Enterprise Maps: Zooming in and out of Enterprise Models

Maja Spahic-Bogdanovic[a] and Knut Hinkelmann[b]
School of Business, FHNW University of Applied Sciences and Arts Northwestern Switzerland, 4600 Olten, Switzerland

Keywords: Enterprise Architecture, Enterprise Modeling, ArchiMate, Zoomability, Zoomability Principle, Enterprise Architecture Navigation.

Abstract: A company's architecture can be represented by domain-specific models, which are defined by domain-specific modeling language. Since not all stakeholders are interested in the same models, dedicated views can be created to support navigation through the enterprise models. These views offer a snippet of the entire company and cover stakeholder-specific concerns. The relationships between the different views and models remain hidden and can be unveiled with much effort. The developed concept of the zoomability principle offers the ability to change the degree of detail using zoom in and out of the enterprise model. The different models and modeling languages used to express an enterprise are considered, and a form of navigation is established similar to an online map. The concept is based on two pillars, "Zoom Within" and "Zoom into Complements". For this purpose, a metamodel was developed, which formalizes the elements used in the concept and their relationships. Developing the artifact, rules were defined that contribute to a generic approach allowing an application to another case. Furthermore, a prototype was developed, representing the zoomability principle and offering the possibility to perform zooming behavior. The artifact was evaluated through a demonstration. An additional prototype was created to demonstrate that the developed concept can be applied to a predefined set of situations.

1 INTRODUCTION

The goal of enterprise modeling (EM) is to support enterprise analysis, communication, collaboration, and decision making by representing the enterprise from multiple perspectives (Vernadat, 1996). The different graphical models support communication between the stakeholders involved in the design of the enterprise (Hinkelmann et al., 2016). Models are the result of a construction process in which the perception of reality or what has to be redesigned is described using a modeling language (Sandkuhl et al., 2014). The individual models consist of graphical elements and relations, which are defined in the metamodel. Since not all stakeholders are interested in the same information, dedicated views can be created to address specific concerns (ISO 42010, 2011). These views offer a snippet of the entire company. The relationships between the individual views and models are not visible or can be unveiled with a lot of effort.

Taking a map as a metaphor, the views remind us of the time before online maps existed. Paper maps were used in the decency of a digital map, which showed a specific area to a certain degree of detail, like an overview or detailed maps of particular areas. Another map was needed if the desired location was outside the map or to get a more detailed view. Furthermore, there are maps with different scales for overview maps on country levels and detailed city maps. The current situation in using enterprise models evokes this time.

Digital maps, however, do not need separate maps. It is possible to navigate in a single environment. When zooming into a map, more details become visible. Figure 1 shows an example from Google maps with an overview map of Europe. When zooming in, more and more details become visible. On a city level, details like streets and additional information like hotels and restaurants become visible - depending on the user's concerns.

Lankhorst et al. (2017) mentioned the poor definition of the relations between the different views for enterprise models and pointed out that created models are not further integrated. The entire overview of the links between the individual models and the possibility of zooming in and out the enterprise models and thus changing the degree of detail is a de-

[a] https://orcid.org/0000-0003-1625-0162
[b] https://orcid.org/0000-0002-1746-6945

Spahic-Bogdanovic, M. and Hinkelmann, K.
Enterprise Maps: Zooming in and out of Enterprise Models.
DOI: 10.5220/0011063700003179
In *Proceedings of the 24th International Conference on Enterprise Information Systems (ICEIS 2022) - Volume 2*, pages 515-526
ISBN: 978-989-758-569-2; ISSN: 2184-4992

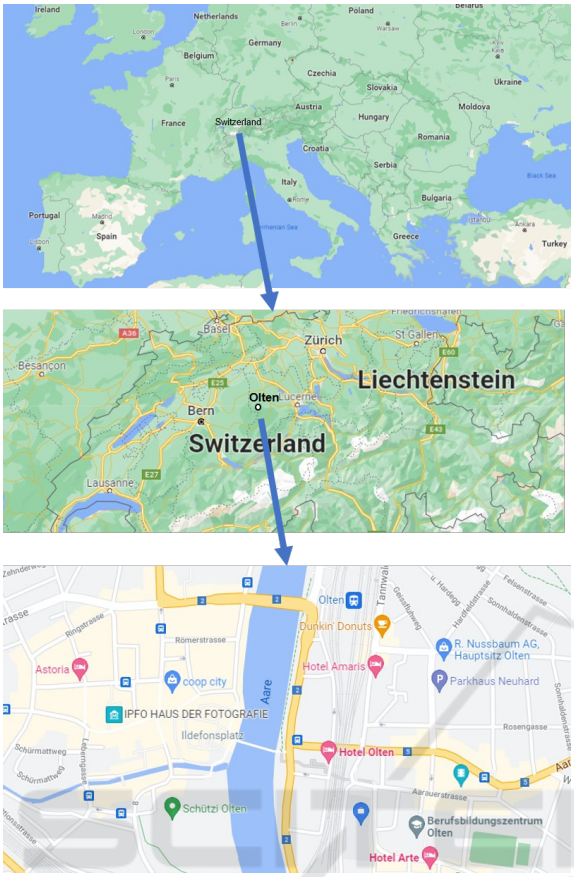


Figure 1: Zooming into an online map.

sire that has not yet been satisfied (Bork and Alter, 2018). This concept of ”zoomability” (Bork and Alter, 2018) would bring significant benefits to the decision-makers to see the relationships and dependencies between the models visualized and be able to identify the potential impact of a change to the company. The principle of zoomability is adopted from online maps and applied to enterprise models.

This paper introduces a concept that establishes zooming in and out and navigation in enterprise models like an online map. The Design Science Research (DSR) paradigm was followed to identify practice problems and develop and evaluate a prototype. The main contribution is a zoomability concept that allows stakeholders to see relationships across views and enrich the view with more detailed models.

This article is structured as follows: In Section 2 the relevant information about Enterprise Modeling and Enterprise Architecture as well as techniques for navigation through enterprise models are introduced. Section 3 focus on the methodology, Section 4 focuses on input from the practice and Section 5 introduces the concept of ”zoomability”. In Section 5.4 the meta model of the concept and a formalization of the rules are presented. Section 6 explains the evaluation and in Section 7 the conclusion is presented.

2 STATE OF THE ART

This section creates an awareness of the area of interest. It provides the fundamentals as the current state of research in the area of Enterprise Modeling (EM), Enterprise Architecture (EA), and navigation and visualization approaches.

2.1 Enterprise Modeling and Enterprise Architecture

Enterprise modeling refers to the abstract representation of different perspectives using enterprise modeling methods and languages (Vernadat, 1996). Representing a holistic view of an enterprise in one model is unrealistic (Vernadat, 2014). Therefore, a large number of different models represent the company from different viewpoints. A widely used approach is to partition the enterprise models into separate views covering a specific aspect of the architecture. The focus is set on stakeholder and their concerns while excluding others. Tailored views with relevant models are created. The concept of modeling views and viewpoints has been standardized in (ISO 42010, 2011).

Different methods, tools, and best practices are offered to cover the various perspectives of an enterprise. These perspectives are expressed as a set of different models. For various stakeholders and concerns, there can be different modeling languages. The advantage of different modeling languages is that they are adequate for certain kinds of information (Bjekovic et al., 2012). While a process map provides an overview, a process model represents a flow of work in a single process. If a process flow is modeled, the focus is on different information than if the architecture is represented.

Enterprise Architecture (EA) has become increasingly important to enable a holistic view of the enterprise. An EA model describes the overall design of the enterprise, including its components and the connections between them on different layers (Ahlemann et al., 2012; Lankhorst et al., 2017). These layers cover information starting at the enterprise strategy to the infrastructure layer. The different layers are reflected in Enterprise Architecture Frameworks (EAF) like the Zachman Framework (Zachman, 2016), TOGAF (The Open Group, 2018) or ArchiMate (The Open Group, 2019a).

ArchiMate is a prominent domain modeling language for describing EA (The Open Group, 2019a).

An advantage of ArchiMate is that it can be mapped to TOGAF (Desfray and Raymond, 2018) and Zachman Framework (Zachman, 2016). ArchiMate is an attempt to develop a unified modeling language that can integrate relevant aspects of a company (Lankhorst et al., 2010). It is a common, standardized modeling language for enterprise architecture. It is not intended to displace other modeling languages like BPMN, UML, or ERM, which cover different concerns on design level (Ahlemann et al., 2012). ArchiMate should be seen as an umbrella and various Domain-Specific Modeling Language (DSML) as an enhancement of the level of detail (Lankhorst et al., 2017). Figure 2 visualizes the level of details and the scope of various modeling languages.

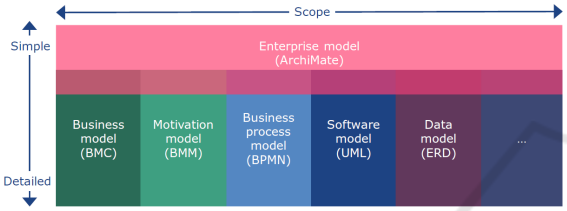


Figure 2: ArchiMade as umbrella (Lankhorst et al., 2017).

2.2 Techniques for Visualizing Enterprise Architectures

In ArchiMate, viewpoints are an essential concept that enables the modeling of specific aspects of the enterprise architecture (Lankhorst et al., 2017). A viewpoint contains a subset of ArchiMate elements and their relationship, covers one or more stakeholder concerns, serves a specific purpose, and covers a specific scope (The Open Group, 2019b). A view represents a subset of the Enterprise Models using only the concepts and relationships of the viewpoint. Figure 3 shows an example of an ArchiMate view representing the high-level organization model of an enterprise.

Javed et al. (2015) emphasize in their paper how important it is for a system architect to be able to ”zoom in” and ”zoom out”, for example, ”zoom in” from an overview model into details of the system. Javed et al. (2015) makes extensive use of business and technology patterns, and based on user input as well information from the existing views, multi-views are created. This approach combines two concerns, those of enterprise architecture and information systems development. It also promotes the development of downstream artifacts by using the upstream architecture description as a reference (Javed et al., 2015). This approach requires that the enterprise models are semantically enriched, and a repository is in use.

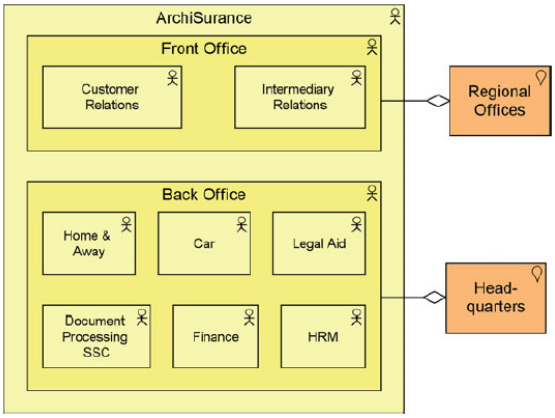


Figure 3: Organisation View (Lankhorst et al., 2017).

Van der Torre et al. (2006) have introduced a formal model for landscape maps. A matrix is the basis of a landscape map, whereby the dimensions are freely selectable. Van der Torre et al. (2006) argues that the 2D landscape maps are simple to read and provide an overview of architecture relations across layers. Using a 2D landscape map offers a good overview of the EA, but with increasing complexity and dimensions, it becomes difficult to navigate between the maps.

In certain domains, the zoom in and out function is already common. In the process architecture, the decomposition relationship is already established. According to Dumas et al. (2013) decomposition reveals a hierarchical relationship. The different levels are visualized in the form of a pyramid, which specifies the level of detail. The first level corresponds to the process map, the second level shows the business process model, and the third level shows the business process, including exposed sub-processes.

Osterwalder et al. (2014) have developed the Value Proposition Canvas as a detailed view of two blocks of Business Model Canvas, the value proposition and customer segments. The Value Proposition Canvas is used to develop ideas, concepts, and business plans for new products and services.

2.3 Zoomability in EA Tools

The zoom in and out of an enterprise model refers to the enlargement or reduction of a specific model. Thereby, no additional details are added to or removed from the enterprise model.

Modeling tools like Visual Paradigm[1] or Enterprise Architect[2] offer a zoom in functionality that changes the section but not the level of detail. Both

[1] See https://www.visual-paradigm.com/
[2] See https://sparxsystems.com/

tools also offer the possibility to create hyperlinks as 1:n relationships from elements of one enterprise model to a more detailed model. For example, a hyperlink can connect a process element in an architecture model to a more detailed architecture model representing its subprocesses or a BPMN model representing the process flow. The modeler explicitly adds the links and can be used for zoomability. Mapping on the meta-level is not supported.

2.4 Approaches for Navigation and Zooming

Rehring et al. (2019) developed an approach inspired by a city metaphor. The EA objects are replaced by the objects of a city map and thus defined as a new formal language. For example, the streets represent the business process, and the car represents the data transport.

To promote navigation, other approaches have been pursued. Rehring and Ahlemann (2020) have developed a new approach that visualizes EA through Augmented Reality (AR). The approach consists of a three-layer model, each containing relevant EA elements. As soon as an EA object in the model is selected, relationships to the object in the underlying layer are displayed.

3 METHODOLOGY

The Design Science Research (DSR) paradigm was followed to develop the artifact. The core of DSR is the development of an artifact following a five-step iterative problem-solving process (Vaishnavi and Kuechler, 2015).

The first phase of the research focused on *understanding the problems* with the current visualization and navigation approaches through literature review, unstructured interviews with practitioners, and a case study. For the interviews, senior consultants of two consulting companies were approached, each having years of practical experience in implementing EA projects. The interview's main focus was to get insight into already implemented projects and how the consultants designed the navigation between the different enterprise models.

The case study refers to the fictitious ArchiSurance case provided by The Open Group, which shows a practical application of ArchiMate (Jonkers et al., 2019). Analyzing the implementation of ArchiMate on a case offers the possibility to identify potential improvements in terms of navigation with and between the individual models and layers. The analysis of the existing navigation approaches formed the basis for the research.

In the *suggestion phase*, the preliminary idea for the problem-solution was specified. Subsequently, the concept was further refined and implemented as a prototype. The result of the *development phase* was an artifact that implements the concept of navigation enabling zoomability. The developed artifact improves the usefulness of enterprise models in terms of navigation.

For *evaluation*, the concept was applied to another case. A new prototype was built by means of scenarios, which demonstrates that the artifact is a generic solution.

4 UNDERSTANDING THE NAVIGATION PROBLEM IN THE PRACTICE

To understand the navigation problem from a practical point of view, the various models of the fictitious ArchiSurance case were analyzed (Jonkers et al., 2019), and interviews with senior consultants were conducted. The implementation of the case follows the Architecture Development Method of TOGAF (Desfray and Raymond, 2018). Each phase addresses an architecture layer. Defining views offers the possibility of focusing on the essential aspects relevant to certain stakeholders and their concerns. The views act as dedicated entry points into the enterprise models.

The interviews with the practitioners were structured as an open discussion. The aim of the interviews was to learn more about how people in a company navigate in a large set of models. For this purpose, the interview partners showed various practical examples which were realized in different companies. Typically, companies have a model of the EA landscape, which provides an overview of the company's enterprises architecture. The landscape is usually inspired by ArchiMate layers, offering the individual adjustment according to the stakeholder requirements. The stakeholder concerns are covered by different views placed on the different layers. Each view unveils a dedicated model.

The advantage of this solution is the reduction of complexity. The disadvantage, however, is that the relationship between the individual views is not apparent. The relationships between the individual elements of the views are difficult to identify, in particular, because the same elements can appear in several views. Furthermore, ArchiMate is not appropriate to model details of business processes or data, such that

references to other modeling languages like BPMN or ER diagrams need to be made.

5 NAVIGATION CONCEPTS FOR ENTERPRISE MODELS

This chapter provides information about the development steps for the zoom in and zoom out concept.

5.1 Overview of the Zoom Principles

A familiar concept, such as the zoom in and out in an online map, is used as inspiration and applied to the navigation in enterprise models. The idea of navigation is like an online map: a section is visible, and if there is interest in details, it can be zoomed in. The developed concept is shown graphically in Figure 4. The basis builds the ArchiMate Full Framework with the different enterprise architecture layers. As view-based enterprise modeling is widespread and broadly accepted in the research community as well in practice, the layers contain the different views and indicate possible entry points of the enterprise map. Two different zoom principles were considered and named as ”Zoom Within” and ”Zoom into Complements”. ”Zoom Within” defines the procedure when zooming within ArchiMate and ”Zoom into Complements” defines zooming between ArchiMate and other modeling languages that allow modeling specific aspects like process flows or data structures in more detail.

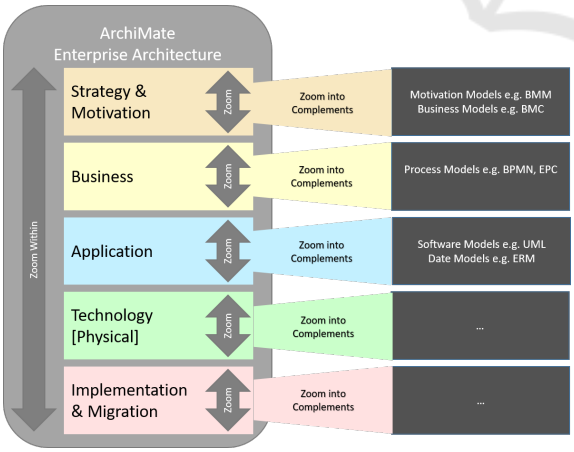


Figure 4: Overview of the Developed Concept.

In the following, the zoom principles are demonstrated with examples from the ArchiSurance case (Jonkers et al., 2019). A prototype of the ArchiSurance Enterprise Map is available via the following link[3]. All colored or bordered red elements can be clicked and trigger a certain behavior. The prototype covers different scenarios, explaining the idea behind the zoom principles ”Zoom Within” and ”Zoom into Complements”.

Figure 5 shows the prototype with the welcome page, different enterprise layers, and the corresponding views (number 3). The menu bar (number 1) offers the possibility to set various filters. Elements that are not interesting for the stakeholder can be hidden. The ArchiMate relationship tables provide the basis for which elements can be related to each other. Furthermore, it is possible to apply the derivation rules for relationships (The Open Group, 2019b). Functions like opening the welcome page or returning to the previous page, stepping forward (number 2), and increasing or decreasing the view have been considered (number 4). Zoom icons enable zooming in and out of a model (number 5). A minimap helps with orientation in the enterprise map (number 6). Further, users can save the current zoom under favorites or download it as an enterprise model (number 7).

5.2 Zoom Within

”Zoom Within” describes the zoom behavior between ArchiMate elements on the same layer and across layers. The concept is explained using different scenarios. The entry points into the enterprise map built again the views placed on different enterprise architecture layers, visualized in Figure 5.

The first elements displayed are those mentioned in the name of the view. The zoom in is achieved by clicking on the magnifying glass with a plus symbol and zoom out by magnifying glass with a minus. The zoom concept is demonstrated using the stakeholder view[4]. With a click on stakeholder view, zoom in is performed, and defined stakeholders are displayed (see Figure 6a) and build the level 0. Next, elements that are directly connected to the two stakeholders are displayed. This corresponds to zoom level 1 visualized in Figure 6b. In this case, five driver elements are displayed. If it is a nested representation, then the element which includes nested elements as well the nested elements are considered as level 0.

[3]Link: https://lwqv40.axshare.com. Additionally, the prototype is preserved on Zenedo https://doi.org/10.5281/zenodo.5732852 and can be run locally.

[4]This scenario can be seen in the online prototype as ”Scenario1 - Zoom Within”

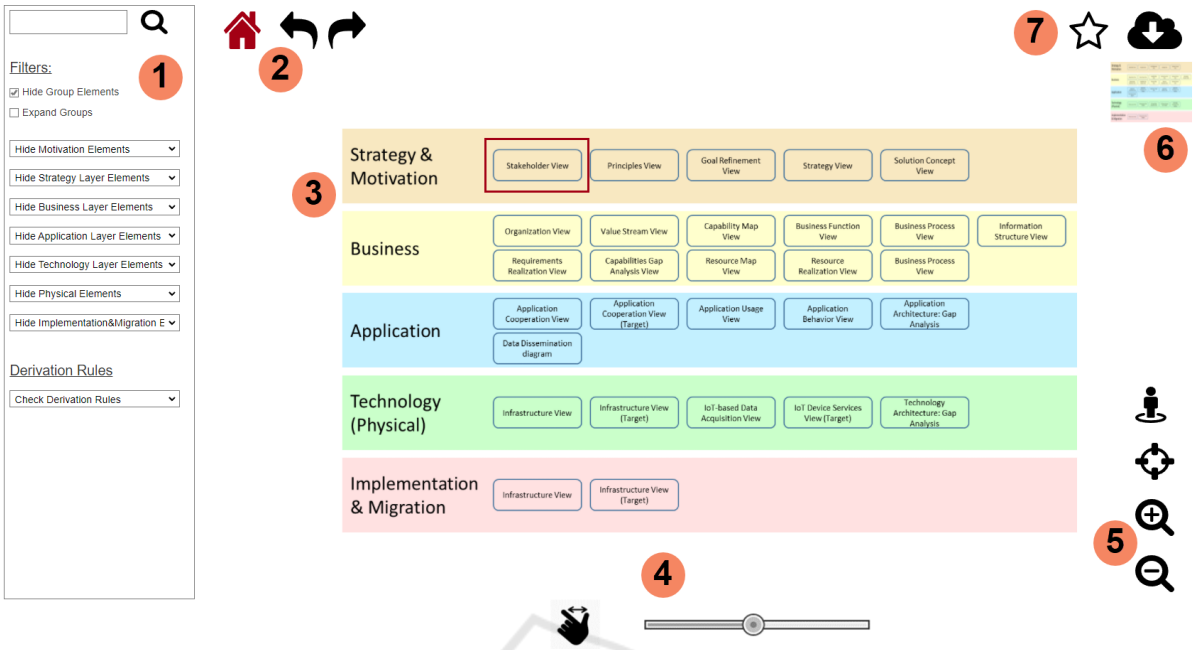
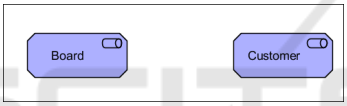
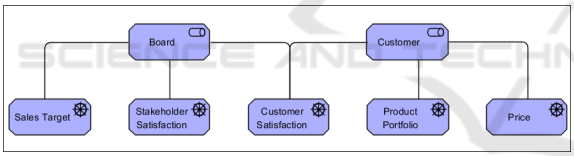


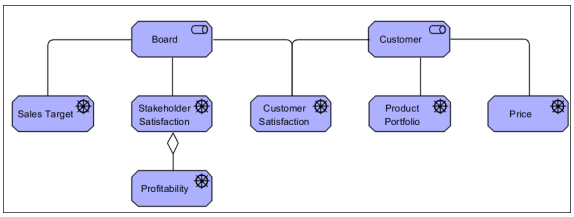
Figure 5: Prototype Overview.



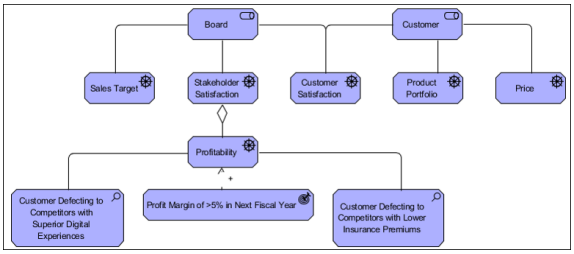
(a) Stakeholder View - Level 0



(b) Stakeholder View - Level 1



(c) Stakeholder View - Level 2



(d) Stakeholder View - Level 3

Figure 6: Zoom in - Stakeholder View.

The next zoom level shows the elements which have a direct relation to the elements shown in the previous level, see Figure 6c. Figure 6d shows the next zoom level. This can be continued until all elements are displayed. The entry point is considered as level 0, and the last level is n. In this scenario, the first element displayed is ”Stakeholder”, which according to the ArchiMate metamodel, is also the first element associated with the core element Motivation. Therefore, there are no elements above stakeholders. For this reason, the zoom is arranged in one direction in this scenario.

At each zoom, the elements are displayed which have a direct relation to the already displayed elements, as seen in Figures 6c and 6d. From this, the first rule is derived:

(R01) At each zoom, the elements are displayed, which have a direct relation to the already displayed elements.

The different relationships that ArchiMate modeling language has are not prioritized. The second rule is derived from this fact:

(R02) All relationship types are treated equally.

ArchiMate elements can have multiple relations to other elements on the same layer and across layers. Thereby such relations can arise as shown in the Figure 7. If the first rule is followed, all elements should be displayed that have a direct relationship to the requirement element ”CRM Data Should Be Maintained Centrally”. But, other motivation elements are displayed, followed by strategy elements.

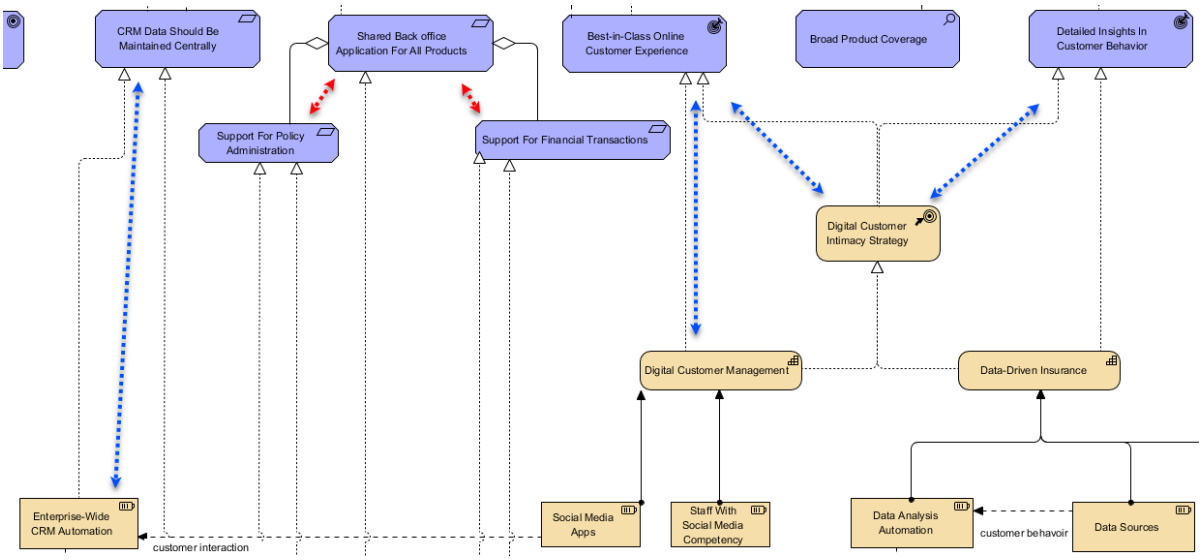


Figure 7: Stakeholder View - Relationship Across Layers.

A distinction is made between layers or element types, where the relationship between elements of the same type or the same layer is preferred. Another rule is derived:

(R03) Relationships between elements of the same type or layers will be weighted higher than cross-type or cross-layer relationships.

Another characteristic is the use of transitive dependencies, which is known especially from databases. As shown in Figure 7, there is a direct relationship between strategy element ”Enterprise-Wide CRM Automation” and motivation element ”CRM Data Should Be Maintained Centrally” and strategy element ”Social Media Apps”. This element is in addition connected to another strategy element, which is then related to a motivation element. In this case, there is a sort of transitive dependency with the motivational elements. From this point of view, another rule is derived:

(R04) If a transitive dependency exists, the element is displayed when the element over which the transitive dependency exists is revealed.

This means that the strategy element ”Enterprise-Wide CRM Automation” is only displayed when the strategy element ”Social Media App” is shown.

In the former scenario, the first element displayed was on top in the hierarchy. Figure 8 visualizes a scenario where the value stream element ”Aquire Insurance Product” is at level 0. Zoom in will unveil all the elements on level 1 as well as level -1.

If an element has relations to elements above or below, then at each zoom, every element, when it is first displayed, becomes level 0 for itself and applies the rules for itself at each further zoom. As soon as an element on level 0 is displayed, which has relations to elements above or below, a recursion occurs[5].

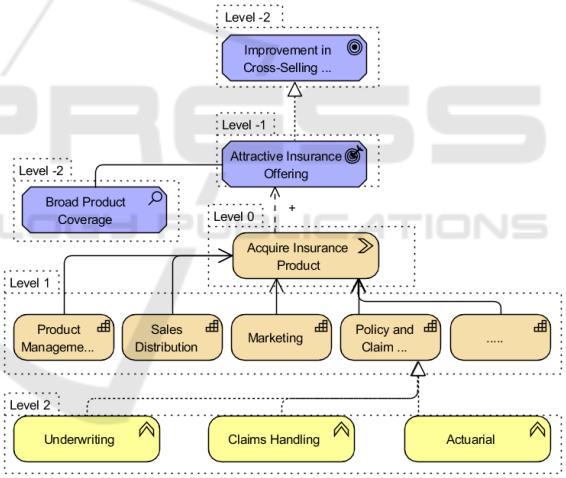


Figure 8: Zooming through the Hierarchy.

In order to zoom in and zoom out, it is assumed that a superior model exists, which consists of ArchiMate elements. ArchiMate elements have a relationship to none, one or more other ArchiMate elements. These can be elements of the same type or layer, a layer above or a layer below. The reason why an element is considered to be level 0 lies in the anatomy of the ArchiMate modeling language. Lankhorst et al. (Lankhorst et al., 2010) defined three levels to establish ”a metamodel covering a set of modeling concepts that would allow us to model domains in gen-

[5]This scenario can be seen in the online prototype as ”Scenario3 - Zoom Within”

eral". At level 0, a modeling concept Element was defined, consisting of a Concept (graphical representation) and Relations (lines and arrows between the concepts). In the further development of the ArchiMade modeling language, the Element, Relationship, and Relationship Connector were defined as the specialization of Concept. Structuring information into clusters and patterns has a significant cognitive impact (Naranjo et al., 2015). For this reason, each zoom makes sure that elements of the same type are displayed first and then cross-layer.

5.3 Zoom into Complements Principle

The ArchiMate language provides a standardized architectural modeling concept including their relationships, called ArchiMate metamodel. Figure 9 illustrates this concept, where synergies with other modeling languages can be realized in order to provide detailed information to the consumers of enterprise models.

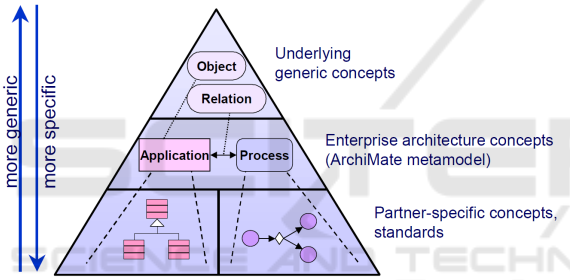


Figure 9: Metamodels at different levels of specificity (Jonkers et al., 2004).

The design of ArchiMate allows a drill down into domain-specific models and thus offers the possibility to establish zooming (Jonkers et al., 2004). ArchiMate serves as a hub, which is related to the various domain-specific models (Jonkers et al., 2004). This concept was the basis for developing the zoom principle "Zoom into Complements", which defines zooming between ArchiMate and various DSML. Concepts in the ArchiMate language can have a direct connection to concepts in other DSML (Lankhorst et al., 2017). In this way, ArchiMate enables different domain-specific enterprise models to be integrated in a reasonable way (Lankhorst et al., 2017). The basis is provided by the mapping between ArchiMate concepts and various DSML.

Table 1 illustrates an example of the mapping between Business Model Canvas (BMC) concepts and ArchiMate concepts, where the relation 1:mc can be associated (Lankhorst et al., 2017). Mapping helps to establish the relationship between elements of various DSML and ArchiMate and also to justify it.

Table 1: ArchiMate and BMC.

Business Model Canvas	*ArchiMate*
Key Partner	Business Actor (or Role)
Key Activity	Capability
Key Resource	Resource
Value Proposition	Product + Value
Customer Relationship	Business Collaboration
Channel	Resource (realised by Interface)
Customer Segment	Business Actor
Cost Structure	Value attached to architecture elements
Revenue Stream	Value + Flow

Based an a scenario the navigation from an ArchiMate element Capability to BMC is demonstrated [6]. Entry point is again the view overview, visualized in Figure 10a. By opening the capability Map view, the entire content of this view gets visible. If there is a mapping toward another model, this is indicated by a pin, depicted in the Figure 10b. With a right-click on the element, a selection list is displayed, which shows the DSML to which a relationship exists. Figure 10c illustrates this behavior.

Another scenario with the business process view explains a behavior when an ArchiMate element is mapped to another model and occurs in several processes[7]. First, an overview with all affected processes is shown, and the desired one can be selected, see Figure 11. Afterward, a dynamic graphical symbol is displayed, see Figure 12, which indicates that an overview exists—in this case, a process map with all processes that have a connection to the initial ArchiMate element.

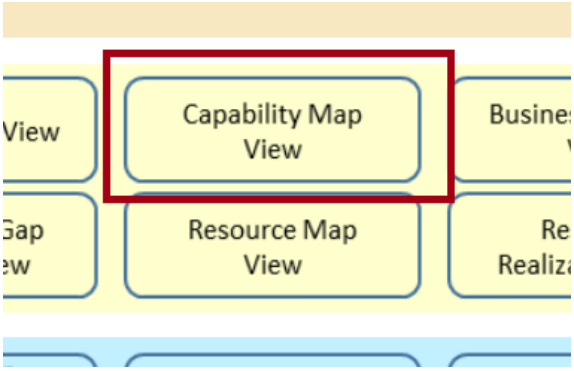
The ArchiMate elements serve as entry points. The mapping between ArchiMate and DSML is based on the elements, but an element belongs to a specific model. For this reason, right-clicking on an element will not display an element but the relevant model. Various DSML represents a more detailed view, which complements the ArchiMate model. For this reason, the entire domain-specific model is directly displayed, and zoom in and out of this model only takes place if a hierarchical representation already exists. For the process architecture or Value Proposition Canvas, a zoom function already exist, which was mentioned in Section 2.

5.4 Zoomability Rules and Metamodel

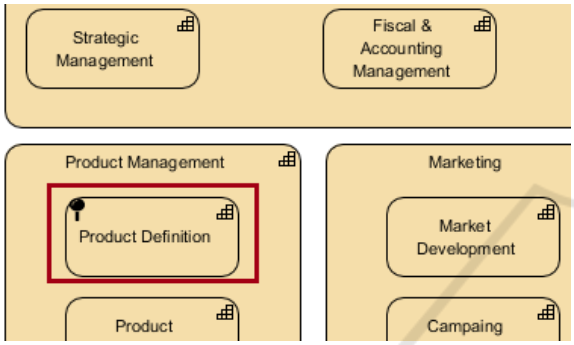
Figure 13 visualizes the concept of the zoomability principle as a metamodel. It is assumed that a su-

[6]This scenario can be seen in the online prototype as "Szenario4 - Zoom Complements BMC"

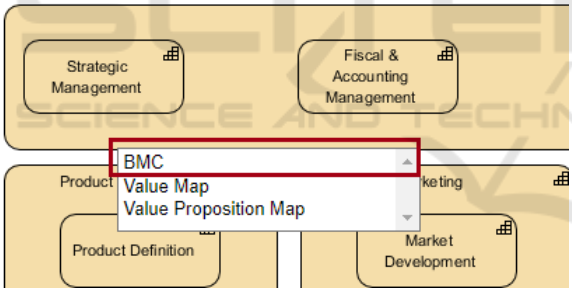
[7]This scenario can be seen in the online prototype as" Scenario5 - Zoom ComplementsBPMN"



(a) Entry Point into the Enterprise Map



(b) Pin indicates Mapping



(c) Mapped Models get visible

Figure 10: Zoom in - Capability Map View.

perior model exists, which is defined by ArchiMate concepts. The ArchiMate concepts, in turn, consists of ArchiMate elements. Those are specialized by: (1) top ArchiMate elements, (2) same level ArchiMate elements, and (3) below ArchiMate elements. ArchiMate elements are associated with none, one or more models. Those models are expressed by various DSML and consist of DSML elements. The ArchiMate elements are mapped to none, one or more DSML elements. The zoomability principle is specialized by ”Zoom Within” and ”Zoom into Complements”. Zoomability of the superior model is defined by zoomability within and of models by ”Zoom into Complements”. ArchiMate itself is a DSML, which

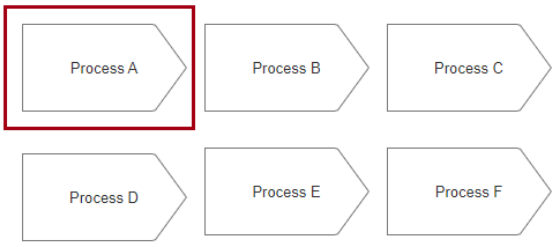


Figure 11: Overview of the affected processes.

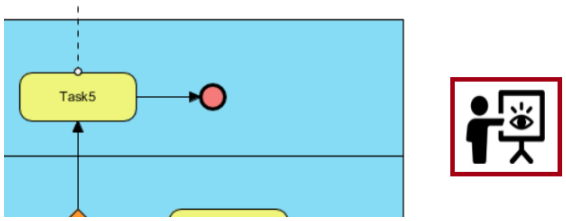


Figure 12: Dynamic Graphical Symbol.

can represent the Enterprise Architecture (Lankhorst et al., 2010). The metamodel implies a relationship between ArchiMate and various other DSML.

During the development of the artifact, rules were defined, which contributed to a generic approach and allowed an application to another case. The derivation of the rules as explained in Section 5.2. Summarized are the four rules that have been defined:

- (R01) At each zoom, the elements are displayed, which have a direct relation to the already displayed elements.
- (R02) All relationship types are treated equally.
- (R03) Relationships between elements of the same type or layers will be weighted higher than cross-type or cross-layer relationships.
- (R04) If a transitive dependency exists, the element is displayed when the element over which the transitive dependency exists is revealed.

6 EVALUATION OF THE DEVELOPED CONCEPT

As the development of the artifact is novel, the realization is shown employing a demonstration (Vaishnavi and Kuechler, 2015). For this purpose, a set of different situations, which may occur in practice, were defined. A prototype was created to demonstrate that the solution can be applied to those situations. For the evaluation of the developed solution, another case, ArchiMetal (Band et al., 2019) was used as a basis.

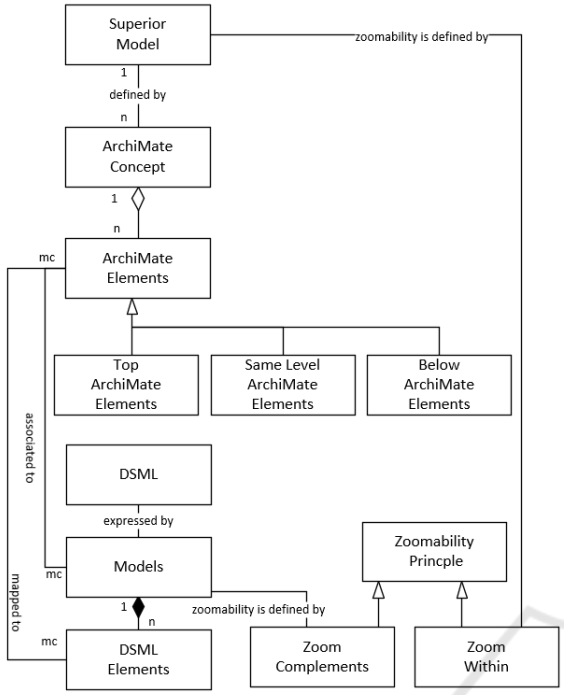


Figure 13: Metamodel of the Proposed Solution.

First, the ”Zoom Within” principle is evaluated[8]. All the zoom levels of the ArchiMetal case were defined, and this corresponds to the ”Superior Model” defined in the metamodel of the proposed solution in Figure 13. As a persona, a Process Owner was chosen, who is interested in examining the relationships of the process ”Register Order”. The overview of all views serves as an entry point, see Figure 5. The Business Process Map View shows an overview of the business process of the organization, see Figure 14.

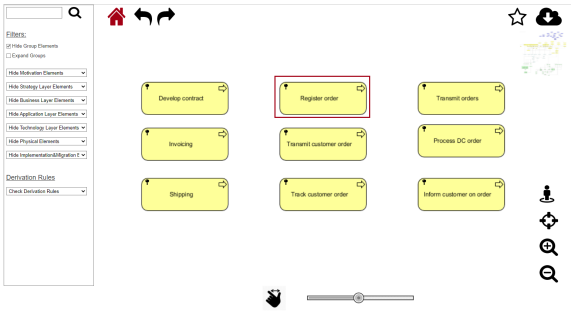


Figure 14: Business Process Map View.

Since it is a nested representation and the process ”Register order” is composed of three subprocesses, these are also revealed directly. Figure 15 shows the different levels. The first two zoom levels show the

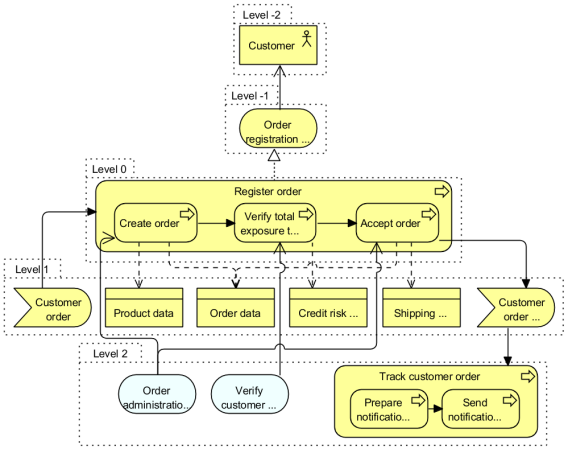


Figure 15: Evaluation of the Zoomability Principle.

principle and application of the defined rules. With each zoom, more and more elements are displayed while the type of the relation is treated equally according to the rule R02. Table 16 explains which elements appear at which zoom level. On the zoom level 0, there is the main process ”Register order” and the three sub processes ”Create order, Verify total exposure to customer, Accept order”, so four elements in total. For each of the four elements, the defined rules in Section 5.4 are applied. Element ”Register order” directly relates to the top ArchiMate element ”Order registration service” which corresponds to level -1. The same rule can also be applied to the representation of the element ”Customer order”, which then corresponds to level 1, also to below ArchiMate element. This procedure is repeated until all elements included in the superior model are displayed.

The zoom principle puts the element in the foreground therefore, the element which is subject to a transitive dependency is displayed after the element over which this dependency is present. Therefore not only the relationship between the elements is shown while zooming, but the element itself and its relationship to the already visible elements. The same procedure is applied to the three other elements, which are on level 0. Whit the next zoom, all the elements which have been added before on level -1 and level 1 become level 0, and the defined rules are applied again. Table 16 visualizes the appearance of the recursion. The rule R03 is taken into account, and elements from other layers are only displayed if no other elements of the same layer can be displayed, like demonstrated with the application service elements ”Order administration service” and ”Verify customer exposure service” in Figure 15.

After the application of ”Zoom Within” has been demonstrated within an example using a prototype, the applicability of ”Zoom into Complements” is be-

[8]This scenario can be seen in the online prototype as ”Evaluation-Scenario1 - Process”

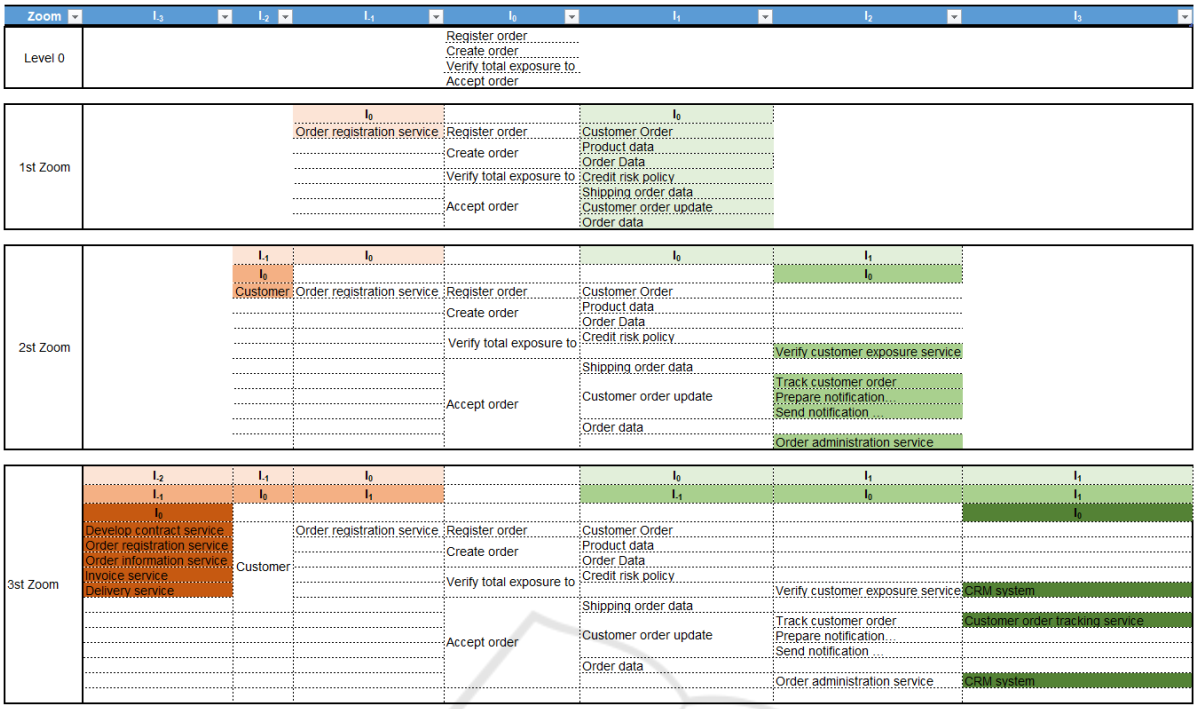
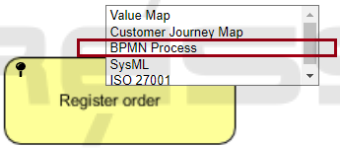


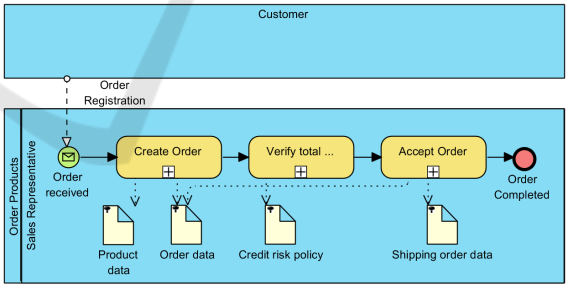
Figure 16: Zoom Levels Explained.

ing evaluated. Using scenarios[9] a prototype was built, which demonstrates the procedure. The entry point into the enterprise map is the view overview visualized in Figure 5. A pin sign on process "Register order" indicated a mapping to another modeling language, visualized in Figure 17a. In this example, the BPMN process is selected and the process modeled according to the notation BPMN 2.0 is displayed indicated in Figure 17b. If a zoom option exists for the displayed model, as in process architecture, then the level of detail can be adjusted. In this example, the sub-processes are expanded visualized in Figure 17c. Further, if a mapping to another language exists, in this case, data objects indicated a mapping, detailed zoom can be applied.

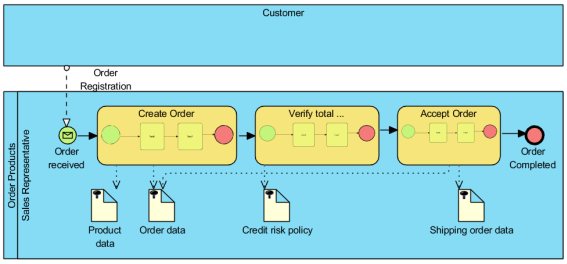
The developed concept was applied to a new situation and it was demonstrated that the zoomability concept has a general approach, and reveals the connection between the models on different degree of detail. Further, the evaluation showed the applicability of the defined rules and the metamodels.



(a) Zoom into BPMN Process Model



(b) Zoom into BPMN Process Model



(c) Zoom into BPMN Process Model

Figure 17: Zoom in - Capability Map View.

[9]This scenario can be seen in the online prototype as "Evaluation-Scenario3 - Complements ProcessView" and "Evaluation-Scenario4 - Complements Motivation"

7 CONCLUSIONS

The main contribution is a development of a zoomability concept that allows stakeholders to see relationships across views and to enrich the view with more detailed models. The developed concept offers the possibility to see the possible impact of a change from a dedicated view by using the zoom levels. A widely accepted standard was used as a basis, and rules were defined on how to implement the zoomability principle. The rules serve to represent a hierarchical output of zoom levels. The metamodel is generic and can be implemented in various EA tools. The concept offers a good basis to be equipped with further navigation features. For example, the possibility to compare baseline and target architecture, building own views, set focus, or further features. Several possible navigation features were defined in the prototype[10], which need to be developed further.

REFERENCES

Ahlemann, F., Stettiner, E., Messerschmidt, M., and Legner, C. (2012). *Strategic enterprise architecture management: challenges, best practices, and future developments*. Springer Science & Business Media.

Band, I., Bjeković, M., Else, S., Kroese, R., and Lankhorst, M. (2019). The archimetal case study. online.

Bjekovic, M., Proper, H. A., and Sottel, J.-S. (2012). Towards a coherent enterprise modelling landscape. In *Short Paper Proceedings of the 5th IFIP WG 8.1 Working Conference on the Practice of Enterprise Modeling*. CEUR Workshop Proceedings, Vol-933.

Bork, D. and Alter, S. (2018). Relaxing modeling criteria to produce genuinely flexible, controllable, and usable enterprise modeling methods. In *EMISA*, pages 46–50.

Desfray, P. and Raymond, G. (2018). *TOGAF, Archimate, UML et BPMN-3e éd.* Dunod.

Dumas, M., La Rosa, M., Mendling, J., and Reijers, H. A. (2013). *Business process management*. Springer.

Hinkelmann, K., Gerber, A., Karagiannis, D., Thoenssen, B., Van der Merwe, A., and Woitsch, R. (2016). A new paradigm for the continuous alignment of business and it: Combining enterprise architecture modelling and enterprise ontology. *Computers in Industry*, 79:77–86.

ISO 42010 (2011). *Systems and software engineering — Architecture description*. International Organization for Standardization. https://www.iso.org/standard/50508.html; Accessed July 12, 2020.

Javed, A., Azam, F., and Umar, A. (2015). Model driven upstream and downstream artifacts. *Procedia Computer Science*, 64:514–520.

Jonkers, H., Band, I., Quartel, D., and Lankhorst, M. (2019). The archisurance case study. online.

Jonkers, H., Lankhorst, M., Van Buuren, R., Hoppenbrouwers, S., Bonsangue, M., and Van Der Torre, L. (2004). Concepts for modeling enterprise architectures. *International Journal of Cooperative Information Systems*, 13(03):257–287.

Lankhorst, M. et al. (2017). *Enterprise architecture at work*. Springer, 4 edition.

Lankhorst, M., Proper, H. A., and Jonkers, H. (2010). The anatomy of the archimate language. *International Journal of Information System Modeling and Design (IJISMD)*, 1(1):1–32.

Naranjo, D., Sánchez, M. E., and Villalobos, J. (2015). Evaluating the capabilities of enterprise architecture modeling tools for visual analysis. *Journal of Object Technology*, 14(1).

Osterwalder, A., Pigneur, Y., Bernarda, G., and Smith, A. (2014). *Value Proposition Design - How to Create Products and Services Customers Want*. John Wiley & Sons.

Rehring, K. and Ahlemann, F. (2020). Evaluating the user experience of an augmented reality prototype for enterprise architecture. In *15th International Conference on Wirtschaftsinformatik*.

Rehring, K., Brée, T., Gulden, J., and Bredenfeld, L. (2019). Conceptualizing ea cities: Towards visualizing enterprise architectures as cities. In *European Conference on Information Systems ECIS*.

Sandkuhl, K., Stirna, J., Persson, A., and Wißotzki, M. (2014). *Enterprise modeling*. Springer.

The Open Group (2018). The TOGAF® standard, version 9.2.

The Open Group (2019a). Archimate 3.1 Specification. http://pubs.opengroup.org/architecture/archimate3-doc.

The Open Group (2019b). *ArchiMate® 3.1 Specification*. Van Haren.

Vaishnavi, V. K. and Kuechler, W. J. (2015). *Design science research methods and patterns: innovating information and communication technology*. CRC Press Taylor & Francis Group, 2nd edition.

Van der Torre, L., Lankhorst, M., ter Doest, H., Campschroer, J. T., and Arbab, F. (2006). Landscape maps for enterprise architectures. In *International Conference on Advanced Information Systems Engineering*, pages 351–366. Springer.

Vernadat, F. (1996). *Enterprise modeling and integration*. Chapman & Hall.

Vernadat, F. (2014). Enterprise modeling in the context of enterprise engineering: State of the art and outlook. *International Journal of Production Management and Engineering*, 2(2):57–73.

Zachman, J. A. (2016). The framework for enterprise architecture: Background, description and utility.

[10]See online prototype "Navigation Features - ..."