

2011

Construction and Evaluation of a Meta-Model for Enterprise Architecture Design Principles

Stephan Aier

University of St. Gallen, stephan.aier@unisg.ch

Christian Fischer

University of St. Gallen, christian.fischer@unisg.ch

Robert Winter

University of St. Gallen, robert.winter@unisg.ch

Follow this and additional works at: <http://aisel.aisnet.org/wi2011>

Recommended Citation

Aier, Stephan; Fischer, Christian; and Winter, Robert, "Construction and Evaluation of a Meta-Model for Enterprise Architecture Design Principles" (2011). *Wirtschaftsinformatik Proceedings 2011*. 51.
<http://aisel.aisnet.org/wi2011/51>

This material is brought to you by the Wirtschaftsinformatik at AIS Electronic Library (AISeL). It has been accepted for inclusion in Wirtschaftsinformatik Proceedings 2011 by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.

Construction and Evaluation of a Meta-Model for Enterprise Architecture Design Principles

Stephan Aier

Christian Fischer

Robert Winter

Institute of Information Management
University of St.Gallen
Müller-Friedberg-Strasse 8
9000 St. Gallen, Switzerland
+41 (0) 71 224 3360

stephan.aier@unisg.ch

Institute of Information Management
University of St.Gallen
Müller-Friedberg-Strasse 8
9000 St. Gallen, Switzerland
+41 (0) 71 224 3877

christian.fischer@unisg.ch

Institute of Information Management
University of St.Gallen
Müller-Friedberg-Strasse 8
9000 St. Gallen, Switzerland
+41 (0) 71 224 2190

robert.winter@unisg.ch

ABSTRACT

Based on an IEEE definition and its adaptation by The Open Group enterprise architecture (EA) is often defined as the fundamental organization of a company or government agency and the principles governing its design and evolution [16, 25]. While design representation issues like meta-modeling or notations have been discussed in EA literature [3], design activity issues and design principles in particular are often neglected. This is surprising because EA principles play an important role in practice. As a contribution towards a clear definition of EA principles, we analyze state-of-the-art EA principle definitions first. Based on this state-of-the-art analysis already discussed in [11] the original contribution of this paper is the construction and evaluation of a meta-model defining EA design principle as a second step. Our proposal differentiates a core definition of EA principle dealing with a principle itself (statement, rationale, implications, key actions, and measures) and an extended definition taking the use and impact of an EA principle in its environment into account. Important elements of an EA principle's environment are corporate strategy, the constructional view on EA transformation projects, and EA itself including its layers and its dimensions in time like as-is and to-be EA. We evaluate our meta-model in two case studies. Our consolidated meta-model provides the basis to analyze phenomena of actual EA principles in practice and thus to uncover the latent structures of EA principle taxonomies.

Keywords

enterprise architecture, principle, meta-model.

1. INTRODUCTION

One of the most often cited publications for defining Enterprise Architecture (EA) is that of the IEEE standard 1471-2000 [16] and its adaptation to EA by The Open Group [25]. Architecture is defined there as (1) “[t]he fundamental organization of a system embodied in its components, their relationships to each other, and

to the environment”, and as (2) “the principles guiding its design and evolution” [16]. In the field of EA, ‘system’ is then substantiated by The Open Group as an enterprise meaning “any collection of organizations that has a common set of goals” e.g. a company or government agency [25]. The (1) *fundamental organization* of a system is often represented by models of the as-is state or the to-be state of a system. For these purposes, meta-models, methods, and frameworks have been developed and extensively discussed in literature [22, 23]. However, (2) *activities, rules*, and particularly *principles* guiding an architecture's design and evolution from an as-is state into a to-be state are often neglected and thus are hardly covered in literature.¹ Stelzer's [24] review of EA literature identifies only six publications that specifically address EA design principles.

In practice, many companies' EA departments formulate principles and some review projects based on these principles.² For this purpose, documentation and communication of EA principles is essential. The fundament for such documentation is a clear definition of the principle's structure and of its relations to its environment. However, our practitioner interviews in a non-representative sample, aiming at a deeper understanding of EA principles' use in practice shows that except for a few cases EA principles are unequally and only selectively defined (regarding the scope of EA) and that their impact varies significantly.

Our in-depth analysis of different notions of EA principles, from scientific as well as from practitioner's literature [11], reveals that there is no consensus on a definition of the term *EA principle*. The aim of this research is therefore to analyze these different notions of EA principle in order to derive a consolidated understanding. Thus, this paper aims at defining and evaluating a construct which forms the vocabulary of a domain [19].

The paper at hand is structured as follows: In section two, different notions of EA principle are analyzed. In section three, these notions are discussed and consolidated into a meta-model for EA principle. In section four, we use two case studies to evaluate the

¹ Exceptions to this generalized observation are [11, 24] as far as EA *rules* and *principles* are concerned as well as [1, 2, 7]. as far as *activities* guiding an architecture's design and evolution from an as-is state into a to-be state are concerned.

² Cf. for instance the Open Group's architecture compliance review method proposed in TOGAF 9 [25].

proposed meta-model. In section five, we discuss our contribution and give an outlook on further research.

2. RELATED WORK

In this section, we analyze related work dealing with EA principles in order to develop a consolidated understanding of what an *EA principle* is.³ Therefore we analyze six approaches with respect to their understanding of EA principle. The selection of the papers analyzed is based on Stelzer's [24] literature review. He selects relevant literature by applying Weber and Watson's [26] guidelines: (1) IS journals and conference proceedings are analyzed using the search term: "*enterprise architecture*" AND ("*principle*" OR "*design*" OR "*rule*" OR "*guideline*"). (2) Stelzer extends his research to further sources and ensures that all top 20 IS journals and the top IS conferences (e.g. ICIS, AMCIS, ECIS, HICCS, and Wirtschaftsinformatik) are included. In total, 42 relevant articles are identified. (3) Each of these articles is analyzed in detail. Based upon this analysis, 27 articles are excluded. (4) The citations of the remaining 15 articles are analyzed; this way, four further articles are added. (5) These 19 articles are analyzed in detail. Articles from related research areas such as software engineering, organizational design, and engineering are excluded. Principles for designing or evaluating architecture frameworks and principles for service oriented architectures are excluded, too.

As a result of his analysis Stelzer identifies eleven articles on EA principles. His analysis differentiates EA *design* principles from EA *representation* principles. EA design principles refer to the design of EA while EA representation principles refer to its representation. Lindström [18] makes a similar distinction by differentiating syntactic (i.e. representation) and semantic (i.e. design) principles. Examples for representation (or syntactic) principles are understandability, consistency, and unambiguosity [18, 24]. As EA representation principles are out of scope of this publication, we exclude all papers that solely refer to EA representation principles.

Table 1: EA design principles according to Stelzer [24]

Reference	Method	Principle definition
Richardson, 1990 [21]	case study	"Principles are an organization's basic philosophies that guide the development of the architecture. ... Principles provide guidelines and rationales for the constant examination and re-evaluation of technology plans." (p. 389)
Armour, 1999 [5]	conceptual	"... simple, direct statements of how an enterprise wants to use IT. These statements establish a context for architecture design decisions by translating business criteria into language and specifications that technology managers can understand and use. Architecture principles put boundaries around decisions about system architecture." (p. 38)

³ The analysis itself has already been published in [11]. The analysis in [11] provides the foundation for the artifact design which is an original contribution of the paper at hand.

Hooger-vorst, 2004 [14]	conceptual	<i>no explicit definition</i> , "collectively the design principles are identified as enterprise architecture" (p. 217)
Chen, 2004 [8]	conceptual	"Architecting principles are rules to use when elaborating enterprise architectures." (p. 1214)
Wilkinson, 2006 [27]	case study	<i>no explicit definition</i>
Lindström, 2006 [18]	case study	"Architectural principles define the underlying general rules and guidelines for the use and deployment of all IT resources and assets across the enterprise ..." (p. 2)

The characteristics of the six remaining articles are summarized in Table 1 and analyzed in the following subsections. The reconstructed meta-models of the analyzed articles have been adopted from [11].

We have verified Stelzer's literature review and found it to hold very well. However, in some cases we have added further literature by the same author or school in order to further clarify the respective position.

2.1 Richardson et al., 1990 [21]

Richardson et al. [21] document EA principles which they have extracted from a case study of Star Enterprise. The principles are attributed to different layers: organization, applications, data, and infrastructure.

For each principle, Star Enterprise documents (1) the principle itself, (2) a rationale explaining how the principal is assumed to work, and (3) concrete implications (Figure 1).

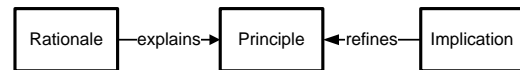


Figure 1: Meta-model of EA principles according to Richardson et al. [21]

2.2 Armour et al., 1999 [5]

Armour et al. [5] take a "big picture look at enterprise architectures" [5] from a practitioner's perspective and mainly develop an EA framework.

For this framework, they propose five views: (1) business view, (2) work view, (3) function view, (4) information view, and (5) infrastructure view. The framework "begins with a business vision—including the IT vision—which determines IT goals and objectives. Together, the business and IT visions drive the business view and architecture principles. [...] To provide the structure and guidelines for EITA [enterprise information technology architecture] development, most frameworks will include a set of architectural principles, architectural views, a technical reference model, and a standards profile" [5]. Standards and technical reference model are meant to "make sure everyone has a common understanding of function and term" [5]. The meta-model of the principle definition by Armour et al. is illustrated in Figure 2.

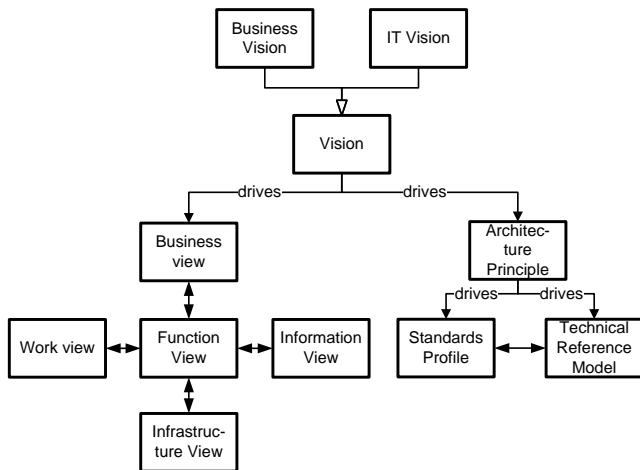


Figure 2: Meta-model of EA principle according to Armour et al. (1999) [5]⁴

2.3 Hoogervorst, 2004 [14]

Hoogervorst [14, 15] understands architecture solely as a prescriptive concept comprising “a set of design principles and standards that guide design” [14]. In accordance with Dietz [10], Hoogervorst argues that architecture normatively restricts design freedom. For Hoogervorst [14, 15] and Dietz [10], EA is hence limited to the second part of the architecture definition by IEEE Std. 1471-2000 [16], i.e. principles governing the architecture’s design and evolution; they explicitly exclude its first part, i.e. representations of “the fundamental organization of a system”. Hoogervorst’s understanding of EA principles is illustrated in Figure 3.

Also in accordance with Dietz [9, 10], Hoogervorst [14, 15] differentiates a functional view and a constructional view on an enterprise. Whilst the functional view (teleological view, black box view) deals with the purpose or goal of a system, the constructional view (ontological view, white box view) is about how the system’s functions are brought to life [9]. For Hoogervorst [14], design principles refer to the constructional view. In contrast, requirements refer to the functional view on a system [15].

Hoogervorst [14] differentiates between four types of architecture: (1) business architecture, (2) organizational architecture, (3) information architecture, and (4) technology architecture. For each type, he proposes an architecture framework highlighting the main areas of the respective architecture type.⁵ Each of these architecture types contains “a logically consistent and coherent set of principles and standards that guide” [14]

- “how a particular field of (commercial) endeavor will be exploited and explored” [14] (business architecture),
- “how the purposeful activities are to be organized” [14] (organization architecture), and

⁴ The double-arrows “ \leftrightarrow ” indicate an interdependency between the two entities concerned.

⁵ For instance, the business architecture comprises principles concerning the enterprise’s mission, its strategy, its market, its competitors, its product services, its key resources, its operating method(s), its economic and revenue model, its customers, its stakeholders, and its environment [14].

- “how information is to be managed” [14] (information architecture).

Besides the principle statement, Hoogervorst [15] claims for documenting its rationale(s), its implication(s) and its key action(s). The *rationale* says why the principle is defined. The *implication* states how relevant system stakeholders are affected by the principle. The definition of *key actions for effectuating the architecture* is implied by the fact that not all architecture principles can be applied immediately, but can only be used under certain conditions. The key actions ensure these conditions, such that the architecture principles can be followed” [15].

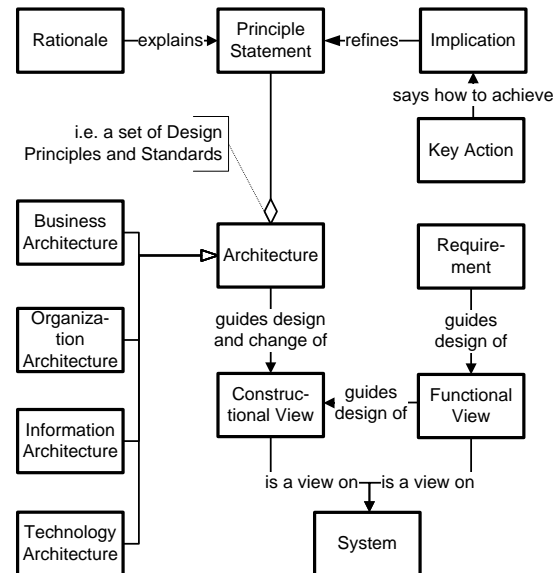


Figure 3: Meta-model of EA principle according to Hoogervorst (2004, 2009) [14, 15]

2.4 Chen & Lillehagen, 2004 [8]

Chen & Lillehagen [8] review literature and reveal the different authors’ understanding of *architecture* and *architecture principles* in particular. Their literature review is mostly based upon practitioner sources like homepages of consultancy companies. Chen & Lillehagen differentiate between *generic* EA principles, i.e. principles that “apply to all enterprises” [8], and *specific* principles “reflecting a level of consensus among the various elements of a particular enterprise, and form[ing] the basis for making future decisions” [8]. They point out that EA principles are meant to facilitate architecture decisions.

Chen & Lillehagen [8] do not explicate a clear definition of components of EA principle. We therefore cannot derive a meta-model from this particular source.

2.5 Wilkinson (2006) [27]

Wilkinson [27] has been Chief Technology Officer at Hewlett Packard (HP) and reports on his experiences at HP.

For him, it is important for enterprises (1) to understand what and how IT is being used and to get control of existing IT assets (stability), (2) to leverage best practice and automation of aspects of IT processes (efficiency), and (3) to align IT governance and business strategy such that IT can rapidly react on business changes (agility). According to Wilkinson, architecture principles and IT governance are a means for realizing an adaptive enter-

prise. In an ideal world, IT governance and IT strategy are connected to corporate strategy. Different frameworks such as ITIL, ITSM, or COBIT help implementing IT governance.

Wilkinson names two main areas for implementing an adaptive enterprise: IT organization and technology. IT organization (1) should focus on innovation in order to support business and (2) should be optimized in order to save costs. A project management office can help realizing these goals by assuring the conformity of projects to corporate strategy. On the technology layer, an adaptive infrastructure should be aimed at.

Wilkinson describes some EA principles at HP although he does not explicitly call them “principle”: *modularity*, *simplification*, *integration*, and *standardization*. He does not explicate a definition of what a principle is and what it is composed of. Nevertheless, we tried to reconstruct Wilkinson’s notion of EA principle in the meta-model illustrated in Figure 4.

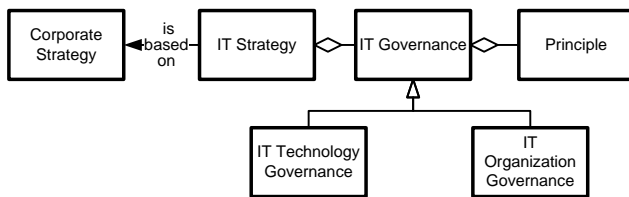


Figure 4: Meta-model of EA principle according to Wilkinson [27]

2.6 Lindström, 2006 [18]

Lindström [18] reviews literature on EA principles. “Principles represents [sic!] a shared understanding on what needs to happen if the organization is to successfully execute the strategies” [18]. For Lindström, architectural principles are important for the transition of today’s architecture to the desired target architecture. This transition is driven by business strategy and business principles. Architectural principles are a tool for supporting this transition process. Therein, “architectural principles can justify architecture activities by showing the rationale for the investment” [18].

Referring to Broadbent et al. [6], Lindström [18] states that IT strategy is based on IT governance, that IT governance is based on architectural principles, that architectural principles are based on business principles, and that business principles are based on business strategy. Business strategy “tells us how an organization is going to compete in a chosen market” [18].

She mainly describes an architectural review of EA principles at Vattenfall in a case study. For this purpose, she defines syntactic and semantic characteristics of good principles. As syntactic quality criteria, she names *consistency*, *verifiability*, *unambiguously*, and *modifiability*; as semantic quality criteria she names *stability*, *verifiability*, *modifiability*, *correctness*, and *completeness*. Moreover, she recommends a syntax for architectural principles which is summarized in Table 2.

Table 2: Components of EA principle according to Lindström [18]

Name	Definition	Example
Statement	What to improve	IT system’s fit to business
Motivation	Why this is important	Increase the effectiveness in the business organization

Implication	What must be done and when, and who is responsible	Investigate the influence on the business processes when a new system is acquired. The project manager is responsible.
Measure	How the fulfillment of the principles is measured. Both for long-term and short-term, e.g. after an investment.	Time to perform a business process

In Figure 5, her notion of EA principle is illustrated as a meta-model.

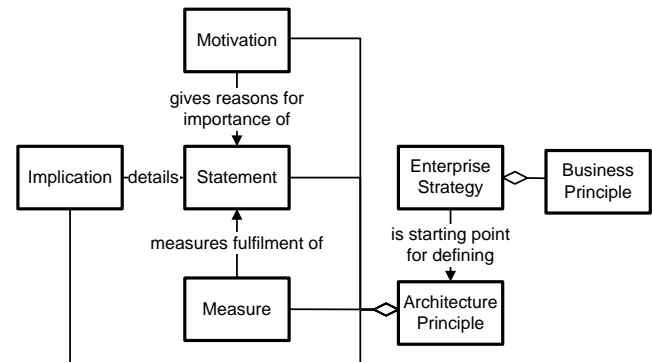


Figure 5: Meta-model of EA principle according to Lindström [18]

3. A CONSOLIDATED EA PRINCIPLE DEFINITION

The discussion in section 2 shows that authors hold different views on what an EA principle is. Nevertheless, their definitions have several aspects in common. In this section, we aim at uncovering these communalities and constructing a consolidated meta-model.

Our analysis also shows that except Richardson et al. [21], authors mix definitions of an EA principle itself with definitions of an EA principle in its environment. For reasons of transparency we will first consolidate definitions of an EA principle itself (*core definition*, section 3.1) and will then extend the core definition by covering the impact that it has on its environment (*extended definition*, section 3.2).

3.1 Core Definition

Richardson et al. [21] mention (1) a rationale explaining how the principle is meant to work and (2) implications that it has to the enterprise. Hoogervorst [14, 15] re-uses the components defined by Richardson et al [21] and adds key actions, i.e. concrete guidelines for implementing the principle. Armour et al. [5] proposes another way to refine architectural principles. As far as the standards profile is concerned, we prefer the more extensive proposition by Richardson et al. [21] and Hoogervorst [14, 15]. Furthermore Hoogervorst [14, 15] as well as Lindström [18] introduce the principle statement. Their description implies that the statement is part of the principle. Lindström [18] also mentions measures as an important part of an EA principle in order to be able to evaluate a principle’s efficacy, thus the fulfillment of the statement, and finally to support the process of managing (introducing,

evaluating, changing, and revoking) EA principles. Figure 6 illustrates the core definition of EA principle in a meta-model.

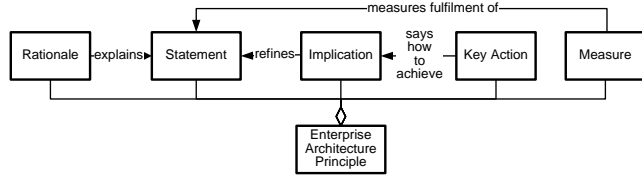


Figure 6: Core meta-model of EA principle

3.2 Extended Definition

To further specify the nature of an EA principle, it is helpful to understand an EA principle's impact on its environment. We will therefore extend our core definition based on our literature analysis as well as on results from focus groups. Our meta-model construction for the extended definition of EA principle is based on a two-step process. In step one we build the basic structure of the extended meta-model. In step two this basic structure is refined based on the different foci taken by the authors of the analyzed related work.

3.2.1 Step 1: Basic Extensions

As with every design the question of where to begin is a difficult one. While we have analyzed various related work none of these contributions provided a substantial starting point since the respective contributions either follow a general but incomplete or a very specific but unbalanced approach. Therefore we have chosen to start with an exploratory focus group [13, 20]. The aim of the focus group has been to identify the main products of EA as well as their relationships. The rationale behind this approach is that EA principles should have a prominent role in the development and advancement of EA. Thus understanding the products of EA as well as its relations should provide a valuable understanding of EA principles' environment from an EA perspective.

The participants of the focus group are practitioners that are experts in the field of EA and have experience managing and using EA principles. The focus group has nine participants from seven different companies from Germany and Switzerland plus the focus group's moderator.

As a result the focus group identified five main products of EA (*EA transparency*, *EA guidelines and principles*, *EA plans*, *EA implementation*, and *EA education*) as well as their respective components. The focus group has also been asked to discuss the relations among the five main products. The analysis of these results focusing EA principles leads to the basic extended meta-model illustrated in Figure 7.

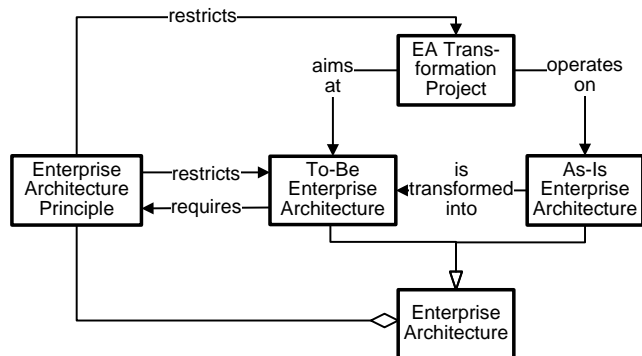


Figure 7: Basic EA principle meta-model extensions

In this basic extended meta-model, we have omitted EA education. While EA education is an important product of EA, it does not belong to the same level of abstraction as the other EA products. Furthermore we have substituted EA transparency by *as-is enterprise architecture* and EA plans by *to-be enterprise architecture* for internal consistency of the model.⁶ The substitution of EA transparency by as-is EA is valid since the focus group members discussed transparency as the transparency of the current EA. The substitution of EA plans by to-be EA is valid since the focus group members discussed EA plans as the future state of EA resulting from EA implementation transforming the current as-is state. This argumentation also accounts for the relations between *EA transformation project*, *to-be EA* and *as-is EA*. A defined to-be EA requires for certain *EA principles* in order to be achieved by EA transformation projects. Therefore EA principles also have to restrict an EA transformation project's freedom of choosing a design in order to ensure a development towards the to-be EA. Finally there also may be EA principles that restrict the possible to-be EAs.

3.2.2 Step 2: Refinement of Basic Extensions

With the background of the basic extended meta-model resulting from the focus group, we aim at consolidating the different definitions of EA principle in the analyzed publications.

Armour et al. [5] introduce the notion of a model of a system. In order to cover the differences between an enterprise and its model, we have fundamentally extended the basic meta-model and put the enterprise into its centre. We differentiate between an existing enterprise and a desirable enterprise. Both, existing and desirable enterprise, are possible enterprises, being part of possible future worlds.⁷ A special desirable enterprise is the enterprise that has been defined as a target enterprise for an EA transformation project. An EA transformation project begins to operate on the existing enterprise while aiming at changing it such that the target enterprise is realized.

EA principles give advice how to design target architecture by restricting the design freedom of EA transformation projects [9, 10, 14, 15]. In contrast to business requirements referring to the functional view of projects⁸, architecture principles refer to the constructional view of the project⁹.

⁶ A reviewer of an earlier version of this paper has remarked that the common differentiation in *as-is*, *intermediate*, and *target architecture (vision)* [1, 7, 17] might be appropriate here. Following this terminology our to-be EA is equivalent to *intermediate architecture* because these architectures are actually realized and restricted by EA principles. The *target architecture* may influence EA principle definition but it will most probably never be achieved. Instead it will constantly be reformulated and/or become the next *intermediate architecture*.

⁷ Cf. Frank [12] for further information on possible worlds in IS; for the term *world* cf. Wittgenstein [29].

⁸ Functional view on projects: "What functionality of the enterprise does the project change?"

⁹ Constructional view on projects: "How must the elements be changed that provide the enterprise's functionality?"

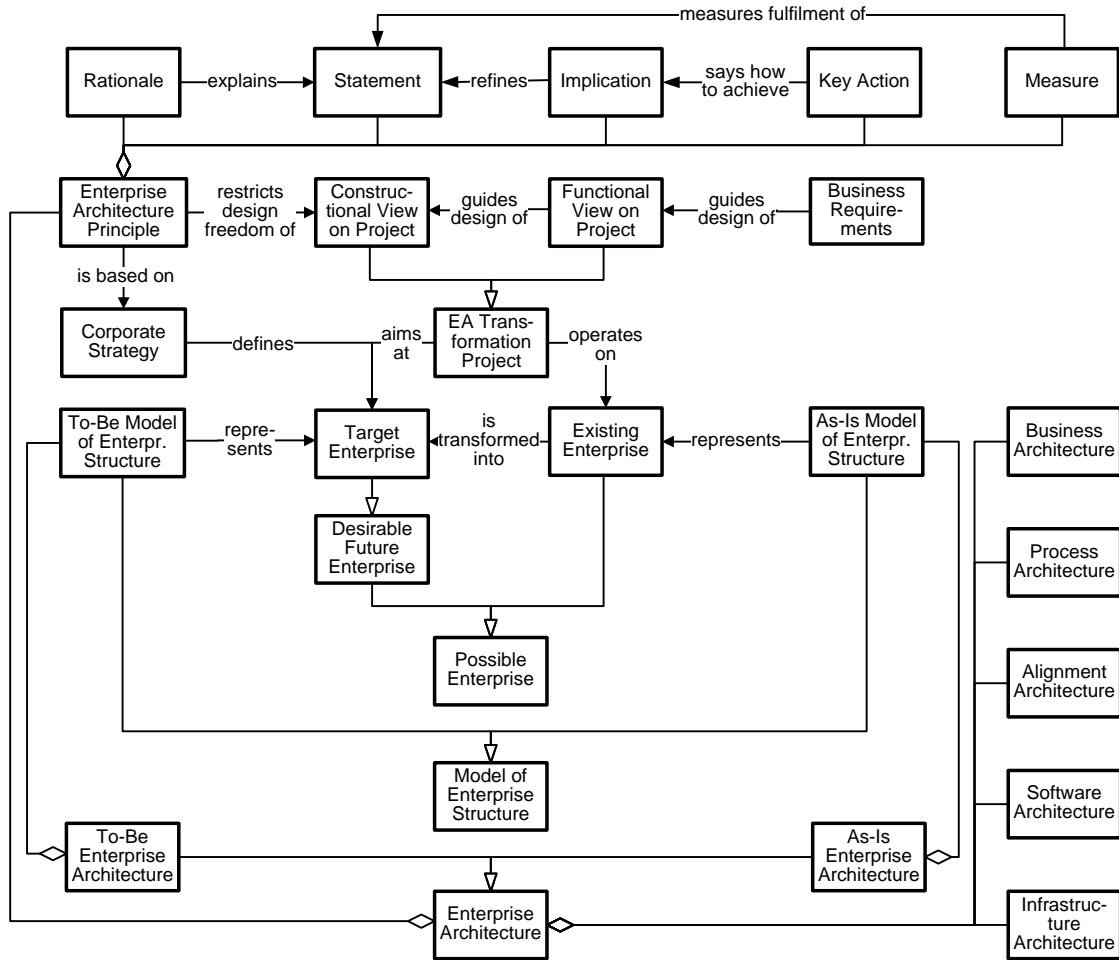


Figure 8. Consolidated meta-model of EA principle

Different authors propose different architecture layers. Whilst Hoogervorst [14, 15] proposes a business architecture, an organization architecture, an information architecture, and a technology architecture, Armour et al. [5] propose a business view, a function view, a work view, an information view, and an infrastructure view. Winter and Fischer [28] consolidated a variety of EA frameworks and identified four essential architectures: a business architecture, a process architecture, an alignment architecture,¹⁰ a software architecture, and an infrastructure architecture. As Fischer and Winter [28] already consolidated the understanding of different layers, we adopt their proposition in our meta-model.

The structure of an enterprise can be represented in a model: the existing enterprise in an as-is EA model, the target enterprise in a to-be EA model. In accordance with the architecture definition in the IEEE Std. 1471-2000 [16], both the models of the enterprise structure and the architecture principles form the architecture.

As the main input for an EA principle Armour as well as Wilkinson [27] and Lindström [18] highlight the influence of corporate

strategy. Figure 8 illustrates our consolidated meta-model of EA principles.

4. META-MODEL EVALUATION

In the following subsections, the case studies of two companies are presented in order to evaluate the applicability of our proposed meta-model in practice. These companies have introduced EA principles for guiding evolution of EA several years ago. Data for the case studies have been collected in interviews with representatives. In accordance with Yin [30], our case study is based upon different data sources. We have not only analyzed internal documents, but also, as described by Hevner and Chatterjee [13], have performed a focus group workshop with representatives from IT management and EA management in order to gather additional information and to ensure the elimination of misunderstandings.

4.1 Selection of Evaluation Cases

Company A is a major transportation and logistics service provider. It offers both cargo and passenger transportation and provides rail infrastructure. A couple of years ago, the inauguration of a new CIO resulted in renewed architecture efforts including the creation of a corporate EA team. The EA team is complemented by domain architecture teams, which are changing their focus from a domain and software centered perspective to an EA pers-

¹⁰ While Winter and Fischer [28] initially named the central layer *integration architecture* Aier and Winter [4] renamed it to *alignment architecture*.

pective. EA processes have been set up altering existing development processes to reflect architectural issues, e.g. by defining quality gates, which projects cannot surpass without fulfilling EA principles. This change in processes is fostered by a broad range of efforts to enhance EA attention, knowledge, and skills throughout the company. Therefore a broad training program, addressing architects as well as non-architects, was set up. In addition to that, further initiatives were set up. For example (1) EA communication has been advanced by an EA tool providing a broad set of EA artifacts in an easy-to-use web interface, (2) all information required to meet EA principles in the quality gates is available through a well-organized intranet web application.

Company B is an IT service provider for a large banking network. In its current form, the network is the result of several mergers of formerly independent, regional IT service providers. Every formerly independent company had its own, evolutionary grown banking solution. However, none of these solutions had a predominant position within the network. Therefore the network decided to implement a new and common system as their core banking solution. The development started in 2002 and was finished in 2005 for the time being. The new system design follows a service oriented paradigm in its alignment and software architecture in order to adapt and to consistently provide the implemented functionality to every partner. The business architecture design of company B follows the process reference model which has been defined for the banks belonging to the network. For alignment, software, and infrastructure architecture; strict principles are defined. These EA principles are enforced through tools, repositories, and processes (e.g. for release management) which are the basis of company B's development. Because of this highly structured and tool supported processes, any development outside this environment is almost impossible and thus non-existent. At the same time company B has no explicit EA roles except for an EA board. Instead EA principles and their enforcement are built into the highly standardized change and production processes.

We have chosen these two particular companies because their culture of defining and enforcing EA principles is very different. While company A follows a very participative, grass roots democracy like approach, company B follows a very strict top-down driven approach – resulting from the necessity to efficiently and effectively manage several post-merger integration scenarios.

None of the two companies have participated in the focus groups used for constructing the extended EA principle definition.

4.2 Company A

The EA division of company A's information technology (IT) department defines several architecture design principles. Before such principles have been defined, most architectural decisions were taken ad-hoc. As a consequence, (1) architecture decisions of different projects were inconsistent and (2) architecture decisions were often intensively discussed, took a long time, and bound many resources.

In order to overcome these shortcomings, company A has defined a set of EA design principles. These principles are formulated [statement]¹¹ such that they correspond to corporate strategy [is based on]. By means of concrete guidelines [implications/key actions], the principles are refined. Both principles and guidelines

are intended to guide architectural decisions in projects [restricts design freedom of].

Every employee of company A is allowed to propose an architectural principle or a guideline. Therefore the principle or guideline needs to be well founded [rationale]. An architectural board elaborates these proposals, declares proposals to be valid principles, and revises them, based upon the experience and feedback in projects. If a principle does not lead to the desired effects, it is revoked by the architectural board. Therefore the effectiveness of a principle is measured [measure].

All principles are available in the company's intranet and all projects are obliged to respect them when taking an architecture decision. Projects at company A are based upon the waterfall model and are structured in six phases. After each phase, projects must pass a quality gate. In each of these quality gates, the quality gate committee evaluates whether the principles and guidelines are respected. Thus company A successfully ensures that projects having impact on EA transform EA towards a defined to-be state [target enterprise].

4.3 Company B

In company B, EA principles focus on alignment, software, and infrastructure architecture only. Business and process architecture are based on a reference model which is defined outside of company B [EA layers]. EA principles are documented [statement] in the tools, repositories, and workflows which implement the standardized project procedures. These workflows clearly advise how to perform certain development tasks and thus how to observe EA principles [implications/key actions]. In order to foster these workflows' acceptance, it is also explained why the respective steps are necessary [rationale]. As the entire company is driven by performance figures, the principles implemented in workflows are evaluated on a regular basis [measure].

In this case, the individual banks are the owners and customers of company B that need their business requirements to be implemented by the common banking solution. The main strategic proposition of company B, however, is that company B can serve each and every of the network's banks (currently more than 400 banks with more than 10,000 branch offices) using the very same (maybe differently configured) banking solution. Therefore the banking solution needs to be highly standardized, but configurable. EA principles guiding the evolution of the banking solution must reflect this strategic proposition [is based on corporate strategy]. If company B fails in enforcing these principles, it loses its right to exist.

5. Discussion and Outlook

Apart from Chen & Lillehagen [8], all existing publications on EA principles allow for reconstructing their EA definition in a meta-model. The analysis shows that while authors focus different aspects of an EA principle definition, they do not contradict each other's definitions.

For the purpose of constructing a consolidated meta-model of EA principle, we have differentiated a core definition (dealing with the EA principle itself) and an extended definition (dealing with the impact of an EA principle on its environment).

The evaluation of our consolidated EA meta-model shows that despite the cultural differences of the cases illustrated above, our meta-model for EA principle serves both cases well. The terminology used in each case is specific to the respective company and therefore is not identical with the terminology used in our meta-

¹¹ The terms in square brackets refer to the respective meta-model element illustrated in Figure 8.

model. The structure of meta-model elements, however, fits the situation of each case very well. Our case studies have also shown the importance of EA principles in practice. EA principles serve to constantly guide the evolution of an EA definition to a to-be EA.

Our proposed meta-model of EA principle can serve as a basis to systematically analyze existing EA principles in practice. The aim of such analyses is to understand the latent structure of EA principles and to derive a corresponding taxonomy. Possible (hierarchies of) dimensions in such taxonomy could be degree of generality, architectural layers concerned, life cycle dependencies, stakeholders etc. Once this underlying structure of EA principle in practice is understood, it will be possible to more systematically construct EA principle instantiations for specific situations (i.e. comparable to reference models) or even for particular application cases.

6. REFERENCES

- [1] Aier, S., Gleichauf, B. Application of Enterprise Models for Engineering Enterprise Transformation. *Enterprise Modeling And Information Systems Architectures*, 5, 1 (2010), 58–75.
- [2] Aier, S., Gleichauf, B.: Applying Design Research Artifacts for Building Design Research Artifacts: A Process Model for Enterprise Architecture Planning. In: *Proceedings of the Global Perspectives on Design Science Research, 5th International Conference on Design Science Research in Information Systems and Technology (DESRIST 2010)* (St. Gallen, 04.06.2010). Springer, 2010, 333–348.
- [3] Aier, S., Riege, C., Winter, R. Unternehmensarchitektur – Literaturüberblick und Stand der Praxis. *Wirtschaftsinformatik*, 50, 4 (2008), 292–304.
- [4] Aier, S., Winter, R. Virtual Decoupling for IT/Business Alignment – Conceptual Foundations, Architecture Design and Implementation Example. *Business & Information Systems Engineering*, 51, 2 (2009), 150–163.
- [5] Armour, F.J., Kaisler, S.H., Liu, S.Y. A Big-Picture Look at Enterprise Architectures. *IEEE IT Professional*, 1, 1/2 (1999), 35–42.
- [6] Broadbent, M., Kitzi, E.S. Interweaving business-driven IT strategy and execution: Four foundation factors. *Ivey Business Journal*, 69, 3 (2005), 1–6.
- [7] Buckl, S., Ernst, A.M., Matthes, F., Schweda, C.M.: An Information Model for Landscape Management – Discussing Temporality Aspects. In: *Proceedings of the Service-Oriented Computing – ICSOC 2008 Workshops* (Berlin, 01.12.2008). Springer, 2009, 363–374.
- [8] Chen, D., Lillehagen, F.: Enterprise Architectures – Review on Concepts, Principles and Approaches. In: *Proceedings of the 10th International Conference on Concurrent Engineering (ISPE CE 2004)* (Beijing, Tsinghua University Press, 2004, 1211–1216.
- [9] Dietz, J.L.G. *Enterprise Ontology – Theory and Methodology*. Springer, Berlin, Heidelberg, 2006.
- [10] Dietz, J.L.G. *Architecture. Building strategy into design*. Academic Service, The Hague, 2007.
- [11] Fischer, C., Winter, R., Aier, S. What is an Enterprise Architecture Design Principle? Towards a Consolidated Definition. In: Lee, R. (ed.) *Computer and Information Science 2010*. 193–205. Springer, Berlin, Heidelberg, 2010.
- [12] Frank, U. *Towards a Pluralistic Conception of Research Methods in Information Systems Research*. ICB Research Reports 7, Institut für Informatik und Wirtschaftsinformatik (ICB), Universität Duisburg-Essen, Essen, 2006.
- [13] Hevner, A.R., Chatterjee, S. *Design Research in Information Systems: Theory and Practice*. Springer US, Dordrecht, Heidelberg, London, New York, 2010.
- [14] Hoogervorst, J.A.P. Enterprise Architecture: Enabling Integration, Agility and Change. *International Journal of Cooperative Information Systems*, 13, 3 (2004), 213–233.
- [15] Hoogervorst, J.A.P. *Enterprise Governance and Enterprise Engineering*. Springer, Berlin, 2009.
- [16] IEEE IEEE Recommended Practice for Architectural Description of Software Intensive Systems (IEEE Std 1471-2000). (2000)
- [17] Lankhorst, M. *Enterprise Architecture at Work: Modelling, Communication and Analysis*. Springer, Berlin et al., 2005.
- [18] Lindström, Å.: On the Syntax and Semantics of Architectural Principles. In: *Proceedings of the 39th Annual Hawaii International Conference on Systems Sciences* (Los Alamitos, CA, USA, 04.01.2006). IEEE Computer Society, 2006.
- [19] March, S.T., Smith, G.F. Design and Natural Science Research on Information Technology. *Decision Support Systems*, 15, 4 (1995), 251–266.
- [20] Morgan, D.L. *Focus Groups as Qualitative Research*. Sage Publications, Thousand Oaks, 1997.
- [21] Richardson, G.L., Jackson, B.M., Dickson, G.W. A Principle-Based Enterprise Architecture: Lessons From Texaco and Star Enterprise. *MIS Quarterly: Management Information Systems*, 14, 4 (1990), 285–403.
- [22] Schelp, J., Winter, R.: Language Communities in Enterprise Architecture Research. In: *Proceedings of the Diversity in Design Science – 4th Conference on Design Science Research in Information Systems and Technologies (DESRIST2009)* (Philadelphia, PA, USA, 07.05.2009). ACM, 2009, 1–10.
- [23] Schönherr, M.: Towards a Common Terminology in the Discipline of Enterprise Architecture. In: *Proceedings of the Service-Oriented Computing – ICSOC 2008 Workshops* (Sydney, 01.12.2008). Springer, 2009, 400–413.
- [24] Stelzer, D.: Enterprise Architecture Principles: Literature Review and Research Directions. In: *Proceedings of the 4th Workshop on Trends in Enterprise Architecture Research (Pre-Proceedings)* (Stockholm, 23.11.2009). 2009, 21–35.
- [25] The Open Group *TOGAF Version 9 – The Open Group Architecture Framework (TOGAF)*. The Open Group, 2009.
- [26] Webster, J., Watson, R.T. Analyzing the Past to prepare for the Future: Writing a Literature Review. *MIS Quarterly*, 26, 2 (2002), 13–23.
- [27] Wilkinson, M. Designing an "Adaptive" Enterprise Architecture. *BT Technology Journal*, 24, 4 (2006), 81–92.
- [28] Winter, R., Fischer, R. Essential Layers, Artifacts, and Dependencies of Enterprise Architecture. *Journal of Enterprise Architecture*, 3, 2 (2007), 7–18.
- [29] Wittgenstein, L. *Tractatus logico-philosophicus*. Routledge & Kegan Paul, London, 1981.
- [30] Yin, R.K. *Case Study Research. Design and Methods*. Sage Publications, Thousand Oaks, London, New Delhi, 2003.