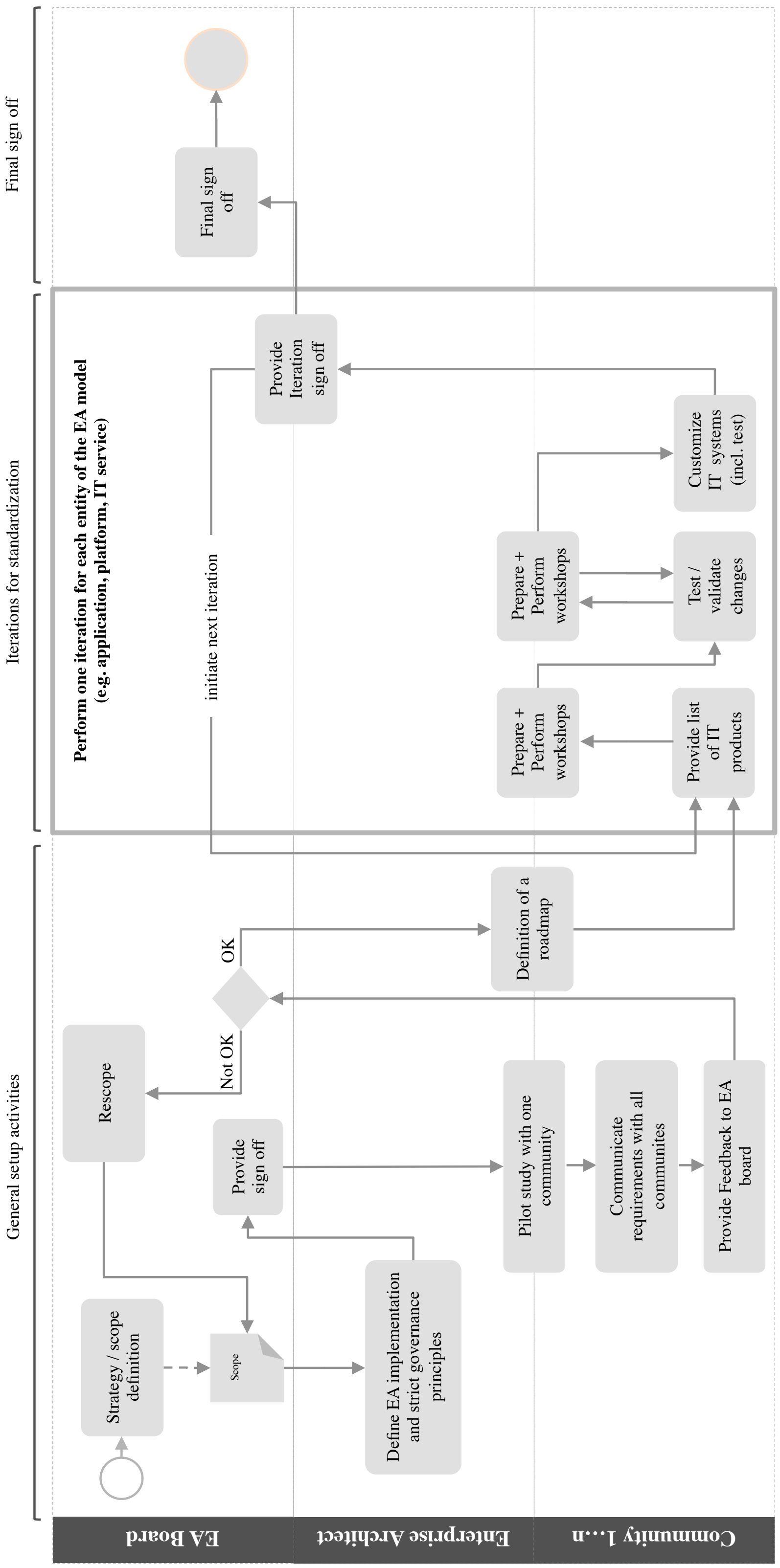


Figure 4.7.: Alignment of terminology process

Enterprise Architects initiate a *pilot study with one community.* This pilot study provides a first feedback by a random community to the Enterprise Architects regarding the defined governance principles. After that, the final requirements will be *communicated with all communities.* The communities *provide feedback to the EA board.* In case of to divergent interests, the EA board have to *rescope* the overall strategy, based on the delivered feedback. Otherwise, the Enterprise Architects will define a detailed *roadmap* for the next activities in collaboration with the respective communities.

- **Iterations for standardization:** The EA board defines the scope of the alignment process. This scope provides information regarding the IT products – in our case called entities – that have to be considered within an EA model – for instance application, platform and IT service. The alignment process requires to run one iteration for each entity with the respective communities. The iteration consists of *workshops* with the Enterprise Architects and all communities. The communities start each iteration by providing a *a list of IT products* to the Enterprise Architects. The list gives a detailed overview of the implemented applications, IT processes, platforms and further information, depending on the defined scope. The delivered list will be used to *prepare and perform workshops* between the Enterprise Architects and the communities. The workshops should provide a clear allocation of the single instances to the respective entities. The final allocation will be *tested and validated* regarding correctness, completeness and towards potential conflict situations. Based on the validations, further *workshops* might be necessary. After the successful testing phase, the productive IT systems of all communities have to be *customized* regarding the defined instance $\longrightarrow$ entity allocation. The EA board and the Enterprise Architects run final quality assurance activities and *sign-off* the respective iteration. After that a further iteration for the next entity will be initiated.
- **Final sign-off:** After all entities in scope have been aligned to a standardized terminology, the EA board have the provide a *final sign-off* of the alignment process.

4.3.6. Automated vs. Manual Information Transfer

As outlined in section 3.3, there is the possibility of manual and automated transfer of EA information from the communities to the EA model. It turned out that the choice depends on the complexity of the EA information that should be transferred to the EA model. Figure 4.8 illustrates the feedback of the EA experts in a comprehensive way.

The term *Complexity* is a widely used term, but defined differently within research [GM95, BT96, Si62]. In the case of federated EAMM, it can be assumed that the complexity of an information object $\times$ – referring to a meta or data model object – depends on the *amount of attributes* α, the defined *associations* of the respective object β and the *risk of conflict* γ:

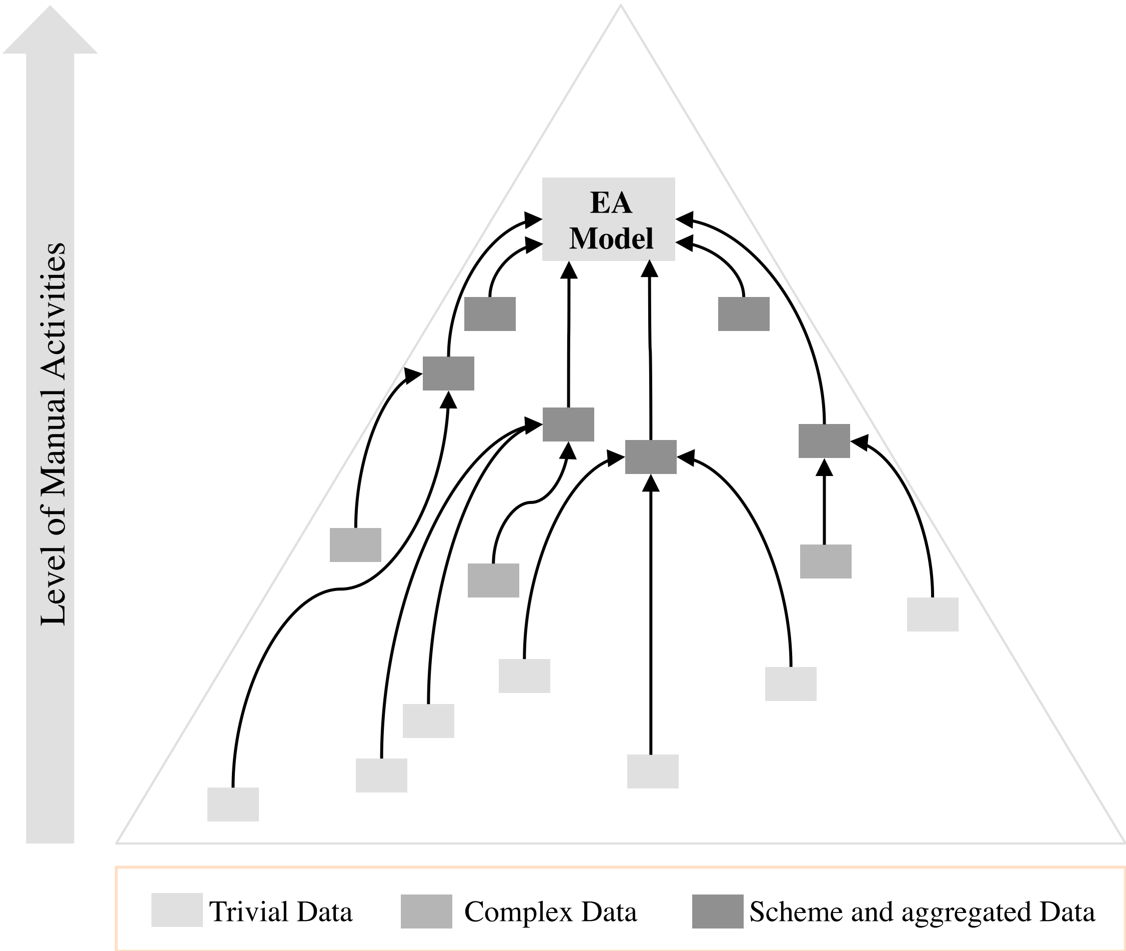


Figure 4.8.: Manual vs. automated data transfer

$$\alpha = \frac{\text{number of attributes in object}\times}{\text{number of attributes in}\varnothing}$$

$$\beta = \frac{\text{number of associations in object }\times}{\text{number of associations in}\varnothing}$$

$$\gamma = \frac{\text{overlaps with other objects by }\times}{\text{overlaps with other objects in }\varnothing}$$

$$\vartheta = \frac{\alpha + \beta + \gamma}{3}$$

Interpretation of ϑ:

$$\vartheta = \begin{cases} \text{if } < 1 & \text{low degree of complexity} \\ \text{if } = 1 & \text{average degree of complexity} \\ \text{if } > 1 & \text{high degree of complexity} \end{cases}$$

Referring to data model information – or instances – information objects with a *low degree of complexity* value can be transferred automatically to the EA model. For instance: An interviewed EA expert mentioned that he documents the present amount of virtual machines in his environment and the present amount of allocated software licenses within the EA model. Instances that refer to these type of values are always transferred automatically to the EA model. He also stated that instances of these types have a trivial structure: License and virtual machine instances contain a small amount of attributes and do not include overlaps with other information objects or complex associations with other instances – in our case information objects with $\vartheta < 1$. On the other side, the same EA expert presented an example of data model instances that will be transferred manually to the EA model: The respective company has a meta model entity that refers to databases. This entity also includes attributes with general hardware information. The problem is that general hardware information and database information will be maintained by different communities, which leads to overlaps within the respective instances. These overlaps result in conflicts. It can be hypothesized that the complexity ϑ is > 1 and manual reconciliations are necessary.

However, all EA experts confirm that meta model changes are conducted manually: Meta model changes have a significant impact on the EA model. In case of errors, further efforts of fixing the error and the affected data model objects have to be taken. Furthermore, various reconciliations between the respective communities and the EAM team are necessary. As a result, it can be stated that only data model information with $\vartheta < 1$ and partially $\vartheta = 1$ can be transferred automatically to the EA model.

4.3.7. Process of Meta Model Update

This section describes how EA experts prefer to update meta model changes within a specific community to the holistic EA model. As aforementioned in section 4.3.6, all EA experts confirmed to run meta model changes manually. Moreover, experts within industry prefer a lean approach of meta model changes: As illustrated in figure 4.9, the meta model change process involve three roles: A *Domain Architect* of the respective source, *Enterprise Architects* and *Developer*.

- **Step 1:** A community conduct meta model changes within its respective community – for instance the introduction of a platform entity. In this case, the respective Domain Architect – or another person in charge – *informs the EAM team about the changes.* The information can be provided via an e-mail, via call etc.

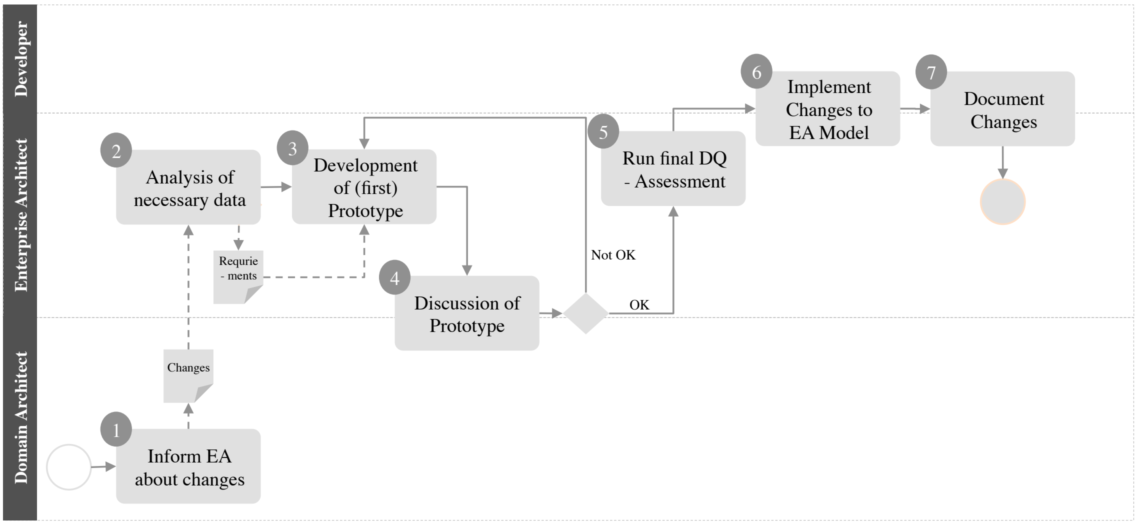


Figure 4.9.: Governance Process of Meta Model Changes

- **Step 2:** The Enterprise Architect *analyzes the information* and defines specific requirements – for instance the necessary information from the community.
- **Step 3:** The Enterprise Architect *develops a prototype* of the entity that should be implemented within the holistic EA model. The development of a first prototype can be a draft of the EA model or just a concept. The development is based on the requirements from step 2.
- **Step 4:** The Enterprise Architect presents the prototype to the respective Domain Architect and they *discuss the prototype* regarding correctness. In case of a negative feedback by the Domain Architect, the Enterprise Architect have to develop a further prototype.
- **Step 5:** The Enterprise Architect conducts a final *DQ Assessment* and analyzes, whether the new prototype does not occur conflicts with other entities within the EA model. This step also includes the conflict management activities as illustrated in section 4.3.9 and may include the involvement of further roles – for instance the EA Stakeholder or Data Owner. The involvement of further roles depends on the root cause of the conflict and its complexity.
- **Step 6:** The Enterprise Architect and the Developer implements the changes within the EA model. The involvement of a Developer depends on the EA documentation approach: There might also be the possibility of using a simple vector graphics software that does not required any development activities. In this case, the Enterprise Architect implements the changes without the support of a Developer.
- **Step 7:** After all changes have been implemented successfully, the Enterprise Architect (and the Developer) have to document all performed activities in terms of traceability reasons.

4.3.8. Process of Instance Mapping

The process within figure 4.10 illustrates how new instances of a specific entity – for instance a new application – are transferred from a specific community to the EA model. Just as mentioned in section 4.3.7, EA experts prefer a lean approach for a model management. As a consequence, only two roles are invovled within the instance mapping process: The respective Domain Architect and an Enterprise Architect.

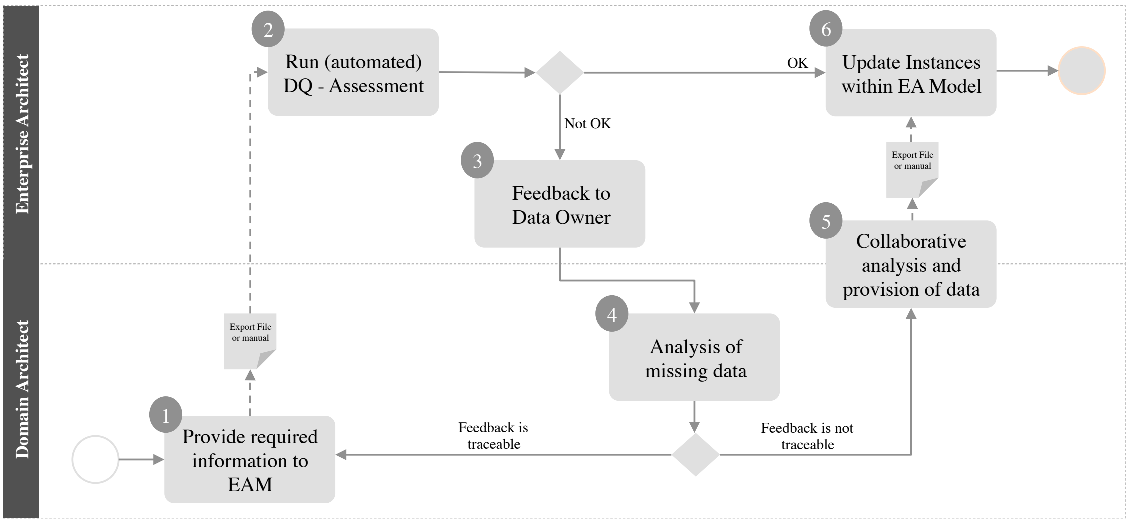


Figure 4.10.: Governance process of data model changes

- **Step 1:** The respective Domain Architect contact the EAM team about the change and *provide thew new information about the instance* to the EAM team. Information about the instance – or instances – might be transferred automatically, manually by using an export file or via e-mail. Further information referring the automization option, is illustrated in section 4.3.6.
- **Step 2:** The Enterprise Architect *runs DQ assessments*, which includes the detection of overlaps with other data objects, possible conflicts and the evaluation of quality of the provided data regarding completeness and correctness. In case of failures or problems, the process resume with step 3, otherwise step 3, 4 and 5 are skipped and the process continues with step 6.
- **Step 3:** The Enterprise Architect *provides a feedback* to the respective Data Owner with a clear description of the problem.
- **Step 4:** The Domain Architect *analyzes* the problem or missing information. In case of full traceability, the Domain Architect provides an updated version of the instances. Otherwise the process continues with step 5.
- **Step 5:** The Domain Architect and the Enterprise Architect perform discussions or workshops – depending on the complexity of the problem – and *analyze and provide*

collaboratively a solution for the problem. This step can be seen as the conflict resolution activity and is performed manually.

- **Step 6:** The Enterprise Architect *updates the instances* within the EA model.

4.3.9. Process of the Conflict Resolution

All interviewed EA experts have the similar attitude towards the conflict resolution process: It turned out that almost all conflicts will be solved manually. EA experts stated that the use of a *Master-Slave-Hierarchy* would be useful to solve conflicts automatically. The Master-Slave-Hierarchy would be established between communities: One community acts as a master for a respective data object – for instance a specific SAP instance. In the case of different values from different communities for this SAP instance, the value of the defined master community would be accepted for the EA model. However, EA experts highlighted that conflicts might be more complex and demand for reconciliations between respective parties. Figure 4.11 illustrates the defined conflict resolution process.

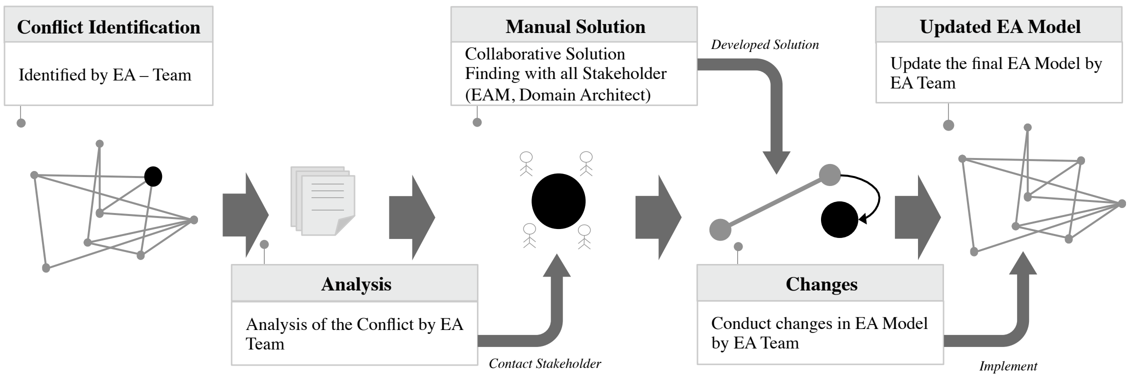


Figure 4.11.: Collaborative conflict management

After the conflict has been identified by the EAM team, a profound analysis of the conflict will be performed. The analysis ends with a clear identification of the root cause. The resolution process will be performed with further parties, which have a relationship to the conflict – for instance EA Stakeholders or Domain Architects. As aforementioned, the conflict resolution – especially meta model conflicts – will be conducted manually. Experts from industry prefer a pragmatic approach to resolve conflicts. Depending on the complexity and the risk of the conflict, the resolution can be performed unbureaucratic – for instance by performing a short call between the respective parties – or lead to further activities – such as the setup of workshops between the respective parties. After the respective parties agree to a specific solution, the conflict information and the EA model will be manipulated by the EAM team. Only community member are allowed to manipulate information in their information systems or meta and data models of a respective community. After the EAM team has manipulated the EA model and tested the correctness of the manipulated EA model, the productive EA model will be updated.

4.3.10. Further Characteristics

Unidirectional vs. Bidirectional Data Flow

Figure 3.9 illustrates different approaches of data flow. The interviewed EA experts had slightly different opinions towards unidirectional vs. bidirectional data flow:

Arguments for unidirectional data flow:

- Communities still have the lead about their own business and their operational data. As aforementioned in section 1.2, communities operate in an autonomous way. The EAM team cannot manipulate any data, model or settings within the information systems and concepts of the respective communities.
- One EA expert highlighted the problem of legacy systems: The respective community operates with various legacy systems – for instance databases or applications – which are restricted regarding their scalability. As a consequence, the EA expert stated that these legacy systems cannot be customized with further interfaces or other communication channels. Moreover, customization operations at legacy systems are risky and could lead to a show stopper within the daily business.

Arguments for bidirectional data flow:

- EA experts – especially members of the EAM team – noticed that bidirectional data flow is the best way to communicate new standards and group wide concepts to the single communities. One EA expert stated that the company he works for, performs weekly meetings with EAM team members and at least one representative from each community – for instance the EA Stakeholder of the respective community. By following this approach, the EAM team ensures that new group wide standards are communicated to all communities and further steps towards IT standardization are realized. Nonetheless, this type of bidirectional communication does not implicate *machine to machine* communication – for instance the EA repository $\xrightarrow{\textit{manipulates}}$ information systems within communities.
- Collaboration between communities and the EAM team is a mandatory element to provide an efficient federated EAMM. In case of unidirectional communication, the collaboration aspect of the model management would suffer: The communities have to know what kind of information is required from the EAM team and what kind of format is necessary to minimize data cleansing and transformation operations within the staging level.

Option of Versioning

Most of the EA experts prefer the implementation of a versioning option, which documents the evolution of the IT landscape and the EA model. By providing different states of the EA model on a timeline, the EAM team can run different kind of analysis and benchmarks on the evolution of the EA within the organization. Based on these analysis and benchmarks, the EAM team can evaluate successful choices referring to the chosen technology and implemented processes and evaluate the impact of these choices to the efficiency and effectivity of the EA landscape. Furthermore, an EA model versioning option enables a traceable auditing documentation – for instance to the CIO and to regulatory supervisors.

However, a minor group of the EA experts do not prefer the implementation of a versioning option: This group advocate that versioning gives only information about the evolution of the EA and past information, which is not interesting for further planning activities. They prefer to plan next steps, by focusing on the as is IT landscape.

Problem of Missing Support of all Communities

Section 3.3.4 describes that collaboration between the communities and the EAM team is mandatory. Moreover, section 1.2 notices the fact that business stakeholder rarely participate in EA activities and in EAMM activities. The EA experts were asked, how they accomplish this obstacle. Otherwise the EA model would not be usable because of missing up to date information by the communities. It turned out that two fundamental approaches are followed within industry: Some organizations make use of *Governance Pressure* and some of more *Social Methods*. Figure 4.12 illustrates these approaches.

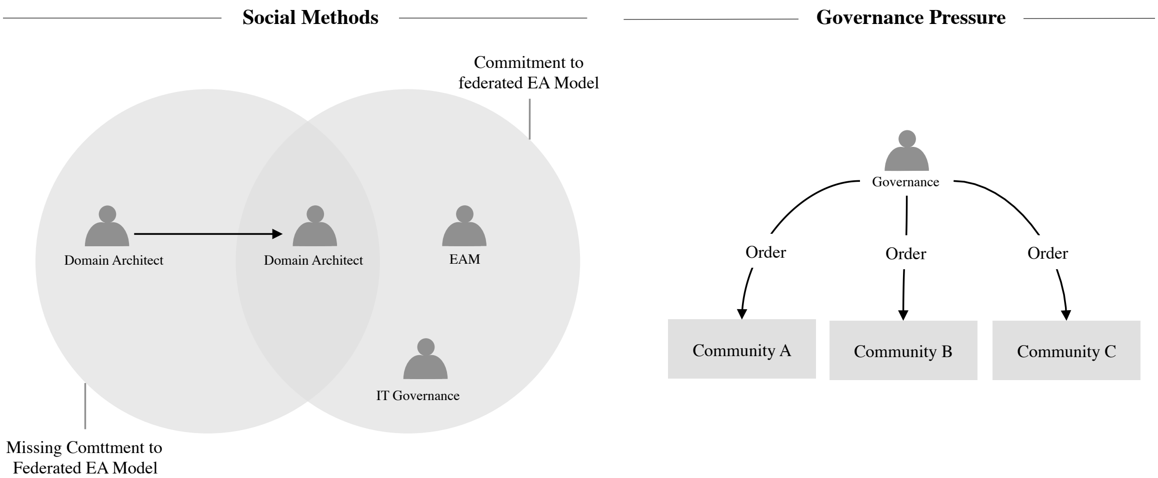


Figure 4.12.: Approaches to convince all Data Owner to collaborate

Social Methods:: The EAM team and the supervisory try to convince communities and further significant stakeholders for the data provision – for instance Domain Architects or Data Owner – by providing appeals to the respective employees:

- Agreement on objectives
- Extra bonus
- Convince about the benefit

Governance Pressure: The other approach make use of strict governance principles. The

EAM team – or a respective supervisor – is authorized to issue directives to the respective stakeholder. Furthermore, escalation paths are foreseen in case of disputes between communities or further parties.

5. Evaluation of the Online Survey

As highlighted in section 1.3, an online survey were conducted to justify the defined artifacts. This chapter describes the design and the results of the online survey.

5.1. Design of the Online Survey

On the one hand, the survey deals with governance aspects of the federated EAMM, and on the other hand also with technical aspects – for instance the engineering aspects of the model reconciliation activities.

The design of the online survey considers to make use of questions that provide measurable answers [Fi03] – for instance nominal scales. However, in some cases the participants were also asked to enter comments – such as opinions towards the capability of ontologies. This information gives further insides towards the specific topic and are evaluated with a qualitative approach. The survey is divided into 12 question groups. Each question group includes information regarding a specific manner – for instance meta model changes. Four out of the 12 clusters deals with the governance aspects of the federated EAMM. The online survey also includes question groups that refer to the technical aspects of the federated EAMM. The results of these question groups are documented in the master thesis of Kirschner [Ki14]. The considered questions within the online survey are illustrated in Kirschner [Ki14]. Table 5.1 gives on overview of the question groups with focus on the governance aspects.

Potential participants were contacted via e-mail. In line with Kirchhoff [Ki03], the following information was included in the cover letter to provide an overview of the research:

- Name and address of the chair
- Short description of the federated EAMM and the research goal
- Benefits for the participant
- Duration of the online survey
- Mention of anonymous and aggregated usage of the survey results

The online survey was conducted by 48 participants.

Question group	Name	No. of questions	Content
#2	Alignment of terminology	6	Further analysis of artifact in section 4.3.5; evaluate the duration of the activities within the federated EAMM
#3	Mapping of new instances	7	Evaluate the artifact in section 4.3.8 with regard to the suggested role allocation; identify the degree of automated conflict resolution and frequency of upcoming conflicts
#4	Change of meta model	4	Evaluate the artifact in section 4.3.7 with regard to the suggested role allocation; identify the degree of automated conflict resolution and frequency of upcoming conflicts
#5	Further characteristics	6	Focus on illustrated characteristics in section 4.3.10, especially ontologies, direction of the data flow and general benefits of federated EAMM

Table 5.1.: Overview of question groups with governance focus

5.2. Results of the Online Survey

5.2.1. Question Group #2: Alignment of Terminology

In this question group the terminology alignment process – illustrated in figure 4.7 – is evaluated. The participants were asked to what extent they agree with the suggested process and if they prefer a more pragmatic approach for the alignment process. Six participants (21%) disagree with the suggested process and Five (18%) participants do not prefer a more pragmatic approach. Moreover, the participants were asked to comment their improvement suggestions. 18 participants entered a comment within the online survey.

In line with Ambler [Am14], the comments show a clear trend towards stronger business involvement. It turned out that the role of EAM is not completely established within today's companies, in some cases the *EA Board is replaced by the ordinary management* and the EA board is divided in single IT boards in each business unit. One participant stated that *Business Operations rules* these kind of activities.

Another representing opinion was the suggestion of a more pragmatic approach. The participants named the following reasons:

- Reduce complexity of the process by being less intrusive and more natural
- Enterprise Architects do not need to participate in every activity
- Perform a more agile approach with less prefixed activities

The suggested artifact includes escalation paths to the EA board within each activity. 22 participants (81%) agree with this suggestion. The participants named the following reasons:

- The directives have to be issued by the upper management

Activity	Role	Percentage
Provide information to EAM	Domain Architect	46%
Run DQ-assessment	Enterprise Architect	32%
Feedback to Data Owner	Enterprise Architect	42%
Analysis of missing data	Domain Architect	29%
Collaborative analysis and provision of missing data	Data Steward	29%
Update Instances within EA model	Enterprise Architect	63%

Table 5.2.: Most preferable roles in charge in each activity for the data model change process

- Without an EA board, there is the risk of handling the coordination between business and IT departments
- EA board should utilize its governance control to ensure the resolution of any show stoppers
- EA board is authorized to enforce implementation activities
- Especially in companies that operates across various countries with different cultures, an EA board with the authorization to enforce issues is mandatory
- EAM serves as an independent third party in case of disputes between communities
- Silo thinking in communities is avoided

A minority of the participants di not agree with the provision of escalation paths: Escalation paths might not work *in an environment with responsibilities, distributed at a low level.* Furthermore, a participant scrutinize the meaningfulness of governance pressure, when respective communities do not find a consensus. However, this view is not shared by the majority of the participants. The participants would spend 16 months on average for the alignment process.

Lessons Learned:
→ Further involvement of business stakeholder
→ Implementation of escalation paths is mandatory
→ Follow a more pragmatic approach

5.2.2. Question Group #3: Mapping of New Instances

It can be distinguished between meta model and data model changes. This question group focuses on changes regarding the data model of a respective community – for instance the implementation of new IT services. In section 4.3.8 an instance mapping process is illustrated. The participants were asked to assess the suggested process with regard to the advocated role involvement. Table 5.2 illustrates the most chosen role for each activity.

Table 5.3 illustrates the involvement of each role within the complete instance mapping

Role	Average Involvement
Enterprise Architect	29%
Domain Architect	18%
Data Steward	16%
Business Architect	12%
Data Owner	9%
Modeling Expert	9%
Enterprise Architecture Coordinator	2%
Decision Maker	1%
Other	1%

Table 5.3.: Involvement of each role on average

process on average.

In section 4.3.8, the results of the expert interviews with regard to the instance mapping process are presented. The results of the expert interviews outline that EA experts prefer a lean approach, when mapping new instances to the EA model. The results of the online survey confirm this preference. The statistics of the online survey show that most of the participants prefer the involvement of the Enterprise Architect and the respective Domain Architect. This result shows that experts from industry avoid the involvement of too many roles. However, it turned out that the Data Steward is also considered within the instance mapping approach. The Data Steward is considered as the most preferable person in charge, when conflicts come up within the mapping approach and further reconciliations are necessary. The second activity within the instance mapping process is the running of DQ assessments. The Enterprise Architect is the most chosen role as the person in charge within this activity, whereby the Data Steward comes as the second place with 18%. Also in the analysis of the missing data, the Data Steward comes on average as the second chosen person in charge with 25%

It turned out that the Data Steward plays a significant role in activities with a focus on data analysis. The Data Steward has profound knowledge about special information sources and supports granular analysis steps.

Lessons Learned:
→ Keep a lean instance mapping approach with involvement of chosen roles
→ Consider the involvement of specialists in case of obstacles and conflicts that refer to the respective domain

5.2.3. Question Group #4: Change of Meta Model

This question group focuses on the evaluation of meta model changes, based on the provided artifact in section 4.3.7. The meta model change process – illustrated in figure 4.9 – con-

Activity	Role	Percentage
Inform EAM about changes	Domain Architect	53%
Analysis of necessary data	Enterprise Architect	42%
Development of prototype	Enterprise Architect	37%
Discuss prototype	Enterprise Architect	47%
Run DQ-assessment	Enterprise Architect	53%
Implement Changes to EA Model	Enterprise Architect	58%
Document Changes	Enterprise Architect	58%

Table 5.4.: Most preferable role in charge in each activity of the meta model change process

sists of seven process steps and asks for the participation of Enterprise Architects, Domain Architects and Developers. The participants prefer on average the illustrated roles in table 5.4 for the respective activities.

The statistics show clearly that meta model changes should be allocated to the Enterprise Architect. Meta model changes of a respective community might affect the federated EA model. The Enterprise Architects are responsible for the correctness and completeness of this model. Thus, the Enterprise Architects should take the main responsibility of the conducted activities.

5.2.4. Question Group #5: Further Characteristics

Section 5.2.1, 5.2.2 and 5.2.3 present the evaluation results of specific artifacts. Section 5.2.4 does not focus on a specific artifact, but rather on the evaluation of further characteristics, as mentioned in section 4.3.10. The question group concentrates on further evaluation of the direction of data flow and ontologies. The evaluation of the question group provides the following information:

- **Direction of data flow:** The majority of the participants – 14 participants, 78% – prefer a bidirectional data flow, whereby the EAM is not authorized to manipulate data within the information systems of the communities. The EAM team should communicate information that refer to changes of the EA model to the communities. No participant suggested an unidirectional data flow from the communities to the EA model.
- **Ontologies:** The participants were asked, wether or not they are familiar with the concept of ontologies and furthermore, if they would make use of ontologies for automated EA documentation activities. Only 55% of the participants are familiar with the concept of ontologies, which reveals the finding that the concept of ontologies does not figure a prominently role in today's industry, but rather has an academical significance. Those participants, who were familiar with ontologies, stated that ontologies might be interesting in future, but other topics have a higher prioritization at this time. Furthermore, one participant argued that today's business applications and information systems are poor in electronic documentation possibilities. The quintessence of the capability of ontologies for automated EA documentation is that the concept

illustrates an efficient way for EA documentation activities, but various obstacles – for instance the willingness to fund such a complex implementation – need to be resolved in advance.

6. Aggregated View on the Research Results

In this section the evaluation results will be aggregated to a holistic artifact that includes the required activities when initializing, designing and maintaining a federated EAMM. The holistic artifact is based on the research results in section 4 and section 5. Furthermore, this section provides a reconciliation between the provided research results of this thesis and results of already conducted research.

6.1. Aggregated View on a Federated EA Model Management from a Project Perspective

Figure 6.1 represents a process model that includes necessary activities to *initialize*, *design and develop* and *maintain* a federated EAMM within an organization.

- **Initialization:** Before starting to implement a federated EAMM, the project team should care about general project parameters: As highlighted in section 1.2, business stakeholder rarely participate in EA activities, whereby the participation of them is mandatory. As a consequence, it can be hypothesized that upper management support is necessary to establish a federated EAMM. Moreover, common project initialization activities – such as timeline definition, budgeting, scoping, etc. – should be performed.
- **Design and development:** The second phase starts with the design activities of the federated EAMM, by aligning the EA terminology across all communities. The detailed alignment process is provided in section 4.3.5. Furthermore, a first version of the meta model need to be established, based on a clear model scope. The detailed scope definition, asks for the participation of all communities, Enterprise Architects and members of the EA board or another former project lead and includes the definition of necessary entities within the meta model, the definition of the included attributes and the discussion of functional characteristics – e.g. unidirectional vs. bidirectional data flow. The implementation of the first meta model version will be conducted collaboratively and will be controlled by the EA board. The last activity includes the import of the present instances from the communities. There is a risk that various conflicts between communities have not been identified and considered when aligning the EA terminology and setting up the meta model. This activity can be seen as a DQ gate, which identifies major conflicts and indicates further adjustment activities referring to the EA meta model.
- **Maintenance:** After the first version of the federated EAMM is established, the process continues with maintenance activities of the EA model. Maintenance activities are necessary, when a community wants to report new instances to the holistic EA

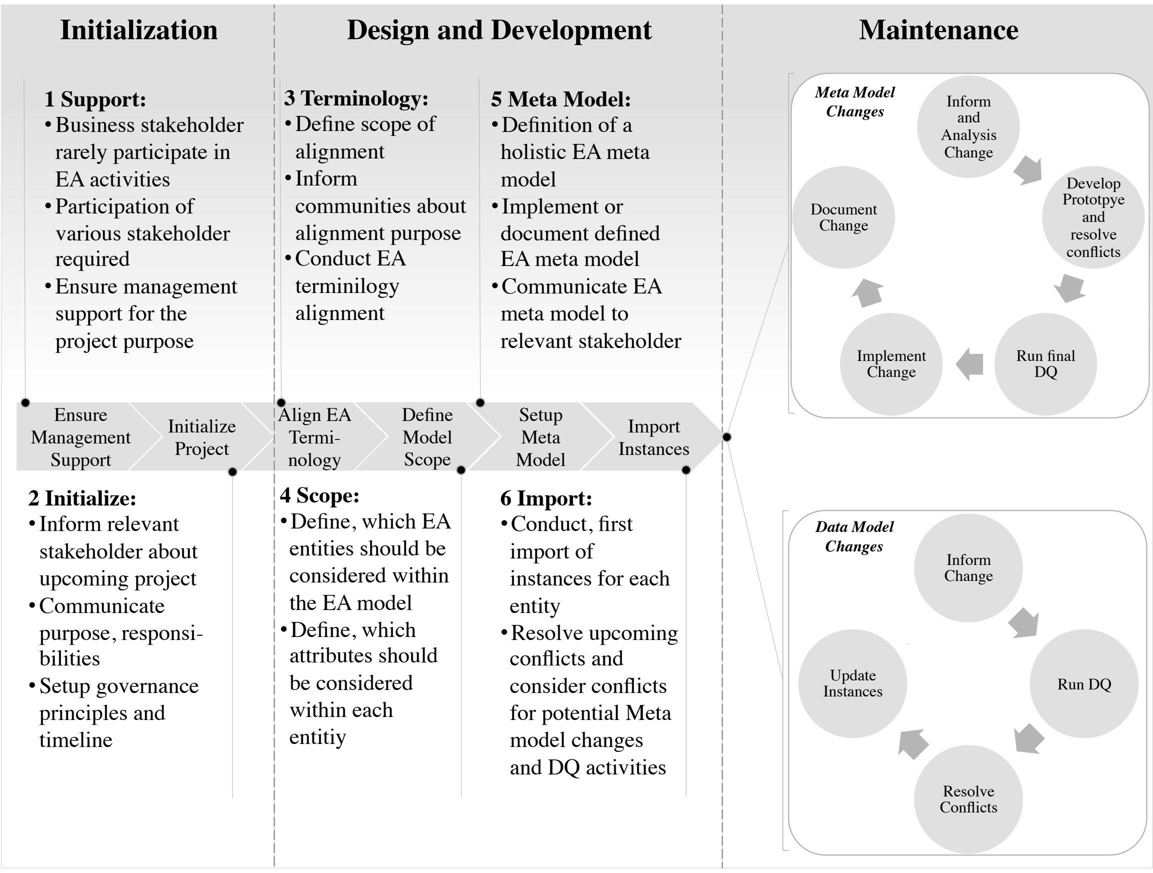


Figure 6.1.: Project plan view on federated EAMM

model or the meta model of a community has changed. The detailed process definitions are provided in section 4.3.7 and 4.3.8.

6.2. Reconciliation with Conducted Research

Figure 6.2 illustrates a reconciliation between the research results of this thesis and already conducted research with regard to EA documentation, federated EAMM or familiar topics. The reconciliation shows that DQ issues regarding EAM are a widely identified challenge. Moreover, most of the researchers agreed that EA models may help to facilitate an EA documentation. However, some findings within this thesis were not highlighted by familiar research yet:

- The results of this thesis reveals that most of the industry experts prefer a lean approach for EA documentation and federated EAMM activities – especially for the role allocation. Familiar research – for instance by Fischer et al. [FAW07] – do not align with this research result and defined several roles for the federated EAMM – for instance Modeling Experts or EA Repository Manager. The results of this thesis, renounce on such roles and suggest a lean approach for the role allocation.

- The results of the online survey highlighted that federated EAMM is a business driven functionality and requires a strong involvement of business stakeholder. Major use cases – for instance regulatory requirements – present famous scenarios that should benefit from a federated EAMM. This finding were not highlighted from this viewpoint yet.
- Section 5.2.1 illustrates that the terminology alignment process is a mandatory for the federated EAMM and asks for major efforts. Familiar research do not highlight the significance of the alignment process yet.
- This thesis highlights various aspects of the data delivery setup – for instance unidirectional vs. bidirectional data delivery. Automated data delivery definitions does not suit for all cases – for instance for meta model changes. Conducted research highlighted the benefits of an automated data flow definition, but rather mentioned use cases that would not benefit of an automated data flow.

	Degree of agreement in research								
	[Ha14]	[Ha13b]	[FAW07]	[HMR12]	[Ro13a]	[Ro13b]	[Bu12b]	[Fa13]	This Thesis
Industry experts prefer a pragmatic/agile EA documentation approach	100%	0%	0%	0%	0%	0%	0%	0%	25%
Organizations faces the challenge of missing ROI	25%	0%	0%	100%	50%	50%	50%	25%	75%
Industry experts prefer a minimum involvement of roles	25%	0%	0%	0%	0%	0%	0%	0%	100%
EAMM activities are mostly promoted by IT employees	25%	25%	0%	50%	0%	25%	25%	100%	25%
Federated EAMM is a business driven discipline	25%	0%	0%	0%	0%	0%	0%	0%	50%
Organizational culture and parameters influences the federated EAMM	0%	100%	0%	25%	50%	0%	0%	0%	25%
The terminology alignment is a major challenge	0%	25%	0%	0%	25%	25%	0%	0%	75%
EA models helps to document the current state of EA	0%	0%	100%	25%	75%	50%	75%	0%	100%
EA models faces lacks of DQ	0%	25%	100%	100%	100%	75%	25%	100%	50%
EAMM faces the lack of defined roles	0%	0%	25%	100%	0%	0%	0%	0%	0%
The definition of data delivery contracts is mandatory	0%	0%	100%	0%	25%	0%	0%	0%	100%
EAMM faces strong acceptance among all stakeholders	0%	0%	100%	0%	25%	0%	0%	0%	25%
Data delivery activities are an ongoing process	0%	0%	100%	0%	25%	0%	0%	0%	100%
An automated data delivery definition suits not in all cases	0%	0%	100%	0%	0%	0%	0%	0%	100%

Agenda (degree of agreement): 100% 75% 50% 25% 0%

Figure 6.2.: Reconciliation with Conducted Research

7. Conclusion, Discussion and Future Work

The last chapter recaps the major findings of the research, discusses the capability of the created artifacts and gave an outlook of further work regarding EA documentation.

7.1. Conclusion

This thesis starts with a motivation and the mandatory of an EA documentation mechanism within today's organizations. Based on current research, it turned out that information – and also EA information – are a key success factor for companies and can assure competitive advantage in today's markets. Beside this competitive advantage, regulatory requirements force companies, to ensure a clear transparence within their IT landscape and to provide required EA information – such as defined data flows between information systems – to the respective supervisory. However, companies are facing the challenge of heterogeneous communities and thus heterogeneous information systems and data models. This obstacle needs to be considered, when designing, implementing and maintaining a federated EAMM within an organization.

The second part focuses on the foundation of the federated EAMM. The defined role allocation from recent research and specify the major use cases, when maintaining a federated EAMM were elaborated. Moreover, the general framework conditions and specific characteristics that might have an impact on the design of the specific use cases are highlighted. The capability of common EAM frameworks are analyzed regarding federated EAMM. It turned out that EAM frameworks partly support an EAMM, but do not consider significant challenges like the collaboration aspect or the definition of major roles within the EAMM.

After the motivation of the topic and the explanation of the foundations, this thesis continues with the evaluation chapter. Semi-structured interviews with 11 EA experts from various industries have been conducted for the definition of the first draft of the desired artifacts: These artifacts illustrate process definitions for meta model changes, data model changes and conflict resolution activities. The quintessence of the process definitions is that due to the uniqueness of upcoming conflicts, major activities have to be performed manually. Furthermore, the research results confirm the findings, provided by Hauder et al. [Ha14]: It turned out that experts from the industry prefer a lean approach by taking only a few parties into account and following a more pragmatic approach within EA documentation activities. Considering too many parties could lead to bureaucratization of the EA documentation process. During the execution of the interviews, it turned out that the alignment of a standardized EA terminology is mandatory for the federated EAMM. As a consequence, an artifact for the terminology alignment process is also provided. The terminology alignment process is a time-consuming process and requires the participation of various stakeholders. However, this activity is mandatory to avoid further conflicts within the maintenance activities. Moreover, further characteristics of the EAMM – such as unidirectional vs. bidirectional data flow – are illustrated. To assess the stability of the artifacts and designated characteristics, an online survey with 145 questions were performed. 48 experts participated to the online survey. The results of the online survey reveal the gathered information from the expert interviews: EA experts prefer a lean and pragmatic EAMM approach with chosen persons in charge. Moreover, the participants stated the significance and the necessary effort of aligning the EA terminology across several communities.

7.2. Capability of the Defined Artifacts

this thesis defines and evaluates four major artifacts:

- Process of EA terminology alignment
- Process definition and role allocation of meta model change
- Process and role allocation of data model change
- Process of conflict resolution strategy

These artifacts describe how to proceed the respective issues by providing a list of required activities in a particular sequence and by allocating the activities to respective roles. However, the aspects in the following subsections have to be kept in mind.

7.2.1. Information from IT-versed Experts as Reference

The foundation of the federated EAMM is based on current research artifacts that mainly have an *architectural* view on EA documentation. The conducted semi-structured interviews with experts from the industry refer to experiences, views and estimations from various industries. However, all interviewed experts are IT-versed persons – especially Enterprise Architects – with respective experiences and interests. Business experts were not interviewed; nevertheless, the results of the online survey reveal the significance of business stakeholder within the EAMM approach: Business requirements – e.g. regulatory requirements – are the main driver of such a purpose and provide the most suitable use cases for it. There is the risk that significant business needs are not considered within the process definitions in this thesis. Moreover, the first draft of the artifacts base on information of only 11 interviewed experts.

7.2.2. Uniqueness of IT Landscape in Today's Companies

Section 1.1 mentions that companies live with heterogeneous IT landscapes. It can be hypothesized that the heterogeneous IT landscapes differ between today's companies: Every company has a different culture, with different principles and employees with different backgrounds that have an impact on the respective IT landscape. As a consequence, it can be assumed that IT landscapes differ within their internal structure, the used technologies and in the designated significance of respective information systems. The defined artifacts may not be adaptable in selected scenarios – e.g. in organizations where business stakeholder have the lead about the IT landscape design.

7.2.3. Assumption of Upper Management Support

In line with Ross [Ro03], section 3.3.4 already mentioned that business stakeholder rarely participate in EA activities. They do not identify a benefit for their daily business. However, as aforementioned the participation of various parties – also business stakeholder – is mandatory for the federated EAMM. As a consequence, it can be assumed – especially for the terminology alignment process – that upper management support is given when conducting the single processes and we do not face any obstacles referring to missing support by business and related stakeholder or missing budget to establish the foundation of federated EAMM.

7.3. Future Work

7.3.1. Refinement of the Terminology Alignment Artifact

An artifact that suggests a terminology alignment process definition is provided in section 4.3.5. The suggested process definitions addresses the following issues:

- Consider various stakeholder within the alignment process
- Define strict EA principles and establish escalation paths to EA board
- Enterprise Architectures are closely coupled with the EA board and the single communities
- Iterative approach of alignment process with collaborative workshops

However, the process does not provide detailed information about the content and the strategy of the performed workshops, the desired artifacts after the workshops and does not detail the scope of the EA entities that should be considered within the single iterations. The alignment process is a continuous process and require a maintenance mechanism, which is not elaborated within the artifact. Further research might provide additional insights and best practices regarding the terminology alignment process. The results of the online survey reveal that industry experts prefer a stronger involvement of business stakeholder within the alignment process. The respective role of business stakeholder has to be evaluated in further research.

7.3.2. Raise the Awareness of Significance of EA

It turned out that EA does not obtain deep acceptance across all stakeholder within today's companies – especially business stakeholder – and non-EA-versed parties do not identify any benefit within EAM activities. However, section 4.3.3 highlights use cases with a clear reference to business and management issues. Section 4.3.10 describes, how to convince business stakeholder to participate in EA activities, whereby the illustrated strategies do not have an impact on the awareness of EA to business stakeholder. Further research might elaborate detailed strategies that do not *force* business stakeholder to participate in EA activities, but also to recognize the significance and the benefit in EA and EAM for the daily business.

7.3.3. Further Steps Towards Standardization

A resolution strategy that refers to upcoming meta or data model conflicts is highlighted in section 4.3.9. It turned out that – due to the uniqueness of most of the conflicts – automated conflict resolutions are not suitable. However, conflicts occur due to differences in data types, different EA terminologies etc. All these root causes refer to a lack of standardization and DQ issues within single communities. It might be advisable, to develop further process definitions towards standardization purposes, considering necessary activities, maintenance mechanism and a clear role allocation.

7.3.4. Consider EA Documentation in Present EAM Frameworks

The TOGAF and the Zachmann framework are analyzed in section 3.3.4 regarding their capability for federated EAMM. It turned out that significant elements – e.g. the role allocation or the collaborative requirement – are not considered in these frameworks. Further research might extend current EAM frameworks regarding these requirements.

A. Appendix

A.1. Interview Guideline

Interview Guideline

This interview guideline is used to conduct expert interviews referring to a master thesis at Technische Universität München. The aim of the master thesis is, to identify governance structures, role allocations and used processes referring to **Federated Enterprise Architecture (EA) Model Management.** The results of the expert interviews will be treated strictly confidential and will be published only anonymously and aggregated.

General questions about your person and your company
What kind of services do the company, your work for, provide for the customer?
What kind of position do you represent within your company?

Status of EA within your company
Which status do EA have within your company? • *How far is EA management recognized as an **asset** within your company?* • *How many capacities are **allocated** to EA management within your company (e.g. number of employees, boards)?* • *Did you established a formal **IT – Governance board** referring to EA?* • *What kind of **processes, standards and role allocations** does the EA board control?* • *Is the EA management **connected** with other management functionalities?*
EA documentation activities • *Do you already conduct EA documentation activities?* • *Do you already consider to conduct federated EA model management activities?* • *Do you already established a holistic EA Meta model within your company?* • *How far do all EA stakeholder make use of a standardized terminology for application, IT services and IT processes?* • *What kind of use cases do you identify for a federated EA model management?*

Role allocation
What kind of **roles** would you establish for a federated EA model management? Which responsibilities would you allocated to a respective role? *Single roles:* • *EA Coordinator* • *Enterprise Architect* • *Role for technical issues of an EA repository or the holistic EA model* • *Role for technical issues of the single communities* • *Rolle for modeling activities* • *Further EA stakeholder (e.g. Data owner, domain architects)* • *Would consider allocating more than one role to a respective employee?*

Do you consider **collaboration** between roles as a significant principle to maintain a federated EA model efficient? What kind of collaboration activities would you consider between the following roles? • *Enterprise architect* • *Technical roles* • *Business stakeholder* • *What kind of conflicts would you assume between the roles?*
What kind of **aspects** would you also consider within the role allocation?

Processes
What kind of governance and process principles would you establish for the following use cases? How would you handle the listed characteristics? *Holistic synchronization process:* • *How do you identify relevant information sources referring to EA information? Who has the main responsibility for the identification process?* • *Would also consider making use of specific tools (e.g. crawler) for the information identification and information extract?* • *Would you consider manipulating information within the holistic EA model? Would you inform the respective community about the change?* • *Would you consider performing periodic **Quality Checks** of the EA model?* *Definition of Mappings:* • *Which **roles** are involved within the mapping process?* • *Do you perform the **data transfer** manually or automatically?* • *In case of **changed information** within a respective community: How do you ensure that the change is also updated within the EA model?* • *Would you consider making use of **ontologies** within the mapping process?* *Staging Process:* • *Do you have to **transform** extracted EA information before transfer it to the EA model?* • *Do you conduct the transformation process **manually** or **automatically**?* • *Do you make use of **mapping functions** to transfer EA information to the EA model?* • *What kind of **DQ problems** (correctness, granularity, completeness, actuality) do you face within the staging process? Do you consider different activities, depending on the root cause of the DQ issue? What kind of **roles** are involved within the cleansing process?* • *Do you consider **formal sign offs** for data cleansing activities?* • *What kinds of conflicts do occur during the staging process? How do you handle these conflicts?* • *Would you prefer a **master slave definition** between information sources?* • *Do you differ between **critical** and **non-critical** conflicts? How would you differ this characteristic?* *Modell Merge* • *Do you conduct a **reconciliation** of the EA models (before change vs. after change)?* • *Do you conduct the **merging process automatically**? What kind of role is the person in charge for this process?* • *Specific Characteristics:* • *How do ensure the **participation** of all relevant EA stakeholders?* • *Do you prefer a **unidirectional** or **bidirectional** data flow?* • *What kind of data, processes, tools etc. would you **standardize**?* • *Do you make use of a **versioning** functionality of data, models?*
• *Would you prefer **escalation paths** to the supervisory in case of obstacles or missing support by respective stakeholder?*

Standards / Compliance
How far would you consider common EA management standards and frameworks (e.g. TOGAF, COBIT) within the maintenance process of a federated EA model management?

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