UNIVERSITEIT GENT

FACULTY OF ECONOMICS AND BUSINESS ADMINISTRATION

Ghent University
Faculty of Economics and Business Administration
Department of Business Informatics and Operations Management

From Business Logic to Business Process:

Designing Strategy-aligned Business Processes

Ben Roelens

Advisor: Prof. dr. Geert Poels

Submitted to the Faculty of Economics and Business Administration of
Ghent University in fulfillment of the requirements for the degree of
Doctor in Applied Economics
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Als de droom of zelfs de illusie sterven is het gedaan met de schoonheid die wij nastreven in dit bestaan. Heb daarom geduld en richt uw schreden naar morgen. Er bestaat een kans dat het goede zegeviert. Misschien niet nu, misschien niet morgen, misschien niet volgend jaar. Maar later zeker, misschien.

Luc De Vos

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On September 22, 2013, my alarm clock was ringing at 6 a.m. Although this is not a habit on a Sunday morning, it was the beginning of my journey to Corsica, together with seven of my best friends. We had the plan to bridge the first part of the GR 20 by hiking from Haut Asco to Calenzana. Unfortunately, the air travels in my free time regularly attract unforeseen circumstances, ranging from persistent fog and strong winds to erupting volcanos. Whereas nature was at our side today, the information system of the airport broke down at the moment we arrived there. The implications of this event were tremendous: waiting queues were growing, flights were delayed, luggage labels needed to be written manually, etc. Although I was still lightheaded this early in the morning, I then understood the true relevance of my PhD topic. Indeed, it seems that the impact of information systems has grown to the extent in which a major failure results in total chaos. By completing this doctoral research, I hope to have provided a modest contribution to the realization of well-designed information systems, which preserves the comfort we experience every day.

We arrived in Nice with a delay of almost 12 hours, while our luggage arrived later that evening. The rest of the holiday was perfect, so apparently there is always a chance that things get right in the end. Walking the GR 20 was probably one of the most beautiful, yet hardest physical experiences I ever had in my life. Reaching the top of a mountain made you realize that an even higher obstacle was on your way and perseverance would be needed to overcome it. The lesson that I learned from this experience was even more useful in the further course of my PhD project. Even if things seem impossible at the start, you will eventually reach your final objective if you divide it into smaller problems that can be effectively conquered. In this respect, I owe credits to Julius Caesar, the Roman emperor who successfully applied this strategy 2000 years ago.

But most of all, I was not walking alone. Thanks to our friendship, everybody of us made it to Calenzana. Apart from sharing tents, food, and water, it’s just more fun to realize your objectives together. As this was also a crucial aspect in the realization of this PhD project, I would like to thank everybody who supported me during this period. The list of people is long, but some of them deserve extra attention.

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Ben Roelens
Gent, May 2015

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List of Acronyms

A

A	Attribute
ADM	Architecture Development Method
ADR	Action Design Research
AHP	Analytic Hierarchy Process

B

BIM	Business Intelligence Model
BPMN	Business Process Model and Notation

C

CEO	Chief Executive Officer
CIO	Chief Information Officer
CFO	Chief Financial Officer
COO	Chief Operations Officer

D

DSML	Domain-Specific Modeling Language
DEMO	Design & Engineering Methodology for Organizations
D^T	Data Type

E

EA	Enterprise Architecture
Enum	Enumeration

F

FDMM	Formalism for Describing ADOxx Meta models and Models

I

IS	Information System
IT	Information Technology

K

KAOS	Knowledge Acquisition in autOmated Specification of software systems

M

MEMO	Multi-perspective Enterprise MOdeling
MIS	Management Information Systems
MT	Model Type

O

O^T	Object Type

P

PGA	Process-Goal Alignment

R

REA	Resource-Event-Agent
RQ	Research Question

S

SLR	Systematic Literature Review
SWOT	Strengths, Weaknesses, Opportunities, and Threats

T

TOGAF	The Open Group Architecture Framework

U

UML	Unified Modeling Language

V

VDML	Value Delivery Modeling Language
VNA	Value Network Analysis

W

WS-BPEL	Web Service Business Process Execution Language

Nederlandse Samenvatting
- Summary in Dutch -

Het ontwerpen van strategisch gealigneerde bedrijfsprocessen vereist een coördinatie tussen de strategie en de processen binnen een onderneming. Binnen het onderzoeksgebied van het Conceptueel Modelleren kan deze coördinatie verwezenlijkt worden door het gebruik van waardemodellen. Modelleertalen voor waardemodellen brengen zowel de creatie van waarde binnen de onderneming, als de uitwisseling van waarde tussen de onderneming en haar ruimer netwerk, in kaart. Binnen dit doctoraatsonderzoek wordt het gebruik van deze modelleertalen gecombineerd met het bedrijfsmodel van de onderneming, een concept dat zijn oorsprong vindt in Strategisch Management. Het combineren van conceptuele modelleertalen met relevante raamwerken uit de management literatuur zorgt er voor dat conceptuele modellen ontwikkeld kunnen worden binnen een afgelijnde strategische context. Hierdoor worden concepten gebruikt die een duidelijke betekenis hebben voor de eindgebruikers binnen de onderneming, waardoor het eenvoudiger wordt voor hen om de uiteindelijke modellen te begrijpen.

Het onderzoek binnen dit doctoraatsproefschrift is opgesplitst in drie delen. Het eerste deel (hoofdstuk 2) beschrijft de ontwikkeling van een integrerend raamwerk voor het bedrijfsmodel, zoals het gepercipieerd wordt binnen Strategisch Management. De belangrijkste reden voor dit onderzoek was het gebrek aan een gemeenschappelijke visie binnen dit onderzoeksdomein. Het raamwerk werd ontwikkeld door middel van een literatuurstudie en leidde tot de identificatie van 10 elementen en hun onderlinge relaties binnen het bedrijfsmodel. De toepasbaarheid van dit raamwerk werd geïllustreerd door het toe te passen op de Southwest Airlines gevalstudie.

Het onderzoek uit hoofdstuk 3 bouwt verder op dit raamwerk aangezien het gericht is op de realisatie van *IT support* voor de ontwikkeling van bedrijfsmodellen. Hiervoor zijn we nagegaan welke modelleerconstructen, die gebruikt worden bij het opstellen van waardemodellen, geschikt zijn om de elementen binnen het bedrijfsmodel weer te geven. Nadien zijn deze modelleerconstructen gecombineerd tot het nieuwe *business model viewpoint* binnen VDML. Deze modelleertaal werd recent ontwikkeld door de Object Management Group als een standaard voor het modelleren van de waardecreatie en –uitwisseling door de onderneming. Het *VDML business model viewpoint* heeft als doel om het begrip van de eindgebruikers over de onderliggende bedrijfsinformatie te vergroten. Dit effect werd nagegaan door het uitvoeren van een experiment, waarvan de statistische resultaten aantonen dat het gebruik van dit nieuwe model een significante en positieve invloed heeft op het de accuraatheid en de snelheid waarmee eindgebruikers de onderliggende informatie kunnen afleiden.

Het laatste deel van het onderzoek (hoofdstuk 4) is gericht op the realiseren van strategische afstemming binnen de bedrijfsarchitectuur. Dit werd verwezenlijkt door de ontwikkeling van een modelleertechniek die gericht is op de creatie van *business architecture heat maps*. Deze techniek steunt op raamwerken uit Strategisch Management om de relevante elementen binnen de bedrijfsarchitectuur te identificeren. In dit opzicht maken we hier dus ook gebruik van de onderzoeksresultaten uit hoofdstuk 2. De realisatie van de *heat maps* is gebaseerd op het toevoegen van een kleurencode die zowel de prestatie als het strategisch belang aanduidt van de elementen binnen de bedrijfsarchitectuur. De creatie van deze *heat maps* wordt ondersteund door een software programma dat ontwikkeld werd via het ADOxx platform. De voorgestelde modelleertechniek werd toegepast en geëvalueerd door middel van drie gevalstudies bij een grootschalig internationaal bedrijf dat software ontwikkelt. De resultaten van deze gevalstudies hadden tot doel om de voorgestelde modelleertechniek verder te verfijnen, waardoor een mooie balans gevonden werd tussen het bijdragen van kennis aan de betrokken onderzoeksdomeinen en het bieden van een oplossing voor een praktisch bedrijfsprobleem.

1 Introduction

1.1 Research Context

1.1.1 Research Problem

The design of strategy-aligned business processes can be understood as the realization of a fit between the strategic positioning of the company and the development of supportive actions to execute this organizational strategy (Henderson and Venkatraman, 1999). Since the 1980s, realizing strategic fit is an ongoing concern for companies as it is a major determinant for the organization's ability to successfully compete in its customer markets (Schieman, 2009). However, a successful translation of the high-level strategy into effective operations is hardly realized in today's businesses (Verweire, 2014).

Strategic fit is further clarified by the Amsterdam Information Management Framework (Maes, 2007), which identifies the infrastructure perspective as the key intermediate layer to align the strategy and process perspectives of an organization (see figure 1.1). This infrastructure perspective can be understood as the whole of the business, information/communication and technology infrastructures that gives shape to the organization. It consists of elements like organizational roles and departments, business functions, data and knowledge bases, information systems (ISs) and software applications, machinery and property, and computing and network infrastructure.

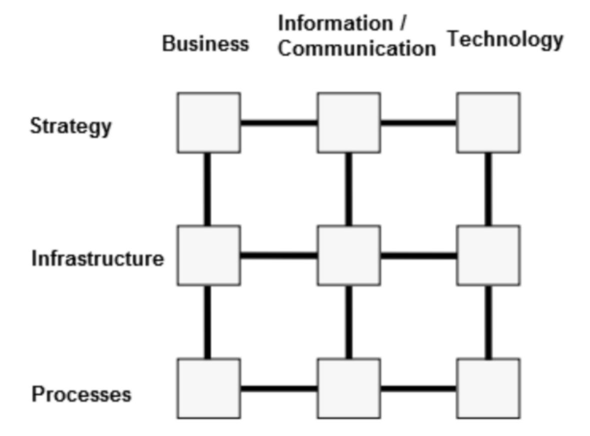


Figure 1.1: Amsterdam Information Management Framework (Maes, 2007)

In the management literature, a wide range of techniques is available to facilitate the analysis and design of the strategy, infrastructure, and process perspectives of a company (see section 1.1.2). Although the widespread application of these concepts and instruments by managers and business consultants demonstrates their value for business analysis, little is known about their integrated use for the alignment of the different perspectives (Lueg et al., 2014). Furthermore, explicit mechanisms are missing to communicate the results of applying these techniques to other stakeholders in the company.

This issue can be overcome by the use of conceptual modelling techniques (see section 1.1.3), which provide *formal descriptions of some aspects of the physical and social world around us for purposes of understanding and communication* (Mylopoulos, 1992). In addition to facilitating the understanding and communication between the involved stakeholders (Lankhorst, 2009, Frank, 2014a), these representations allow for a model-based analysis of strategic fit (Andersson et al., 2009, Pijpers et al., 2012). This dissertation explains how the issue of unrealized strategic fit can be solved by conceptual modeling techniques.

1.1.2 Management Literature

In the management literature, the strategy perspective is addressed by the Balanced Scorecard, which classifies organizational goals into four interrelated categories (i.e., internal, customer, financial, and learning and growth) with according measures to provide a comprehensive view on the business (Kaplan and Norton, 1992). In Kaplan and Norton (2004), Strategy Maps are introduced as a generic framework for describing and building strategies, which specifies paths to better align the goals of the different Balanced Scorecard categories. This approach can be complemented by a

SWOT (i.e., Strengths, Weaknesses, Opportunities, and Threats) analysis (Andrews, 1980) to account for external situations and internal factors that have a positive or negative impact on the realization of the strategic goals. The business model concept can be used to analyze the infrastructure perspective of the organization. This concepts represents the business logic, which is required to implement a strategy, by explicating how to create value and exchange it with the external value network (Shafer et al., 2005). Since the late 1990s, research on business models has contributed knowledge to the definition of the business model concept, the identification of the constituting components, the development of generic taxonomies, the analysis of adoptions factors, the development of evaluation criteria, and the formulation of methodologies to innovate and change existing business models (Pateli and Giaglis, 2004). Within a wide variety of frameworks, the Business Model Ontology (Osterwalder, 2004) is frequently referenced. This framework defines the interrelations between nine business model component categories: customer segments, value propositions, channels, customer relationships, key resources, key activities, key partnerships, revenues streams, and the cost structure. This framework is accompanied by the Business Model Canvas technique as a management tool to offer a comprehensive overview of an organization's business model (Osterwalder et al., 2010). The process perspective is addressed in the management literature by the Value Chain concept of Porter (1985), who considers the value activities that are performed in a company as a key source of competitive advantage. More specifically, primary value activities cover the complete product life cycle, which ranges from product creation to providing after-sales services. These activities need to be combined with support and management activities, which provide the necessary inputs and other general business functions (Porter, 1985).

1.1.3 Conceptual Modeling

1.1.3.1 General

Since its emergence, conceptual models have been applied in different contexts. The remainder of this paragraph describes Requirements Engineering (section 1.1.3.2) and Enterprise Architecture (EA) (1.1.3.3) as two application contexts that are relevant for this PhD research.

1.1.3.2 Requirements Engineering

The importance of conceptual models became prevalent in the 1970s in the context of database design. The Entity-Relationship Model (Chen, 1976) was proposed as a model that can be used to consistently structure data and to provide semantic information about the surrounding reality. Another example is the Resource-Event-Agent (REA) Accounting Model (McCarthy, 1982), which was developed as a framework to store data that can be shared between accountants and non-accountants in the company.

In the 1980s, the focus of Conceptual Modeling was broadened to the specification of requirements for the development of software systems. More specifically, conceptual models are useful for the identification of stakeholder needs and for the representation of these needs in a form that facilitates subsequent analysis, communication, and implementation (Nuseibeh and Easterbrook, 2000). The development of Goal-Oriented Requirements Engineering techniques (e.g., KAOS (i.e., Knowledge Acquisition in autOmated Specification of software systems) (Dardenne et al., 1993), i* (Yu et al., 2011)) enabled to go beyond the mere functional requirements of a software system and to understand how it contributes to the objectives of the wider business context (Yu and Mylopoulos, 1998). The emergence of electronic business facilitated the development of Value-Based Requirements Engineering techniques. In this context, e^3-value (Gordijn and Akkermans, 2003) provides insights in how electronic products, which heavily rely on Internet and World Wide Web technologies, can be developed and evaluated for their potential profitability.

1.1.3.3 Enterprise Architecture

The EA field provides a different scope for the application of conceptual models. Indeed, EA techniques (e.g., the Zachman framework (Zachman, 1987), The Open Group Architecture Framework (TOGAF) (The Open Group, 2011), ArchiMate (Lankhorst, 2009), etc.) make use of conceptual models in a *coherent whole of principles and methods to offer a holistic view on the design and realization of an enterprise's organizational structure, business processes, ISs, and architecture* (Lankhorst, 2009). The three upper layers of the EA constitute the business architecture, which is a multi-perspective blueprint of the enterprise that provides a common understanding of the formulation of the organizational objectives (i.e., the strategy perspective), through strategy implementation (i.e., the infrastructure perspective), to operational process decisions (i.e., the process perspective) (OMG, 2012a).

Different conceptual modeling languages provide visual representations of these business architecture perspectives (see figure 1.2). Goal modeling languages have been designed to address the strategy perspective by contributing to a better understanding of the organizational goals that shape the strategic context of a company (Kavakli and Loucopoulos, 2005). Value modeling techniques are used to represent the organizational infrastructure perspective in terms of what an enterprise must do (i.e., processes) and needs (i.e., capabilities and resources) to create value and deliver it to the various stakeholders (Andersson et al., 2009, OMG, 2014b). Apart from those languages having a Requirements Engineering origin (i.e., the REA ontology

(Geerts and McCarthy, 2002) and e[3]-value (Gordijn and Akkermans, 2003, Pijpers et al., 2012)), other value modeling languages were developed in research fields as Intellectual Capital (i.e., Value Network Analysis (VNA) (Allee, 2008)) and Capability Management (i.e., Capability Maps (Hafeez et al., 2002)). The Value Delivery Modeling Language (VDML) (OMG, 2014b) was developed to integrate the concepts of the existing value modeling languages, which address different and partial aspects of the infrastructure perspective. Finally, the process perspective is addressed by using process modeling languages which identify the collection of interlinked organizational processes that are needed to execute the organizational value creation/delivery activities. These are further specified by operational design aspects such as individual responsibilities, activities, data flows, information flows, and the workflow between business process activities (List and Korherr, 2006, Ko et al., 2009, Dumas et al., 2013).

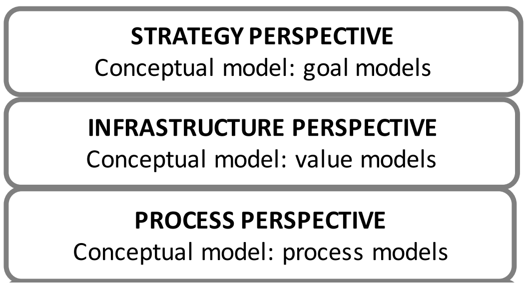


Figure 1.2: Business architecture perspectives with the corresponding conceptual models (Maes, 2007, Andersson et al., 2009, Pijpers et al., 2012)

1.2 Research objectives

1.2.1 General

In this dissertation, we want to tackle the issue of unrealized strategic fit within the business architecture by using the infrastructure perspective as an intermediate layer to align the strategy and process perspectives of the organization. This problem will be approached by combining techniques from the management literature with the use of conceptual modeling languages to provide a model-based solution for the realization of strategic fit, which can be easily understood and communicated by all business stakeholders.

The first research objective (i.e., research cycle A) is oriented towards the infrastructure perspective of the organization to solve the lack of information technology (IT) support for the design and analysis of the business model concept, as conceived in the management literature. This problem will be tackled by investigating how value modeling techniques can provide a business representation that explicitly supports the understanding of the underlying knowledge by business stakeholders. This representation will offer them a model-based solution, which is based on the appropriate business model and value model constructs, that gives insights in how to facilitate the implementation of the strategy in terms of value creation and exchange. As this can help to close the gap that currently exists between the organizational strategy and processes (Veit et al., 2014), this research contribution will facilitates the realization of strategic fit within the business architecture.

However, the realization of strategic fit further depends on the actual alignment of goal models and process models by means of the developed business model representation. To implement this model alignment, a review of the existing alignment techniques in the Conceptual Modeling field is required to decide which of these efforts provides a suitable starting point. This issue is addressed by the second research objective (i.e., cycle B), which aims to align the strategy, infrastructure, and process perspectives within the business architecture. This objective is important as current conceptual modeling techniques only partially address this problem. To solve this, we will propose a model-based solution that incorporates the strengths of existing conceptual modeling languages by realizing strategic fit in a way that explicitly improves the understanding and communication of the organizational strategy by business stakeholders. Therefore, a new modeling technique (i.e., a modeling language, a modeling procedure, and a prototype software tool) is designed by building on appropriate frameworks in the management literature (see section 1.1.2). This includes the use of the business model concept to capture the organizational infrastructure perspective. In this regard, both research contributions rely on the same conceptual basis as developed by the business model literature.

In the remainder of this section, research cycle A and B are presented in more detail. An overview of cycle A, which describes the development and the experimental evaluation of a business model representation, is given in section 1.2.2. The second research contribution (i.e., cycle B) presents a solution for realizing strategic fit with business architecture heat maps (see section 1.2.3).

1.2.2 Cycle A: The Development and Experimental Evaluation of a Business Model Representation

1.2.2.1 Research Problem

Veit et al. (2014) identified the development of IT to support the design and analysis of business models as an unaddressed research gap. This issue is relevant for companies as business models provide a management tool that can help to deal with the increased competition and fast technological changes (Veit et al., 2014). More specifically, the concept is useful to address the infrastructure perspective of the business architecture. As this perspective can be used to align the organizational strategy and processes, research cycle A contributes to the realization of strategic fit (see figure 1.3).

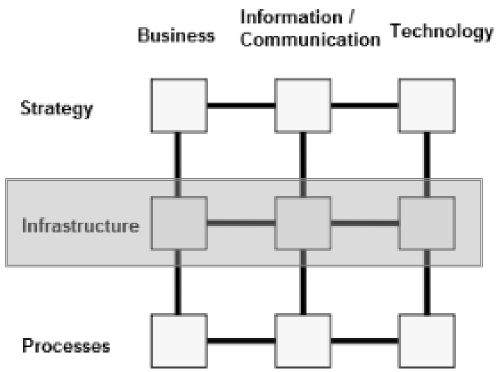


Figure 1.3: Focus of research cycle A

The lack of IT support for designing and analyzing business models can be solved by (i) providing a business model representation by (ii) making use of a conceptual modeling language to create a common language for the relevant business stakeholders, which (iii) results in a better understanding about the underlying business model knowledge (Gordijn and Akkermans, 2003, Osterwalder et al., 2005).

The development of a business model representation was not straightforward as several interpretations and applications of the business model concept co-existed (Shafer et al., 2005). Although integrative research was performed to unify the early ideas, there was no agreement on a common conceptual basis for the business model concept. This fragmented view hindered the understanding about the relation between the business and IS design (Osterwalder et al., 2005). This could be solved by initiating a convergent thinking phase about the business model concept. Therefore, the following research question (i.e., RQ A1) needed to be solved.

RQ A1 Which common business model components (i.e., model elements and their interrelations) underlie the integrative research on the business model concept?

As the scope of value models is explicitly oriented towards the creation and exchange of value (OMG, 2014b), these conceptual modeling languages are suited to provide a business model representation. VDML (OMG, 2014b) is our choice of representation language as it is the only value modeling language that can be used to provide a complete business model representation. This is an important advantage as it enables us to represent all business elements by a single modeling language, which facilitates the integration of information between different diagrams. Indeed, the application of multiple value modeling techniques could result in inconsistencies in the definition and use of modeling constructs, which hinders a clear understanding of the underlying knowledge. However, the VDML meta-model also consists of constructs that are beyond this scope. Therefore, it was investigated which VDML constructs are explicitly needed to provide the business model representation (i.e., RQ A2).

RQ A2 Which VDML meta-model constructs are needed to provide a business model representation?

Finally, the current graphical representation of VDML was evaluated to assess whether adaptations were needed to facilitate the understanding about the underlying business model knowledge. Therefore, the following research question was formulated (i.e., RQ A3).

RQ A3 How can the VDML meta-model constructs be represented to increase the understanding about the underlying business model knowledge?

1.2.2.2 Research Design

Research cycle A results in the design of three main research artifacts: (i) a set of business model components, (ii) a set of VDML meta-model constructs, and (iii) a business model representation. The creation of these research artifacts (i.e., constructs and models) is guided by the Design Science methodology to contribute new knowledge to the existing disciplinary knowledge base (i.e., scientific significance) and to provide solutions to important business needs (i.e., practical relevance) (Hevner et al., 2004). This methodology is implemented by iterative cycles of the build-and-evaluate research process., which consists of the following activities: problem identification and motivation, definition of the solution objectives, design and development, demonstration, evaluation, and scholarly communication (Peffers et al., 2007) (see figure 1.4).

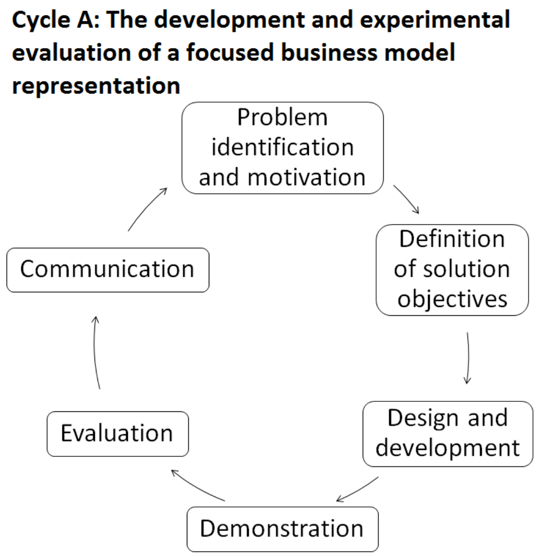


Figure 1.4: Research design of cycle A

- Problem Identification and Motivation

The identification of the research problem and its practical relevance are discussed in section 1.2.2.1. Furthermore, this section also clarifies how a better design and analysis of business model contributes to the realization of strategic fit.

- Definition of Solution Objectives

The definition of the solution objectives was already discussed in section 1.2.2.1, which infers these objectives from the addressed research problem and existing solutions (Peffers et al., 2007). This resulted in the formulation of three main research questions (i.e., RQ A1-A3).

- Design and Development

The identification of the business model components, which addresses RQ A1, was informed by a Systematic Literature Review (SLR) (Kitchenham et al., 2004, Brereton et al., 2007, Kitchenham et al., 2009) to discover and analyze the relevant integrative business model research. To provide an answer to RQ A2, the VDML meta-model constructs were evaluated with respect to their coverage of the business model components that are identified by RQ A1. Based on the definitions of these components, we were also able to assess whether the constructs are defined at the right level of abstraction. The development of the solution for RQ A3 was guided by principles of the Physics of Notations design theory for diagrammatic effectiveness (Moody, 2009) to assess and improve the extent to which the existing graphical notation of VDML supports human understanding.

- Demonstration

The proposed business model representation, which provides an answer to RQ A3, was demonstrated by applying it to the healthcare (OMG, 2012b) and manufacturing (OMG, 2012c) case examples. Apart from showing the feasibility of both design process and product (Hevner et al., 2004), these model instantiations were used for the subsequent evaluation of the proposed improvements.

- Evaluation

The effect of the proposed business model representation on the understanding of the underlying business model knowledge was evaluated by means of a controlled lab experiment with students. This evaluation method was particularly useful to protect the internal validity by making use of a controlled experimental design, strictly applied operational procedures, and a homogeneous group of participants. The investigated effect was the efficacy of understanding the new case model instantiations in comparison with the efficacy of understanding the original VDML diagrams. The design of this experiment was guided by guidelines (Bodart et al., 2001, Gemino and Wand, 2004, Parsons and Cole, 2005, Burton-Jones et al., 2009, Poels et al., 2011) that limit possible validity threats.

- Communication

The answer to RQ A1 was presented at the forum of the 25th International Conference on Advanced Information Systems Engineering (CAiSE 2013). Chapter 2 presents an extended version of this paper, which was accepted after a review process that resulted in an acceptance rate of 21.1% of the submitted papers. The research about RQ A2 and A3 is published in the Business and Information Systems Engineering journal, which is listed in the 2nd quartile of the ISI Science Citation Index (impact factor 2013: 1.095). The answer to RQ A2 was further communicated by a short paper at the 32th International Conference on Conceptual Modeling (ER'13), which was characterized by an acceptance rate of 31.7% of the submitted papers). Chapter 3 of this dissertation integrates both papers. Detailed references can be found in section 1.4.

1.2.3 Cycle B: Realizing Strategic Fit with Business Architecture Heat Maps

1.2.3.1 Research Problem

The realization of strategic fit within the business architecture was an important challenge in practice to ensure that the proper activities are executed to sustain the organizational goals (Schieman, 2009, Popova and Sharpanskykh, 2011, Verweire, 2014). Research in the field of Conceptual Modeling addresses this issue by the development of a wide range of modeling techniques that provide visual representations to improve the understanding and communication about the business architecture. These techniques address the three main drivers for the realization of strategic fit by (i) the alignment of the business architecture perspectives in a top-down and/or bottom-up manner, (ii) the use of performance measurement to guide process outcomes towards the intended strategic objectives by setting clear performance targets and keeping track of the actual organizational performance, and (iii) the development of a conceptual model that is explicitly oriented towards improving the understanding and communication of the organizational strategy by business stakeholders.

However, as none of the modeling techniques has the appropriate characteristics to address all three drivers of strategic fit, they only provide partial solutions to the articulated problem. Hence, RQ B was formulated to design a conceptual modeling technique that contributes to a better alignment of the strategic and process perspectives in the business architecture (see figure 1.5).

RQ B How can we realize strategic fit within the business architecture by means of a conceptual modeling technique, which builds on the strengths of existing techniques to address all three drivers of strategic fit?

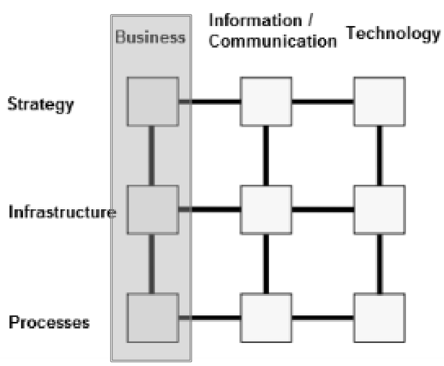


Figure 1.5: Focus of research cycle B

1.2.3.2 Research Design

Different research artifacts emerge from answering RQ B. Indeed, designing a conceptual modeling technique involves the design of a modeling language, which is defined by its syntax, semantics, and visual notation, and a modeling procedure that guides the actual creation of model instantiations (Karagiannis and Kühn, 2002). Moreover, a prototype software tool was developed to implement the modeling technique. The design of these research artifacts is guided by the Action Design Research (ADR) methodology (Sein et al., 2011), which is a specific type of Design Science research, to design a research artifact that explicitly provides theoretical contributions to the academic knowledge base, while solving a practical organizational problem (Sein et al., 2011). Given the practical nature of the research problem, ADR is particularly useful to ensure a rigorous design of the research artifact, which is further shaped through interaction with the organizational context. To this end, ADR differentiates between the following research stages: problem formulation, building, intervention, and evaluation, reflection and learning, and formalization of learning (see figure 1.6).

Cycle B: Realizing strategic fit with business architecture heat maps

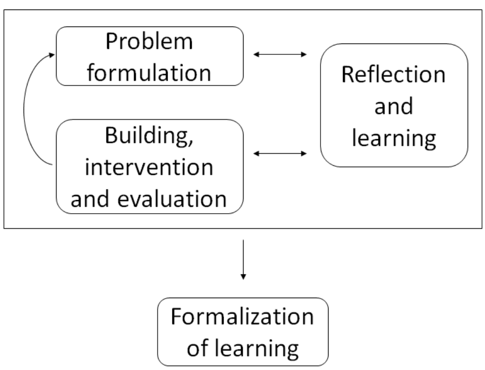


Figure 1.6: Research design of cycle B

- Problem Formulation

The issue of unrealized strategic fit in the business architecture is clarified in section 1.2.3.1. Moreover, this section provides an argumentation for the design of a new modeling technique that fully addresses the main drivers of strategic fit.

- Building, Intervention, and Evaluation

The design of the new Process-Goal-Alignment (PGA) technique included the development of a modeling language that integrates business architecture elements, which are related to the strategy, infrastructure, and process perspectives. By adopting this approach, strategic fit could be realized both in top-down and bottom-up manner. The identification of the relevant elements was based on appropriate conceptual frameworks in the management field (i.e., the Balanced Scorecard (Kaplan and Norton, 1992), the business model concept as addressed by RQ A1, and the Value Chain concept (Porter, 1985)) to improve the understanding and communication of the organizational strategy by business stakeholders. In this respect, we build on the research results of RQ A1. This modeling language was extended by a heat mapping technique to incorporate a performance measurement mechanism and to provide an intuitive visualization that further improves its comprehensibility by business stakeholders. This newly designed language was also accompanied by a modeling procedure that guides the proper application of the PGA technique.

The intervention in the organization was implemented by three case studies that were performed in collaboration with representative end-users of a major IT solution provider. Each of these case studies provided a practical context, in which the PGA technique could be applied to gain insights in how to better realize strategic fit in the business architecture. In the first case study, it was investigated whether the existing business architecture was suited to address changed customer expectations in the product market. While the second application of the PGA technique was oriented towards sustaining the future growth of the company, the third case study was needed to address the gap between the strategy that was adopted in the product market and the operational processes. These interventions were guided by a strategy consultant, who applied the PGA technique in collaboration with the end-users. To enable an automated application of the proposed technique during the case studies, a software tool was developed by means of the ADOxx meta-modeling platform (Fill and Karagiannis, 2013).

The intervention through case studies allowed an evaluation of the proposed technique by both the consultant and the end-users. The evaluation by the consultant was based on a qualitative analysis of the complexity, applicability, and comprehensibility of the different mechanisms in the PGA technique (Lüftenegger, 2014). The end-user evaluation included a quantitative and qualitative assessment of how well the technique supports the requirements for realizing strategic fit. This evaluation is an important aspect in the application of the ADR methodology (Frank, 1998).

- Reflection and Learning

Reflection and learning is performed in parallel with the first two ADR stages, which stresses the importance of a continuous shaping of the research artifact by organizational use, perspectives, and participants (Sein et al., 2011). This was implemented by using the results of the case studies as input for the refinement of the modeling technique. More specifically, these refinements were primarily based on the evaluation of the proposed technique by the strategy consultant (cfr., supra).

- Formalization of Learning

Formalization of learning includes the development of the proposed technique into a generic solution for the class of field problems (Sein et al., 2011). To improve the generalizability of the situational learning, the proposed modeling technique was incrementally adapted during the different case studies.

1.3 Structure of the PhD Dissertation

This PhD dissertation consists of five chapters. The first chapter is an introduction, which provides insights to the reader about the coherence between the research of chapter 2, 3, and 4. These chapters are a collection of papers, which are either published in (i.e., chapter 2 and 3) or submitted to (i.e., chapter 4) international journals, conferences, and/or workshops (see section 1.4 for more details). The last chapter is a conclusion, which provides a summary of this dissertation.

- Chapter 1: Introduction

  The introduction clarifies the research context (section 1.1), objectives and design (section 1.2) of the research presented in chapters 2, 3, and 4. Furthermore, it describes the structure of the PhD dissertation (section 1.3) and provides an overview of the research that was published during the course of this PhD (section 1.4).

- Chapter 2: Towards an Integrative Component Framework for Business Models: Identifying the Common Elements Between the Current Business Model Views

  This chapter presents a component framework that provides a common conceptual basis for the business model concept. More specifically, the results of this research are described in section 2.4, which provides an answer to RQ A1. These results are further used in chapter 3 and 4.

- Chapter 3: The Development and Experimental Evaluation of a Business Model Representation

  Chapter 3 describes the research results of research cycle A. Section 3.2 identifies the set of VDML meta-model constructs that is suited to capture the business model concept, which solves RQ A2. As section 3.3 is oriented towards the design of the new business model viewpoint, it answers RQ A3. Ultimately, the experimental evaluation of the new business model representation is presented in section 3.4.

- Chapter 4: Realizing Strategic Fit with Business Architecture Heat Maps

  This chapter presents a modeling technique that is suited to realize strategic fit within the business architecture (i.e., RQ B). In section 4.4.1, the initial version of the PGA technique is presented, while section 4.4.2 describes the adaptations that resulted from the case study application. The evaluation of the technique by the end-users is discussed in section 4.4.3. Finally, section 4.4.4 is oriented towards the formalization of learning.

- Chapter 5: Conclusion

  The conclusion gives an overview of the main research results, which answer the research questions that were raised in the introduction. Furthermore, this chapter discusses implications and opportunities for future research.

1.4 Publications

This section gives an overview of all publications, which are realized during the PhD project, in international journals (section 1.4.1) and peer-reviewed conference proceedings (section 1.4.2), as well as the presentations that were made at other conferences and workshops (section 1.4.3). After each reference, it is indicated which chapter of this dissertation contains the contents of these publications/presentations. It should be noted that the research of chapter 4 is submitted to an academic journal and at the moment of writing under review. The papers that were part of our research, but are not directly related to the research objectives central to this dissertation, are marked with the tag *[Not included]*.

1.4.1 Publications in Peer-reviewed International Journals

- Roelens B and Poels G (2015) The Development and Experimental Evaluation of a Focused Business Model Representation. Business & Information Systems Engineering 57(1), 61-71. *[Chapter 3]*
- Poels G, Decreus K, Roelens B, and Snoeck M (2013) Research Review: Investigating Goal-oriented Requirements Engineering for Business Processes. Journal of Database Management 24(2), 35-71. *[Not included]*

1.4.2 Publications in Peer-reviewed International Conference Proceedings

1.4.2.1 Listed in Web of Science (P1)

- Roelens B and Poels G (2014) The Creation of Business Architecture Heat Maps to Support Strategy-aligned Organizational Decisions. In 8th European Conference on IS Management and Evaluation (ECIME '14). Devos J and De Haes S (eds.), Gent, Belgium. [Chapter 4]

- Boone S, Bernaert M, Roelens B, Mertens S, and Poels G (2014) Evaluating and Improving the Visualisation of CHOOSE, an Enterprise Architecture Approach for SMEs. In 7th IFIP WG 8.1 Working Conference on the Practice of Enterprise Modeling (POEM '14). Frank U, et al. (eds.), LNBIP, vol. 197, pp. 87-102, Springer, Heidelberg. *[Not included]*

- Roelens B and Poels G (2013) Towards a Strategy-Oriented Value Modeling Language: Identifying Strategic Elements of the VDML Meta-model. In 32nd International Conference on Conceptual Modeling (ER '13). Ng W, et al. (eds.), LNCS, vol. 8217, pp. 454–62, Springer, Heidelberg. *[Chapter 3]*

1.4.2.2 Not listed in Web of Science

- Roelens B and Poels G (2013) Towards an Integrative Component Framework for Business Models: Identifying the Common Elements Between the Current Business Model Views. In CAiSE'13 Forum at the 25th International Conference on Advanced Information Systems Engineering. Deneckère R and Proper H (eds.), CEUR-WS, vol. 998, pp. 114-21, Valencia, Spain. *[Chapter 2]*

1.4.3 Other Conference and Workshop Contributions

- Roelens B and Poels G (2015) Realizing Strategic Fit with Business Architecture Heat Maps (Abstract). In 9th International Workshop on Value Modeling and Business Ontology (VMBO '15). Tilburg, the Netherlands. *[Chapter 4]*
- Roelens B (2013) A Method to Ensure the Value of IT Investments. In NESMA najaarsconferentie. Baarn, The Netherlands. [Chapter 4]
- Roelens B and Poels G (2013) Towards a Formal Framework for Business Models: Identifying and Visualizing the Common Elements Between the Current Business Model Views (Abstract). In 7th International Workshop on Value Modeling and Business Ontology (VMBO '13). Delft, The Netherlands. *[Chapter 2]*
- Roelens B (2012) From Business Logic to Business Process: Designing Strategy-Aligned Business Processes. In Doctoral Consortium at the 6th International Conference on Research and Practical Issues of Enterprise Information Systems (CONFENIS '12). Gent, Belgium. *[Chapter 1]*
- Roelens B, Lemey E, and Poels G (2012) A Service Science Perspective on Business Modeling. In 6th International Workshop on Value Modeling and Business Ontology (VMBO '12). Vienna, Austria. *[Not included]*

2

Towards an Integrative Component Framework for Business Models: Identifying the Common Elements Between the Current Business Model Views

Abstract

The business model literature has surged since the beginning of this millennium, but is currently characterized by a lack of shared understanding of the concept. This lack of consensus inhibits the effective use of business models for achieving business-IT alignment, which includes both formulating the appropriate IS requirements and using ISs as strategic resources to differentiate business models. To overcome this problem, a framework is proposed that builds on existing integration efforts to initiate a convergent thinking phase about the business model concept. Therefore, we will make use of the SLR methodology to rigorously select the relevant research. The resulting integrative framework is illustrated by the Southwest Airlines case example.

Keywords

Business Model Concept, Integrative Framework, literature review, Business Model Components

Research contribution

This research was performed to provide an answer to RQ A1 of research cycle A, which describes the development and experimental evaluation of a business model representation (see section 1.2.2.1). This research question was formulated as follows:

RQ A1 Which common business model components (i.e., model elements and their interrelations) underlie the integrative research on the business model concept? (see section 2.4.3)

2.1 Introduction

The business model concept became popular in the late 1990s when the shares of Internet-based enterprises, the so-called dot-com companies, were rapidly increasing (Osterwalder et al., 2005). Business models were then used as instruments to convince investors of the vast potential of electronic business (Magretta, 2002, Shafer et al., 2005). It could be argued that the burst of the Internet bubble made the concept irrelevant. However, the economic concepts which underlie the business model concept are not restricted to e-business as they date back to the early conduct of organized economic trade (Baden-Fuller and Morgan, 2010). Indeed, business models reflect the way in which a company implements its strategy, of which the ultimate goal is value creation for both the enterprise and its customers (Shafer et al., 2005). In other words, the strategic choices of a company and their implications for the way an enterprise does business and what is required hereto, are made explicit in these models (Casadesus-Masanell and Ricart, 2010).

The articulation of a business model will determine the kind of information that is needed by the company and the role this information plays in the implementation of the strategy. As such, the business model used by an enterprise is a major determinant of the functional and non-functional IS requirements (Eriksson and Penker, 2000). Furthermore, the correspondence between the goals of the IS and the business model is crucial to obtain business-IT alignment, which ensures that business value is returned on investments in IT.

The development of the business model concept is a creative problem-solving process, which aims at improving the existing insights. This process is ongoing as evidenced by the vast amount of literature on the topic since the beginning of this millennium. Early thinkers have applied divergent thinking to produce distinct ideas about business models, which has led to an important increase in the existing knowledge, but also to different interpretations and uses of the concept and the coexistence of research in fields such as e-business and IS, besides the management literature (Pateli and Giaglis, 2003, Shafer et al., 2005). Ideally, this variety of new knowledge is used in a subsequent phase of convergent thinking. The goal of this later phase is the search for more rigorous frameworks, by building upon the existing literature (Cropley, 2006).

Although it is clear that the existing business model literature needs a convergent wave of academic research, this phase has not yet been initiated today. Integration efforts were already made in the past (e.g., (Hedman and Kalling, 2003, Osterwalder, 2004, Pateli and Giaglis, 2004, Morris et al., 2005, Shafer et al., 2005, Tikkanen et al., 2005, Al-Debei and Avison, 2010, Demil and Lecocq, 2010, Zott and Amit, 2010)), but there is a lack of shared opinions between these efforts. Although the diversity in thinking can be partly explained by the multi-disciplinary nature of the business model concept (Pateli and Giaglis, 2003), there is still no agreement on a common conceptual basis which underlies the existing frameworks. Consequently, the current business model research can be considered as the result of a second wave of divergent thinking, based on the results of the first wave. After more than a decade, the development of an integrative, broadly accepted framework for business models still remains an important challenge. Overcoming this challenge is important for a clearer formulation of business models, since the existing fragmented view often hinders the mutual understanding about the relation between the business and the IS domain (Osterwalder et al., 2005). This problem is important as the IS currently plays a strategic role in many companies, since it facilitates the creation of a competitive advantage that is hard to imitate (Hedman and Kalling, 2003). The lack of a mutual understanding inhibits the identification of both the right IS requirements and new business model opportunities, potentially realized by ISs. This understanding is crucial for the realization of business-IT alignment and the improvement of choices concerning the IT infrastructure and its applications (Osterwalder et al., 2005).

The goal of our research is to create a common basis for the business model concept through an integrative framework. We aim at (i) defining the constituting elements of a business model and (ii) defining the interrelations between these elements, which provides a basis for the development of conceptual models. Our framework will facilitate academic research on business model taxonomies, adoption factors, change methodologies, and evaluation models (Pateli and Giaglis, 2004). Indeed, a better understanding of the elementary core elements of business models can help researchers to define new kinds of business models (i.e., taxonomies), to specify new determinants for the use of business models, (i.e., adaption factors), to discover new ways for realizing business model innovation (i.e., change methodologies) (Chesbrough, 2010), and to define criteria for assessing business models (i.e., evaluation models).

The development of the framework was informed by a literature review, performed according to the method that was developed by Kitchenham et al. (Kitchenham et al., 2004, Brereton et al., 2007, Kitchenham et al., 2009). This review enabled us to discover and analyze relevant business model research. In particular, we used the existing integrative research to develop a component framework for business models. This choice is important as the ultimate goal of this research is the real start of the convergent thinking phase, while not just providing another integration effort, which is based on the early literature on business models. This framework is illustrated by making use of the Southwest Airlines case example (Morris et al., 2005, Chesbrough, 2007, Teece, 2010).

The remainder of this chapter is structured as follows. Section 2.2 gives an overview of related work, which was developed within the IS field. In section 2.3, SLR (Kitchenham et al., 2004, Kitchenham et al., 2009) will be discussed as the appropriate methodology that needs to be followed by this research. The actual search and analysis of the integrative business model literature, the resulting component framework, and the illustrative example are presented in section 2.4. This section explicitly provides an answer to RQ A1 (see section 1.2.2.1) of research cycle A, which aims to the development and experimental evaluation of a business model representation. Furthermore, these results were also used in research cycle B for realizing strategic fit with business architecture heat maps (see section 4.4.1.1). Section 2.5 discusses conclusions and some directions for further research.

2.2 Related Work

The IS Engineering discipline has investigated the business model concept in the context of Value-Based Requirements Engineering (Gordijn and Akkermans, 2003), in which value models are developed that offer the potential for elaborate representations of business models in terms of elementary constructs like actors, objects, interface, resources, etc. For instance, models that are constructed by using the meta-model and graphical notation of e^3-value (Gordijn and Akkermans, 2003), show the flow of valuable products (e.g., goods, services, money, etc.), called value objects (Weigand et al., 2006), through a business network of actors. The analysis capabilities of the e^3-value toolset (i.e., net cash flow analysis and sensitivity analysis) allow evaluating alternative designs for a constellation of actors, such that each actor derives utility or profit from participating in the network. It has also been investigated how requirements for the design of business processes can be derived from such value models (Andersson et al., 2006, Edirisurija and Johannesson, 2009). The REA ontology (Geerts and McCarthy, 2002) is a conceptual modeling language, which provides concepts, relations and axioms that can be used to represent the exchange of valuable products and the effect this exchange has on the resource composition, hence value of the involved parties. This ontology has been used to represent transactions and the resulting resource inflows and outflows. Consequently, it helps with the conceptual design of the enterprise IS that supports the realization of the organization’s business model (Sonnenberg et al., 2011). Recently, VDML (OMG, 2014b) is proposed as a standard for value modeling that integrates the existing techniques. In this regard, VDML also allows to include organizational capabilities in the business model representation.

Although the use of value modeling approaches provides representations of the business logic of an organization in terms of value creation and exchange, these approaches not explicitly oriented towards representing business model components. These components are important to capture the business rationale of an organization in terms of the implementation of its strategy. Hence, it is difficult to evaluate whether a value model possesses the ability to implement the organization’s strategy as some of the necessary business model elements remain implicit in the value model representation.

An alternative to value modeling is goal modeling (e.g., i* (Yu et al., 2011), Goal-oriented Requirements Language (Amyot et al., 2010), Business Motivation Model (OMG, 2014a)), which results in representations that facilitate the elicitation, specification, and analysis/validation (e.g., through goal propagation and conflict detection algorithms) of business requirements, from which to derive IS requirements. As goal models are expressed in terms of which objectives a company wants to achieve (i.e., a formulation of the intended strategy), they operate at a higher level of abstraction than business models. Indeed business models are meant to implement the intended strategy and are more expressive with respect to the overall value chain of business activities that runs through the organization and extends beyond the organization’s borders. Consequently, it is important for companies to ensure the alignment of goal models and business models, as this alignment determines whether a company can successfully implement its strategy according to the goals it wants to achieve.

Our review of related work indicates that the research on business model representation is also divergent, as approaches may focus on different aspects of the intended strategy (i.e., value modeling, capability modeling, and goal modeling). Furthermore a Requirements Engineering perspective on the business model concept is taken with the aim of ensuring the alignment of business, process, service, and system requirements. Overall, there is little grounding of the business model representation research on the business model concept research, making it hard to evaluate whether these representations really capture the concept as intended. Therefore, the proposed framework is based on the integration of the business model research (for defining the constituting elements of business models and their interrelations), while acting as an important bridge between the different representations of the strategy of a firm. Consequently, this framework can help to provide business model representations, which could be further used to develop conceptual models of business processes and ISs.

2.3 Methodology

The SLR methodology was developed by Kitchenham et al. in the context of evidence-based Software Engineering (and inspired by evidence-based Medicine), but is also applicable outside this field (Kitchenham et al., 2004). The purpose of this literature study methodology is to integrate the existing body of knowledge of a certain research topic (Kitchenham et al., 2009). The main advantage of using SLR for literature study is the use of a systematic approach that employs an a priori defined review protocol to search the literature. This review protocol consists of three elements: the identification of research questions (section 2.3.1), the definition of the study selection criteria (section 2.3.2), and the definition of the study quality assessment criteria (section 2.3.3). Although the SLR methodology guides the general use of this research protocol, the specific selection and quality assessment criteria were based on own insights in the available business model literature.

2.3.1 Identification of Research Questions

The explicit formulation of research questions, driven by the research problem and research objectives, is important as it makes explicit the information that is searched for in the literature (Kitchenham et al., 2004). The following research question (i.e., RQ A1) needed to be answered to deliver the content of an integrative framework for the business model concept:

RQ A1 Which common business model components (i.e., model elements and their interrelations) underlie the integrative research on the business model concept?

Although an element can be considered as common if it is proposed by at least two researchers, only those components that appear in the majority of the integrative research were included in our framework. This choice was made deliberately to ensure that the proposed framework explicitly captures the common conceptual basis for the business model concept.

2.3.2 Study Selection Criteria

Due to the multi-disciplinary character of the business model concept, the search process was not restricted to discipline-specific e-libraries, but Google Scholar was chosen as the electronic source to search as much scientific material as available in the existing literature. Indeed, as the relevant business model literature is identified in research fields such as management, e-business, and IS (Shafer et al., 2005), it was better not to exclude certain publication sources (i.e., journals, books, or conference proceedings) upfront. Indeed, this allowed for a broad search on the literature about the business model concept, as it is conceived in these research fields. Afterwards, an ex-post evaluation of the publication data of the relevant research was performed (Al-Debei and Avison, 2010). This was implemented by analyzing the number of citations and the impact factors of the journals of the selected literature. Research efforts were excluded if their total number of citations was significantly lower (i.e., lower than 5%) than the citation count of the most-cited work <u>and</u> the current impact factor (i.e., 5-year impact factor 2011) of the publication source is lower than 2 or is not applicable. The use of these thresholds allowed us to retain scientific literature, which is published in high-quality academic journals and/or is broadly accepted within its research field. The search results were sorted on relevance to ensure that the most significant research was included in the literature list that is displayed by Google Scholar, which consists of a maximum of 1000 references.

The second decision to be taken in the selection of studies is the definition of the search terms, which is informed by the formulation of the research question. Since the ever-growing use of the term *business model*, both inside and outside the academic literature since the beginning of the millennium (Zott et al., 2011), we decided not to expand the search terms to any other alternative of "*business model"*. More specifically, all publications between 1998 (i.e., the moment at which early business model literature was published) and 2012 (i.e., the time at which this literature study was performed) were included.

As our aim is the creation of a common basis for the business model concept through an integrative framework, in order to start the initiation of a convergent thinking phase in the existing ideas about business models, the inclusion and exclusion criteria that were imposed are more restrictive. A first criterion (i.e., the *business model components criterion*) aims to only include literature about the definition of the business model concept. Literature that adopts an existing definition, but in which other aspects related to the business model concept are the object of study (e.g., business model evaluation models, business model change methodologies, business model adoption factors) is excluded from the analysis. The second criterion (i.e., the *normative research criterion*) includes research that develops a normative view (Casadesus-Masanell and Ricart, 2010) on the constituting elements of a business model (i.e., the overarching business model concept (Osterwalder et al., 2005)). Many authors take a descriptive view by discussing the business model concept as it is applied by a particular enterprise (e.g., the business model of McDonalds) or by identifying business model patterns based on commonalities in the business models observed for a group of similar enterprises (e.g., the McDonalds business model for fast-food companies). If research does not analyze the constituting elements in terms of which business model information is expressed, it is excluded from the analysis. However, purely defining the constituting elements is not sufficient as our aim is the review of the integrative business model research. Hence, the last criterion (i.e., the *integration effort criterion*) imposes relevant literature to build on existing views about the business model concept. This criterion was operationalized by investigating the research motive and only including those efforts that explicitly claimed to provide an integration effort of the existing business model literature.

These selection criteria were assessed following the two-stage process suggested by Brereton et al. (Brereton et al., 2007). In a first step the title, abstract, introduction, and conclusion were analyzed by two researchers. If they both concluded that a search result was irrelevant, it was definitively rejected. For the other literature, the full version was revised and a final unanimous decision (i.e., disagreements were discussed and resolved) on the selection criteria was taken.

2.3.3 Study Quality Assessment Criteria

The quality of the research that satisfies the selection criteria can be assessed by using further criteria, which are specified in quality assessment questions. Within the scope of this research, the assessment questions were important to ensure that the proposed framework builds on (i) integrative research, which (ii) is of sufficient quality by performing a thorough review of the early (i.e., first-generation) research on the business model concept. Consequently, two quality assessment questions were formulated:

QA_1: Did the research develop an own integrative framework, either textual or graphical, which extends the review of previous literature?

QA_2: Did the research perform a thorough search for the available literature at that point of time?

These questions were scored by the two researchers on a ordinal scale including Y (yes), P(partly), and N (no) (Kitchenham et al., 2009). Also here, any differences in opinion were discussed and resolved to reach consensus. As the purpose of this assessment is to provide support for the selection process by the further refinement of the integration effort criterion that is imposed on the selected literature, only those research efforts that score at least Y for QA_1 and P for QA_2 were used for the final integrative framework.

QA1: Y: An own integrative framework, either textual or graphical, is presented in the research.

N: The integration is limited to a review of previous research.

QA2: Y: The research refers to at least 50% of the aggregated first-generation academic work.

P: The research refers to between 25% and 50% of the aggregated first-generation academic work.

N: The research refers to less than 25% of the aggregated first-generation academic work.

An article was considered as being of the first generation if at least two authors within the set, which results from applying the study selection criteria, referred to it. Papers written by the same authors and dealing with the same research subject, were aggregated.

2.4 Results

2.4.1 Selection Results

The analysis of the 1000 most relevant search results of Google Scholar led to the identification of 55 papers, which met the business model components criterion. After applying the normative research and integration effort criteria, 15 papers remained and were considered to be relevant for our research. More information about the literature that met the consecutive selection criteria can be found in table 2.1.

Criterion	**Number of papers complying to the criteria**
Business model components criterion	55
Normative research criterion	49
Integration effort criterion	15

Table 2.1: Results of the application of the selection criteria

The publication data of the selected papers were evaluated afterwards, based on the last available impact factors of the journals (i.e., 5-year impact factor 2011) and the total number of citations of the individual research efforts (according to the data given by Google Scholar). This resulted in the exclusion of two conference papers, as the respective number of citations (i.e., 0.8% (Verstraete and Jouison, 2007) and 3.2% (Warnier et al., 2004)) was less than 5% of the citations of the most-cited research (Osterwalder, 2004) and the impact factor was not applicable. More details about the ex-post evaluation of the publication sources can be found in table 2.2.

Reference	Publication source	5-year impact factor 2011	Number of citations
Al-Debei and Avison (2010)	European Journal of Information Systems	2.218	49
Hedman and Kalling (2003)	European Journal of Information Systems	2.218	331
Morris et al. (2005)	Journal of Business Research	2.473	536
Osterwalder (2004)	PhD dissertation	-	594
Pateli and Giaglis (2003) Pateli and Giaglis (2004)	Electronic Commerce Conference European Journal of Information Systems	- 2.218	127 160
Shafer et al. (2005)	Business Horizons	0.900	420
Teece (2010)	Long Range Planning	2.372	330
Tikkanen et al. (2005)	Management Decision	1.302	142
Verstraete and Jouison (2007)	Conference of the International Association of Strategic Management	-	5
Warnier et al. (2004) Lecocq et al. (2006) Demil and Lecocq (2010)	Conference of the International Association of Strategic Management Expansion Management Review Long Range Planning	- - 2.372	19 36 97
Zott and Amit (2008) Zott and Amit (2010)	Strategic Management Journal Long Range Planning	3.783 2.372	257 159

Table 2.2: Ex-post evaluation of the publication data

2.4.2 Study Quality Assessment

The last step in the execution of the search protocol was the assessment of the quality of the 13 papers included in the analysis. The overview of this analysis can be found in table 2.3. The calculation of the reference percentage was based on table 2.4, in which 24 aggregated first-generation research efforts were identified. An article was considered as first-generation business model research if at least two of the 13 articles referred to it. Calculating the ratio of the number of references to this first-generation research and the total set of 24 articles, results in the percentages that are listed in table 2.3.

The result of the first quality assessment question was that all of the remaining research provides an integrative framework, which results in a score of Y for these efforts. The second quality assessment provided more differentiation: 30% of the selected research referred to more than 50% of the aggregated first-generation academic work, 60% referred to between 25% and 50% of the first-generation literature, and one paper referred to only 12.5% of this first-generation academic work. Consequently, this research (Teece, 2010) was not further used for the development of the integrative business model component framework.

Reference	Research field	Integrative framework	Reference Percentage
Osterwalder (2004)	IS	Y	Y (20/24 = 83.3%)
Pateli and Giaglis (2003) Pateli and Giaglis (2004)	e-business IS	Y	Y (16/24 = 66.7%)
Morris et al. (2005)	Management	Y	Y (13/24 = 54.2%)
Shafer et al. (2005)	Management	Y	P (10/24 = 41.7%)
Al-Debei and Avison (2010)	IS	Y	P (9/24 = 37.5%)
Hedman and Kalling (2003)	IS	Y	P (9/24 = 37.5%)
Lecocq et al. (2006) Demil and Lecocq (2010)	Management Management	Y	P (8/24 = 33.3%)
Tikkanen et al. (2005)	Management	Y	P (7/24 = 29.2%)
Zott and Amit (2008) Zott and Amit (2010)	Management Management	Y	P (6/24 = 25.0%)
Teece (2010)	Management	Y	N (3/24 = 12.5%)

Table 2.3: Results of the study quality assessment

As can be further seen in table 2.3, the performed literature study resulted in the identification of a wide variety of research. Indeed, the identified academic work originates in the e-business, IS, and management literature. This indicates a parallel evolution of the business model concept in these research fields, which can be explained as the relevant integrative frameworks largely build on the same set of first-generation research.

Paper / Refers to	Al-Debei and Avison 2010	Hedman and Kalling 2003	Lecocq et al. 2006 Demil and Lecocq 2010	Morris et al. 2005	Osterwal-der 2004	Pateli and Giaglis 2003, 2004	Shafer et al. 2005	Teece 2010	Tikkanen et al. 2005	Zott and Amit 2008, 2010
Afuah and Tucci 2001		x		x	x	x	x			x
Alt and Zimmerman 2001				x	x	x				
Amit and Zott 2001	x	x	x	x	x	x	x	x	x	x
Applegate 2001		x		x	x	x				
Brandenburger and Nalebuff 1996			x		x					
Chesbrough & Rosenbloom 2002 Chesbrough 2003	x (02)		x (02)	x (02)	x (02)	x (02)	x (03)	x (02)		x (02)
Dubosson-Torbay et al. 2001	x			x	x		x			
Gordijn and Akkermans 2001, 2003	x (01)			x (01)	x (02)	x (01)				
Hamel 1999, 2000				x (00)	x (00)	x (00)	x (00)		x (99)	
Kraemer et al. 2000						x				
Linder and Cantrell 2000	x			x	x	x				
Magretta 2002	x		x		x	x	x	x	x	x
Mahadevan 2000					x	x			x	
Papakiriakopoulos et al. 2001					x	x				
Porter 1980, 1985, 2001		x (80, 85, 01)	x (80, 85, 01)	x (85)	x (85,01)		x (01)		x (80)	x (85)
Rappa 2002		x			x	x				
Rayport and Jaworsky 2002		x		x			x			
Stähler 2002	x				x					
Tapscott et al. 2000					x	x				
Timmers 1998	x	x	x	x	x	x	x			
Vankatraman and Hendersson 1998	x		x						x	
Weill and Vitale 2001		x		x	x	x	x			
Williamson 1975, 1999		x (99)	x (75)		x (75)				x (99)	x (99)

Table 2.4: Mutual references to first-generation business model research

2.4.3 Integrative Business Model Framework

2.4.3.1 Business Model Elements

To identify the common business model elements of the existing integrative frameworks, an extensive analysis of the selected papers that survived the quality assessment was performed. As comparable to the approach of Osterwalder (2004), we provided an integrative view by performing an in-depth analysis of both the proposed concept definitions and the supporting research context of these integrative efforts.

Table 2.5 identifies 15 distinct components that are proposed by the selected research, of which 10 elements were eventually included in the model as they are supported by the majority of the literature. As can be seen in this table, authors use different concepts to define the business model components. Therefore, it was needed to integrate these views and to propose definitions for these elements (see infra). In this context, the definitions of customer segment, supplier, competitor and partner are aggregated into the definition of value network. For the reason of clarity, the different business model elements are highlighted in the text.

- Value Proposition

As this element is included in each of the integrative frameworks, it is considered as a core element of the business model concept. Some authors use synonyms for this concept, such as <u>*offering*</u> (Hedman and Kalling, 2003, Shafer et al., 2005), <u>*product and service flow*</u> (Shafer et al., 2005), and <u>*product and service offering*</u> (Tikkanen et al., 2005). As the common denominator of a <u>*value proposition*</u> and its synonyms is the set of offered products and/or services, the following definition was proposed:

The offered set of products and/or services that provides value to the customers and other partners, and competes in the overall value network (Osterwalder, 2004, Tikkanen et al., 2005, Al-Debei and Avison, 2010).

- Competence

The concept of a <u>*(core) competence*</u> and a <u>*capability*</u> occur equally in the identified research. However, we included the competence concept in the integrative framework as it is directly related to organizational value creation, in contrast to capabilities that capture the skillset of individual resources (cfr., infra). Although there is a lot of debate about the meaning of competences, the definition of this concept is based on how it is conceived in the field of competence-based Strategic Management (Prahalad and Hamel, 1990, Sanchez, 2004). As this research field has been maturing since the 1990s, it provides a stable view on this business model element. To further increase the validity of the definition, it is in accordance with the proposal of LEADing practice, which has been developing a wide range of standards for enterprise modeling, EA, etc. For the reason of completeness, both the competence and capability concept are defined below.

Competence
An integrated and holistic set of knowledge, skills, and abilities, related to a specific set of resources, which is coordinated through the value chain to realize the intended value proposition (Prahalad and Hamel, 1990, Sanchez, 2004, LEADing Practice, 2015)

Capability
The ability to perform a particular skillset, which is a function, process or service (LEADing Practice, 2015).

- Resource

Resources are included in all but one integrative research efforts. Although alternative concepts are used for this element (i.e., *key resources* (Osterwalder, 2004) and *assets* (Shafer et al., 2005)), three different resource types are usually identified: human skills (Hedman and Kalling, 2003, Osterwalder, 2004, Tikkanen et al., 2005, Demil and Lecocq, 2010), tangible resources (e.g., capital, raw materials, semi-finished products) (Hedman and Kalling, 2003, Osterwalder, 2004, Tikkanen et al., 2005, Al-Debei and Avison, 2010, Demil and Lecocq, 2010), and intangible resources (e.g., patents, goodwill) (Osterwalder, 2004, Tikkanen et al., 2005, Al-Debei and Avison, 2010). However, these definitions do not explicitly incorporate that these resources are under control of the organization (Geerts and McCarthy, 2002). Therefore, this business model element was defined as follows:

Human skills, tangible means, and intangible means under control of an organization by being bought or licensed, which are combined within the value chain of activities (Geerts and McCarthy, 2002, Osterwalder, 2004).

- Value Chain

Three concepts are closely related within the integrative business model research: *(key) activities* (Hedman and Kalling, 2003, Pateli and Giaglis, 2003, Osterwalder, 2004, Pateli and Giaglis, 2004, Shafer et al., 2005, Lecocq et al., 2006, Zott and Amit, 2008, Demil and Lecocq, 2010, Zott and Amit, 2010), (internal) *processes* (Pateli and Giaglis, 2003, 2004, Morris et al., 2005, Shafer et al., 2005, Tikkanen et al., 2005), and the *value chain* (Lecocq et al., 2006, Demil and Lecocq, 2010). Although activities are proposed by the majority of authors, we chose to incorporate the value chain element within the integrative business model framework. This was done to avoid confusion between the infrastructure and process perspectives of an organization (see section 1.1.1). Indeed, as business models focus on the implementation of a strategy (i.e., the infrastructure perspective), they should not be explicit about operational process details such as individual activities. As a result, the value chain concept can be seen as a representation of the resources that are input and output of black-box (i.e., an aggregation of the constituting activities (Porter, 1985)) processes to create the organizational competences. This resulted in the following definition:

The business process architecture, which aggregates a structured set of activities that combines resources to create the organizational competences (Porter, 1985, Tikkanen et al., 2005, Demil and Lecocq, 2010).

- Financial Structure

The *financial structure* combines the cost and revenue model of the organization. The literature study revealed that a consistent denomination of this concept is missing as each of the reviewed frameworks proposes an own alternative. However, as the underlying meaning is quite commonly supported, we built on the proposal of Osterwalder (2004):

A representation of the costs, resulting from acquiring resources, and the revenues in return for the offered value proposition (Osterwalder, 2004).

- Value Network

The targeted customer segment is identified as relevant by all existing integrative frameworks. Although this element is commonly denominated as *customer* (Hedman and Kalling, 2003, Morris et al., 2005, Shafer et al., 2005, Lecocq et al., 2006, Zott and Amit, 2008, Demil and Lecocq, 2010, Zott and Amit, 2010), the concept of a *customer segment* (Osterwalder, 2004, Tikkanen et al., 2005) was preferred as it refers to a group with similar characteristics and/or preferences (OMG, 2014b). Apart from the targeted customer segment, all but one of the relevant business model research efforts stress the importance of building relationships with *partners*, who provide resources and/or benefit from the offered value proposition. Finally, the majority of the reviewed literature also includes *suppliers* (Hedman and Kalling, 2003, Osterwalder, 2004, Shafer et al., 2005, Tikkanen et al., 2005, Lecocq et al., 2006, Zott and Amit, 2008, Al-Debei and Avison, 2010, Demil and Lecocq, 2010, Zott and Amit, 2010) and *competitors* (Hedman and Kalling, 2003, Shafer et al., 2005, Tikkanen et al., 2005, Lecocq et al., 2006, Zott and Amit, 2008, Al-Debei and Avison, 2010, Demil and Lecocq, 2010, Zott and Amit, 2010) as relevant actors in the value network. This resulted in the following definition for the *value network*:

Web of relations created between the company and its external stakeholders, including suppliers, customers, competitors and partners (Shafer et al., 2005, Demil and Lecocq, 2010).

- Distribution Channel

Two concepts are used to capture customer contacts in the integrative business model research: *(distribution) channel* (Osterwalder, 2004, Morris et al., 2005, Tikkanen et al., 2005, Al-Debei and Avison, 2010) and *(customer) relationships* (Osterwalder, 2004, Shafer et al., 2005). These concepts are clearly related as the choice of a distribution channel (e.g., direct sales via the internet) will determine the kind of relationship that can be developed with the targeted customer segment (e.g., short-term, superficial relationships). As the concept of a distribution channel is commonly used in the relevant literature, this business model element was defined as follows:

The way in which the offering is made available to the customers (Morris et al., 2005).

- Strategy – Mission

Mission (Pateli and Giaglis, 2003, 2004, Shafer et al., 2005) and *(competitive) strategy (and structure)* (Morris et al., 2005, Shafer et al., 2005, Tikkanen et al., 2005) are included to capture the strategic objectives that give meaning and direction to the development of the business model (Tikkanen et al., 2005). Although these concepts are useful for the analysis of the strategy perspective of an organization (see section 1.1.1), they are outside the scope of the business model concept.

- Investment model

The *investment model* is proposed as a business model element by Morris et al. (2005) to capture the organizational time, scope, and size ambitions. More specifically, these aspects cover the financial growth rate of the company and the return on investment that is offered to investors. The investment model is related to *governance*, which is proposed as a business model element by two authors (Tikkanen et al., 2005, Zott and Amit, 2008, 2010) of the reviewed literature. This concept is oriented towards the use of appropriate mechanisms to align management interests with those of capital suppliers (Shleifer and Vishny, 1997). Although these elements are not explicitly included in our proposal, such decisions can be supported by considering investments as a monetary resource, which is provided by shareholders or bought from financial institutions (see section 2.4.3.2). Moreover, financial growth can be analyzed through the financial structure, which represents both the organizational costs and revenue streams.

- Differentiation

Differentiation is discussed in the integrative framework of Shafer et al. (2005) to analyze how the company can offer a value proposition to the targeted customer segment, which is fundamentally different than the value propositions of its competitors (Porter, 1985). Differentiation is a generic strategy that is often contrasted to cost leadership, which focuses on offering products and/or services at the lowest cost in the market (Porter, 1985). The implementation of both a cost leadership and differentiation strategy are included in the proposed framework by the following business model elements: value proposition, customer segment, competitor, and financial structure.

- Management

Apart from the interrelations between the elements, *management* (Hedman and Kalling, 2003) was proposed to include a longitudinal component in the business model framework. This involves *the management of knowledge, norms and values, aspiration levels, and organizational incentives* (Hedman and Kalling, 2003). Although this addresses an important aspect of business models as a whole, it is not generally accepted as being a constituting component. A possible reason is the longitudinal nature of the management concept, which is not in congruence with the constructive view that is adopted by the other business model elements.

- Branding

Although Shafer et al. (2005) distinguish between *branding* and customer relationships, these elements are closely related. Indeed, branding refers to the *firm's ability to engage customers, suppliers, and other partners in mutually beneficial value exchanges that determines its relationship capital and brand* (Dubosson-Torbay et al., 2002). As discussed before, this element is captured through the distribution channel component in the proposed integrative framework.

Concept \ Author	Al-Debei and Avison 2010	Hedman and Kalling 2003	Lecocq et al. 2006, Demil and Lecocq 2010	Morris et al. 2005	Osterwalder 2004	Pateli and Giaglis 2003, 2004	Shafer et al. 2005	Tikkanen et al. 2005	Zott and Amit 2008, 2010	Total occurences
Value proposition	Value proposition	Offering	Value proposition	Value proposition	Value proposition	Value proposition	Value proposition Offering Product and service flow	Product and service offering	Value proposition	9
Customer segment	Market segment	Customer	Customer	Customer	Customer segment	Target market	Customer	Customer segment	Customer	9
Competence	Core competence		Competence	Core competence	Capability	Capability	Capability Core competence	Capability Core competence	Capability	8
Resource	Resource	Resource	Resource		Key resources	Resource	Resource Asset	Resource	Resource	8
Value chain		Activity	Value chain Activity	Internal process	Key activities	Key activities Process	Activity Process	Process	Activity	8
Partner	Partner	Partner	Partnership		Key partners	Partnership	Partner	Extra-business relationships	Partner	8
Financial structure	Value finance		Cost and revenue structure	Revenue source	Cost structure Revenue streams	Cost and revenue model	Cost Profit Financial aspect	Finance and accounting		7
Supplier	Supplier	Supplier	Supplier		Supplier		Supplier	Supplier base	Supplier	7
Competitor	Competitor	Competitor	Competitor				Competitor	Competitor	Competitor	6
Distribution channel	Channel			Distribution channel	Distribution channel Relationship		Customer relationship	Distribution channel		5
				Competitive strategy		Mission	Srategy Mission	Strategy and structure		4
				Investment model				Governance	Governance	3
							Differentiation			1
		Management								1
							Branding			1

Table 2.5: Analysis of the common business model components in the existing frameworks

2.4.3.2 Interrelations

Figure 2.1 shows the relations that exist between the 10 business model elements. These relations are also explicitly included in the definition of the elements (see section 2.4.3.1). Relevant references are added to the following description to indicate the occurrence of relations in the reviewed literature. For the reason of clarity, the business model elements are highlighted in the text.

Companies can obtain their *resources* in two different ways, either by paying *suppliers* for the provision of resources (i.e., a *bought resource*: an employee who is paid for providing labor, a supplier for providing technology, raw materials, or semi-finished products, financial institutions for providing capital, etc.) (Hedman and Kalling, 2003, Osterwalder, 2004, Shafer et al., 2005, Tikkanen et al., 2005, Demil and Lecocq, 2010, Zott and Amit, 2010) or by entering into a *partnership* with an outside actor (i.e., a *licensed resource*: acquiring money from an investor for increasing the equity of the company, insourcing activities from an outside company to achieve economies of scale, acquiring governmental authorizations for performing certain activities, etc.) (Hedman and Kalling, 2003, Osterwalder, 2004, Shafer et al., 2005, Tikkanen et al., 2005, Zott and Amit, 2010). The acquisition of resources implies a cost that affects the *financial structure* of the firm (Osterwalder, 2004, Demil and Lecocq, 2010). Within the internal *value chain*, which reflects the overall business process infrastructure, these resources are combined (Hedman and Kalling, 2003, Osterwalder, 2004, Tikkanen et al., 2005, Al-Debei and Avison, 2010, Demil and Lecocq, 2010) to create *competences* (Hedman and Kalling, 2003, Morris et al., 2005, Tikkanen et al., 2005, Demil and Lecocq, 2010), which realize the *value proposition* of the company (Hedman and Kalling, 2003, Morris et al., 2005, Shafer et al., 2005, Tikkanen et al., 2005, Zott and Amit, 2010). This value proposition is offered (Hedman and Kalling, 2003, Osterwalder, 2004, Morris et al., 2005, Tikkanen et al., 2005, Demil and Lecocq, 2010) to the target *customer segment* through one or more *distributions channels* to realize the value creation for the client (Hedman and Kalling, 2003, Osterwalder, 2004, Morris et al., 2005, Shafer et al., 2005, Tikkanen et al., 2005, Al-Debei and Avison, 2010, Zott and Amit, 2010). Furthermore the value proposition also create revenues (Osterwalder, 2004, Shafer et al., 2005, Tikkanen et al., 2005, Demil and Lecocq, 2010, Zott and Amit, 2010), which will influence the *financial structure* and the eventual value creation for the firm. As companies operate within a *value network* of actors, the rivalry with the existing *competitors* (Hedman and Kalling, 2003, Shafer et al., 2005, Tikkanen et al., 2005, Al-Debei and Avison, 2010, Demil and Lecocq, 2010, Zott and Amit, 2010) and the value creation for the other *partners* (Shafer et al., 2005, Tikkanen et al., 2005, Al-Debei and Avison, 2010, Demil and Lecocq, 2010, Zott and Amit, 2010), who benefit from the value proposition, are also included in the business model.

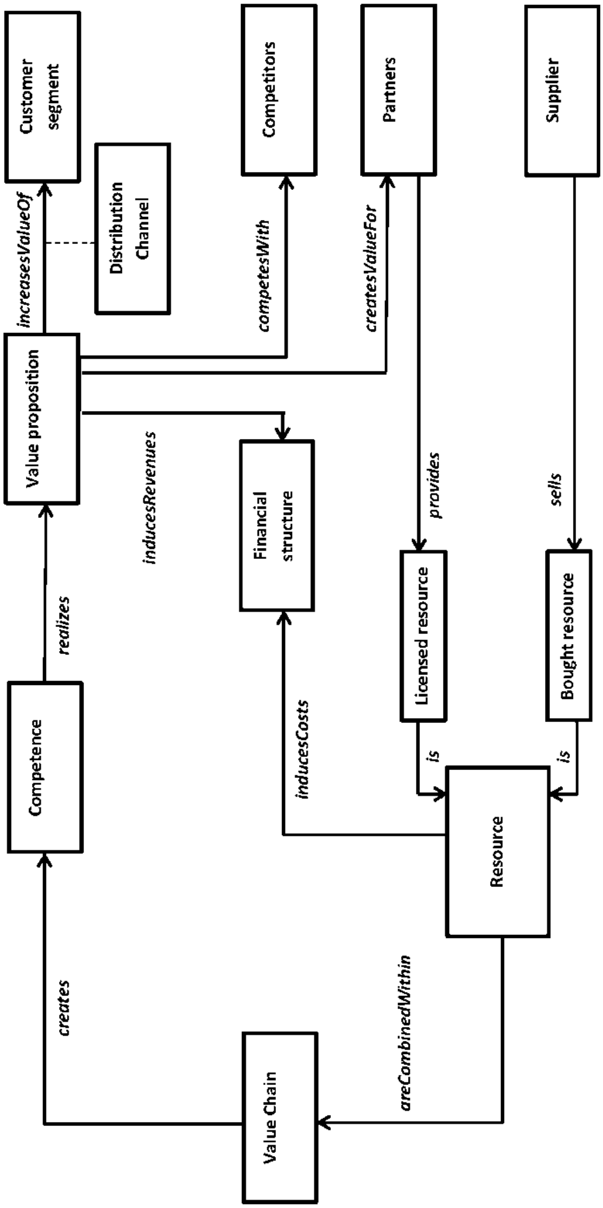


Figure 2.1: Proposed integrative business model framework based on the existing literature

2.4.4 Illustrative Example: Southwest Airlines

The business model of Southwest Airlines, an American low-cost airline company, often recurs in the business model literature as an example that is hard to replicate for competitors (Morris et al., 2005, Chesbrough, 2007, Teece, 2010). The proposed business model framework is applied to this case example to illustrate its use by demonstrating the core elements of the business model concept. The resulting model is given in figure 2.2.

The value proposition of Southwest Airlines is built upon four main components: direct, short-distance flights, limited delays, low fares, and no frills (i.e., no first class, no seat reservations, limited offer of food and drinks, etc.) (Morris et al., 2005, Teece, 2010). This value is offered to the customers in regional markets (i.e., both companies and individual passengers) by a direct sales model, in which no intermediate travel agencies are used (Teece, 2010). In the industry, direct competitors are companies as Delta Air Lines, JetBlue Airways, US Airways Group, and Allegiant Travel (Forbes, 2015). To realize its value proposition, Southwest Airlines has developed an efficient internal operating system as a unique competence, which includes the ability to sustain a high flight capacity and to internalize the strategic values on the operational level (Morris et al., 2005). This competence is created by neither the traditional hub-and-spoke route system (i.e., traffic moves via a central hub) nor code sharing with other airlines. Indeed, the value chain depends on three critical processes: a selective hiring of employees, innovative ground operations, and independent luggage handling (Morris et al., 2005). Southwest Airlines makes use of frontline employee skills (Morris et al., 2005) and standard Boeing 737s (Teece, 2010) as key resources, which are bought from its suppliers. Moreover, the development of partnerships with remote airports enables the company to benefit from an uncongested environment (Morris et al., 2005). These business model components result in a financial structure that is characterized by low costs and a fixed revenue source, which leads to low and stable margins (Morris et al., 2005).

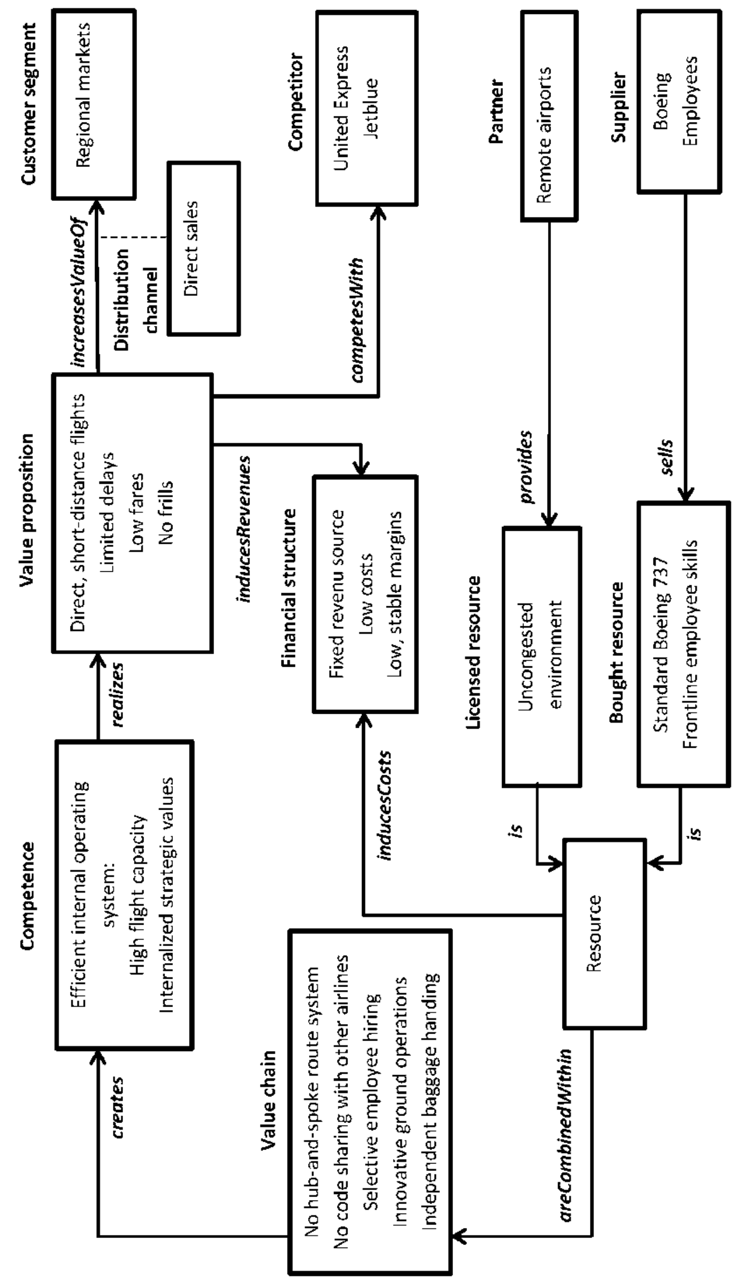


Figure 2.2: Integrative business model framework applied to the Southwest Airlines case example

2.5 Conclusion

The research objective of this chapter was the identification of the constituting components (i.e., elements and their interrelations) of the business model concept, as described in the e-commerce, IS, and management literature. By applying the SLR methodology, 10 components were identified as being common to the majority of the identified integrative research on the business model concept. The applicability of the model was shown by the case example of Southwest Airlines. This case provides an early illustration of the framework by demonstrating the use of the core elements of the business model concept. However, further evaluation of the proposed framework is performed in chapter 3 and 4 (cfr., infra).

As this research was performed to initiate a convergent thinking phase about the business model concept, the proposed component framework is not primarily introduced to be a better alternative than existing integrative frameworks. However, our framework can help to assess this integrative research by providing a minimal set of components that should be covered to provide a complete view on the business model. More particularly, the proposed framework can be related to the research of Tikkanen et al. (2005) and Shafer et al. (2005), who use a complete set of business model components that is similar to our proposal. However, both of these research efforts include other components (i.e., strategy, mission, governance, differentiation, and branding), which are not generally supported by other frameworks. Although these elements can be useful in specific application contexts (see section 2.4.3.1), they are not explicitly needed for the general design and analysis of business models. However, future research is needed to perform a further evaluation that enables to draw profound conclusions about the usefulness of the proposed framework in comparison with the existing integrative research.

The proposed business model framework was applied to the Southwest Airlines case example to illustrate its use by demonstrating the core elements of the business model concept. The further evaluation of this framework is performed in the next chapters. As such, the insights that result from this literature study were needed to complete both research cycle A and B. The proposed framework, which reveals the fundamental base which underlies the different visions that exist in the current business model literature, could inform the existing value models to represent the business rationale of the firm. Consequently, future research includes the analysis to which extent existing value models are able to incorporate this rationale and which adaptations are needed to improve this integration (see chapter 3). The integrative framework can also be applied to align the strategy and process perspectives of the company (see chapter 4). This includes using the business model concept to assess whether a company implements its strategy in a way that is consistent with the goals it wants to achieve and the processes it performs. These opportunities will enable a full integration between the representation of organizational perspectives and the requirements of ISs that can be derived from these conceptual models (see section 1.1.3.2).

3

The Development and Experimental Evaluation of a Business Model Representation

Abstract

Business models are the central concept to understand the business logic of an organization. Value modeling techniques contribute to the conceptualization of business models by providing explicit representations of the organizational value creation and exchange. A proper business model representation helps to increase the understanding and communication about the underlying knowledge for the stakeholders within a company. However, the existing value modeling languages have a different and partial focus on the business model concept due to their various backgrounds. This prevents the large-scale adoption of these representations in practice. Therefore a business model viewpoint is developed, which explicitly facilitates the understanding about the underlying business model components. To this end, existing VDML diagrams were adapted to prescriptions of the Physics of Notations, which is a normative theory for cognitive effectiveness of diagrammatic representations. The effect on the understanding was evaluated by an experiment with 93 master students. The results confirm the research hypothesis that the new business model viewpoint increases the understanding of the modeled business model components.

Keywords

Business Model Representation, Value Modeling, VDML, Experimental Evaluation

Research contribution

This research contributes to a solution for RQ A2 & A3 of research cycle A, which aims to the development and experimental evaluation of a business model representation (see section 1.2.2.1). More specifically the following research questions are addressed:

RQ A2 Which VDML meta-model constructs are needed to provide a business model representation? (see section 3.2)

RQ A3 How can the VDML meta-model constructs be represented to increase the understanding about the underlying business model knowledge? (see section 3.3-3.4)

3.1 Introduction

The importance of the business model concept is recognized both in industry and academia. Since the rise of the internet, business models help companies as a management tool to cope with increased competition and faster technological changes (Veit et al., 2014). The concept is particularly useful to bridge the design of the strategy and the processes within an enterprise (Andersson et al., 2009, Pijpers et al., 2012). Indeed, a business model represents the implementation of a strategy to create value and exchange it with the external value network (Shafer et al., 2005). Aligning the organizational strategy and processes is crucial to realize Business-IT alignment, which includes communicating IT requirements to support business operations as well as identifying business opportunities that can be exploited by the use of IT.

Academic literature in the fields of e-business, management, and IS has been developing knowledge about business models (Shafer et al., 2005). Nowadays, the business model research area is maturing as it aims to integrate different interpretations to facilitate the understanding and design of business models (Zott et al., 2011, Osterwalder and Pigneur, 2013, Veit et al., 2014).

IT support for developing business models is an existing gap within the Business Informatics discipline (Veit et al., 2014). This includes the provision of a business model representation that creates a common language for the relevant stakeholders, such as chief executive officers (CEOs), chief operations officers (COOs), chief financial officers (CFOs), chief information officers (CIOs), marketers, and consumer groups (Gordijn and Akkermans, 2003, Osterwalder et al., 2005). This results in a better understanding and communication about the underlying business model knowledge to bridge differences in background between business domains. As the scope of value modeling languages is explicitly oriented towards the creation and exchange of value (OMG, 2014b), these conceptual modeling languages are suited to provide a business model representation. However, candidate value models (i.e., Capability Maps (Hafeez et al., 2002), e^3-value (Gordijn and Akkermans, 2003, Pijpers et al., 2012), the REA ontology (Geerts and McCarthy, 2002), and VNA (Allee, 2008)) address different and partial aspects of business models (section 3.2.2.1), which prohibits their adoption in practice (Veit et al., 2014). This can be solved by developing a business model representation, which includes: the discovery of relevant business model components, the representation of these components by a value model, and the evaluation to which extent this representation conveys the semantics of the modeled business model components (Parsons and Cole, 2005, Osterwalder and Pigneur, 2013).

The identification of the business model components was described in chapter 2, in which a framework is proposed based on existing integration efforts about the constituent business model components. This chapter aims to identify the VDML meta-model constructs that are needed to represent these components. VDML (OMG, 2014b) is our choice of representation language as it is the only value modeling language that can be used to provide a complete business model representation (see section 3.2.2.1). This is an important advantage as it enables us to represent all business elements by a single modeling language, which facilitates the integration of information between different diagrams. Indeed, the application of multiple value modeling techniques could result in inconsistencies in the definition and use of modeling constructs, which hinders a clear understanding of the underlying knowledge. However, the identification of the relevant VDML constructs is not straightforward as the meta-model also contains constructs related to the operational details of customer value delivery and even constructs beyond the scope of the business model elements. To overcome this problem, the following method is used in this research: (i) an investigation of the modeling scope of value modeling languages to identify a set of techniques that is able to provide a complete business model representation (i.e., the completeness requirement) (see results in section 3.2.2.1), (ii) an analysis of the meta-model constructs of the relevant value modeling languages to assess whether they are defined at the same abstraction level than the proposed business model components (i.e., the strategy implementation depth requirement) (see results in section 3.2.2.2), and (iii) a mapping between these constructs and VDML to identify the set of meta-model constructs that are needed to offer an appropriate business model representation (see results in section 3.2.2.3). Furthermore, it is investigated how the VDML meta-model constructs should be combined in a new viewpoint to further facilitate the understanding of the represented business model components. In this respect, the existing VDML viewpoints are used as a benchmark for the development (see section 3.3.2.1), which is further realized by applying design principles on the cognitive effectiveness of diagrammatic representations (Moody, 2009) on these VDML diagrams (see section 3.3.2.2). The impact on the understanding is evaluated by an experiment that compares the new viewpoint with the existing VDML diagrams (see section 3.4).

By building upon chapter 2, chapter 3 supports the further communication of the results for research cycle A (see section 1.2.2), which is guided by the Design Science methodology. This methodology guides the creation of research artifacts (i.e., the new business model viewpoint) through six steps: problem identification and motivation, definition of solution objectives, design and development, demonstration, evaluation, and communication (Peffers et al., 2007). The first two steps are described in this introduction.

The identification of the relevant VMDL meta-model constructs (i.e., RQ A2 of section 1.2.2.1) is discussed in section 3.2, while the development of the new viewpoint (i.e., RQ A3 of section 1.2.2.1) is presented in section 3.3. Section 3.4 describes the results of the experimental evaluation, which is based on diagrams that demonstrate the use of the developed viewpoint (see section 3.3.2.2 and Appendix A). Section 3.5 concludes with the main findings and future research steps.

3.2 Identification of the Relevant VDML Meta-model Constructs

3.2.1 Methodology

The identification of the relevant VDML meta-model constructs is implemented by an evaluation whether these constructs apply to both the *completeness requirement* and the *strategy implementation depth requirement*. These requirements are based on chapter 2, in which research was reviewed to identify the elements that provide an integrative view on the business model concept (see figure 2.1). This business model framework provides a theoretical basis to argue that these elements constitute the set of constructs that should be covered by the intended meta-model (i.e., *the completeness requirement*). This *completeness requirement* is implemented by an analysis of the modeling scope of candidate modeling languages (Geerts and McCarthy, 2002, Hafeez et al., 2002, Gordijn and Akkermans, 2003, Dunn et al., 2005, Allee, 2008, Pijpers et al., 2012, OMG, 2014b) (see section 3.2.2.1). As VDML is the only value model that is able to provide a complete business model representation, it was chosen as the representation language in this research. However, its meta-model also consists of constructs that are outside the scope of the business model (i.e., a violation of the *completeness requirement*). This can be overcome as the results in section 3.2.2.1 indicate that a combination of value modeling languages, which separately are not applying to the *completeness requirement*, can be chosen to ensure that they collectively cover the seven business model elements and therefore apply to the *completeness requirement.* Applying the implementation depth requirement on this combination of value modeling techniques can help (via a subsequent mapping) to distinguish between those elements of the VDML meta-model that are relevant to the model business model elements and those that are not. The *strategy implementation depth requirement* is operationalized by assessing whether the value modeling constructs (of the combination that collectively applies to the *completeness requirement*) are defined at the right level of abstraction as prescribed by the business modeling literature (section 3.2.2.2). This abstraction level (e.g., a black box view on external business partners, on individual business processes, on the internal organizational structure, etc.) is based on the definitions of the business model elements (see section 2.4.3.1). In section 3.2.2.3, a mapping between the relevant constructs of the combination of value modeling techniques and the according VDML elements will be established to identify the set of meta-model elements, which applies to both requirements. These construct mappings will be based on a comparison of the definitions of the various elements.

3.2.2 Results

3.2.2.1 Modeling Scope of Value Modeling Languages

Most value modeling languages do not comply with the completeness requirement as they only cover loose elements of the business model framework (see table 3.1). The *REA Value Chain Specification* (Geerts and McCarthy, 2002, Dunn et al., 2005) represents *resources* and the *value chain* as an enterprise script, which is related to the overall business process architecture. The *REA Value System Level* (Dunn et al., 2005) models the resources that are exchanged between a company and its external environment and corresponds with the *value network* element. The *Value System Level* can also model the *financial structure*, which reflects the monetary flows between the company and its environment. *VNA* (Allee, 2008) captures the conversion of tangible and intangible assets into value in the context of internal (e.g., within the company) and external networks (e.g., between the company and its partners). Hence, the meta-model of VNA represents the *value chain* and the *resources* that are the input to its processes, as well as the *value network* element. Although value models (except VDML; confer infra) do not include competences (e.g., only a pragmatic approach is presented by Hafeez et al. (2002)), *Capability Maps* are well known in management practise. A Capability Map is a representation of 'what' a company does to reach its objectives (Cook, 2007), which can be used to model *competences*. E^3-value (Gordijn and Akkermans, 2003) offers a representation of the *value proposition* within the context of e-business. To evaluate this value proposition, profitability sheets are used, which include a mathematical calculation of the monetary streams related to the inflow and outflow of value objects. Although this evaluation is linked to the financial structure within the business model, it does not make use of any modeling constructs. *E^3-forces* (Pijpers et al., 2012) was introduced as a variant of e^3-value, which explicitly models the strategic perspective of a *value network.*

Although the meta-model of VDML (OMG, 2014b) is able to cover all the business model elements, this meta-model has to be refined as it also contains constructs related to the operational details of customer value delivery and even constructs beyond the scope of the business model elements. Therefore, it still needs to be investigated which constructs apply to both the *strategy implementation depth requirement* and the *completeness requirement*.

<table>
<tr><th>Business model element(s)</th><th colspan="2">Value modeling techniques</th></tr>
<tr><td>Resources
Value chain</td><td>REA Value Chain Specification
VNA</td><td rowspan="4">VDML</td></tr>
<tr><td>Competence</td><td>Capability Maps</td></tr>
<tr><td>Value proposition,
Distribution channel
Value network</td><td>REA Value System Level Modeling
VNA
e³-forces</td></tr>
<tr><td>Financial Structure</td><td>REA Value System Level Modeling</td></tr>
</table>

Table 3.1: Overview of the modeling scope of the value modeling languages

3.2.2.2 Identification of Relevant Value Modeling Constructs

<u>Resources and Value Chain.</u> The REA Value Chain Specification (see figure 3.1) shows the economic resources that are input and output of processes. As the REA Value Chain adopts a black box view on processes, the meta-model is specified at the right level of abstraction for modeling strategy implementation choices. Also VNA is oriented towards the deliverables that are conveyed between organizational roles through transactions (see figure 3.2). As internal roles relate to the internal organizational structure, they are not further included.

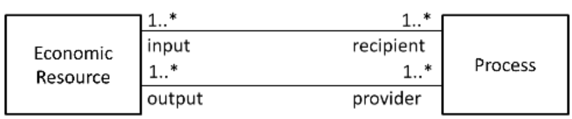


Figure 3.1: Meta-model elements of the REA Value Chain Specification

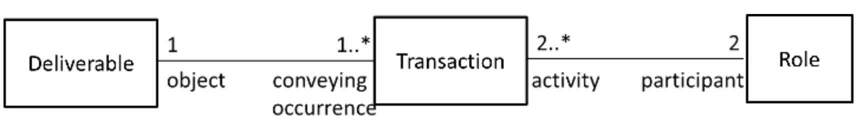


Figure 3.2: Meta-model elements of VNA

Competence. *Capability Maps* (see figure 3.3) enable to derive organizational competences from hierarchies of capabilities that enable value delivery to the customer. As a result, this hierarchy of capabilities provides the right level of abstraction for specifying the value layer within the organization.

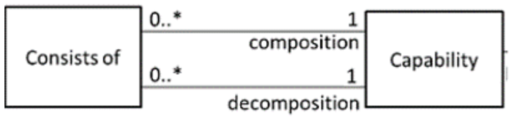


Figure 3.3: Meta-model elements of Capability Maps

Value Proposition, Distribution Channel, and Value Network. REA *Value System Level Modeling* (see figure 3.4) is concerned with the *economic resources* that are exchanged between the *enterprise* and its *external business partners*. These elements apply to the *strategy implementation depth requirement* and are further included in the analysis. The meta-model of *VNA* (see figure 3.2) augments the vision of the REA ontology as it includes the *transactions* through which the *deliverables* are conveyed. Now, the *role* concept within VNA is relevant as it may refer to the company and its external business partners. The meta-model of e^3-forces (see figure 3.5) uses the concepts of *constellation* and *market* to capture the strategic perspective of a value network. The other elements (i.e., *actor, value interface, value offering, value port, value exchange, and value object*) originate from e^3-value and model the value exchange between a company and its value network.

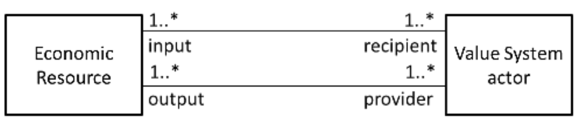


Figure 3.4: Meta-model elements of REA Value System Level Modeling

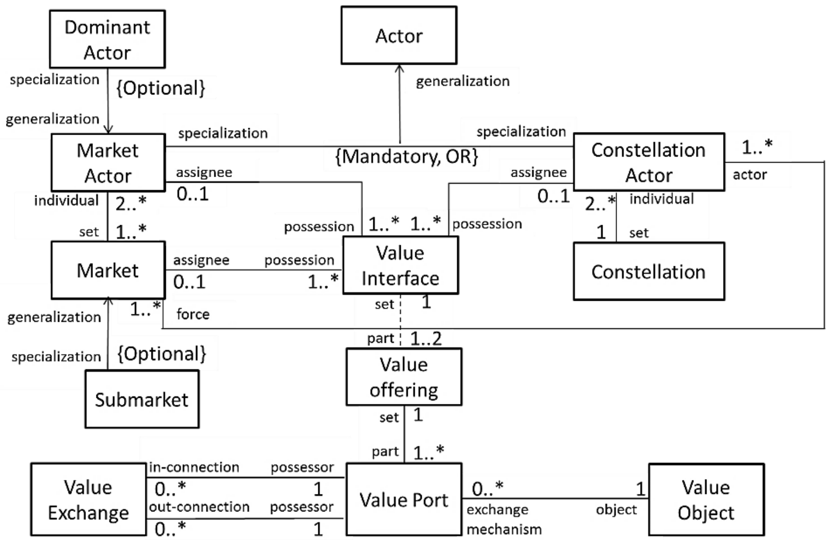


Figure 3.5: Meta-model elements of e³-forces (adapted from Gordijn and Akkermans (2003))

<u>*Financial Structure.*</u> The financial structure can be considered as a specific model view in the REA *Value System Level Modeling* (see figure 3.6) as the relevant revenues and costs can be captured by *monetary resources* that are exchanged by the *enterprise*.

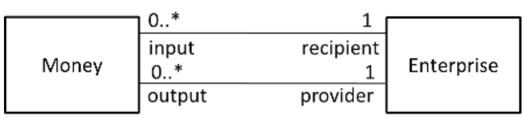


Figure 3.6: Elements of the financial structure model

Table 3.2 provides a summary of the value modeling elements that are relevant according to the *strategy implementation depth requirement*.

Business model element	**Value modeling technique**	**Meta-model elements applying to strategy implementation depth requirement**
Resources Value Chain	REA Value Chain Specification	Economic Resource, Process
	VNA	Deliverable, Transaction
Competence	Capability Maps	Capability
Value Proposition Distribution Channel Value Network	REA Value System Level Modeling	Economic Resource, Enterprise, External Business Partner
	VNA	Deliverable, Transaction, Role
	e^3-forces	Constellation, Market, Market Actor, Value Interface, Value Offering, Value Port, Value Object, Value Exchange
Financial Structure	REA Value System Level Modeling	Money (as an Economic Resource), Enterprise

Table 3.2: Overview of relevant meta-model elements for strategy-oriented value modeling

3.2.2.3 Mapping to VDML Meta-Model Constructs

The mappings between the extracted elements and the VDML meta-model constructs (see tables 3.3-3.5) extend the mappings provided in OMG (2014b). Corresponding elements of the definitions, as they were proposed in the respective modeling languages, are characterized by the same layout inside the tables. Due to two reasons, this is not a clear one-to-one mapping. First, some of the value modeling techniques (e.g., REA, VNA) can be used to represent different business model elements (see table 3.2). As a result, their meta-model elements can be mapped to different VDML constructs. Moreover, some of the VDML constructs are used in a different context than originally proposed by the other value modeling techniques. Consequently, some meta-model elements of these techniques do not have an identical counterpart in VDML. Therefore, more details about these mappings are discussed in the text. This finally resulted in the identification of 16 relevant VDML constructs: BusinessItem, Store, DeliverableFlow, CapabilityMethod, CapabilityOffer, ValueProposition, ValuePropositionComponent, ValueAdd, InputPort, OutputPort, OrganizationUnit, Community, Participant, Role, BusinessNetwork, and Party.

Value model	**Meta-model element**	**Definition**
REA Value Chain Specification	Economic Resource	*Objects* that are scarce and have utility and are **under the control of** an enterprise (Geerts and McCarthy, 2002).
VNA	Deliverable	The actual (physical or non-physical) *things* that move from one role to another (Allee, 2008).
VDML	Business-Item Store	*Anything* that can be acquired or created, that conveys information, obligation or other forms of value and that can be conveyed from a provider to a recipient (OMG, 2014b). Represents **the container** of *resource*, which is identified by a BusinessItem (OMG, 2014b).
VNA	Transaction	Occurrence in which a *deliverable*, originated by one role, is conveyed to and received by another role (Allee, 2008).
VDML	Deliverable-Flow	The transfer of a *deliverable* from a provider to a recipient (OMG, 2014b).
REA Value Chain Specification	Process	The exchange or conversion of an *input resource* (or set of resources) to an *output resource* of more value (Geerts and McCarthy, 2002).
VDML	Capability-Method	A Collaboration specification that defines the Activities, DeliverableFlows, *BusinessItems*, CapabilityRequirements and Roles that deliver a Capability and associated value contributions (OMG, 2014b).
Capability Maps	Capability	The *ability* to make use of resources *to perform some task or activity* (Hafeez et al., 2002).
VDML	Capability-Offer	The *ability to perform a particular kind of work* and deliver desired value, by applying resources that are managed together, possibly based on formalized methods (OMG, 2014b).

Table 3.3: Mapping between the relevant meta-model constructs that address resources, value chain, and competence to the corresponding VDML elements

Within the VDML value chain, resources are held in a Store to be delivered as BusinessItems over a DeliverableFlow to a CapabilityMethod (OMG, 2014b). This transfer between Stores and CapabilityMethods is enabled by means of InputPorts and OutputPorts, which receive and provide the delivered resources. A CapabilityMethod (see table 3.3) is defined as a process at the value layer of the business architecture, which focuses on delivering CapabilityOffers and the resulting value contribution (OMG, 2014b). This value contribution is addressed by the ValueAdd construct, which represents the values that are provided by an OutputPort. However, the definition of a CapabilityMethod also includes activities and individual responsibilities, which are outside the scope of a strategy-oriented value modeling language. Therefore, this concept will be used as a black-box construct in the VDML business model viewpoint (see section 3.3). The definition of a BusinessItem (table 3.3), which includes anything that is conveyed between two roles, is too broad to only capture resources that are exchanged between black box processes that abstract from internal roles. In section 3.3, this problem will be overcome by restricting the use of BusinessItems as deliverables for CapabilityMethods.

Value model	Meta-model element	Definition
REA Value System Level	Economic Resource	*Objects of economic value* (with or without physical substance) that are provided or consumed by an enterprise (Dunn et al., 2005).
VNA	Deliverable	The actual (physical or non-physical) *things* that move from one role to another role (Allee, 2008).
e^3-forces	Value Object	*Product and services* that are of *value* for one or more actors (Pijpers et al., 2012).
e^3-forces	Value Offering	Models *what* an actor *offers* to or requests from its environment, which is a set of equally directed *value* ports (Gordijn and Akkermans, 2003).
VDML	Value-Proposition Component	Expression of the *values offered* to a recipient evaluated in terms of the recipient's level of satisfaction (OMG, 2014b). The *components* that constitute the ValueProposition (OMG, 2014b).
REA Value System Level	Enterprise	An *organization* established to achieve a particular undertaking **involving industrious systematic activity** (Dunn et al., 2005).
VDML	Organization-Unit	Administrative or functional *organizational* **collaboration**, with responsibility for defined resources (OMG, 2014b).
e^3-forces	Market	*Set of* organizations operating in the environment of a constellation (Pijpers et al., 2012).
VDML	Community	A *loose collaboration of* participants with similar characteristics or interests (OMG, 2014b).
REA Value System Level	External Business Partner	*Actors* in the value system such as *suppliers*, *customers*, *creditors/investors*, and *employees* (Dunn et al., 2005).
e^3-forces	Constellation	Coherent set of two or more *actors* **who cooperate** to create value to their environment (Pijpers et al., 2012).
VNA	Role	*Real people or participants* (both individuals and organizations) in the network who **provide contributions and carry out functions** (Allee, 2008).
VDML	Participant Role Business-Network Party	*Anyone or anything* that can **fill a role** in a collaboration (OMG, 2014b). **Expected behavior pattern or capability profile** associated with *participation* in a collaboration (OMG, 2014b). Collaboration between *independent business or economic entities*, **participating in an economic exchange** (OMG, 2014b). **Roles** specific to and contained in the BusinessNetwork (OMG, 2014b).

Table 3.4: Mapping between the relevant meta-model constructs that address value proposition, distribution channel, and value network to the corresponding VDML elements

Within VDML, the value network is captured by the BusinessNetwork construct that represents the collaboration through which ValuePropositions are provided and received by the enterprise. This ValueProposition is further specified by a set of ValuePropositionComponents, which are an expression of individual value components that are offered to the recipient. The BusinessNetwork further consists of a set of Participants (i.e., the company and its external business partners), who fulfill the Role of a Party. A Participant can be further specified as either an OrganizationUnit (e.g., an individual organization) or a Market (e.g., a consumer group).

Value model	**Meta-model element**	**Definition**
REA Value System Level Modeling	Monetary resource	*Monetary Objects* that are provided or consumed by an **enterprise** (Dunn et al., 2005).
VDML	Deliverable-Flow BusinessItem	The transfer of *a deliverable* from a **provider** to a **recipient** (OMG, 2014b). *Anything* that can be acquired or created, that conveys information, obligation or other *forms of value* and that can be conveyed from a **provider** to a **recipient** OMG (2014b).
REA Value System Level Modeling	Enterprise	An *organization* established to achieve a particular undertaking **involving industrious systematic activity** (Dunn et al., 2005).
VDML	Organization-Unit	Administrative or functional *organizational* **collaboration**, with responsibility for defined resources (OMG, 2014b).

Table 3.5: Mapping between the relevant meta-model constructs that address financial structure and the corresponding VDML elements

The financial structure (table 3.5) results from the whole of monetary streams to and from a company. Within VDML, a monetary resource is modeled as a BusinessItem, while the flow of these resources is represented by a DeliverableFlow. The enterprise that is spending or receiving money can be mapped to the VDML construct of an OrganizationUnit.

3.3 Development of the Business Model Viewpoint

3.3.1 Methodology

The existing VDML diagrams (figure 3.7-3.11) that collectively cover the identified VDML constructs (see section 3.2.2.3), provide a benchmark for the development step. To assess the degree to which these diagrams support human understanding, the design principles of the Physics of Notations (Moody, 2009) are applied. This allows detecting flaws in these diagrams, which are solved by a re-arrangement of the meta-models of the existing viewpoints. This will result in the development of the new VDML business model viewpoint. Therefore, only those design principles, which affect the combination of meta-model constructs used in a diagram but not the redesign of the visual VDML syntax, are applied. These are the principles of semiotic clarity, complexity management, cognitive integration, and graphic economy (table 3.6).

Principle	Description
Semiotic clarity	There should be a 1:1 correspondence between meta-model constructs and graphical symbols.
Complexity management	Include explicit mechanisms for dealing with diagrammatic complexity, which is measured by the number of symbol instances on a diagram.
Cognitive integration	Include explicit mechanisms to support integration of information from different diagrams.
Graphic economy	The number of different meta-model constructs should be cognitively manageable as the human ability to discriminate between perceptually distinct alternatives is around six categories.

Table 3.6: Design principles used for the development step (Moody, 2009)

3.3.2 Results

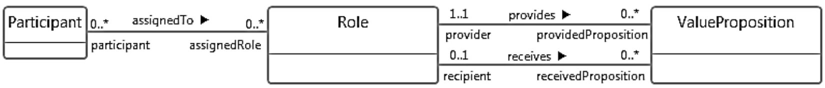
3.3.2.1 Identification of Relevant VDML Viewpoints

VDML offers an abstract representation of a company, which focuses on the creation and exchange of value, by nine viewpoints: capability library map, organization structure, role collaboration, measurement dependency, value proposition exchange, value proposition structure, business network structure, capability management, and activity diagrams (OMG, 2014b). The last five viewpoints have the right level of abstraction for representing business models as they capture the VDML concepts that are needed for this purpose (see section 3.2.2.3). Although the other viewpoints are beyond the scope of business models, they are useful in other application domains. Indeed, capability library maps enable to identify a taxonomy of capability definitions, which provides a common vocabulary that fosters standardization of the business design (OMG, 2014b). An organization structure diagram defines the chain of responsibilities for resources, operations, and budgets within the company (OMG, 2014b). A role collaboration diagram focuses on the products and services that are exchanged within a business network, which only implicitly incorporates the associated value. Still, it can be used in a general analysis of value networks, as done by VNA modeling. A measurement dependency defines the relation between measurements of business characteristics (OMG, 2014b). This supports performance measurement, which can supplement existing conceptual modeling techniques (e.g., by the creation of heat maps). This section is limited to the meta-model and the visualization of the viewpoints that are oriented towards business models (figure 3.7-3.11). For the reason of completeness, the definitions of the VDML constructs are collectively listed in table 3.7.

Construct	Definition
Participant	Anyone or anything that can fill a role in a collaboration.
Role	Expected behavior pattern or capability profile associated with participation in a collaboration.
ValueProposition	Expression of the values offered to a recipient evaluated in terms of the recipient's level of satisfaction.
ValueProposition-Component	Components that constitute a ValueProposition.
BusinessNetwork	Collaboration between independent business or economic entities, participating in an economic exchange.
Party	Roles specific to and contained in the BusinessNetwork.
Community	Loose collaboration of participants with similar characteristics or interests.
OrganizationUnit	Administrative or functional organizational collaboration, with responsibility for defined resources.
CapabilityOffer	Ability of an organization to perform a particular type of work.
Store	Representation of a container of a resource.
CapabilityMethod	Collaboration specification that defines the activities, deliverable flows, business items, capability requirements and roles that deliver a capability and associated value contributions.
PortContainer	Abstract class that associates Ports with CapabilityMethods and Stores.
Port	Connection point to a PortContainer, used to handle inputs (i.e., InputPort) or outputs (i.e., OutputPort).
ValueAdd	Value contribution of a PortContainer that contains the associated OutputPort.
DeliverableFlow	Transfer of a deliverable from a provider to a recipient.
BusinessItem	Anything that can be acquired or created, which conveys a form of value, and that can be conveyed from a provider to a recipient.

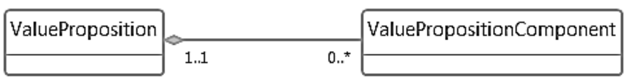
Table 3.7: Definition of the VDML meta model constructs oriented to business models (OMG, 2014b)

The value proposition exchange diagram (figure 3.7) shows ValuePropositions that are exchanged between the Roles of a provider and a recipient. A Role is assigned to a Participant to represent the entity that fulfills this role. The structure of each ValueProposition is analyzed in a separate viewpoint that defines its components (figure 3.8). In the business network structure diagram (figure 3.9), a Participant is further specified as either an OrganizationUnit or a Community, which fulfills the Role of a Party in the BusinessNetwork of the company.



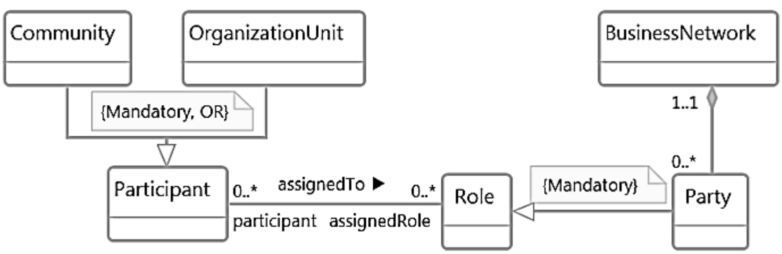
Meta-model construct	Participant	Provides/ Receives	ValueProposition
Visualization	Name		Name

Figure 3.7: Meta-model and visualization of the value proposition exchange diagram (OMG, 2014b)



Meta-model construct	ValueProposition	ValuePropositionComponent
Visualization	*Text*	*Text*

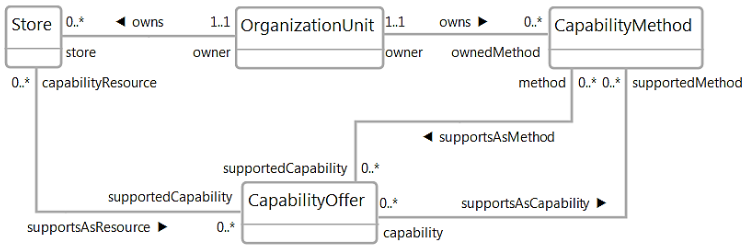
Figure 3.8: Meta-model and visualization of the value proposition structure diagram (OMG, 2014b)



Meta-model construct	BusinessNetwork	Community	Organization-Unit	Consists of	Role
Visualization	Name	Name	Name		Text

Figure 3.9: Meta-model and visualization of the business network structure diagram (OMG, 2014b)

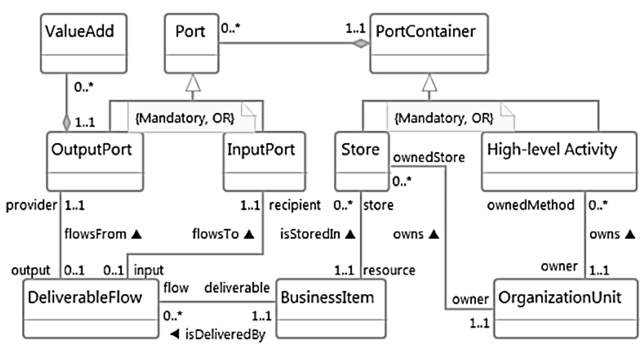
A capability management diagram (figure 3.10) shows the CapabilityOffers that are provided by an OrganizationUnit. These CapabilityOffers are supported by resources that are held in Stores, and CapabilityMethods, which are both owned by the OrganizationUnit. Moreover, low-level capabilities that support organizational processes (i.e., CapabilityMethods) are also identified.



Meta-model construct	Organization-Unit	Capability-Method	Store	Capability-Offer	Supports-AsMethod Supports-AsResource	Supports-AsCapability
Visualization	Name	Name	Name	Name		

Figure 3.10: Meta-model and visualization of the capability management diagram (OMG, 2014b)

Activity diagrams (figure 3.11) model a process by BusinessItems that flow between Stores and High-level Activities as two types of PortContainers that are owned by the OrganizationUnit. To enable this flow, a PortContainer makes use of Ports (i.e., InputPort(s) and/or OutputPort(s)). A ValueAdd construct is added to an OutputPort if the output of a PortContainer yields value for a company.



Meta-model construct	Role	Deliverable-Flow	Business-Item	Store	High-level Activity	InputPort	OutputPort + ValueAdd
Visualization	Name	Text:BusinessItem	*Text*	Name	Name		

Figure 3.11: Meta-model and visualization of the activity diagram (OMG, 2014b)

3.3.2.2 Development of the VDML Business Model Viewpoint

The VDML diagrams that represent the business model components (section 3.3.2.1) are either externally-oriented as they focus on the exchange of value between the company and its value network (i.e., value proposition exchange (figure 3.12), value proposition structure (figure 3.13), and business network structure (figure 3.14) diagrams), or internally-oriented viewpoints that model the organizational resources, processes, and capabilities (i.e., capability management (figure 3.17), and activity (figure 3.18) diagrams).

The externally-oriented VDML viewpoints consist of multiple diagrams (see figure 3.12-3.14), which supports both the management of diagrammatic complexity and graphic economy. Indeed, this enables both to limit the number of different meta-model constructs of a certain viewpoint, as well as the amount of symbol instances in a diagram. Nevertheless, the value proposition structure diagram only contains textual elements (see figure 3.13), which is an important drawback. Cognitive integration is realized as overlapping elements (i.e., ValueProposition that appears in the meta-model of the value proposition exchange (see figure 3.7) and the value proposition structure (see figure 3.8) viewpoints and Role in the meta-model of the value proposition exchange (see figure 3.7) and the business network structure (see figure 3.9) viewpoints) support the integration of information between the diagrams. However, a ValueProposition *(e.g., 'Doctors & Patients')* is encoded graphically in the value proposition exchange (see figure 3.12) and textually in the value proposition structure diagram (see figure 3.13), which violates semiotic clarity. Furthermore a Role construct (e.g., *'Partner'*) is graphically visualized in the business network structure (see figure 3.14), but not in the value proposition exchange diagram (see figure 3.12), which only includes the concept of a Participant (e.g., *'Partner doctor'*).

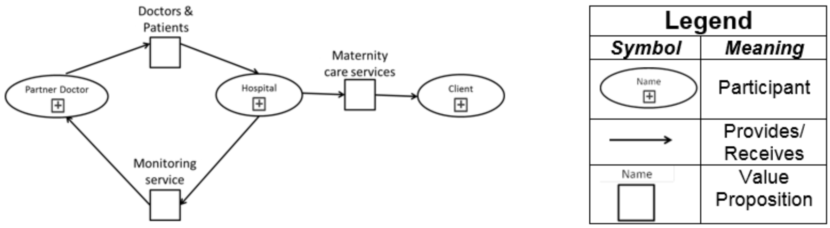


Figure 3.12: Value Proposition Exchange Diagram for the Healthcare Case (OMG, 2012b)

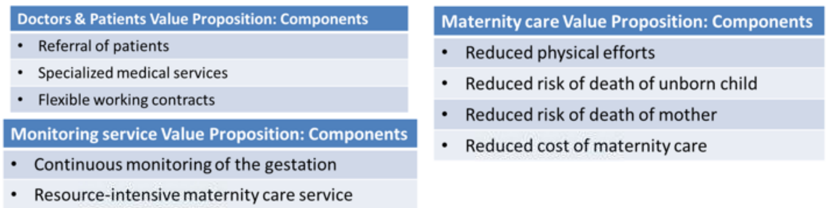


Figure 3.13: Value Proposition Structure Diagram for the Healthcare Case (OMG, 2012b)

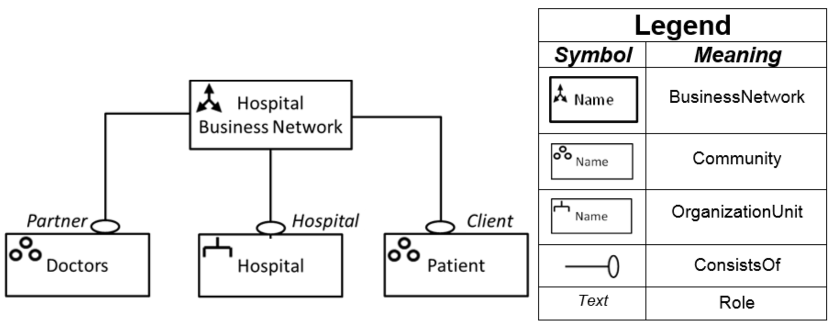


Figure 3.14: Business Network Structure Diagram for the Healthcare Case (OMG, 2012b)

These drawbacks are solved in the new business model viewpoint by the development of the business network diagram (see figure 3.15 for the meta-model and figure 3.16 for an example), which integrates the externally-oriented viewpoints. Although diagrammatic complexity is increased by using a single diagram (e.g., the *'IsA'* relation is included in the meta-model to link a Participant with a Community or an OrganizationUnit (see figure 3.15)), graphic economy is obtained by omitting a graphical symbol for a Role, a Party, a BusinessNetwork, and the *'ConsistsOf'* relation (see figure 3.16). The resulting decrease of semiotic clarity is solved by incorporating these elements in the supporting definitions (Moody, 2009). Consequently, the definition of a Participant (see table 3.7) is adapted to 'anyone or anything that can be assigned to the role of a Party in a BusinessNetwork'. Furthermore, by integrating the externally-oriented meta-model constructs, cognitive integration is increased and each construct is visualized either by a graphical (e.g., Community *‘Patients’*, OrganizationUnit *‘Hospital’*, Participant *‘Client’*, ValueProposition *‘Monitoring service’*, *‘IsA’* and *‘Provides / Receives’*) or textual symbol (e.g., ValuePropositionComponent *‘Referral of patients’* in figure 3.16).

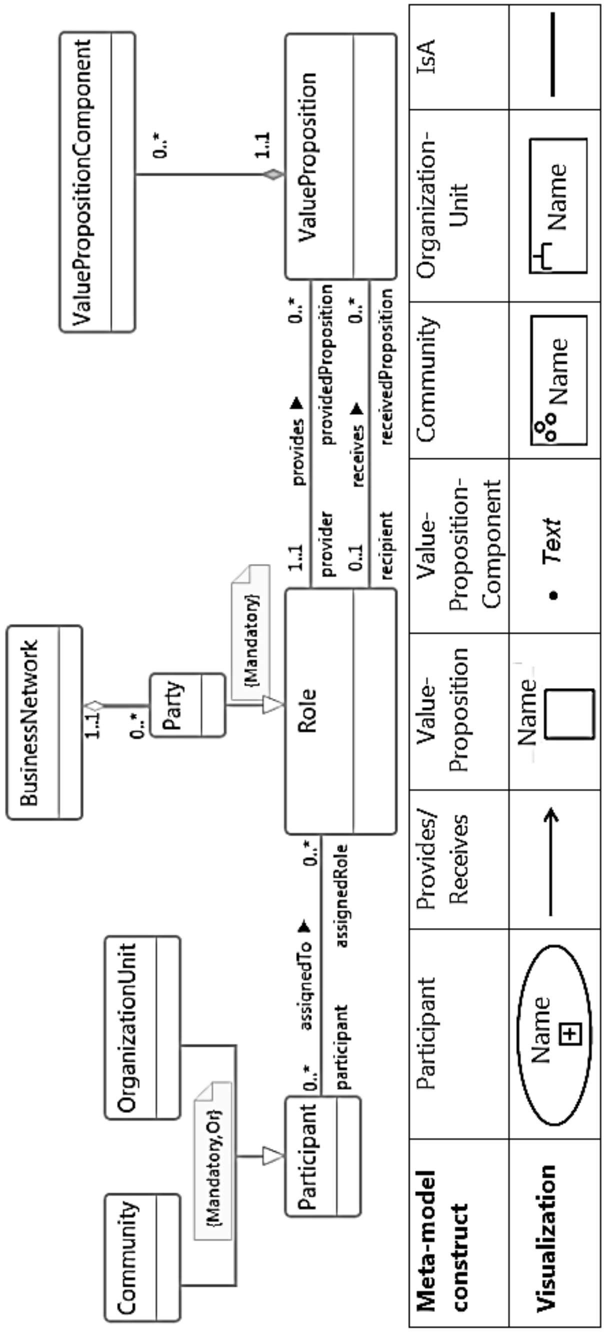


Figure 3.15: Meta-model and visualization of the business network diagram

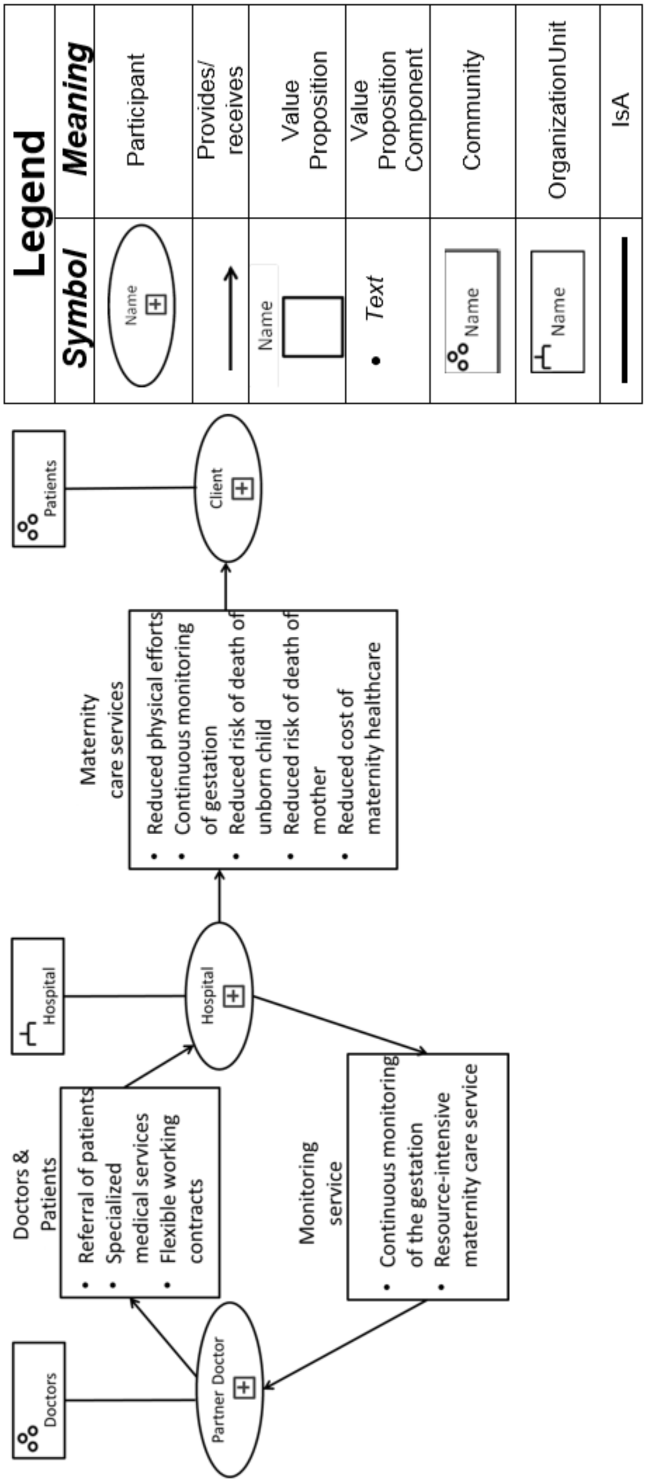


Figure 3.16: Business Network Diagram for the Healthcare Case

The meta-model of the internally-oriented VDML viewpoints (see examples in figure 3.10-3.11) are linked by the element of an OrganizationUnit, a Store and a CapabilityMethod/High-level Activity. As a result, the principles of complexity management and graphic economy are supported. Still, it is a drawback that organizational processes appear as CapabilityMethods (e.g., *'Operating room'*) in the capability management diagram (see figure 3.17) and High-level Activities in the activity diagram (see figure 3.18). In fact, a high-level activity is a more general concept that refers to the work that is performed in a collaboration, of which a CapabilityMethod is a specialization.

Diagrammatic complexity could be improved in the capability management diagram (see figure 3.17) as it combines the supporting relation between Stores and CapabilityOffers (e.g., SupportsAsResource: CapabilityOffer *'ER nurse'* provided by Store *'Nurses'*), CapabilityMethods and CapabilityOffers (e.g., SupportsAsMethod: CapabilityOffer *'Emergency'* supported by the CapabilityMethod *'Emergency'*), and the inverse relation of CapabilityOffers supporting CapabilityMethods (i.e., SupportsAsCapability: CapabilityOffer *'ER nurse'* that supports CapabilityMethod *'Emergency'*).

In an activity diagram (see figure 3.18), hierarchical modeling is employed to visualize sub-processes, which includes the use of an activity diagram (e.g., the business network activity diagram) for the overarching process and separate activity diagrams for the sub-processes (e.g., the maternity care method activity diagram). Although this technique results in a decrease of diagrammatic complexity, it reduces the overview of the value chain as there is lack of an integration mechanism between the diagrams. This drawback is important as the value chain is identified as a main element within the business model (see chapter 2).

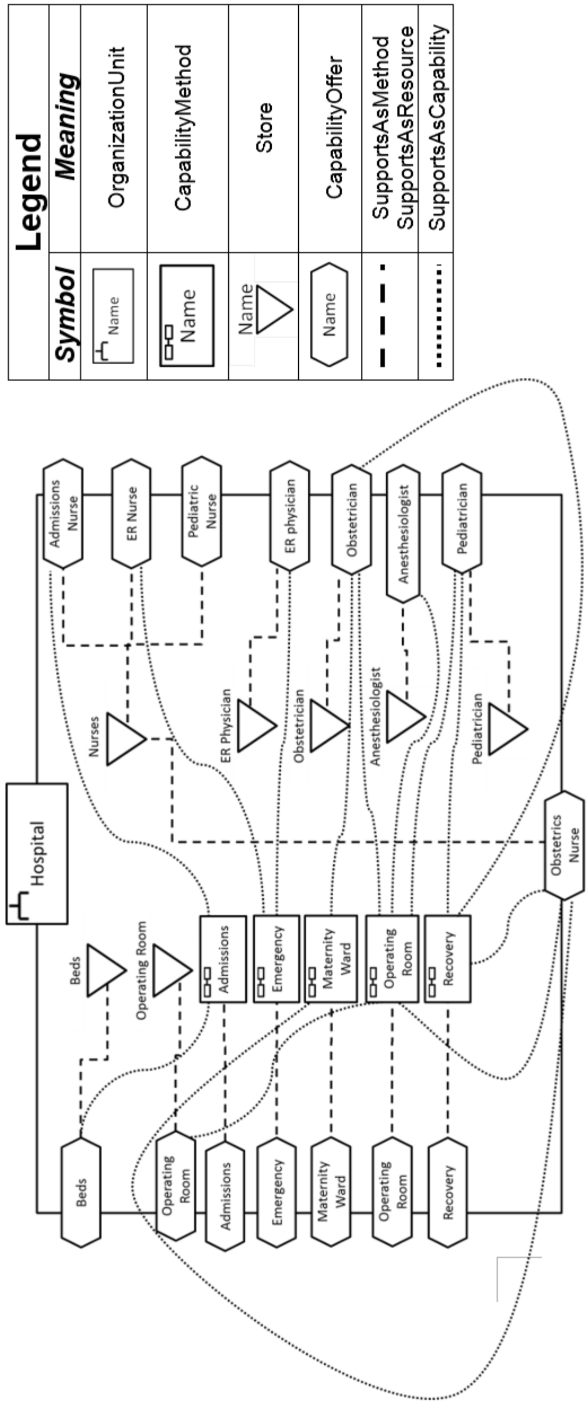


Figure 3.17: Capability Management Diagram for the Healthcare Case (OMG, 2012b)

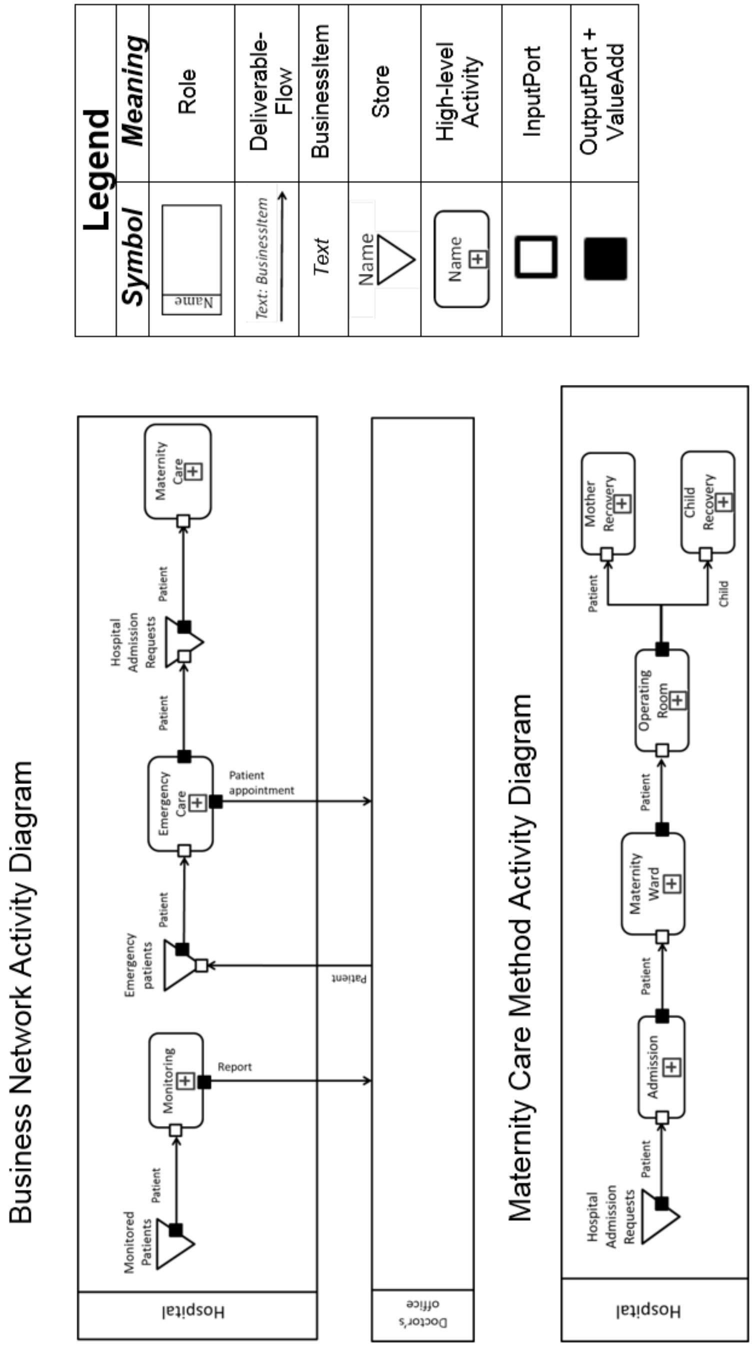
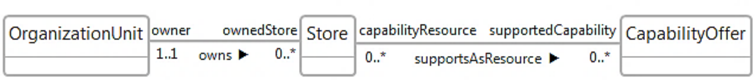


Figure 3.18: Activity Diagram for the Healthcare Case (OMG, 2012b)

These problems are overcome in the new business model viewpoint by two diagrams: the low-level capability diagram (see figure 3.19 for the meta-model and figure 3.20 for an example) and the value stream diagram (see figure 3.21 for the meta-model and figure 3.22 for an example). The problem of diagrammatic complexity is overcome by separating CapabilityOffers that are supported by CapabilityMethods (e.g., the SupportsAsMethod relation between CapabilityMethod *'Emergence care'* and CapabilityOffer *'Emergency'* in in the value stream diagram of figure 3.22) from CapabilityOffers that are supported by Stores (e.g., the SupportsAsResource relation between the Store *'Nurse'* and CapabilityOffer *'ER nurse'* in the low-level capability diagram of figure 3.20). The overlap between the two diagrams is restricted to the OrganizationUnit *(e.g., 'Hospital')* as a direct related element of the Store concept. This ensures the cognitive integration between the diagrams. Furthermore, the relation between CapabilityOffers and CapabilityMethods (i.e., the SupportsAsCapability relation in the meta-model of figure 3.10) is omitted as it can be derived by the overlap of Stores between the two diagrams. Indeed, as Stores (e.g., *'ER nurse'*) are input for a specific CapabilityMethod (e.g., *'Emergency care'*) in the value stream diagram (see figure 3.22), the CapabilityOffers (e.g., *'ER nurse'*) that are provided by these Stores in the low-level capability diagram (see figure 3.20) will support the CapabilityMethods (e.g., *'Emergency care'*) to which these Stores are input. As such, the symbol deficit does not lead to a decreased semiotic clarity.

In a value stream diagram (figure 3.22), organizational processes are represented by CapabilityMethods (e.g., *'Emergency care'*) as this construct is most suitable for representing processes in the context of business models (see section 3.2.2.3). This includes the use of the corresponding InputPort and OutputPort visualizations to model the inflow (e.g., '*ER nurse*') and outflow (e.g., *'Patient'*) of BusinessItems. The PortDelegation relation links the Ports of a CapabilityMethod (e.g., *'Recovery'*) to those of its constituting parts (e.g., *'Mother recovery'*). This allows modeling overarching processes and constituent sub-processes in a single diagram, which increases cognitive integration. As business models adopt a high-level view on processes (i.e., by making abstraction of individual activities), the increase in diagrammatic complexity is limited.



Meta-model construct	Organization-Unit	Store	Capability-Offer	Supports-AsResource
Visualization	Name	Name	Name	- - - ·

Figure 3.19: Meta-model and visualization of the low-level capability diagram

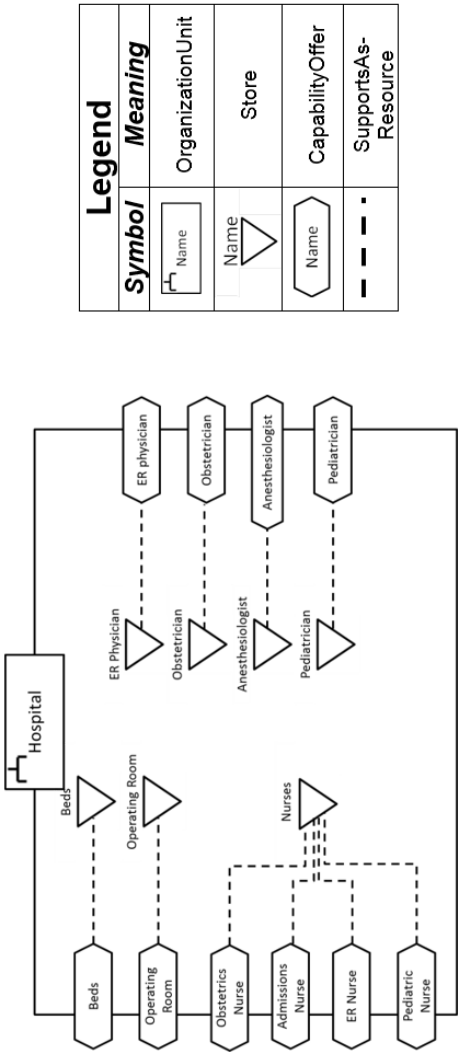


Figure 3.20: Low-level capability diagram for the healthcare case

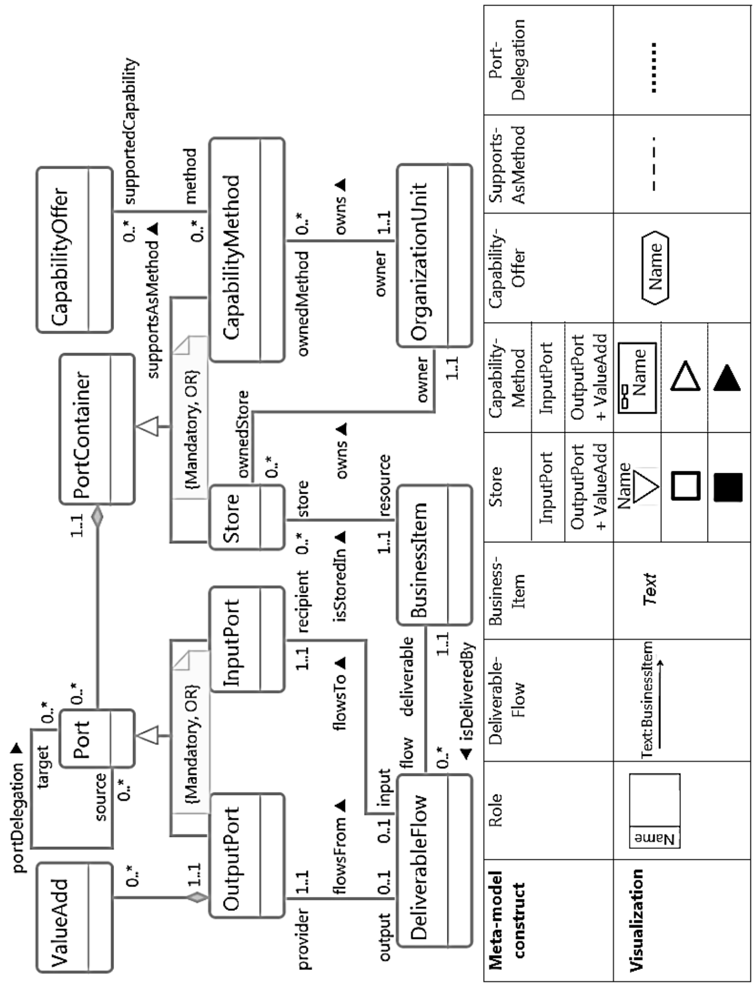


Figure 3.21: Meta-model and visualization of the value stream diagram

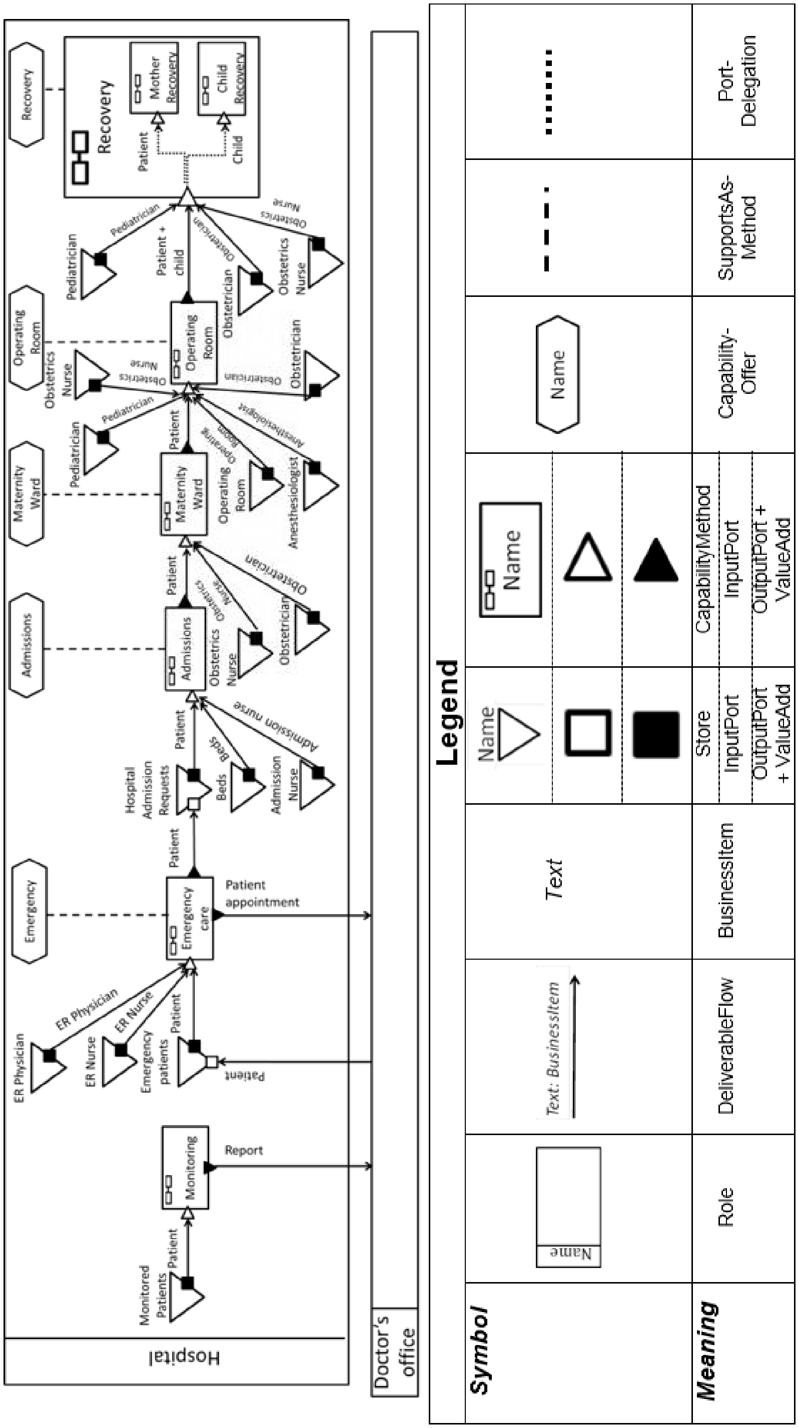


Figure 3.22: Value Stream Diagram for the Healthcare Case

3.4 Experimental Evaluation

3.4.1 Methodology

3.4.1.1 Purpose

The experiment analyzes the effect of the new business model viewpoint on the understanding of the underlying business model knowledge. This section describes guidelines to ensure the reproducibility of the experiment and to limit possible threats to internal validity (i.e., interference with the independent variable) and external validity (i.e., limitation of the generalizability of the results).

3.4.1.2 Hypotheses

Model understanding is measured through comprehension questions, which can be explicitly answered by means of the diagrams, and problem-solving questions that require a deeper understanding of the problem domain. Relevant dependent variables are interpretational effectiveness (i.e., accuracy of comprehending the diagram and extracting information) and interpretational efficiency (i.e., resources used to interpret the diagram) (Gemino and Wand, 2004, Burton-Jones et al., 2009). In case of opposite outcomes, efficacy (i.e., the ratio of effectiveness to efficiency) is used to assess the resulting effect of a treatment (Bodart et al., 2001, Poels et al., 2011).

As design principles are applied on the existing VDML diagrams to improve the understanding about the underlying business model components, it is expected that comprehension effectiveness, efficiency, and efficacy of the new business model viewpoint is higher than that of the existing VDML diagrams.

H_c: The comprehension effectiveness (H_{c1}), efficiency (H_{c2}), and efficacy (H_{c3}) of the new business model viewpoint is higher than the comprehension effectiveness (H_{c1}), efficiency (H_{c2}), and efficacy (H_{c3}) of the existing VDML diagrams.

This research focuses on improving the understanding of the diagrams (i.e., knowledge that is explicitly represented) and not on the interpretation of diagrams (i.e., knowledge that can be inferred, but not necessarily represented). As a result, it is expected that the effect of using the new business model viewpoint on the problem-solving performance measures will not be significant (Burton-Jones et al., 2009).

H_p: The problem-solving effectiveness (H_{p1}), efficiency (H_{p2}), and efficacy (H_{p3}) of the new business model viewpoint and the problem-solving effectiveness (H_{p1}), efficiency (H_{p2}), and efficacy (H_{p3}) of the existing VDML diagrams are equal.

3.4.1.3 Measures

The percentage of correct answers is suited to measure the interpretational effectiveness of the comprehension questions (Bodart et al., 2001). The maximum number of correct problem-solving answers cannot be determined upfront as it depends on the deep-level understanding of the business domain by participants. Therefore, absolute numbers need to be used to measure its effectiveness (Bodart et al., 2001). Time is proposed as the measure for the interpretational efficiency of both comprehension and problem-solving questions (Bodart et al., 2001, Gemino and Wand, 2004). As a result, the ratio of the percentage / absolute number of correct answers to the time needed for answering the comprehension / problem-solving questions is used to measure the interpretational efficacy (Bodart et al., 2001, Poels et al., 2011).

3.4.1.4 Experimental Design

A mixed design is applied, which includes the type of treatment as a within-subjects factor, while the type of case (i.e., healthcare case (OMG, 2012b) or manufacturing case (OMG, 2012c)) and the order in which participants receive the treatments, are used as between-subjects factors. This results in four experimental groups (see table 3.8), which perform the experimental tasks for the two treatments to restrain the effect of personal characteristics and skills. As the used cases are existing VDML examples, it is prevented that they are developed in favor of the new business model viewpoint. It is also ensured that a group receives each case once, which mitigates the learning effect that results from applying the same case. The learning effect from applying a certain treatment is controlled by counterbalancing treatments between group A and B versus C and D.

	Session 1	Session 2
Group A	Treatment 1: healthcare use case	Treatment 2: manufacturing use case
Group B	Treatment 1: manufacturing use case	Treatment 2: healthcare use case
Group C	Treatment 2: healthcare use case	Treatment 1: manufacturing use case
Group D	Treatment 2: manufacturing use case	Treatment 1: healthcare use case

Treatment 1: existing VDML diagrams
Treatment 2: VDML business model viewpoint

Table 3.8: Experimental design

3.4.1.5 Instrumentation and Experimental Tasks

The instrumentation consists of four sets of diagrams: the existing VDML viewpoints and the new business model viewpoint applied on the healthcare and the manufacturing case (see appendix A). Information equivalence is maximized by applying the adaptations (section 3.3.2.2) on the existing VDML case diagrams, without adding new information, as well as by controlling for background knowledge concerning the case topics (Burton-Jones et al., 2009).

The experimental tasks include the same comprehension questions and problem-solving questions (appendix A) for both cases. The comprehension questions also provide hints about which elements to consider while answering a question to ensure that the same information is available for both treatments. The experimental tasks are pre-tested to verify the formulation of the instructions and the questions.

3.4.1.6 Selection of Participants

The participants are Master students in Business Engineering without prior knowledge about VDML. While students differ from business professionals, Parsons and Cole (2005) argue that the use of experts can threaten internal validity as background knowledge is dominant while performing the experimental tasks. Moreover, a homogenous sample allows controlling for differences in skills and personality traits. Still, personal questions are used to control for domain knowledge (Gemino and Wand, 2004, Parsons and Cole, 2005, Burton-Jones et al., 2009), modeling experience (Gemino and Wand, 2004), and gender. Domain knowledge is measured by a working experience of at least three months in the healthcare or manufacturing industry, while the modeling experience of participants is verified by the Management Information Systems (MIS) courses and an eventual MIS master thesis in their curriculum.

3.4.1.7 Operational Procedures

The experiment is implemented as a voluntary class room exercise. Upfront, the participants are randomly assigned to four different slots corresponding with the experimental groups. The students are also informed that the answers are processed anonymously, the experiment can be aborted at any time, and the tasks can be fulfilled at their own pace.

As the set of acceptable answers for the comprehension questions is based on the information in the diagrams, the questions are solved by one researcher and validated by another. One point is assigned for each correct answer within this set, while half a point is distracted for additional answers. However, a small variation between the treatments for the first comprehension answer of the healthcare case needed to be solved to ensure comparability between the comprehension scores. The answers of the problem-solving questions are corrected by three researchers who discriminate between right and wrong answers. The final score is obtained by assigning one point to the answers, which are considered correct by all researchers.

3.4.2 Results

3.4.2.1 Descriptive statistics

The experiment was held on 2013-12-02 and attracted 126 participants from the original population of students, which results in an attendance rate of 77.3% (i.e., 126 out of total of 163 students). The correction of the questions resulted in 93 validly answered questionnaires corresponding with 73.8% of the attending participants. The dropout rate in group B was 65.5% (i.e., 19 out of 29) and in group D 26.7% (i.e., 8 out of 30). This was due to an error in the first problem-solving question of the manufacturing case, which was not detected during the pre-test. As a result, some participants used the wrong case to answer these problem-solving questions, which resulted in the exclusion of their answers. The difference in group sizes is taken into account by the experimental test that is described in section 3.4.2.2.

For the existing VDML diagrams, the mean comprehension effectiveness is 61.75% and the mean comprehension efficiency is 789s, which results in a mean efficacy of 0.078%/s. These figures can be contrasted to the mean effectiveness (i.e., 74.84%) and efficiency (i.e., 716s) of the VDML business model viewpoint. The resulting efficacy for this treatment is 0.105%/s. For the problem-solving questions, the mean effectiveness and efficiency of the existing VDML diagrams is 9.79pt and 382s compared to a mean effectiveness and efficiency of the VDML business model viewpoint of 9.44pt and 434s. This results in a mean problem-solving efficacy of 0.026 for the first treatment and 0.022 for the second treatment. Detailed descriptive statistics (i.e., the respective mean effectiveness, efficiency, and efficacy) of the comprehension (see table 3.9) and problem-solving (see table 3.10) measures for the four experimental groups, can be found below.

	Session 1	Session 2
Group A	Treatment 1 - healthcare use case 60.84% - 989s - 0.062%/s	Treatment 2: manufacturing use case 65.97% - 590s - 0.112%/s
Group B	Treatment 1: manufacturing use case 52.25% - 1047s - 0.050%/s	Treatment 2: healthcare use case 76.00% - 566.7s - 0.134%/s
Group C	Treatment 2: healthcare use case 82.00% - 880s - 0.093%/s	Treatment 1: manufacturing use case 62.50% - 645s - 0.097%/s
Group D	Treatment 2: manufacturing use case 77.16% - 752s - 0.103%/s	Treatment 1: healthcare use case 66.4% - 594s - 0.112%/s

Treatment 1: existing VDML diagrams
Treatment 2: VDML business model viewpoint

Table 3.9: Descriptive statistics for the comprehension questions

	Session 1	Session 2
Group A	Treatment 1 - healthcare use case 11.77pt - 494s - 0.024pt/s	Treatment 2: manufacturing use case 7.68pt - 277s - 0.028pt/s
Group B	Treatment 1: manufacturing use case 7.2pt - 498s - 0.014pt/s	Treatment 2: healthcare use case 10.55pt - 314s - 0.034pt/s
Group C	Treatment 2: healthcare use case 12.35pt - 579s - 0.021pt/s	Treatment 1: manufacturing use case 7.9pt - 308s - 0.026pt/s
Group D	Treatment 2: manufacturing use case 7.45pt - 512s - 0.015pt/s	Treatment 1: healthcare use case 10.76pt - 275s - 0.039pt/s

Treatment 1: existing VDML diagrams

Treatment 2: VDML business model viewpoint

Table 3.10: Descriptive statistics for the problem-solving questions

3.4.2.2 Statistical Method

As the experiment is characterized by a within-subjects design, which results in correlated data, a mixed linear model is used to check the hypotheses and the post-tests. This approach combines fixed effects, which are controlled during the experiment, with random effects that result from taking a sample from a population (Seltman, 2012). The main assumption of normally distributed residuals was analyzed by interpreting the Shapiro-Wilk test. In case the normality assumption was violated (i.e., $p = 0.042$ for H_{c1}, $p < 10^{-3}$ for H_{c2}, H_{p2}, and H_{p3}), a generalized mixed linear model was applied.
For each of the dependent variables, the results of each participant for both treatments were analyzed. The variable 'treatment' was added as the factor variable, while 'gender', 'curriculum', 'MIS thesis', 'working experience', 'case', and 'order' were used as covariates to perform the post-tests. Within the models, a random intercept accounts for random variability of individual participants in the dependent variables.

3.4.2.3 Hypotheses Tests

The experimental results (see table 3.11) confirm the hypotheses H_{c1}, H_{c2}, and H_{c3}. The use of the new business model viewpoint has a significant effect on both the effectiveness (+ 14.0%, $p < 10^{-3}$) and the efficiency (- 109s, $p < 10^{-3}$) of comprehension, compared to the existing VDML diagrams. This also results in a higher efficacy (+ $0.0302\frac{\%}{s}$, $p < 10^{-3}$) of comprehension for the new viewpoint.

Although the new business model viewpoint results in a slightly higher score for problem-solving effectiveness (+ 0.128pt, $p = 0.638$), the existing VDML diagrams are more efficient in this respect (- 27s, $p = 0.202$). However, the results are not significant at a 0.05 level and confirm H_{p1} and H_{p2}. These opposite effects result in a non-significant effect ($p = 0.572$) of the developed viewpoint on the problem-solving efficacy, which supports H_{p3}.

	Shapiro-Wilk p-value for normality of residuals	Effect of VDML business model viewpoint	F value	df value	p-value[1]
H_{c1}	0.042	+ 14.0%	19.548	177	$< 10^{-3}$
H_{c2}	$< 10^{-3}$	- 109s	13.811	177	$< 10^{-3}$
H_{c3}	0.522	+ 0.0302%/s	37.522	178	$< 10^{-3}$
H_{p1}	0.827	+ 0.128pt	0.223	178	0.638
H_{p2}	$< 10^{-3}$	- 27s	1.658	177	0.202
H_{p3}	$< 10^{-3}$	- $< 10^{-3}$pt/s	0.327	177	0.572

Table 3.11: Results of the hypothesis tests

Based on this analysis, the following conclusions can be drawn with respect to the proposed hypotheses.

H_c: The comprehension effectiveness (H_{c1}), efficiency (H_{c2}), and efficacy (H_{c3}) of the new business model viewpoint is significantly higher than the comprehension effectiveness (H_{c1}), efficiency (H_{c2}), and efficacy (H_{c3}) of the existing VDML diagrams.

H_p: There is not a significant difference between the problem-solving effectiveness (H_{p1}), efficiency (H_{p2}), and efficacy (H_{p3}) of the new business model viewpoint and the problem-solving effectiveness (H_{p1}), efficiency (H_{p2}), and efficacy (H_{p3}) of the existing VDML diagrams.

3.4.2.4 Post-tests

An overview of the significant post-test effects is given in table 3.12. The use of the healthcare case has an effect on the effectiveness of both comprehension (+ 6.37%, $p = 0.058$) and problem-solving (+ 3.82pt, $p < 10^{-3}$). The latter is expected as the problem-solving effectiveness score is measured as an absolute number. However, the effect on the internal validity is limited as both treatments are applied on this case example.

The learning effect appears for the efficiency of the comprehension (-306s, $p < 10^{-3}$) and problem-solving questions (- 227s, $p < 10^{-3}$). Due to high significance, it also has an influence on the efficacy of comprehension (+ $0.0368\frac{\%}{s}$, $p < 10^{-3}$) and problem-solving (+ $0{,}001\frac{pt}{s}$, $p < 10^{-3}$). This effect is controlled by counterbalancing treatments between groups (section 3.4.1.4).

Gender and modeling experience that is measured by MIS courses in the curriculum of the participants, tend to have moderate significant effects on the efficiency of understanding (+ 68s for males, $p = 0.021$) and the

[1] For one-sided hypotheses (i.e., H_{c1}, H_{c2}, and H_{c3}), the reported values are the p-values of the two-sided test divided by two.

effectiveness (+ 1.08pt for males, p = 0.057, + 2.25pt for regular curriculum, p = 0.009) and efficiency of problem-solving (+ 48s for males, p = 0.041). However, as participants were randomly assigned to the experimental groups, the effect on the internal validity of the experiment is limited.

	Significant effect	Effect	F value	df value	p-value
H_{c1}	Case: healthcare	+ 6.37%	3.682	177	0.058
H_{c2}	Order: learning effect Gender: male	- 306s + 68s	100.470 5.043	177 177	$< 10^{-3}$ 0.021
H_{c3}	Order: learning effect	+ 0.0368%/s	51.090	178	$< 10^{-3}$
H_{p1}	Case: healthcare Curriculum: regular Gender: male	+ 3.82pt + 2.25pt + 1.08pt	180.274 7.088 3.720	178 178 178	$< 10^{-3}$ 0.009 0.057
H_{p2}	Order: learning effect Gender: male	- 227s + 48s	109.496 5.083	177 177	$< 10^{-3}$ 0.041
H_{p3}	Order: learning effect	+ 0.001pt/s	68.668	177	$< 10^{-3}$

Table 3.12: Results of the post-tests

3.5 Conclusion

This research completes the development of a business model representation by building on chapter 2, in which the components of a business model were identified. In this chapter, it was further investigated to which extent relevant value modeling languages capture these components, which resulted in a set of VDML meta-model constructs that cover the complete business model. These meta-model constructs were developed into the new VDML business model viewpoint to facilitate the understanding of the underlying business model knowledge. This was experimentally evaluated by comparing the new business model viewpoint with the existing VDML diagrams.

The comprehension effectiveness, efficiency, and efficacy of the new business model viewpoint are significantly higher compared to the existing VDML diagrams. This confirms that the development of the new business model viewpoint, based on the design principles of cognitive effectiveness, has a positive effect on the understanding of the underlying business model components. The effectiveness, efficiency, and efficacy of problem-solving are not statistically different between the treatments, which supports comparable research (Parsons and Cole, 2005, Burton-Jones et al., 2009). For this type of questions, the personality traits and modeling experience of participants, rather than the treatments, tend to have an impact on the deep level understanding of the problem domain.

The statistical analysis of this chapter (see 3.4.2.3 and 3.4.2.4), as it published in the Business and Information System Engineering journal, did not include the interaction effect between the treatments and the cases that were used. As this can have an impact on the estimated effects, this analysis was performed afterwards (see appendix A). However, the main conclusions that were drawn in this chapter remain valid as the interaction effect is only statistically significant for the problem-solving efficiency. In this case, the use of the existing VDML diagrams of the healthcare use case tend to have a positive effect (-90s, $p = 0.030$) on the problem-solving efficiency of the participants.

The increased understanding of the underlying business model knowledge is useful in the context of Value-Based Requirements Engineering (Gordijn and Akkermans, 2003). Indeed, the new viewpoint allows the documentation of value-based business requirements in a form that facilitates analysis and communication, to better understand the purpose of IT systems in relation to these higher-level requirements (Nuseibeh and Easterbrook, 2000). However, to assure a proper operationalization of requirements, organizational strategies (e.g., the Unified Business Strategy Meta-Model represented by i* (Giannoulis et al., 2012)) should be further refined via business (e.g., our viewpoint represented by VDML) to process requirements (i.e., operational tasks, responsibilities, and business rules) and subsequent IS requirements (Gordijn and Akkermans, 2003, Andersson et al., 2009).

The experiment implements the evaluation of the new business model viewpoint by comparing it to the existing VDML diagrams. As VDML is only recently adopted as an OMG standard (OMG, 2014b), an evaluation of the existing diagrams was not performed before. In this respect, the insights of our research also contribute to the further development of the VDML modeling language.

In the experiment, the set of comprehension questions is answered by a homogeneous group of respondents. This is a threat for the external validity as stakeholders have various backgrounds in a real-life context. This limitation can be overcome by performing a case-study and a similar experiment with the actual stakeholders of a company. Such an experiment, which requires qualitative research methods as it is characterized by a smaller group of respondents, will eventually enable a practical evaluation of the developed viewpoint.

A limitation of this research is the purely quantitative evaluation of the experiment. It could have been useful to extend this evaluation with qualitative feedback about the perceived strengths and weaknesses of the different treatments, as perceived by the experimental participants. This would provide further insights to support the conclusions of this chapter. This is an important element that should be addressed in future research.

To realize IT support for business model representations, the new viewpoint can be used as the input for the development of a software tool, which should be extended as a proper decision support system to realize the alignment between the organizational strategy, business models and processes (Veit et al., 2014).

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4

Realizing Strategic Fit with Business Architecture Heat Maps

Abstract

The realization of strategic fit within the business architecture is an important challenge for organizations. Research in the field of Conceptual Modeling has resulted in the development of a wide range of modeling techniques that provide visual representations to improve the understanding and communication about the business architecture. As these techniques provide partial solutions to the issue of realizing strategic fit within the business architecture, the new Process-Goal Alignment technique is presented. This technique combines the visual expressiveness of heat mapping techniques with the analytical capabilities of performance measurement and prioritization techniques to provide a comprehensible and well-informed approach for the realization of strategic fit within an organization's business architecture. This chapter reports on the design of the proposed technique by means of the Action Design Research methodology, which included iterative cycles of building, intervention, and evaluation through case studies. To support the automatic application of the technique, a software tool was developed using the ADOxx meta-modeling platform.

Keywords

Strategic Fit, Business Architecture, Conceptual Modeling, Heat Map, Action Design Research

Research contribution

This research presents a conceptual modeling technique that solves RQ B of research cycle B, which aims to realize strategic fit with business architecture heat maps (see section 1.2.2.1). This research question was formulated as follows:

RQ B How can we realize strategic fit within the business architecture by means of a conceptual modeling technique, which builds on the strengths of existing techniques to address all three drivers of strategic fit (see section 4.4)?

4.1 Introduction

The realization of strategic fit within the business architecture remains a challenge in practice (Schieman, 2009, Verweire, 2014). Strategic fit is important for companies to ensure that the proper activities are executed to achieve the organizational goals (Popova and Sharpanskykh, 2011). The business architecture is a multi-perspective blueprint of the enterprise that provides a common understanding of the formulation of the organizational objectives (i.e., the strategy perspective), the implementation of the strategy (i.e., the infrastructure perspective), and operational process decisions (i.e., the process perspective) (Maes, 2007, OMG, 2012a). Research (De Bruin and Rosemann, 2006, Schieman, 2009) has shown that three main drivers are crucial in the realization of strategic fit: the alignment of the strategy, the infrastructure, and the process perspectives of the enterprise, a clear communication of the organizational strategy that ensures its understanding and acceptance by business stakeholders, and the use of a performance measurement system that guides process outcomes towards the intended strategic objectives by setting clear performance targets and keeping track of the actual performance to provide incentives for possible improvements. These improvements differ from innovation, which involves radical changes that go beyond the boundaries of the existing business architecture. These radical changes are implemented by innovation programs (e.g., Open Innovation Paradigm (Chesbrough, 2003)), which are outside the scope of this research.

Conceptual modeling is *the activity of formally describing some aspects of the physical and social world around us for purposes of understanding and communication* (Mylopoulos, 1992). Conceptual Modeling is also an academic research area that has developed different modeling languages for providing visual representations of the aforementioned business architecture perspectives. Goal modeling languages (e.g., i* (Yu et al., 2011), KAOS (Dardenne et al., 1993), the Business Motivation Model (OMG, 2014a)) have been designed to address the strategy perspective by contributing to a better understanding of the organizational goals that shape the strategic context of a company (Kavakli and Loucopoulos, 2005). As they largely abstract from the other perspectives (i.e., the infrastructure needed to implement a strategy and the decisions regarding process design), we position goal models at the highest abstraction level of the business architecture. On an intermediate abstraction level, value modeling techniques (e.g., VDML (OMG, 2014b), the REA ontology (McCarthy, 1982), e^3-value (Gordijn and Akkermans, 2003), VNA (Allee, 2008), Capability Maps (Hafeez et al., 2002, Microsoft, 2006)) are used to represent the strategy implementation or organizational infrastructure perspective in terms of what an enterprise must do (i.e., processes) and needs (i.e., capabilities and resources) to create value and deliver it to the various stakeholders (Andersson et al., 2009, OMG, 2014b). Finally, models developed using process modeling languages (e.g., Business Process Model and Notation (BPMN) (OMG, 2010), UML (i.e., Unified Modeling Language) Activity Diagrams (OMG, 2004), the Web Service Business Process Execution Language (WS-BPEL) (OASIS, 2007), Role Activity Diagrams (Ould, 1995)) are situated at the lowest abstraction level of the business architecture as they identify the collection of interlinked organizational processes that are needed to execute the organizational value creation/delivery activities. These are further specified by operational design aspects such as individual responsibilities, activities, data flows, information flows, and the workflow between business process activities (List and Korherr, 2006, Ko et al., 2009, Dumas et al., 2013).

Different groups of conceptual modeling techniques (see section 4.2) contribute to the drivers of realizing strategic fit. The alignment of the different business architecture perspectives is addressed by techniques, which realize a fit between the modeling languages that are used to represent these perspectives. These model-based alignment techniques can be divided into different subgroups according to the specific approach they adopt. Top-down alignment techniques employ transformation rules and construct mappings to help develop conceptual models at lower abstraction levels from models at higher abstraction levels. Bottom-up approaches annotate conceptual models with information of other models found at higher abstraction levels, while hybrid techniques align the conceptual models that are used for the different business architecture perspectives by combining a top-down and a bottom-up approach. A last group achieves strategic fit in an integrative manner through the use of newly designed modeling languages, which include constructs that are relevant to the strategy, infrastructure, and/or process perspectives of the business architecture. As a result, this group provides the flexibility to align the business architecture perspectives both in a top-down and bottom-up fashion without being dependent on the choice of a particular set of modeling languages for these perspectives.

Capability heat mapping techniques (Hafeez et al., 2002, Microsoft, 2006) exclusively focus on the infrastructure perspective of the enterprise by specifying what is done in the organization to support the creation of value (Microsoft, 2006). These techniques address strategic fit by making use of performance measurement to guide the organizational performance of business capabilities towards the intended strategic objectives. This is realized by setting clear performance targets, as well as by monitoring the actual organizational performance to provide insights in which capabilities can be improved. Furthermore, capability heat maps deploy a prioritization mechanism to identify the strategic value of these capabilities. The performance and strategic value of capabilities are visualized by using appropriate color coding in heat maps, which provide an overview for the stakeholders in the company about the capability gaps that need to be overcome (Keller, 2009). As such, these techniques further contribute to the realization of strategic fit by combining an intuitive visualization with the ability to reduce the size of models through prioritization, which enables the creation of a conceptual model that can be easily understood and communicated by business stakeholders.

Apart from using an intuitive visualization, other conceptual modeling languages (Giannoulis et al., 2012, Francesconi et al., 2013, Horkoff et al., 2014, Kudryavtsev et al., 2014) build on appropriate frameworks in the management field to provide modeling concepts that are especially meaningful for business stakeholders. This increases the comprehensibility of these languages and is intended to result in a better understanding and communication by business people, who are usually not familiar with the use of more formal conceptual modeling languages (Balabko and Wegmann, 2006).

In summary, a wide range of conceptual modeling techniques contributes to the realization of strategic fit. This is realized by: (i) the alignment of the business architecture perspectives in a top-down (i.e., ensuring the realization of strategic goals by identifying the appropriate business processes that sustain these goals) and/or bottom-up manner (i.e., improving the effectiveness of business processes by ensuring that these processes support the strategic goals) (Andolson, 2007, Morrison et al., 2012), (ii) the use of performance measurement (i.e., improving the efficiency of processes by identifying performance targets based on appropriate quality measures and improving the monitoring within the enterprise to ensure that these desired results are achieved over time) (Andolson, 2007, Morrison et al., 2012), and (iii) the development of a conceptual model that is explicitly oriented towards improving the understanding and communication of the organizational strategy by business stakeholders. However, in the current academic literature, there is no conceptual modeling technique that incorporates the right mechanisms to address all three drivers of strategic fit. To solve this gap, the following research question (i.e. RQ B) is formulated:

RQ B How can we realize strategic fit within the business architecture by means of a conceptual modeling technique, which builds on the strengths of existing techniques to address all three drivers of strategic fit?

This chapter presents the PGA technique, which incorporates the technique of heat mapping into an integrative modeling, performance measuring and prioritization-based approach to realize strategic fit. The design of this technique included the development of a new modeling language to model the creation of value throughout a hierarchical structure of business architecture elements, which are related to the strategy, infrastructure, and process perspectives. The identification of the relevant elements for these perspectives was based on appropriate conceptual frameworks in the management field, which make use of a terminology that is meaningful to business users (Frank, 1998), to result in a better understanding and communication of the organizational strategy. To enable the application of heat mapping, the modeling language constructs were extended with appropriate performance measurement attributes. Furthermore, the Analytic Hierarchy Process (AHP) (Saaty, 1990) was incorporated to implement the prioritization mechanism. The visualization of the performance measurement and prioritization outcomes enables the development of business architecture heat maps. The newly developed language is accompanied by a modeling procedure that guides the proper application of the PGA technique.

The chapter is structured as follows. Section 4.2 presents a comparison of the envisioned PGA technique with related research, which demonstrates the need for its development. Section 4.3 describes the ADR methodology, which was used for the design of the PGA technique. This includes a gradual refinement of the technique through intervention and evaluation in real-life enterprise contexts (Sein et al., 2011). Section 4.4 presents the actual results of this research, which provides an answer to RQ B (see section 1.2.3.1) of research cycle B, which aims to realize strategic fit with business architecture heat maps. Section 4.5 concludes by summarizing the contributions that were made and by discussing opportunities for future research.

4.2 Related Work

Related conceptual modeling techniques are applied in the context of aligning business architecture perspectives (section 4.2.1), providing heat map techniques (section 4.2.2), or developing modeling languages that are explicitly oriented towards business stakeholders instead of IT professionals (section 4.2.3). These techniques are grouped in table 4.1 according to their support of the drivers of strategic fit. As none of the related techniques supports the complete set of drivers, it was needed to design the new PGA modeling technique. The overview of this section partly builds on previous research (Poels et al., 2013), which reviewed efforts that align goal and process modeling languages by adopting a top-down and/or bottom approach.

Reference	Alignment of business architecture perspectives		Performance measurement	Business stakeholder orientation	
	Top-down	Bottom-up		Constructs	Visualization
Andersson et al., 2006 Bleistein et al., 2006 Gordijn et al., 2006b Weigand et al., 2006 Frankova et al., 2007 Lapouchnian et al., 2007 Weigand et al., 2007 Andersson et al., 2009 Edirisurija and Johannesson, 2009, de Kinderen et al., 2014	x				
Gordijn et al., 2006a Grau et al., 2008 Buder and Felden, 2012		x			
Zlatev and Wobacher, 2005 Koliadis et al., 2006 Pijpers et al., 2012 Solaimani and Bouwman, 2012 Zachman, 1987 The Open Group, 2011, 2013	x	x			
U.S. Department of Defense, 2010 U.S. Federal Administration, 2013	x	x	x		
Horkoff et al., 2014 Francesconi et al., 2013	x	x	x	x	
Microsoft, 2006 Hafeez et al., 2002			x		x
Frank, 2014a				x	x
Kudryavtsev et al., 2014	x			x	

Table 4.1: Application scope of the related work

4.2.1 Model-based alignment techniques

Alignment techniques approach strategic fit in a top-down (section 4.2.1.1), bottom-up (section 4.2.1.2), hybrid (section 4.2.1.3), or integrative (section 4.2.1.4) manner. Hybrid approaches align conceptual modeling languages that are used to provide a representation of a specific business architecture perspective both in a top-down (e.g., by making use of construct mappings and/or transformation rules) and bottom-up manner (e.g., by making use of annotation or equivalence checks between diagrams). This is different from an integrative approach, which uses a newly designed modeling language that realizes top-down and bottom-up strategic fit by integrating constructs of the different business architecture perspectives. The envisioned PGA technique relates to these research efforts as it adopts an integrative approach for the development of the new PGA modeling language, which combines constructs for the representation of the strategy, infrastructure, and process perspectives. However, except of the Business Intelligence Model (Horkoff et al., 2014), alignment techniques do not incorporate a performance measurement mechanism to guide operational process outcomes towards the intended strategic objectives by setting appropriate performance targets and monitoring the actual organizational performance. This can be explained by the application context of these techniques within EA and Requirements Engineering. Indeed, these models do not include the actual organizational performance as they focus on specifying precise, complete, and business-aligned requirements for developing effective IT systems (Li et al., 2015), which precedes the actual system implementation. Moreover, these models offer a complete and precise view on the business domain by making use of formal modeling constructs. However, this attention to a formal and precise specification tends to increase the size and complexity of the models, which was shown to hinder the understanding and communication of the organizational strategy by business stakeholders (Frank, 1998, Balabko and Wegmann, 2006).

4.2.1.1 Top-down Approaches

Gordijn et al. (2006b) make use of transformation rules to realize a top-down alignment between the strategy and the infrastructure perspectives, which results in iterative cycles of goal modeling and value modeling. Andersson et al. (2009) use similar transformation rules to develop a top-down method, which enables to identify potential e-services from e^3-value models that are aligned with i* goal models. Other research efforts focus on the alignment of value models and process models. de Kinderen et al. (2014) provide a top-down method to align ArchiMate models (i.e., an EA modeling language) with e^3-value models via transaction modeling patterns from the DEMO methodology for Enterprise Engineering (i.e., the Design & Engineering Methodology for Organizations). Another top-down technique (Andersson et al., 2006) allows to derive process models (i.e., UML activity diagrams) from e^3-value diagrams by making use of pre-defined patterns. Similar methods use (an extended variant of) e^3-value as a starting point to align value models with BPMN process models by means of transformation rules (Weigand et al., 2006, Weigand et al., 2007, Edirisurija and Johannesson, 2009). Other researchers directly align goal models with process models (see review of Poels et al. (2013)). Their efforts makes use of (a variant of) i* goal models and various kinds of process models, such as WS-BPEL (Frankova et al., 2007, Lapouchnian et al., 2007) and Role Activity Diagrams (Bleistein et al., 2006).

4.2.1.2 Bottom-up Approaches

Gordijn et al. (2006a) investigate the bottom-up refinement of goal models by using the profitability analysis that is offered by the e^3-value modeling technology. A similar approach is adopted by Buder and Felden (2012), which annotates process models with value information to indicate the contribution of individual processes to the overall value chain. The alignment technique of Grau et al. (2008) employs Script Modeling to develop business process models, from which i* goal models can be derived in a prescriptive and systematic way.

4.2.1.3 Hybrid Approaches

Zlatev and Wobacher (2005) use a combination of top-down and bottom-up alignment to prevent contradictions between e^3-value models and UML activity diagrams, by providing an equivalence check between the overlapping constructs of these perspectives. The Value-Information-Process framework is introduced as a language-independent tool to realize strategic fit between the infrastructure and process perspectives. This framework supports both top-down alignment (i.e., the identification of operational requirements) and bottom-up alignment (i.e., the identification of misalignment between the perspectives) by clarifying the strategic and operational aspects of interactions between actors (Solaimani and Bouwman, 2012). The e^3-alignment framework is proposed to realize inter-organizational business-IT alignment between the business architecture perspectives and ISs (Pijpers et al., 2012). To capture the strategic interactions between organizations, e^3-forces is introduced and aligned with the e^3-value modeling language. For the process perspective, UML activity diagrams are derived from value models via a set of transformation rules. Finally, the alignment technique of Koliadis et al. (2006) directly aligns goal models with process models. This technique makes use of construct mappings and transformation rules to transform Formal Tropos goal models (i.e., an extended variant of i*) into BPMN diagrams and vice versa.

4.2.1.4 Integrative Approaches

The Business Intelligence Model (BIM) (Horkoff et al., 2014) extends the focus of i* goal models to align the strategic perspective with the process perspective. This is realized by the BIM modeling language, which integrates concepts for describing strategic goals and organizational processes. As such, BIM can be compared to the PGA technique as it provides insights into how operations can be aligned with the strategic objectives of an organization. Furthermore, ample attention is attached to the use of performance measures, which enables to perform a goal satisfaction analysis for the evaluation of alternative design options. Since the early version of this technique does not cover the infrastructure perspective, this was by addressed by the Tactical Business Intelligence Model (TBIM) (Francesconi et al., 2013), which augments the BIM modeling language with some concepts of the Business Model Ontology (Osterwalder et al., 2010). This ontology clarifies business models by providing a shared terminology for the concept (see also chapter 2). By using this terminology, TBIM enables a better understanding and communication of the infrastructure perspective by business stakeholders. However, (T)BIM is clearly different from the PGA technique as it lacks a prioritization mechanism and a consistent use of performance measurement (i.e., performance indicators are only used to measure process outcomes), which prevents the application of a visual heat map technique.

The review of model-based alignment techniques is not complete without mentioning EA, which is a coherent whole of principles and methods that offers a holistic view on the design and realization of an enterprise's organizational structure, business processes, ISs, and IT infrastructure (Lankhorst, 2009). To deal with the increasing size and complexity of the EA process, Zachman (1987) proposes a descriptive framework that is able to classify architectural representations for different architecture layers (e.g., the enterprise as a conceptual system, as a logical system, as a physical system) according to six perspectives (i.e., purpose, structure, function, people, time, and location). Within this classification framework, the envisioned PGA technique specifically contributes to a better aligned business architecture with respect to its purpose (why), structure (what), and function (how).

Much of the EA knowledge is assembled in the TOGAF standard, which includes the Architecture Development Method (ADM) as a stepwise approach to realize the different phases of the iterative EA development process (The Open Group, 2011). The ADM is accompanied by guidelines and techniques to facilitate its application in practice. Moreover, it is fully aligned with the use of ArchiMate, a graphical EA modeling language that integrates concepts of the business, application, and technology architectural layers to construct visual representations of the architecture (The Open Group, 2013). Both the PGA technique and ArchiMate provide graphical models that can be used to align the different business architecture perspectives in an integrative manner. However, the latter has a clearly different scope as it primarily oriented towards the (re)design of the organization. Consequently, it aims to provide a complete and formal business architecture model, which might lower the comprehensibility of these models by business stakeholders. Moreover, the use of performance measurement is not supported by ArchiMate.

Although other EA frameworks have been developed in specific organizational contexts such as the U.S. Department of Defense (2010) and the U.S. Federal Administration (2013), the use of generic concepts and comparable architecture layers make them applicable to a broad range of enterprises (Lankhorst, 2009). These techniques are comparable to TOGAF, as an architecture development process is combined with more detailed guidelines and principles for the actual implementation. This enables the development of a holistic view on the organization, which supports strategic fit in an integrative manner. Moreover, the importance of performance indicators is explicitly acknowledged in these frameworks. However, none of the techniques prescribes a formal notation that is able to visualize the different viewpoints. As this issue is important to support the understanding and communication of the organizational strategy by business stakeholders, the PGA technique makes use of a notation for the business architecture hierarchy, as well as for the results of the AHP and the execution of the performance measurement.

4.2.2 Heat Mapping

Capability heat maps (Hafeez et al., 2002, Microsoft, 2006) combine the use of performance measurement with a prioritization mechanism to assess the organizational performance and strategic value of capabilities. In this respect, capabilities are defined as *the ability to perform a particular skillset, which is a function, process or service* (LEADing Practice, 2015). By applying appropriate color coding in heat maps, these techniques provide an overview of the capability gaps that need to be overcome in the organization, which is useful to increase the strategic impact of investment decisions (Keller, 2009). Although a capability heat map is not oriented towards aligning the strategy, infrastructure and process perspectives of business architecture, it provides an intuitive visualization that can easily be understood by business stakeholders.

Prioritization was also used by Kudryavtsev et al. (2014), who deploy the Quality Function Deployment (QFD) methodology to realize a top-down alignment of the different perspectives in the business architecture. To identify business architecture concepts that are meaningful for business stakeholders, this technique makes use of frameworks from the management literature. Although the use of QFD enables to capture the essence of the resulting models, Kudryavtsev et al. (2014) do not take into account the actual organizational performance of business architecture elements, which differs from the envisioned PGA technique.

4.2.3 Business Stakeholder Orientation

Recently, Frank (2014a) has developed the Multi-perspective Enterprise Modeling (MEMO) approach that supports the development of modeling techniques that are explicitly oriented towards the background of prospective business users. This is implemented by the use of domain-specific modeling languages (DSMLs), which can be used in the domain of discourse of a particular enterprise. As the MEMO approach results in the development of a DSML accompanied by a modeling procedure, it is comparable to the PGA technique. Although the domain specificity of a DSML does not necessarily restrain a possible application of these languages in other organizations (Frank, 2014b), the main incentive for designing the PGA technique is solving the generic problem of unrealized strategic fit in enterprises. This is a fundamentally different goal than the creation of DSMLs, which are driven by the requirements of a specific organizational context.

4.3 Methodology

The ADR methodology is a specific type of Design Science research for the design of research artifacts that explicitly provide theoretical contributions to the academic knowledge base, while solving a practical organizational problem (Sein et al., 2011). This methodology is appropriate for building and evaluating modeling languages as it enables to get a substantial impression of the perceptions of end-users, which overcomes the limitations of purely experimental evaluations (Frank, 1998). This section reports on the four stages of the ADR methodology: problem formulation (section 4.3.1), building, intervention, and evaluation (section 4.3.2), reflection and learning (section 4.3.3), and formalization of learning (section 4.3.4).

4.3.1 Problem Formulation

The organizational problem of unrealized strategic fit was already described in the introduction (section 4.1), which clarifies its practical relevance and further explains how this issue is conceived by academic research. Furthermore, this section discussed how existing conceptual modeling techniques contribute to the realization of strategic fit and how these techniques are related to the envisioned PGA technique, which makes use of a unique combination of mechanisms to fully tackle the problem. The need for the new PGA technique was further explained in section 4.2, which shows that related research efforts do not adhere all three drivers of strategic fit.

4.3.2 Building, Intervention, and Evaluation

The second phase of the ADR takes place in the context of real-life case studies and includes the iterative process of building the PGA technique (section 4.3.2.1), intervention in the organization (section 4.3.2.2), and evaluation (section 4.3.2.3) (Sein et al., 2011).

4.3.2.1 Building the PGA Technique

To ensure a rigorous design, building the PGA technique (see section 4.4.1 and 4.4.2 for the actual results) was informed by several theories. The development of the hierarchical structure of business architecture elements was based on frameworks originating in the management field to ensure that the modeling constructs of the PGA technique are meaningful to business stakeholders. These frameworks are considered as analysis theories, which aim to describe a certain domain of interest (Gregor, 2006). The Balanced Scorecard (Kaplan and Norton, 1992, 2004) addresses the strategic perspective of the business architecture by organizing the formulation of organizational goals in four interrelated categories (i.e., internal, customer, financial, and innovation and learning). Other management instruments and frameworks (e.g., SWOT analysis (Andrews, 1980), Blue Ocean strategy (Chan and Mauborgne, 2005)) are useful to support the formulation of the strategy, but are not capturing the actual strategic content. Therefore, these frameworks were not included in the PGA technique. For the infrastructure perspective, the Business Model concept was included as it represents the implementation of a strategy to create value and exchange it with the external value network (Shafer et al., 2005). To identify the relevant business model components for the PGA technique, we built on the research of chapter 2, which presents an integrative component framework that provides a common conceptual basis for this concept. The process perspective of the business architecture was based on the Value Chain concept of Porter (1985), who considers the operational activities that are performed in a company as a key source of competitive advantage. As a result, the activity concept was adopted by the PGA technique.

For the application of a heat mapping technique, it was needed to add a mechanism, which enables end-users to prioritize the extent to which an element supports the creation of value on a higher level in the hierarchical structure of the business architecture (see section 4.4.1.1 for more details). Prioritization was implemented by making use of AHP, which is based on pairwise comparisons of alternatives (Saaty, 2008). AHP is particularly useful to be applied in a heat mapping technique as it enables to prioritize between factors that are arranged in a hierarchical structure (Saaty, 1990). Moreover, this mechanism measures the inconsistency that is inherent to subjective judgments (Hafeez et al., 2002). The heat mapping technique was further implemented by adding a performance measurement mechanism for the identified business architecture elements. In accordance with existing techniques (e.g., (Microsoft, 2006)), the mechanism we developed is able to discriminate between a good, an average, or a bad performance.

The visual representation of the PGA modeling language was informed by the Physics of Notations (Moody, 2009), which is a design theory that prescribes principles for the creation of cognitively effective model representations. These design principles were useful to limit the size and complexity of the PGA model instantiations, which further increases the understanding and communication by business stakeholders.

4.3.2.2 Intervention in the Organization

The intervention in the organization was performed by means of three case studies that were conducted in collaboration with employees of a major IT solution provider. These employees, which could be considered as representative target end-users of the envisioned technique, included two product managers (i.e., cases 1 and 3) and one regional manager (i.e., case 2). The ADR team consisted of two researchers, who provided theoretical input for (re)building and evaluating the technique, and one strategy consultant, who was involved in the company and applied the PGA technique through interventions with the end-users. The role of the strategy consultant was important to introduce practical hypotheses and knowledge of organizational work practices into the application of the technique (Sein et al., 2011). Each of the case studies was characterized by a particular organizational context, which resulted in the development of three different heat maps (i.e., one for each end-user). In the first case study, the context of interest was a product market of the company, which was facing changing market conditions. Although it was sufficient for the organization to focus merely on functional product requirements in the past, the importance of offering integrative solutions and developing partnerships with customers is growing. This required an analysis whether the current value creation in the business architecture is suited to address these changes. For the second case study, the application of the PGA technique provided insights about how to sustain the future growth of the company and how to better communicate this high-level vision on the business architecture to the lower management in the company. The scope of the third case study addressed the gap, as experienced by the manager, between the strategy that is adopted in the product market and the operational processes. The application of the PGA technique revealed this misalignment and provided insights in how the focus of the processes could be changed to better realize the strategy.

The first case study provides input for the running example (see figures 4.3-4.9 in section 4.4), which illustrates the application of the PGA modeling technique. In this running example, firm-specific information is generalized to preserve confidentiality. Furthermore, screenshots are used to provide insights in how the proposed technique was automated by a software tool, which was developed by means of the ADOxx meta-modeling platform (Fill and Karagiannis, 2013). This tool support was crucial for the creation of PGA model instantiations during the case studies. More details about the technical implementation of the software tool can be found in appendix B.

4.3.2.3 Evaluation

The evaluation of the PGA technique was not oriented towards a direct measurement of the degree of strategic fit in the organization, but the intervention through case studies allowed capturing the perceived strengths and weaknesses of the proposed technique by both the consultant and the managers/end-users. The evaluation by the consultant (see section 4.4.2) was based on a qualitative analysis of the complexity, applicability, and comprehensibility of the different mechanisms in the PGA technique (Lüftenegger, 2014). The end-user evaluation (see section 4.4.3) assessed how well the technique supports the three drivers of strategic fit: (i) the alignment of the business architecture perspectives in a top-down and bottom-up manner (i.e., $SF_{top\text{-}down}$ and $SF_{bottom\text{-}up}$ in table 4.2), (ii) the use of performance measurement (i.e., $SF_{perf\text{-}meas1}$ and $SF_{perf\text{-}meas2}$ in table 4.2), and (iii) the development of a conceptual model that is explicitly oriented towards improving the understanding and communication by business stakeholders. The last element, which is a basic requirement for enterprise models (Frank, 2014a), was evaluated by means of the Technology Acceptance Model (TAM) (Davis, 1989). This measurement framework for the user acceptance of IT artifacts has proven to be useful for a wide range of users and technologies (Lee et al., 2003). Moreover, the constructs of perceived usefulness (i.e., the degree to which the end-user believes that a technique is effective in achieving its objectives) and perceived ease of use (i.e., the degree to which the end-user believes that using the PGA technique is free of effort), which are considered as the fundamental determinants of user acceptance, are applicable in more recent technology acceptance frameworks (Venkatesh et al., 2003). These constructs enabled us to capture the perceptions of the end-users concerning the effectiveness and efficiency of the PGA technique in a systematic way, which is crucial in the application of the ADR methodology (Frank, 1998). The evaluation questions for perceived usefulness (i.e., $PU_{1\text{-}8}$ in table 4.2) and perceived ease of use (i.e., $PEU_{1\text{-}6}$ in table 4.2) were based on the refined item scales of the TAM (Moody, 2003), worded in terms of the PGA technique. Some of these questions are formulated negatively to avoid monotonous responses of the end-users. Each of the items in table 4.2 was measured on a seven-point scale, ranging from strongly disagree to strongly agree. Moreover, qualitative feedback about the perceived strengths and weaknesses of the technique was solicited to complement this evaluation of predefined item scales (see section 4.4.3).

Item	Question
$SF_{top\text{-}down}$	The PGA technique improves the realization of strategic goals by identifying the appropriate business processes that sustain these goals.
$SF_{bottom\text{-}up}$	The PGA technique improves the effectiveness of business processes by ensuring that these processes add value to a strategic goal.
$SF_{perf\text{-}meas1}$	The PGA technique improves the efficiency of processes by identifying performance targets based on appropriate quality measures.
$SF_{perf\text{-}meas2}$	The PGA technique improves monitoring within the organization to ensure that desired results are achieved over time.
PU_1	I believe the PGA technique would reduce the effort required to take strategic decisions
PU_2	Understanding strategic decisions using the PGA technique would be more difficult for users
PU_3	The PGA technique would make it easier for users to verify whether strategic decisions are correct
PU_4	Overall, I found it useful to apply the PGA technique
PU_5	Using the PGA technique would make it more difficult to take strategic decisions
PU_6	Overall, I think the PGA technique does not provide an effective solution to take strategic decisions
PU_7	Overall, I think the PGA technique is an improvement to the existing strategic decision mechanisms
PU_8	Using the PGA technique would make it easier to communicate strategic decisions to other stakeholders
PEU_1	I found the procedure for applying the PGA technique complex and difficult to follow.
PEU_2	Overall, I found the PGA technique difficult to use.
PEU_3	I found the PGA technique easy to learn.
PEU_4	I found it difficult to apply the PGA technique in the context of the organization.
PEU_5	I found the rules of the PGA technique clear and easy to understand.
PEU_6	I am not confident that I am now competent to apply the PGA technique in practice.

Table 4.2: Evaluation questionnaire

4.3.3 Reflection and Learning

Reflection and learning is performed in parallel with the first two phases to reflect on how the technique can be iteratively improved. These adaptations are the result of the organizational use and the concurrent evaluation of the technique (Sein et al., 2011). To identify possible improvements, the role of the ADR team consists of being sensitive for possible improvement opportunities to further shape the design of the artifact. In this respect, an indispensable aspect was the evaluation of the complexity, applicability, and comprehensibility of the different mechanisms, which are used in the PGA technique, by the strategy consultant (see section 4.4.2).

4.3.4 Formalization of Learning

Formalization of learning includes the development of the situational learning into a generic solution for the addressed problem (Sein et al., 2011). However, this step needs to be performed with caution as it is not straightforward to generalize results from case study research. However, by incrementally adapting the PGA technique during the three different case studies, the generalizability of the improvements for the modeling language (see section 4.4.4.1) and procedure (see section 4.4.4.2) with respect to the realization of strategic fit was preserved as much as possible.

4.4 PGA Technique

4.4.1 Initial Version

The PGA technique consists of a modeling language (section 4.4.1.1), which is defined by its syntax, semantics, and visual notation, and a modeling procedure (section 4.4.1.2) that guides the actual creation of model instantiations (Karagiannis and Kühn, 2002).

4.4.1.1 Modeling Language

The initial meta-model of the PGA modeling language[2] is given in figure 4.1 (i.e., with the exception of the valueStream* relation, which is the result of a refinement in section 4.4.2). The corresponding definitions can be found in table 4.3.

The PGA modeling language is oriented towards visualizing the creation of value throughout a hierarchical structure of business architecture elements, which are related to the strategic, infrastructure and process business architecture perspectives. This is implemented by the identification of *valueStream* relations between the relevant elements, which support the creation of value at various levels (see L.X in table 4.3) in the business architecture. The process perspective is addressed by the concept of *Activity* (i.e., L1) (Porter, 1985), which enables users to decide on low-level operations that are required for realizing organizational goals. These activities are

[2] The initial version of the technique was presented in Roelens B and Poels G (2014) The Creation of Business Architecture Heat Maps to Support Strategy-aligned Organizational Decisions. In *8th European Conference on IS Management and Evaluation (ECIME '14)*. Devos J and De Haes S (eds.), Gent, Belgium.

aggregated in the value stream to process overviews of the constituting *ValueChain* (i.e., L.2). This element is relevant to the infrastructure perspective, as well as the concept of a *Competence* (i.e., L.3: internal, strategically valuable capabilities), which supports a *ValueProposition* (i.e., L.4: value offered to customers), and results in a *FinancialStructure* (i.e., L.5: revenues and costs) in the overall value stream. The choice of these constructs is based on chapter 2, which identifies the constituting elements of the Business Model concept. To establish the link with the organizational goals (i.e., L.6), Kaplan and Norton (1992) differentiate between the internal, customer, financial, and innovation and learning perspectives. This results in the identification of a *valueStream* relation between a *Competenc*e and an *InternalGoal*, between a *ValueProposition* and a *CustomerGoal*, and between a *FinancialStructure* and a *FinancialGoal*. The innovation and learning perspective is not included as innovation involves radical changes of the business architecture, which is outside the scope of the PGA technique.

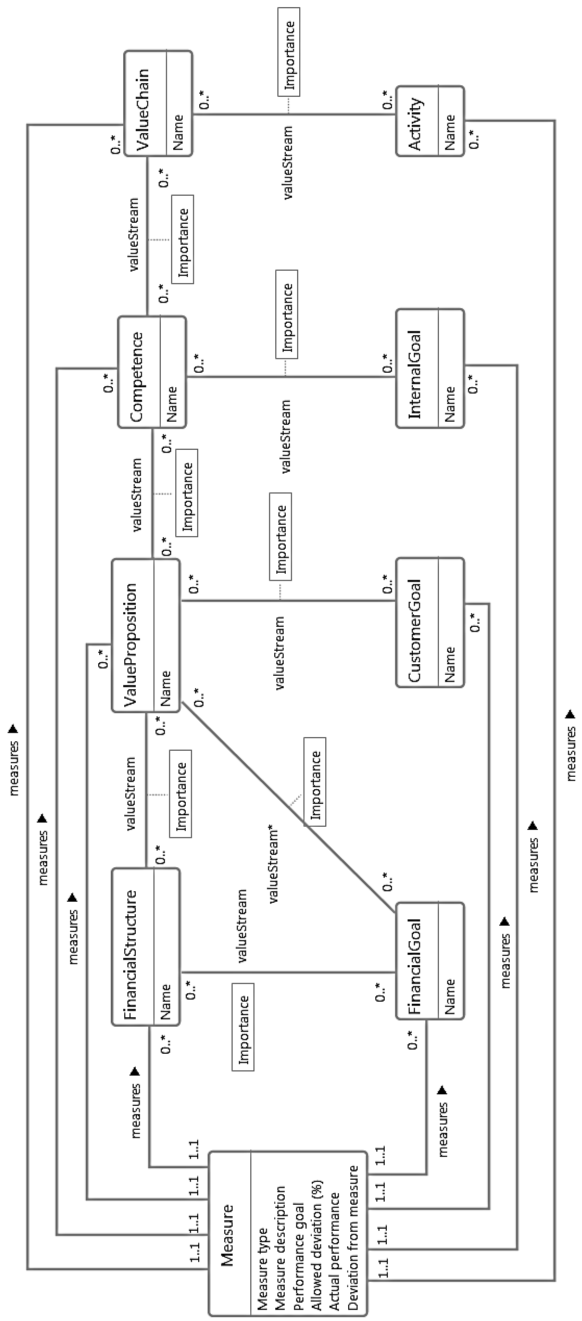


Figure 4.1: Meta-model of the PGA modeling language

The meta-model was extended with additional elements to convert a business architecture model, which is obtained by instantiating these meta-model constructs, into a business architecture heat map. First, the result of the AHP prioritization mechanism is captured by the *importance* attribute of the *valueStream* relations. This attribute measures the extent to which an element supports the creation of value on a higher level in the hierarchical structure of the business architecture. Second, the performance measurement mechanism of the heat maps is realized by using appropriate *Measure* attributes to *measure* the performance of the business architecture elements. These attributes include a *measure type* to account for either positive (e.g., profit: the higher the value, the better), negative (e.g., cost: the lower the value, the better), or qualitative (e.g., a satisfied criterion) indicators. Furthermore the *measure description* attribute provides a textual definition of the performance indicators. The remaining attributes are numerical values, which specify a performance goal with an allowed deviation interval. By comparing these values with the actual performance value (see section 4.4.1.2), it can be calculated whether there is a positive or negative deviation from the value that is minimally acceptable for the organization.

The design of the notation of the PGA modeling language (see table 4.3) was guided by the Physics of Notations (Moody, 2009). The main principle that influenced this design was semantic transparency, which means that the appearance of a symbol suggests its meaning. This was realized by using icons to facilitate the recognition of the constructs by business stakeholders. The results of the AHP and the performance measurement are represented by the use of colors (i.e., red, orange, and green), combined with a certain texture (i.e., solid, dashed, and dotted) to account for printing constraints (see section 4.4.1.2 for more details about how these results are obtained). This choice of colors is guided by existing heat mapping techniques (Microsoft, 2006) to further ensure semantic transparency.

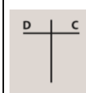
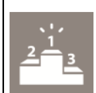
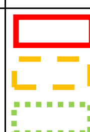
Hierarchy level	Modeling construct	Definition	Notation
L.6	Goal	Strategic objective that describes a desired state or development of the company (Popova and Sharpanskykh, 2011). Relevant categories are financial (upper notation), customer (middle notation), and internal objectives (bottom notation) (Kaplan and Norton, 1992).	
L.5	Financial Structure	A representation of the costs, resulting from acquiring resources, and the revenues in return for the offered value proposition (Osterwalder, 2004).	
L.4	Value Proposition	The offered set of products and/or services that provides value to the customers and other partners, and competes in the overall value network (Osterwalder, 2004, Tikkanen et al., 2005, Al-Debei and Avison, 2010).	
L.3	Competence	An integrated and holistic set of knowledge, skills, and abilities, related to a specific set of resources, which is coordinated through the value chain to realize the intended value proposition (Prahalad and Hamel, 1990, Sanchez, 2004, LEADing Practice, 2015).	
L.2	Value Chain	The business process architecture, which aggregates a structured set of activities that combines resources to create the organizational competences (Porter, 1985, Tikkanen et al., 2005, Demil and Lecocq, 2010).	
L.1	Activity	Work that is performed in a process by one or more actors, which are engaged in changing the state of one or more input resources or enterprise objects to create a single desired output (LEADing Practice, 2015).	
-	value-Stream	Representation of the hierarchical structure, through which value is created at distinct levels in the business architecture.	
-	Measure	A quantitative or qualitative indicator that can be used to give a view on the state or progress of a business architecture element (Popova and Sharpanskykh, 2011, Horkoff et al., 2014).	

Table 4.3: Definition and notation of the PGA modeling constructs

4.4.1.2 Modeling Procedure

The initial modeling procedure consisted of three main activities: (i) developing a prioritized business architecture hierarchy, (ii) executing the performance measurement, and (iii) performing the strategic fit improvement analysis.

- Activity (i): developing a prioritized business architecture hierarchy

The first activity included an interview to both develop the business architecture hierarchy (i.e., the elements connected by valueStream relations) and to perform the AHP to prioritize the extent to which an element supports the creation of value on a higher level in the hierarchical structure of the business architecture. During this interview, a visual aid (see figure 4.2) was used to assist the end-users in adding business architecture elements and to ensure the creation of valid instantiations of the meta-model.

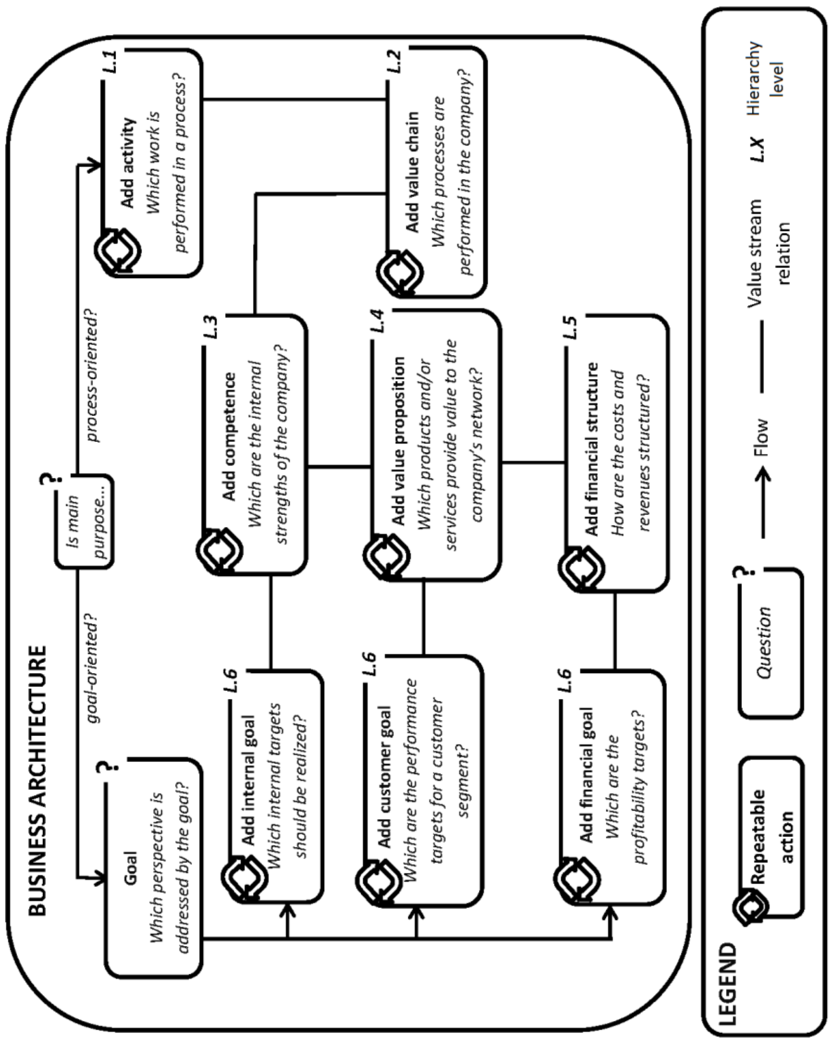


Figure 4.2: Visual aid for the creation of the business architecture hierarchy

The first question in this visual aid was whether strategic fit should be approached in a top-down or a bottom-up manner. Based on the answer, the hierarchy was built in either a top-down or bottom-up manner. In the running example that we provide (figure 4.3), this includes for instance adding

'Defend market position' as a *CustomerGoal* (i.e., in a goal-oriented approach) or 'Close customer deals' as an *Activity* (i.e., in a process-oriented approach). After an element was added, the choice could be made between exploring elements of the same type (depicted via a repeatable action in figure 4.2) and adding elements of another type, which can be reached via the *valueStream* relations. To enable a clear distinction between the different construct types, elements of the same type were grouped as much as possible on the same horizontal level in the resulting model instantiations. If it is assumed that the running example is built in a process-oriented approach, this includes adding 'Attract customers' as a second *Activity* on the same horizontal level or adding 'Selling products' as a *ValueChain* element on a next horizontal level. To facilitate the identification of the various elements, their definition was translated into questions that can be easily understood by end-users (see figure 4.2) (Lüftenegger, 2014). After the identification of the elements, the business architecture hierarchy was completed by adding the relevant *valueStream* relations between these elements. In the running example, this results in the identification of 39 *valueStream* relations (see green, dotted lines) that compose the hierarchy of business architecture elements. The necessary condition for ending the development of the business architecture hierarchy was the completion of a minimal cycle, which includes the creation of a value stream that connects at least one activity (e.g., 'Close customer deals') with one of the organizational goals (e.g., 'Defend market position') via intermediate business architecture elements (e.g., 'Selling products', 'Experience and expertise', and 'Offering partnership support'). The rationale for this condition is based on the purpose of the PGA technique to realize strategic fit within the business architecture, which includes the alignment of the formulation of the strategy with the operational decisions in the enterprise. The sufficient condition to stop the development of the business architecture was determined by the scope of the PGA application in practice. Given this practical scope, the emphasis should be put on the elements that are most important for the creation of value, rather than providing a complete view on the business architecture. This is important to preserve the understanding and communication of the models by the business stakeholders. For the running example that is based on the first case-study, figure 4.3 provides an overview of the developed business architecture hierarchy, which consists of the elements that are most crucial to ensure the creation of value in the context of the changing market conditions. By addressing these changed conditions, the company wants to defend its position in the market (i.e., a customer goal), as well as to generate sufficient revenues (i.e., a financial goal). The following competences are identified in this changed organizational context: the ability to develop customer relationships, the ability to develop integrated product offerings, experience and expertise, and a sound internal organization. To further operationalize these competences, four key processes are needed (i.e., 'Selling products', 'Promoting products', 'Financial management process', and 'Technology research and development'). 'Selling products' is further decomposed in the activities of attracting customers, closing customer deals, and obtaining customer references. The technology research and development cycle consists of a market analysis, the identification of product specifications, and the development and maintenance of the product.

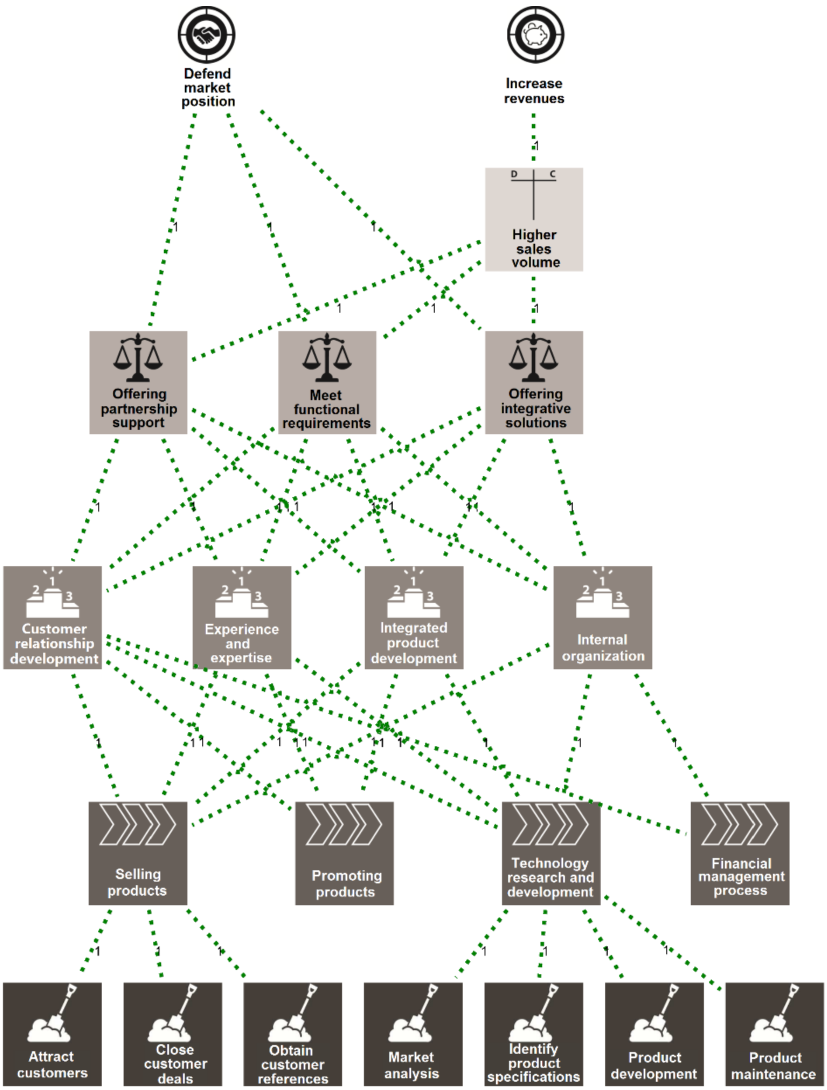


Figure 4.3: Business architecture hierarchy for the running example

Afterwards, the AHP was applied to determine the importance of the *valueStream* relations. In figure 4.4, an illustration of this prioritization process is provided for the running example. This included the pairwise comparison of all elements X (e.g., the competences 'Customer relationship development', 'Experience and expertise', 'Integrated product development', and 'Internal organization'), which are related to the same neighboring element Y (e.g., the value proposition 'Offering integrative solutions') by *valueStream* relations. This neighbor is characterized by a hierarchy level (e.g., L.4 for a *ValueProposition*), which is higher than the hierarchy level (e.g., L.3 for a *Competence*) of the related elements. These detailed hierarchy levels of the business architecture elements are determined based on their definitions (see L.X table 4.3). The pairwise comparison was performed by the use of the AHP comparison scale, which ranges from 1 (i.e., X_i and X_j have equal importance) to 9 (i.e., X_i has absolute importance over X_j), as well as the reciprocal values in case X_j is more important than X_i (Saaty, 1990). For the running example, this results in a list of six pairwise comparisons (see figure 4.4). The results were grouped in a square comparison matrix M (i.e., an element $M_{xi,xj}$ contains the importance of X_i compared to X_j), of which the real Eigenvector represents the absolute priorities of the considered set of elements. To apply AHP in the context of the PGA technique, the resulting priorities were rescaled relatively to the lowest value. This ensures that the priorities can be compared independently from the number of elements, which are connected to the same neighboring element by means of *valueStream* relations. Based on these rescaled priorities, the color of the *valueStream* relations was changed to red for a high importance (i.e., ≥ 5), orange for a medium importance (i.e., ≥ 3 and < 5), or green for a low importance (i.e., < 3). This process was completely automated in the software tool and results in the visualization that is provided at the bottom of figure 4.4. Finally, it was also possible to calculate a consistency ratio, which is an AHP measure for the degree to which the subjective judgments of the end-users contain disproportions. If the value of this ratio is over 10%, appropriate actions should be undertaken to improve the consistency of the judgments (Saaty, 1990). A possible action includes a re-evaluation of the judgments in the pairwise comparison matrix by the end-user (Hafeez et al., 2002). The figures that are provided for the running example result in a consistency ratio of 7.85% (see figure 4.4), which means that the inconsistency of these comparisons, as provided by the end-user, is at an acceptable level.

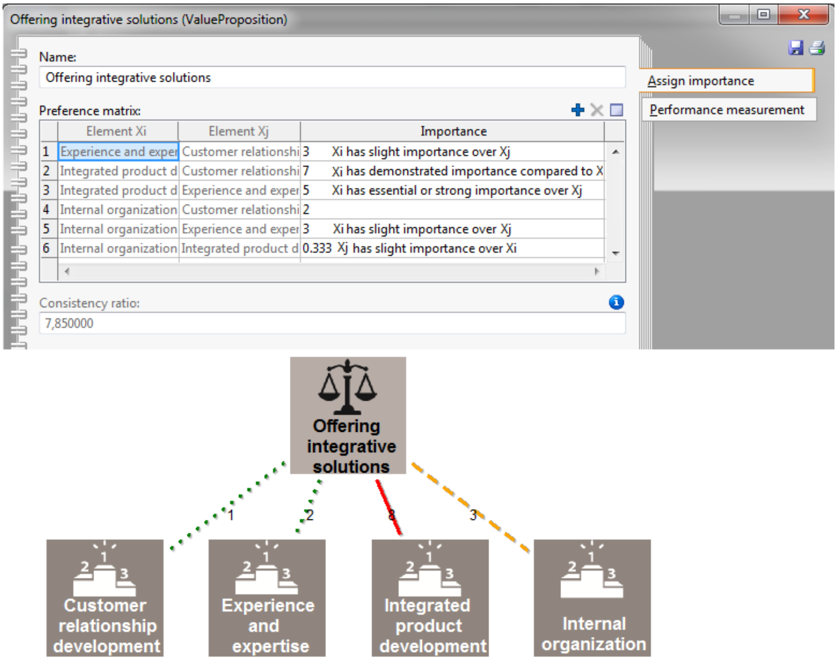


Figure 4.4: AHP for the running example

- Activity (ii): executing the performance measurement

The performance measurement activity aims at collecting information in the enterprise to fill in the relevant *Measure* attributes (i.e., measure type, measure description, performance goal, allowed deviation, and actual performance). Based on the values, it could be determined whether the actual performance of an element is good, average or bad (see table 4.4). A good performance was visualized by a green, an average performance by an orange, and a bad performance by a red border color of the elements. Figure 4.5 gives an example of how the performance measurement attributes were specified for the *Activity* 'Close customer deals' of the running example. This element is assessed by the positive measure 'Percentage of closed deals'. Based on the actual performance (i.e., 60%), which is above the performance goal x (1 + allowed deviation) (i.e., 50% x (1 + 0.05) = 52.5%), a green color was used for the border of this element (see left-hand side of figure 4.5).

Measure type	Actual performance	Interpre-tation
Positive	≥ *performance goal* x (1 + *allowed deviation*)	Good
	≥ *performance goal* x (1 – *allowed deviation*) and < *performance goal* x (1 + *allowed deviation*)	Average
	< *performance goal* x (1 – *allowed deviation*)	Bad
Negative	≤ *performance goal* x (1 – *allowed deviation*)	Good
	> *performance goal* x (1 – *allowed deviation*) and ≤ *performance goal* x (1 + *allowed deviation*)	Average
	> *performance goal* x (1 + *allowed deviation*)	Bad
Qualitative	= 1	Good
	= 0	Bad

Table 4.4: Performance measurement interpretation for the different measure types

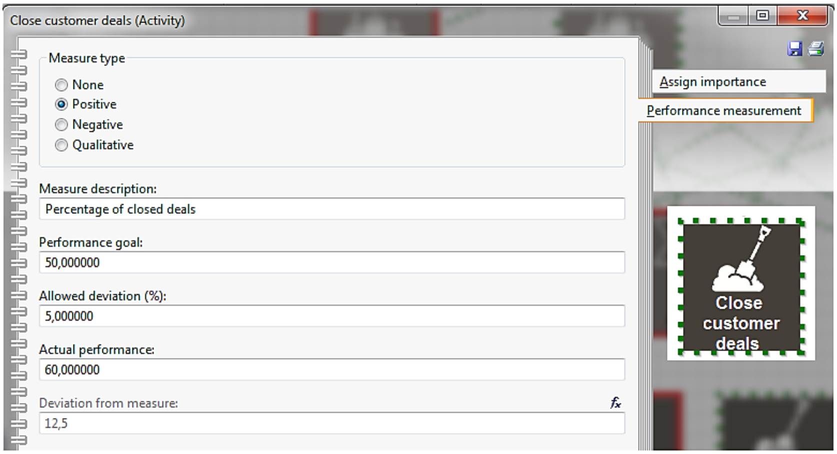


Figure 4.5: Performance measurement for the running example

- Activity (iii): performing the strategic fit improvement analysis

The first two activities in the modeling procedure resulted in the creation of a business architecture heat map (see figure 4.6 for the running example), which could be further used to perform a strategic fit improvement analysis. This analysis included the identification of goals that are on a critical path (i.e., a chain of *valueStream* relations that have a high or medium importance) and which are characterized by a bad performance. It is assumed that improving contributing activities could influence value creation through the business architecture to realize a better performance of the organizational goals. In the running example, this critical path is manually highlighted by a grey color (see figure 4.6). Although the analysis shows that the company is able to successfully defend its market position, this is realized at the expense of revenue creation. This can be explained as the internal organization is not yet fully evolved to support the offering of integrated solutions in the new organizational context. More specifically, the quality of the product maintenance activity (as part of the 'Technology research and development process') can be improved to better support this internal organization. The model also indicates a more indirect way to improve the generation of revenues. Although the *valueStream* relations are characterized by a lower importance, the realization of revenues can also be improved by focusing on obtaining customer partnerships. The value stream further depends on the sale of products, which can be improved by focusing on the activity of obtaining customer references in the new market reality. As figure 4.6 shows that the identification of the critical path is not straightforward for larger models, this analysis was also included in the tool during the actual application of the PGA technique.

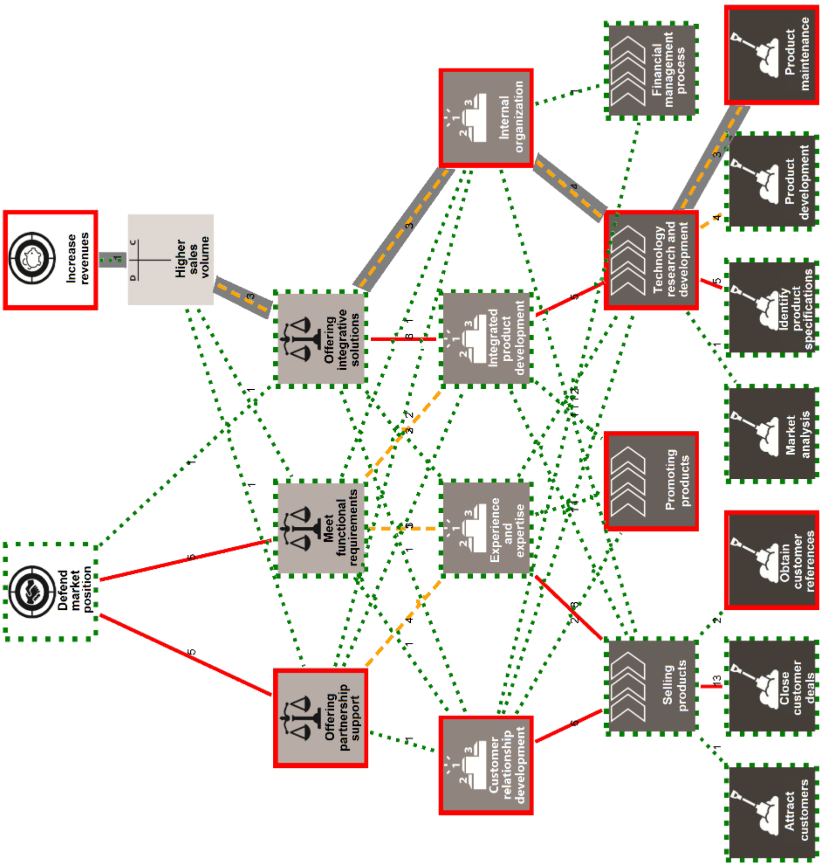


Figure 4.6: Business architecture heat map for the running example

4.4.2 ADR adaptations

4.4.2.1 Modeling Language

The first case study revealed the need to increase the understanding of the elements by making them more clearly distinguishable (i.e., the principle of perceptual discriminability (Moody, 2009)). This was improved by using brightness as a visual variable for redundant coding. More specifically, goals are characterized by a white background, which gradually darkens when moving to elements on a lower level in the business architecture hierarchy. To preserve the clarity of the running example, this background color was already added to the visualization of table 4.3 and consistently used in figures 4.3-4.9.

The applicability of the *FinancialStructure* element was questioned during the first and third case study. Indeed, end-users understood how this element was related to the business architecture as a whole, but the identification of *valueStream* relations with a specific *FinancialGoal* or *ValueProposition* was not straightforward. These relations were limited to those that are obliged to complete the minimal cycle, without really explaining how the *FinancialStructure* contributes to realizing strategic fit. Therefore it was decided to adapt the meta-model and to allow a direct relation between a *FinancialGoal* and a *ValueProposition* (see extra *valueStream** relation in figure 4.1). This resulted in omitting the *FinancialStructure* element (together with the *valueStream* relation that connected this element with a *FinancialGoal*) in the first and third case study models (see table 4.5). For the running example (see figure 4.7), this change was implemented by allowing *valueStream* relations between the *FinancialGoal* 'Generate Revenues' and the respective *ValuePropositions* 'Offering partnership support' and 'Offering integrative solutions'.

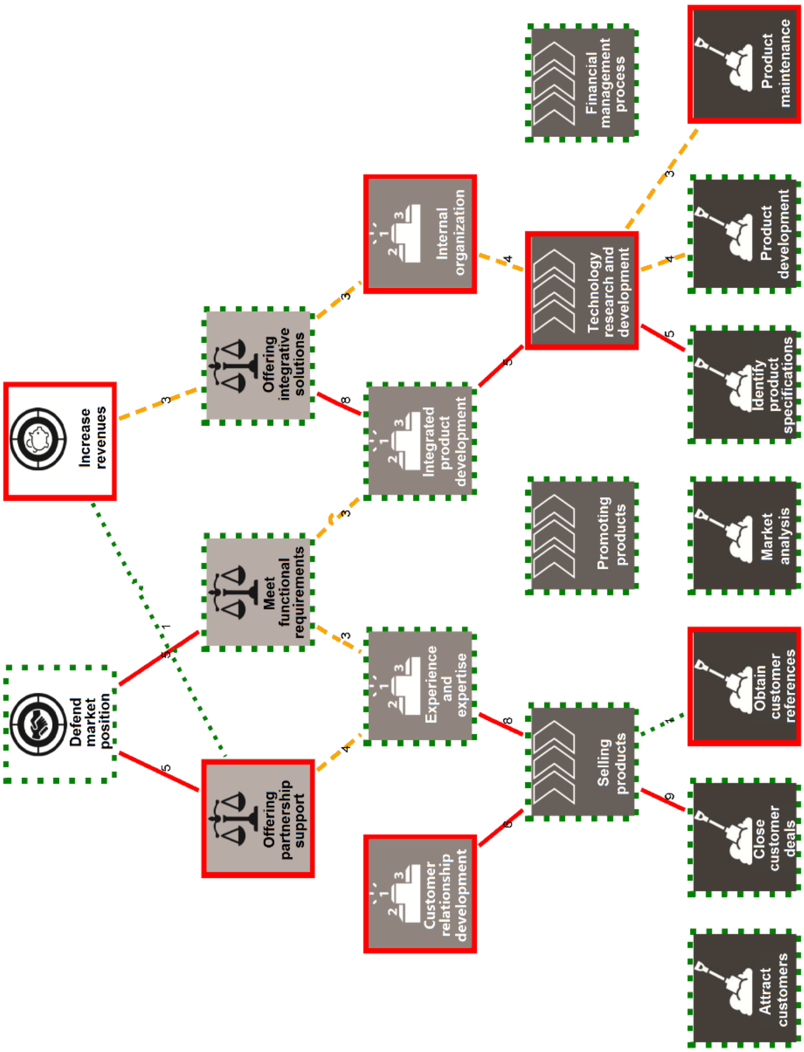


Figure 4.7: Refined business architecture heat map for the running example

4.4.2.2 Modeling Procedure

- Activity (i): developing a prioritized business architecture hierarchy

In the first case study, the end-user preferred to build the business architecture hierarchy element per element. This reduced the complexity of the modeling procedure as it allowed focusing on a certain aspect, instead of continuously moving between different elements. To enable an easy revision of this hierarchy, the identification of the *valueStream* relations and the application of the AHP were moved to a second interview. As such, an end-user could apply adaptations without having to repeat the AHP for the modified matrices afterwards.

An adaptation to the minimal cycles was the result of the second case study. This case study was performed in collaboration with a senior manager and is characterized by a higher level of abstraction than the other cases. As individual process activities were not relevant for the strategic fit analysis by this end-user, it was allowed to consider the *ValueChain* as the element at the lowest hierarchical level in the business architecture. This does not endanger the realization of strategic fit as the *ValueChain* element still provides insights in possible operational improvements to better realize the organizational goals. Although not directly applicable, this adaptation can also be understood in the context of the running example (figure 4.7) by considering 'Promoting products' and 'Financial management process', which are not related to concrete activities, as elements at the lowest level in the business architecture hierarchy.

The AHP process was also adapted based on the first case study. To increase the understanding of the end-users, the choice of a comparison value between two elements (e.g., X_i and X_j) was hereafter preceded by questioning which of the elements is the most important. Answering this question (i.e., X_i is more important than X_j, X_i and X_j have equal importance, or X_i is less important than X_j) ensures a more convenient use of the reciprocal values of the AHP comparison scale by the end-users. However, to limit the complexity of inserting the comparison values by the strategy consultant in the software tool, the technical implementation of this comparison scale (see formula 4 in appendix B) was not adapted.

The application of the first and second case study raised another issue about the applicability of the AHP process as quite some consistency ratios were out of bound (i.e., > 10%). Besides the reason of inconsistencies between the judgments of the end-users, a more thorough analysis revealed another cause. Indeed, a certain degree of inconsistency for the pairwise comparisons is inevitable if the ratio between the most and least important *valueStream* relation, in the group of relations that connects the same upper-level element, is higher than 9. In this case, it was decided to remove the least important *valueStream* relation (i.e., with an importance of 1) from the resulting models. Although this action reduces the completeness of these models, it increases the understanding about the essence of the business architecture by the end-users. This resulted in a decrease of 5.3% (i.e., 2 out of the remaining 38) for the *valueStream* relations in the first case study and a decrease of 28.1% (i.e., 9 out of 32) in the second case study (see table 4.5). Figure 4.8 provides an example of this mechanism for the running example. In the preference matrix, it can be seen that the relative importance of 'Obtain customer references' to 'Close customer deals' is 0.111 and to 'Attract customers' is 3 (see top of figure 4.8). To obtain a comparison without any inconsistency, the relative importance of 'Attract customers' to 'Close customer deals' needs to be about 0.037 (i.e., 0.111 x 0.333). As this is impossible in the existing AHP scale, it is decided to remove the relation between 'Selling products' and 'Attract customers'. This results in the situation, which is depicted at the bottom of figure 4.8.

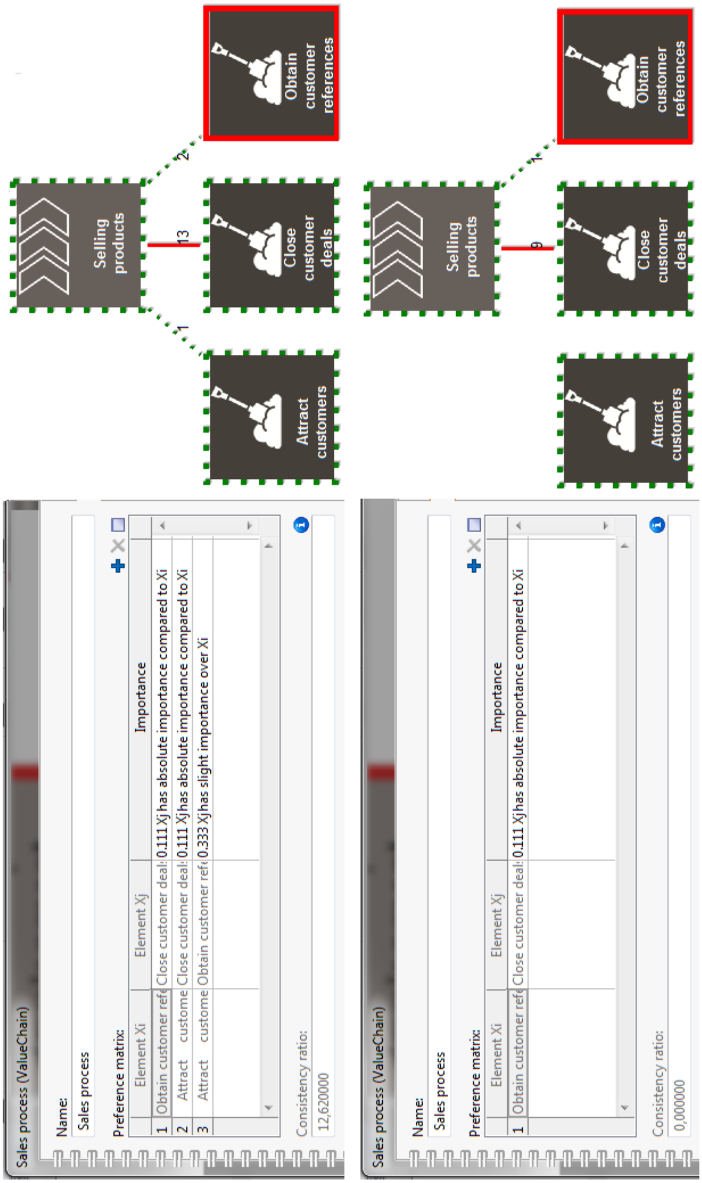


Figure 4.8: Mechanism to remove unimportant relations for the running example

The third case study led to the introduction of a mechanism to reduce the total number of comparisons. This was the result of the finding that during the development of the business architecture hierarchy, end-users do not yet discriminate between unimportant and important *valueStream* relations. To limit the complexity of the AHP process in the next step, a qualitative choice of the different relations was introduced upfront. This resulted in a decrease of 16.0% (i.e., 15 out of the remaining 94) of the relations in the final model (see table 4.5).

Construct	# case study 1	# case study 2	# case study 3
# initial business architecture elements	21	13	33
# initial valueStream relations	39	32	95
# refined business architecture elements	20	13	32
# refined valueStream relations	36	23	79
Priority threshold of strategic fit improvement analysis	50%	50%	4-9

Table 4.5: Model size for the different case studies

- Activity (ii): executing the performance measurement

The application of the performance measurement was refined based on experience gained during each of the three case studies. When collecting the relevant information, it turned out that collecting quantitative measures was not always straightforward (e.g., because certain performance indicators are not explicitly measured, because sensitive information is kept secret). The solution for this issue was the use of qualitative indicators and performing extra interviews to collect the necessary information from the end-users. However, it should be advised to the stakeholders to develop appropriate performance measurement systems to make this activity as objective as possible.

- Activity (iii): performing the strategic fit improvement analysis

To facilitate the strategic fit improvement analysis of the case study models, which incorporated the results of both the AHP process and performance measurement, an explicit mechanism was needed to limit the diagrammatic complexity of the resulting business architecture heat maps. This mechanism was implemented by enabling end-users to specify a relative interval (i.e., specified by a lower and upper bound) of priorities that are visualized in the model. More specifically, all priorities were ranked from high to low importance, after which the relative share was calculated for each group. If the minimum and maximum values of this share were within the specified lower and upper bounds, this priority group was eventually made visible. The analysis of the running example (see figure 4.7), which is based on the first case study, resulted in the visualization of the 50% most important relations (see figure 4.9 for the implementation of this mechanism in the software tool). For the second case study, 50% of the most significant priorities were also sufficient to capture the essence of the business architecture heat map (see table 4.5). Finally, end-users could choose to visualize extra *valueStream* relations, which are not part of the specified interval, to complete a critical path in the business architecture. For the running example (figure 4.7), this principle is applied to complete the critical path analysis by the individual visualization of the *valueStream* relations between 'Generate revenues' and 'Offering partnership support' and between 'Selling products' and 'Obtain customer references'.

The analysis of the third case study was not straightforward as the number of *valueStream* relations in the business architecture heat map (i.e., a total of 79), is significantly higher than in the other case studies (see table 4.5). Moreover, 70 of these relations had an importance between 1 and 4. Due to this skewed distribution, it was harder for end-users to specify a relative visualization interval in the resulting model. Therefore, it was decided to enable the specification of absolute interval boundaries in the strategic fit improvement analysis mechanism. For the third case, this resulted in the visualization of the value stream relations that have an importance between 4 (i.e., the lower bound) and 9 (i.e., the upper bound).

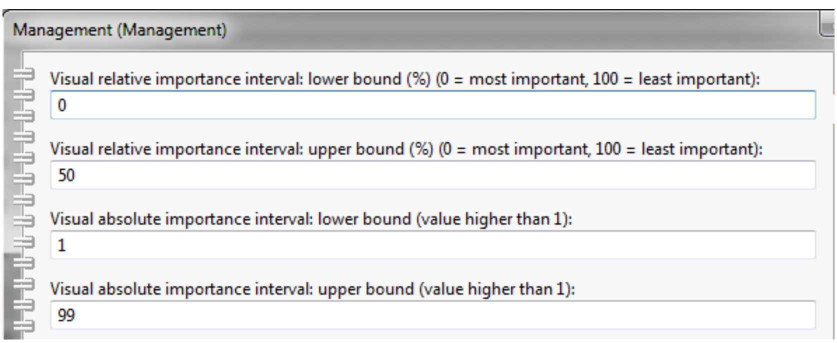


Figure 4.9: Mechanism to facilitate the strategic fit improvement analysis for the running example

4.4.3 End-User Evaluation

Table 4.6 gives an overview of the end-user evaluation scores (i.e., one end-user per case study) for the drivers of strategic fit. For the perceived usefulness and perceived ease of use, the average score of the individual items (i.e., $PU_{1\text{-}8}$ and $PEU_{1\text{-}6}$ of table 4.2) is provided. The detailed figures for the individual items can be found in appendix B. Besides this quantitative evaluation, the strategy consultant also asked the users to provide qualitative feedback about the perceived strengths and weaknesses of the technique.

Construct	**Case study 1**	**Case study 2**	**Case study 3**
$SF_{top\text{-}down}$	6	6	6
$SF_{bottom\text{-}up}$	6	7	6
$SF_{perf\text{-}meas1}$	4	6	7
$SF_{perf\text{-}meas2}$	6	4	5
$PU_{average}$	5.63	5.88	6.25
$PEU_{average}$	5.5	5.33	5.33

Table 4.6: End-user evaluation results

The end-users agree to strongly agree with the fact that the PGA technique contributes to the realization of top-down and bottom-up strategic fit. An explicitly stated advantage of the technique is the provision of an alternative view on the business architecture, which provides new insights or clarifies existing intuitive ideas about how elements are aligned (or misaligned) in the organization. In the context of the case studies, this was particularly useful to overcome the strong emphasis on financial results, which is imposed by the high-level management of the organization. Indeed, the PGA method enabled the end-users to capture the essence of their business, which helped them to understand factors of success and to identify weaknesses.

End-users are more reserved about the performance measurement as they believe that the success of the PGA technique largely depends on how well it can be integrated with existing performance measurement systems in the organization. These systems can range from traditional Balanced Scorecard instruments (Kaplan and Norton, 2004) to large-scale data analytics software. This integration is important as it provides objective figures about the actual performance of a business architecture element. Apart from this integration, it is also crucial to create a long-term engagement with the stakeholders in the organization to update performance indicators and to monitor the impact of changes over time. This will result in a long-term track record that collects information about the effectiveness of strategic decisions within the enterprise.

On average, users more than slightly agree with the usefulness of the PGA technique to support strategic decisions. By combining the business architecture hierarchy, the AHP, the performance measurement, and the strategic fit improvement analysis, end-users are able to identify, adapt and follow-up the essential elements that determine strategic fit within the business architecture. Another reported advantage is the provision of an abstraction of the complex business context to facilitate the communication between stakeholders. More specifically, the model can help to reveal the deep-level meaning of stakeholder opinions, which prevents possible misunderstandings between them. Furthermore, the PGA technique offers a common reference to the business architecture, which is useful to obtain a more objective discussion in case of opposite interests and information asymmetry between stakeholders. This is important for obtaining an agreement about improvement decisions, which are often taken in the context of a limited organizational budget.

The average score for the perceived ease of use is between 'slightly agree' and 'agree'. In this respect, it should be noted that the guidance of a strategy consultant or analyst is essential for applying the AHP technique, as this mechanism is considered as the most difficult to apply. More specifically, it was advised to further refine the AHP application and to develop an instrument for end-users that is more easy to use than the current table-based form (see figure 4.4). However, the guidance of a strategy consultant is also useful outside the AHP context as it enables to guide the end-user in providing the appropriate content for the models. This can be supported by giving examples or rephrasing the content of business model elements to preserve the right strategic scope. Therefore, the role of a strategy consultant will remain important in the further application of the technique. Finally, it was advised to limit the time between the different steps of the modeling procedure. This reduces the effort to be up to date with a previous model version in the beginning of a session. In this respect, it is important to give meaningful name tags to the identified business architecture elements as this will facilitate the recall of the model content by the end-users.

4.4.4 Formalization of Learning

4.4.4.1 Modeling Language

The application of the case studies only led to small adaptations to the initial version of the PGA modeling language. As the final notation of this modeling language makes use of five visual variables (i.e., shape, brightness, vertical position, color, and texture), it supports the principle of visual expressiveness by offering a perceptually enriched representation (Moody, 2009). The understanding of the definitions of the model elements, which is supported by clarifying questions in the visual aid (figure 4.2), did not cause any problems during the application of the technique. Furthermore, the maximum number of distinct elements in the PGA models is only nine, which limits the complexity as the cognitive effort that is needed to use the language is restricted (Moody, 2009). The adaptation that improves the applicability of the *FinancialStructure* element, shows that the modeling language needed extra flexibility in the proposed hierarchical structure of the business architecture.

4.4.4.2 Modeling Procedure

Regarding the modeling procedure, the conclusion of the case studies includes the identification of three main activities: (i) developing the business architecture hierarchy and performing the AHP to obtain a prioritized business architecture hierarchy, (ii) executing the performance measurement, and (iii) performing the strategic fit improvement analysis. The case studies further yielded interesting insights in how the complexity of the modeling procedure can be kept manageable. In this context, the main refinements consist of building the business architecture element per element, the introduction of a qualitative prioritization before the actual AHP application, and facilitating the strategic fit improvement analysis by the specification of a relative or absolute interval of visible *valueStream* relations. Furthermore, the understanding of the reciprocal values in the AHP comparison scale was improved by first asking which of the elements is the most important in the pairwise comparison. Finally, it was analyzed how the modeling procedure can be supported to be better applicable in a real-life organizational context. This resulted in an adaptation of the minimal cycle, the removal of unimportant *valueStream* relations to improve the AHP application, and the use of qualitative measures in case quantitative indicators were not available during the case studies.

4.5 Discussion and Conclusion

In this research, the PGA technique was developed to realize strategic fit within the business architecture. To this end, the technique extends the heat map technique with an integrative approach to align the different business architecture perspectives. Furthermore, the technique aims to support a consistent use of performance measurement, as well as to provide a modeling language that ensures the understanding and communication of the organizational strategy by business stakeholders. The ADR methodology was used to further refine the technique in a real-life organizational context.

These refinements are based on reflection and learning during iterative cycles, which consist of building the technique, intervening in the organization, and evaluating the case study results. This chapter reports on the refinements that were applied to the PGA modeling language and procedure based on the application in three case studies. These adaptations were made to reduce the complexity, or to preserve the understandability and applicability of the technique for the end-users. Although the end-user evaluation confirms the contribution to the realization of strategic fit, users are more reserved with respect to the consistent use of performance measurement. Finally, the end-users at least slightly agree with the usefulness of the technique and its perceived ease of use.

The insights of the proposed technique can provide input for approaches that enable a more formal evaluation of alternative designs (see section 4.2.1.4). As these approaches make use of reasoning techniques to calculate the impact of alternatives on the organizational goals, possible improvements can be compared with the current business architecture. This should support the final decision about the actual implementation of the proposed improvement in the organizational context.

As the PGA technique has just passed its early development phase, further adaptations will be needed to account for more practical concerns. Indeed, it needs to be investigated how the proposed technique can be integrated with existing data analytics systems to solve organizational problems by collecting the relevant information, analyzing this information, and predicting the outcome of a solution (Bose, 2009). To fully address this issue, the PGA technique will need an extension, which enables to test the impact of operational adaptations on the realization of the strategy. As this integration with data analytics is not yet addressed in this chapter, it can be the base for future research

Another important challenge for the PGA technique is deploying a strategy-aligned performance measurement, which ensures consistency between the business architecture elements and the performance indicators that are used to measure them. This issue is important to preserve the validity of the resulting insights. Possible improvements can be based on the work of Popova and Sharpanskykh (2011) as they developed a methodology to formulate consistent performance indicators in the context of strategic goals. Furthermore, it should be investigated whether the use of predefined libraries can provide recommendations for the formulation of consistent performance indicators.

The timing of the activities in the modeling procedure can be refined by verifying whether it is possible to apply the technique during a one-day workshop to reduce the learning time in the beginning of a new session.

Another important issue is the creation of a long-term engagement with stakeholders to enable a more thorough analysis of how the technique can be implemented by iterative cycles of business architecture improvements and performance measurement execution. Finally, it is also needed to investigate how the PGA technique can be applied in the collaborative context of multiple stakeholders. These opportunities for future research will be investigated by the further application of the PGA technique in organizations.

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5 Conclusion

This chapter summarizes the conclusions that were obtained during the two research cycles. Section 5.1 presents the main results, which also includes answering the research questions that were raised in chapter 1. The implications of these results for researchers and practitioners are discussed in section 5.2, while the last section describes limitations that provide opportunities for future research.

5.1 Research Results

5.1.1 General

The research of this PhD project addressed several aspects to align the strategy, infrastructure, and process perspectives within the business architecture. First, we realized a better conceptualization of the infrastructure perspective by providing an integrative business model component framework, which solved the fragmentation in opinions about this concept. Furthermore, the usefulness of this framework was shown as it was applicable for both research cycles, which use it as a basis to further support the realization of strategic fit. The infrastructure perspective was further investigated by using value modeling techniques to provide a visual business model representation. The efficacy of applying these conceptual modeling languages on the business model concept to increase the understanding of the underlying knowledge was confirmed by the results of a laboratory experiment. As such, a better understanding about the infrastructure perspective closes the gap between the strategy and process perspectives of the business architecture, which facilitates the realization of strategic fit. The combined use of conceptual modeling techniques with management frameworks was also suitable to directly support the alignment of the different business architecture perspectives. This resulted in the design of a modeling technique, which was positively evaluated by the end-users in a real-life organizational context with respect to its contribution to the realization of strategic fit, its usefulness, and its ease of use. In the remainder of this section, the answers to the research questions of research cycle A (section 5.1.2) and B (section 5.1.3) are discussed in more detail.

5.1.2 Cycle A: The Development and Experimental Evaluation of a Business Model Representation

RQ A1 Which common business model components (i.e., model elements and their interrelations) underlie the integrative research on the business model concept?

Answering RQ A1 involved the development of the integrative business model component framework, which presents 10 components that underlie the business model concept: suppliers, resources, the value chain, competences, the value proposition, distribution channels, the financial structure, customer segments, partners, and competitors. These components are proposed by the majority of the 12 papers, which were identified as relevant integrative research by means of a literature review (Kitchenham et al., 2004, Kitchenham et al., 2009). As these research papers only implicitly deal with the relations between the components, their identification was based on the component definitions. The proposed framework was demonstrated by applying it on the Southwest Airlines case example.

RQ A2 Which VDML meta-model constructs are needed to provide a business model representation?

VDML (OMG, 2014b) was our choice of representation language as it is the only value modeling language that can be used to provide a complete business model representation, which ensures the integration of information between diagrams and a consistent application of the meta-model constructs. The identification of the relevant VDML constructs, which solves RQ A2, was not straightforward as its meta-model also consists of constructs that are related to operational details of value delivery (i.e., a violation of the strategy implementation depth requirement) and to other aspects that are outside the scope of the business model components (i.e., a violation of the completeness requirement). This problem was solved by applying the strategy implementation depth requirement to those value modeling languages (i.e., REA value chain specification (Geerts and McCarthy, 2002, Dunn et al., 2005), REA value system level modeling (Dunn et al., 2005), VNA (Allee, 2008), e^3-forces (Gordijn and Akkermans, 2003, Pijpers et al., 2012), and Capability Maps (Hafeez et al., 2002)) that address loose aspects of the business model but collectively cover the complete set of business model components, which was identified in the research that addresses RQ A1. Consequently, we were able to identify the meta-model constructs from these different value modeling languages that apply to both requirements. The last step included a mapping between these constructs and the VDML meta-model. This resulted in the identification of 16 VDML constructs: BusinessItem, Store, DeliverableFlow, CapabilityMethod, CapabilityOffer, ValueProposition, ValuePropositionComponent, ValueAdd, InputPort, OutputPort, OrganizationUnit, Community, Participant, Role, BusinessNetwork, and Party.

RQ A3 How can the VDML meta-model constructs be represented to increase the understanding about the underlying business model knowledge?

The VDML meta-model constructs, which were identified to solve RQ A2, are represented in five relevant VDML viewpoints: value proposition exchange, value proposition structure, business network structure, capability management, and activity diagrams. Design principles of the Physics of Notations theory of diagrammatic effectiveness (Moody, 2009) were used to assess and improve the degree to which these viewpoints support the understanding about the underlying business model knowledge. This resulted in the development of the new VDML business model viewpoint, which consists of a business network diagram, a low-level capability diagram, and a value stream diagram.

The effect of the new viewpoint on the understanding of the underlying business model knowledge was evaluated by means of an experiment with 126 master students in Business Engineering. This experiment compared the use of the newly developed viewpoint with the five relevant VDML viewpoints. Therefore, we applied the new viewpoint to the healthcare and manufacturing cases (appendix A), which demonstrates its feasibility. The experimental results of the 93 validly answered questionnaires confirmed that using the VDML business model viewpoint has a positive impact on the understanding of the underlying knowledge. This effect is significant for the accuracy of understanding a diagram and extracting relevant information, as well as for the time that is needed to realize this.

5.1.3 Cycle B: Realizing Strategic Fit with Business Architecture Heat Maps

RQ B How can we realize strategic fit within the business architecture by means of a conceptual modeling technique, which builds on the strengths of existing techniques to address all three drivers of strategic fit?

The new PGA modeling technique, which addresses RQ B, consists of a modeling language that represents the creation of value throughout a hierarchical structure of business architecture elements, which are related to the strategic, infrastructure and process business architecture perspectives. The identification of the relevant elements for these business architecture perspectives was based on conceptual frameworks in the management field: the Balanced Scorecard (i.e., the strategic perspective) (Kaplan and Norton, 1992), the Business Model concept (i.e., the infrastructure perspective) (see RQ A1), and the Value Chain concept (i.e., the process perspective) (Porter, 1985). These frameworks are considered as analysis theories, which aim to describe a certain domain of interest (Gregor, 2006). For the application of the heat map technique, AHP was used to implement the prioritization mechanism. AHP is particularly useful for the PGA technique as it enables to prioritize between factors that are arranged in a hierarchical structure (Saaty, 1990). The heat mapping technique was further implemented by adding a performance measurement mechanism for the identified business architecture elements, which was built in accordance with existing techniques (e.g., (Microsoft, 2006)).

The notation of the modeling language was informed by the Physics of Notations theory (Moody, 2009) to provide cognitively effective model representations to the end-users. This attention to cognitive effectiveness of diagrammatic representations was realized by using icons to enable an easy recognition of the model elements. Furthermore color coding was used to visualize the results of the performance measurement and the prioritization, which supports the realization of business architecture heat maps.

The initial PGA modeling procedure consisted of three main activities: developing a prioritized business architecture hierarchy, executing the performance measurement, and performing the strategic fit improvement analysis. While the first two activities sustain the development of business architecture heat maps, the strategic fit improvement analysis is oriented towards the identification of activities that can be improved to realize a better support of the main organizational objectives.

The application of the PGA technique during the case studies resulted in adaptations to the initial version. While the refinements to the modeling language included small changes of the meta-model (i.e., adding an additional valueStream relation) and the notation (i.e., adding brightness as an extra visual variable), the refinements to the modeling procedure were more profound. Indeed, the initial idea of combining the development of the business architecture hierarchy and the application of the AHP appeared not to be feasible in one interview. Therefore, this activity was split into two separate sessions. Furthermore, the development of the business architecture was adapted as it is easier for end-users to go through the business architecture element per element instead of continuously shifting their focus. Most refinements addressed the application of the AHP. These included the introduction of a qualitative analysis of priorities upfront, the reformulation of the questions that guide the AHP application and the removal of unimportant valueStream relations that interfere with the consistency of the judgments. Moreover, using qualitative information in case quantitative measures were not available during the case study preserved the applicability of the performance measurement. Finally, the strategic fit improvement analysis was refined to decrease the diagrammatic complexity of the models. This was realized by enabling the end-users to specify a visible importance interval, which decreases the number of valueStream relations that are represented in a model.

The PGA technique was evaluated concerning its adherence to the drivers of strategic fit. The end-users agree with the contribution of the PGA technique to the realization of top-down and bottom-up strategic fit. The evaluation of the performance measurement tends to be more neutral as end-users believe that its success depends on two important requirements: the integration of the PGA technique with existing performance measurement systems and the creation of a long-term engagement in the organization to maintain the model over time. The evaluation of the acceptance of the PGA technique indicates that the end-users at least slightly agree with both its usefulness and ease of use. For the perceived usefulness, end-users believe that the application of the technique can help to facilitate the communication and to overcome opposite interests between stakeholders, which is very useful when decisions must be taken in the context of a limited budget. With respect to the ease of use of the PGA technique, the main concern of the end-users is about the complexity of the AHP. Furthermore, it is recommended to limit the time between the different sessions to reduce the effort for the end-users to catch up with an earlier developed model.

The formalization of learning needs to be approached carefully as it not easy to generalize the research results obtained during case studies.

Therefore, the PGA technique was incrementally improved during three sequential case studies, which increases the external validity of the results. The refined modeling language visually represents the value that is created throughout a hierarchical structure of eight business architecture elements: financial goals, customer goals, internal goals, the financial structure, value propositions, competences, the value chain, and activities. These elements are visualized by a notation that makes use of shape, brightness, vertical position, color, and texture as visual variables, which offers a perceptually rich representation to the end-users. The identification of business architecture elements is facilitated by translating their definition into short questions that are more comprehensible for end-users. The generic modeling procedure, which results from the case study refinements, consists of three stages. These stages include developing the business architecture hierarchy and performing the AHP to obtain a prioritized business architecture hierarchy, executing the performance measurement, and implementing the strategic fit improvement analysis.

5.2 Implications

5.2.1 Implications for Researchers

In this dissertation, conceptual models are used to enable a model-based analysis of the different business architecture perspectives. In this regard, our research is related to the Requirement Engineering and the EA field.

The proposed research provides a representation of (some of) the business architecture perspectives that facilitates the understanding of the underlying business knowledge. As such, this research contributes to the design of the business architecture, which can be further related to Goal-Oriented and Value-Based requirements engineering approaches (see section 1.1.3.2). These techniques are oriented towards the documentation of business requirements in a form that supports analysis and communication to better understand the purpose of IT systems in relation to these higher-level requirements (Nuseibeh and Easterbrook, 2000). In this respect, the research contributions could provide input to Requirements Engineering techniques to ensure that the derived IT requirements are in accordance with the design of the business architecture.

Research cycle B (see section 1.2.3), which aims to realize strategic fit with business architecture heat maps, is most closely related with the EA field. Indeed, the PGA modeling technique adopts a similar focus as existing EA approaches (see section 1.1.3.3) by using a conceptual model to offer a holistic view on the business architecture. More specifically, the designed modeling language is closely related to ArchiMate, as part of the TOGAF standard, which provides visual representations of the business architecture in an integrative manner. However, ArchiMate adopts a wider scope as it also includes the application and technology layer as parts of the EA. Moreover, existing EA techniques do not include a performance measurement mechanism to keep track of the actual organizational performance. This provides an interesting opportunity for the PGA technique as it supports the analysis of the current business architecture to identify possible improvements. These improvements could provide input for the redesign of the business, which results in a new iteration of the EA lifecycle (Lankhorst, 2009). Consequently, an interplay could be realized between (re)designing the business architecture by EA techniques and analyzing this business architecture through the use of the PGA technique.

5.2.2 Implications for Practitioners

Although realizing strategic fit is an ongoing concern for companies since the 1980s (Schieman, 2009), a successful translation of the high-level strategy into effective operations is hardly realized in today's businesses (Verweire, 2014). Our research tackles this problem by a combined use of conceptual modeling languages and management frameworks with an explicitly focus on the involvement of practitioners. As such, both research cycles result in the development of a model-based solution that facilitates the realization of strategic fit and increases the understanding and communication by business people. This can help practitioners to: (i) obtain a shared understanding about the organizational value creation and exchange, (ii) create a link between the strategic position of the company and its processes, and (iii) provide an instrument that can help to communicate strategic initiatives throughout the organization.

The business model, which is a central concept in this dissertation, reflects the way in which a company implements its strategy, of which the ultimate goal is value creation and exchange (Shafer et al., 2005). A visual representation of this concept (see chapter 3) offers an important advantage as it reveals the intuitive ideas of the involved stakeholders. These stakeholders, who collaborate to take decisions about how to implement the strategy, are higher-level management such as different chief officers (e.g., CEO, COO, CFO, CIO, etc. (Gordijn and Akkermans, 2003)), regional managers, and product managers (see chapter 4). Creating a unified view between these stakeholders can help to overcome opposite interests and information asymmetry between them. The results of this PhD research are useful to overcome these issues and to obtain a shared understanding about the organizational value creation and exchange.

If the infrastructure perspective is commonly understood by the involved stakeholders, it should be clearly aligned with the other perspectives within the business architecture. The PGA modeling technique (see chapter 4) contributes to this issue by making use of a combination of mechanisms, which enables practitioners to: develop a focused view on how value is created through the hierarchy of the business architecture elements, prioritize between the elements that are most crucial to support the value on a higher level in this hierarchy, and get insights in possible improvements by identifying the elements with the highest priority and the worst performance. This will provide important insights in the development of actions that support the strategic positioning of the enterprise.

According to Schieman (2009), one of the hardest challenges in the realization of strategic fit is the effective communication of strategic initiatives between the management and its employees. Our research addresses this challenge as it offers a visual representation that helps to understand how things are related in the business architecture and how the operational behavior can have a positive or negative impact on the realization of the organizational goals. This aspect is important as it demonstrates that the proposed research can help to overcome a purely functional view on the organization.

5.3 Limitations and Future Research

The new business model viewpoint, which results from research cycle A (see chapter 3), was evaluated by comparing it with the existing VDML diagrams through a laboratory experiment with students. Although the use of an appropriate experimental design allows to control a wide range of external factors and personal characteristics of the participants, some limitations need to be taken into account. For the design of our experiment, a homogeneous group of students was used to control for differences in skills and personality traits, which could possibly interfere with the effect of the treatments. However, this poses a threat to the generalizability of the experimental results as business stakeholders typically have different backgrounds in practice. Therefore, it should be further investigated whether the experimental results also hold in a real-life organizational context. Another limitation is the purely quantitative evaluation of the experiment. Indeed, the evaluation did not collect any qualitative feedback about the perceived strengths and weaknesses of the different treatments, as perceived by the participants. As this feedback could have provided further insights in possible improvements, it is an important element that should be taken into account in future research.

Research cycle B (see chapter 4) proposes and evaluates a new modeling technique for the realization of strategic fit. Given the time of a PhD project, this evaluation is limited to a validation of the proof-of-concept (Wieringa and Heerkens, 2006). Consequently, future research should aim to evaluate the long-term application of the PGA technique in a real-life organizational context. To realize this, it is crucial to create a long-term engagement with the business stakeholders in the company. Although a practical application is useful to evaluate the relevance of the proposed technique, this type of evaluation is less suitable to test the impact of the individual mechanisms that are used in the method. However, it could be useful to test whether each of these mechanisms has an effect on the understanding of business stakeholders about how to realize strategic fit. Therefore, it could be interesting to complement the practical evaluation with an experiment, which provides a controlled set-up to ensure the reproducibility of the results.

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A Appendix Chapter 3

Questionnaire

Supportive Document

Element	Definition
Role	An expected behavior or capability profile, which is associated with participation in a BusinessNetwork.
Participant	Anyone or anything that can fill a role in a collaboration. Participants can be OrganizationUnits or Communities.
BusinessNetwork	A collaboration between companies, individuals or members of communities, participating in an economic exchange.
Community	A loose collaboration of participants with similar characteristics or interests.
OrganizationUnit	An administrative or functional organizational collaboration, with responsibility for defined resources, including business units, departments, projects, or task forces.
ValueProposition	Expression of the values offered to a recipient.
provides receives	Providing or receiving a ValueProposition from or to another Role.
DeliverableFlow	The transfer of a BusinessItem from a provider (or producer) to a recipient (or consumer).
BusinessItem	Resource, which can be acquired or created, that conveys information or other forms of value and is conveyed from a provider to a recipient.
Store	Represents a container of a resource. The resource that is stored is identified by a business item.
High-level Activity	Repeated activity pattern, which implements a specific CapabilityMethod.
Store or activity: InputPort	Connection point for input to a Store or Activity.
Store or activity: OutputPort + ValueAdd	Connection point for output from a Store or Activity.
CapabilityMethod	A business process, which includes the activities, deliverable flows, business items, capability requirements and roles that deliver a capability.
CapabilityMethod: InputPort	Connection point for input to a CapabilityMethod.
CapabilityMethod: OutputPort + ValueAdd	Connection point for output from a CapabilityMethod.
CapabilityOffer	Ability to perform a particular kind of work and deliver desired value.
supports (a CapabilityOffer)	The support of a CapabilityOffer by a CapabilityMethod or a Store of BusinessItems.
supports (a CapabilityMethod)	The support of a CapabilityMethod by a CapabilityOffer.
Port- Delegation	Linking the Port and associated DeliverableFlows of a CapabilityMethod with the Port of a sub-CapabilityMethod.

Table A.1: Definition of the VDML meta-model elements

Experimental Tasks

Personal Questions

1. What is your gender?
2. Study program: please select the courses you already took in your curriculum
   - ‘Informatica I’ (MS Word, MS Excel)
   - ‘Informatica II’ (Java)
   - ‘Beleidsinformatica’ (ER diagrams, BPMN, SQL, Java)
   - ‘Bedrijfsprocesbeheer’
3. MIS thesis: are you doing a thesis at the department 'Beleidsinformatica' (supervisor prof. Poels or prof. Gailly)?
4. Working experience: please select the industries in which you have at least 3 months of working experience
   - Healthcare industry (e.g., a hospital, doctor's office, ...)
   - Manufacturing industry
   - Other / Not applicable

Comprehension Questions

1. Which processes (i.e., Activities / High-level activities [3] or CapabilityMethods [4]) are executed by the company? List these processes in the right order below. When a process is split in sub-processes, first list the name of the complete process, followed by the name of the sub-processes. In case of parallel processes the ranking order does not matter.
2. The Role who receives the ValueProposition with the most Components if fulfilled by the following Participant:
   - Community
   - OrganizationUnit
3. The input resources of processes are provided by Stores. List the input resources of the process (i.e., Activity / High-level activity[3] or CapabilityMethod[4]) that is connected with the most input Stores.
4. List all unique ValuePropositionComponents provided by the OrganizationUnit(s) within the BusinessNetwork.

[3] Hint about which meta-model construct to consider for the existing VDML viewpoints.
[4] Hint about which meta-model construct to consider for the VDML business model viewpoint.

5. Competences are the result of the coordination of resources during the processes of a company. List those Capabilities (i.e., CapabilityOffers) of the hospital that are directly supported by a process (i.e., CapabilityMethod).

Problem-solving Questions

1. Resources, which are held in Stores, can either be material, immaterial, or human. List those human resources, based on the diagrams provided for this case.
2. The cost structure of a company is the result of acquiring resources, either bought from an external supplier or licensed from an external partner. Based on the provided diagrams, try to come up with some cost elements that are economically relevant for the central OrganizationUnit in this case.
3. The revenue streams of a company are acquired by a Company in return for the provided ValueProposition. Based on the diagrams, try to come up with revenue streams that are economically relevant for the central OrganizationUnit in this case.

Instrumentation

Healthcare Case

Existing VDML Viewpoints

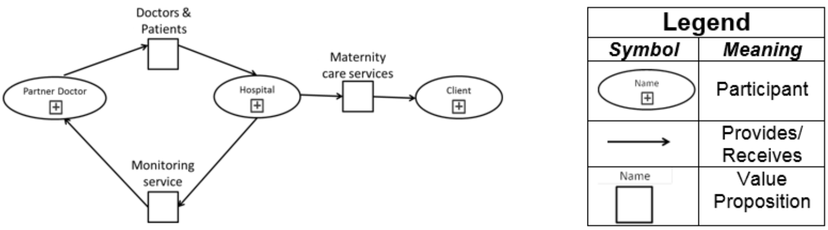

Figure A.1: Value Proposition Exchange Diagram for the Healthcare Case (OMG, 2012b)

Doctors & Patients Value Proposition: Components
• Referral of patients
• Specialized medical services
• Flexible working contracts

Monitoring service Value Proposition: Components
• Continuous monitoring of the gestation
• Resource-intensive maternity care service

Maternity care Value Proposition: Components
• Reduced physical efforts
• Reduced risk of death of unborn child
• Reduced risk of death of mother
• Reduced cost of maternity care

Figure A.2: Value Proposition Structure Diagram for the Healthcare Case (OMG, 2012b)

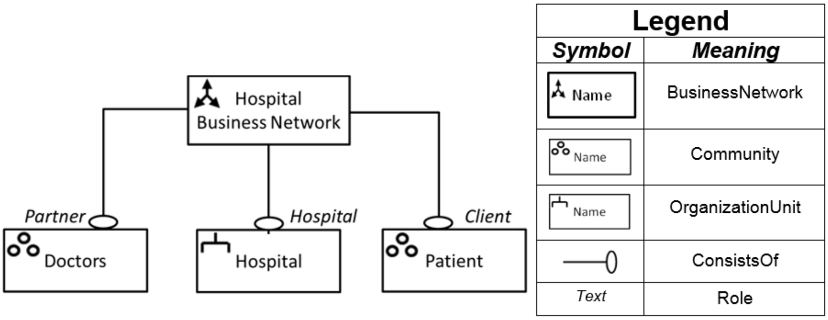

Figure A.3: Business Network Structure Diagram for the Healthcare Case (OMG, 2012b)

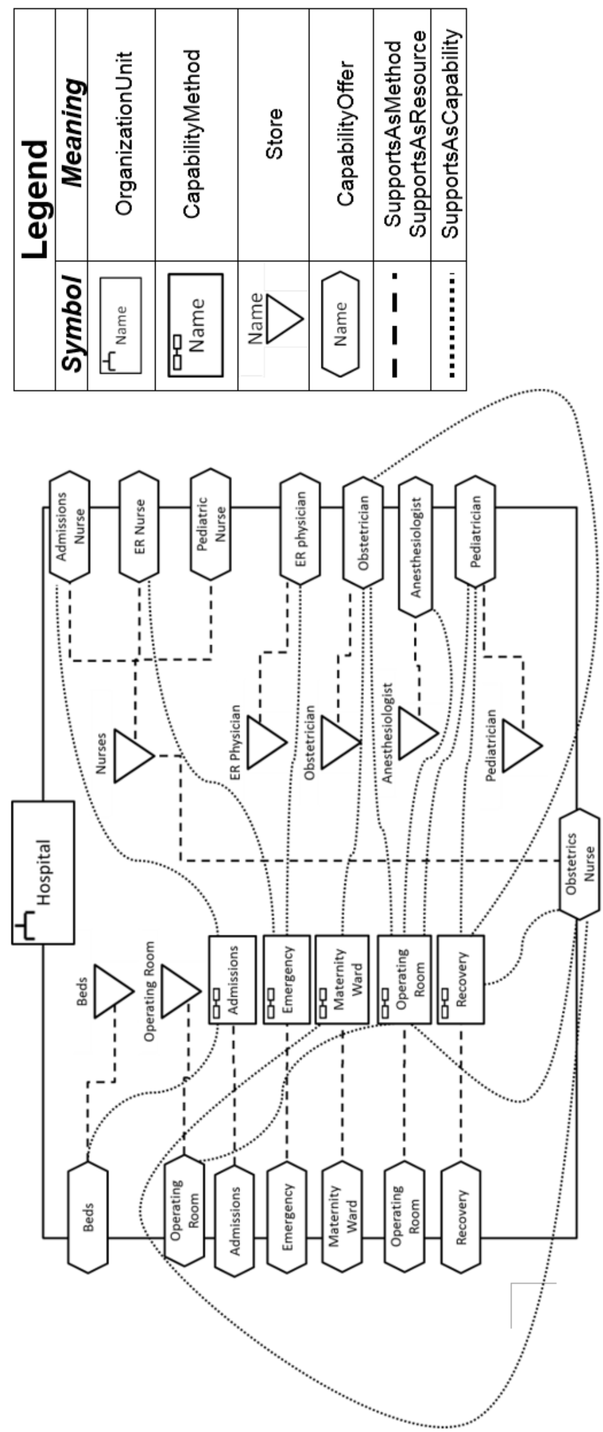

Figure A.4: Capability Management Diagram for the Healthcare Case (OMG, 2012b)

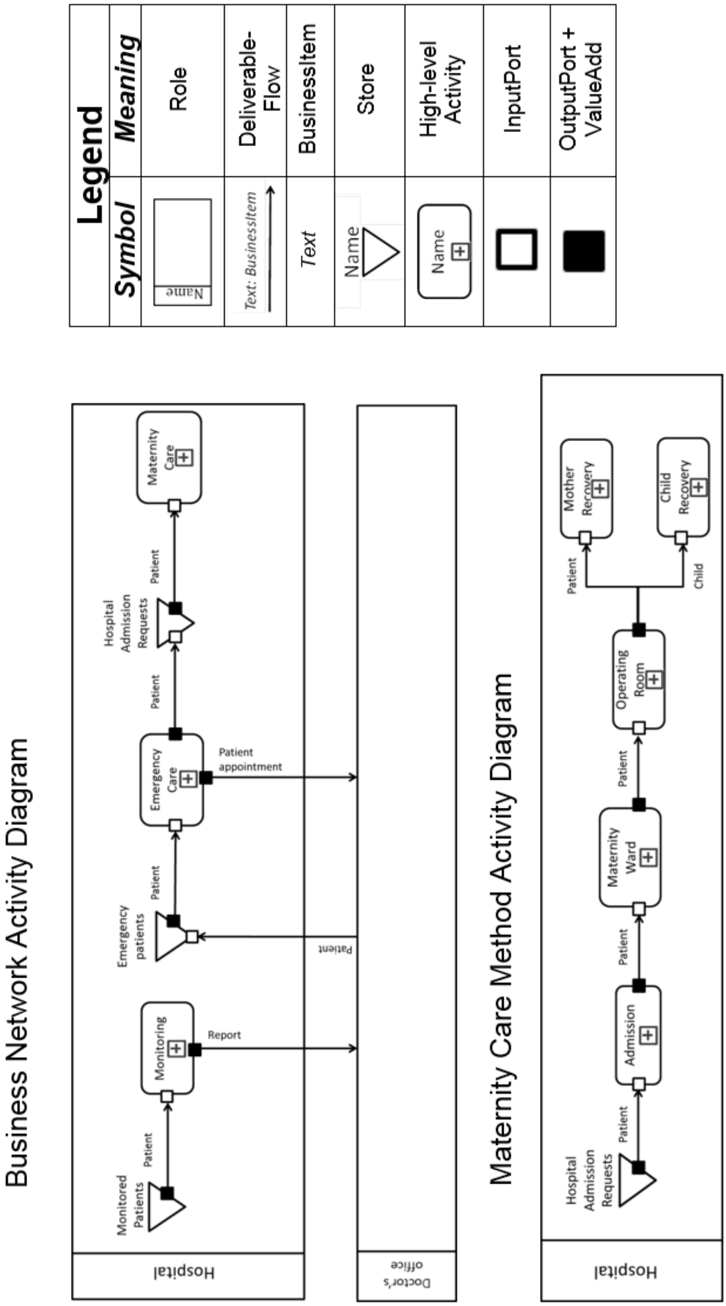

Figure A.5: Activity Diagram for the Healthcare Case (OMG, 2012b)

VDML Business Model Viewpoint

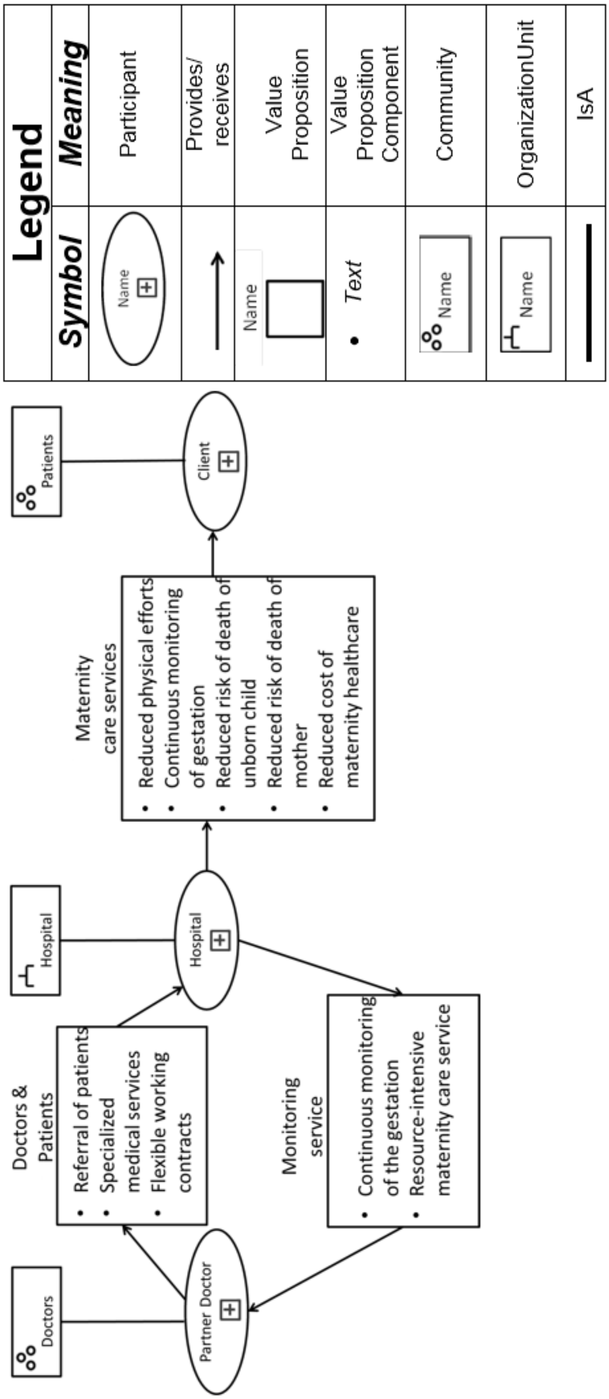

Figure A.6: Business Network Diagram for the Healthcare Case

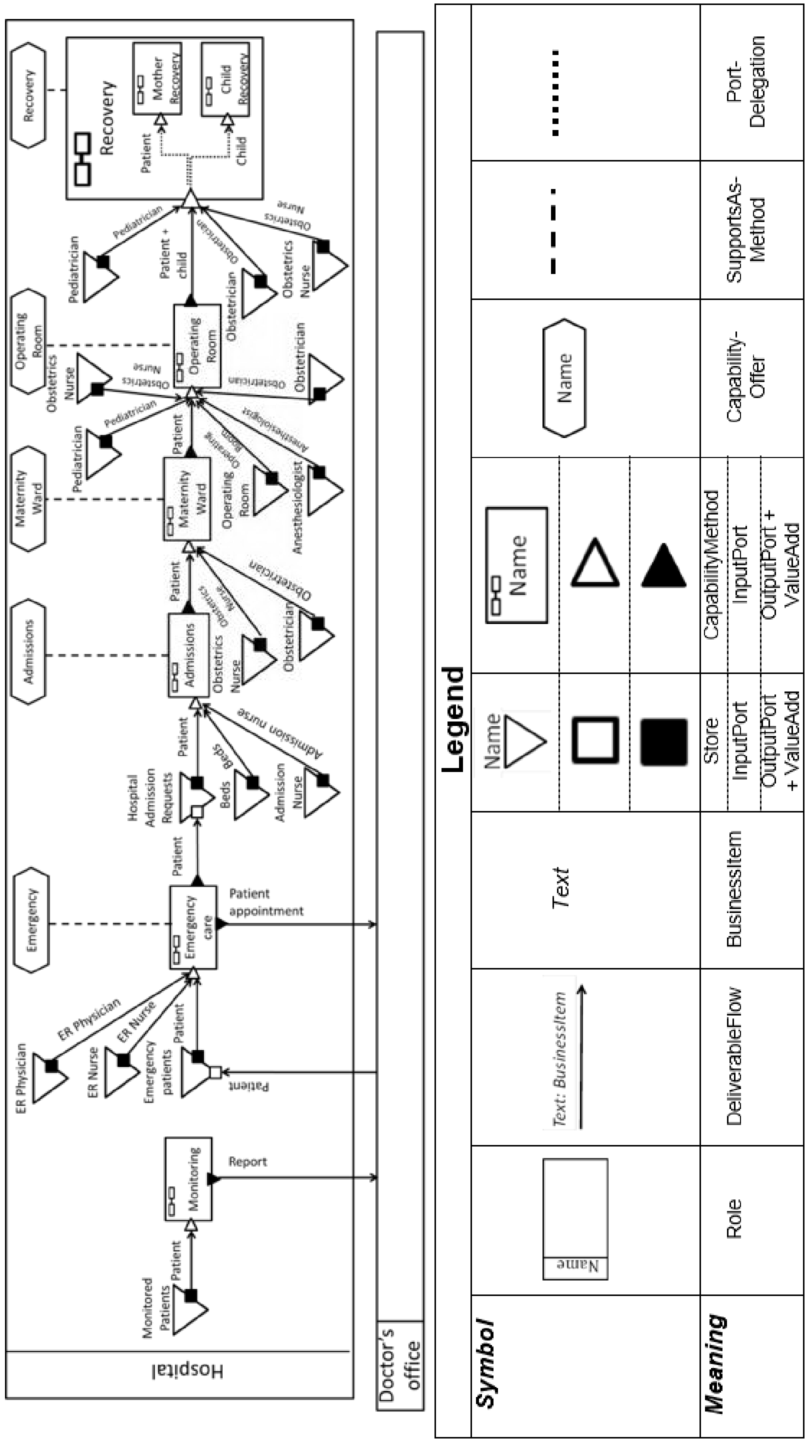

Figure A.7: Value Stream Diagram for the Healthcare Case

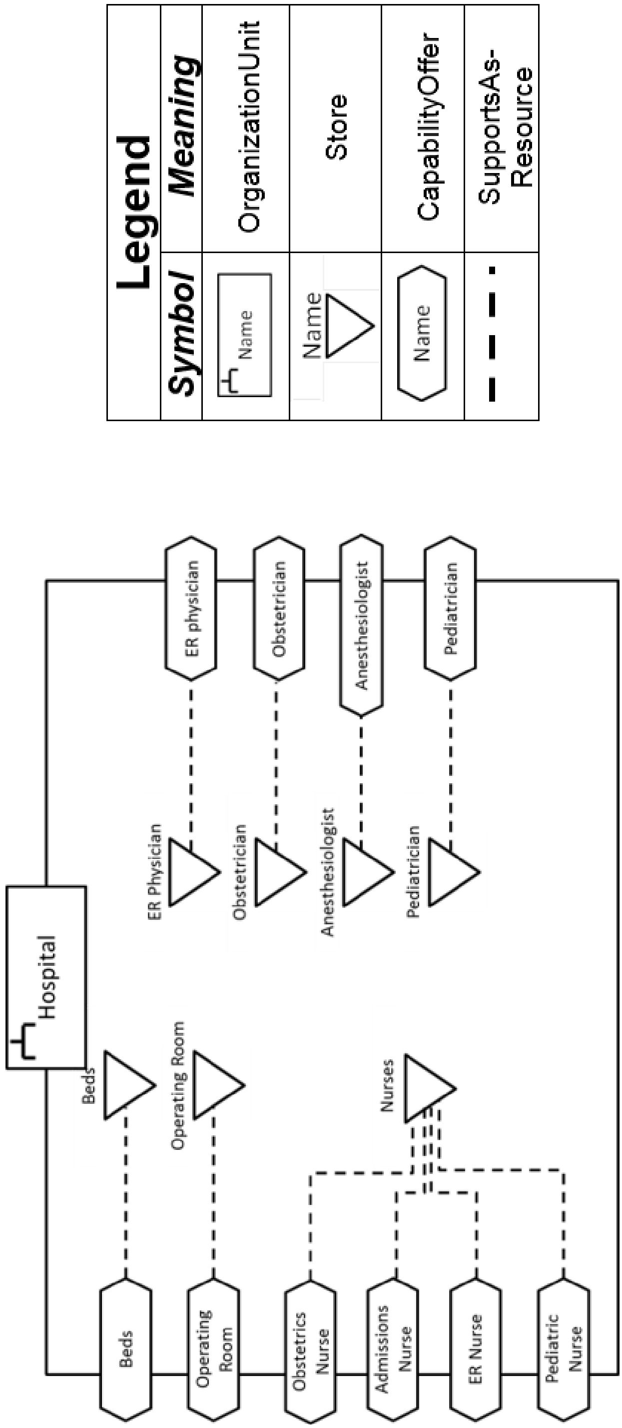

Figure A.8: Low-level Capability Diagram for the Healthcare Case

Manufacturing Case

Existing VDML Viewpoints

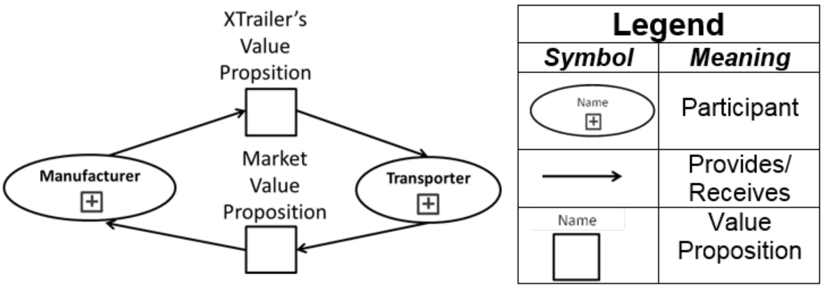

Figure A.9: Value Proposition Exchange Diagram for the Manufacturing Case (OMG, 2012c)

XTrailer's Value Proposition: Components
• Fair Price
• Market-driven Design
• Fast Innovation
• Late Specification Freeze

Market Value Proposition: Components
• Clear customer specifications
• Innovation suggestions

Figure A.10: Value Proposition Structure Diagram for the Manufacturing Case (OMG, 2012c)

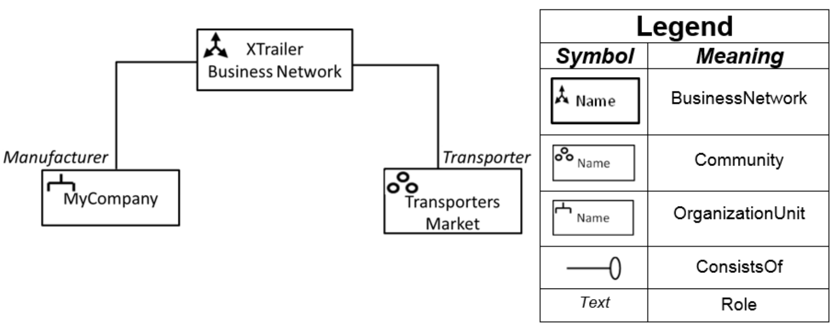

Figure A.11: Business Network Structure Diagram for the Manufacturing Case (OMG, 2012c)

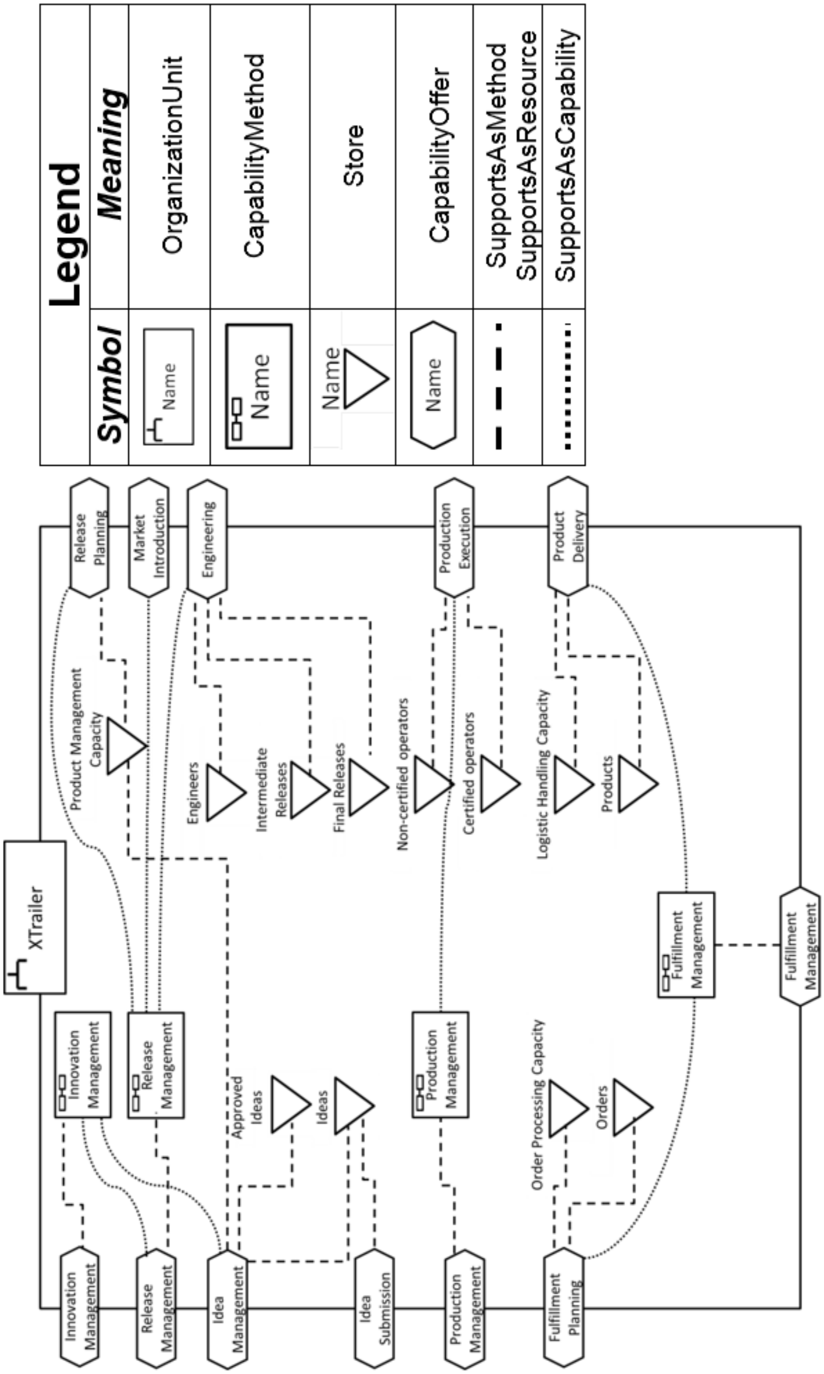

Figure A.12: Capability Management Diagram for the Manufacturing Case (OMG, 2012c)

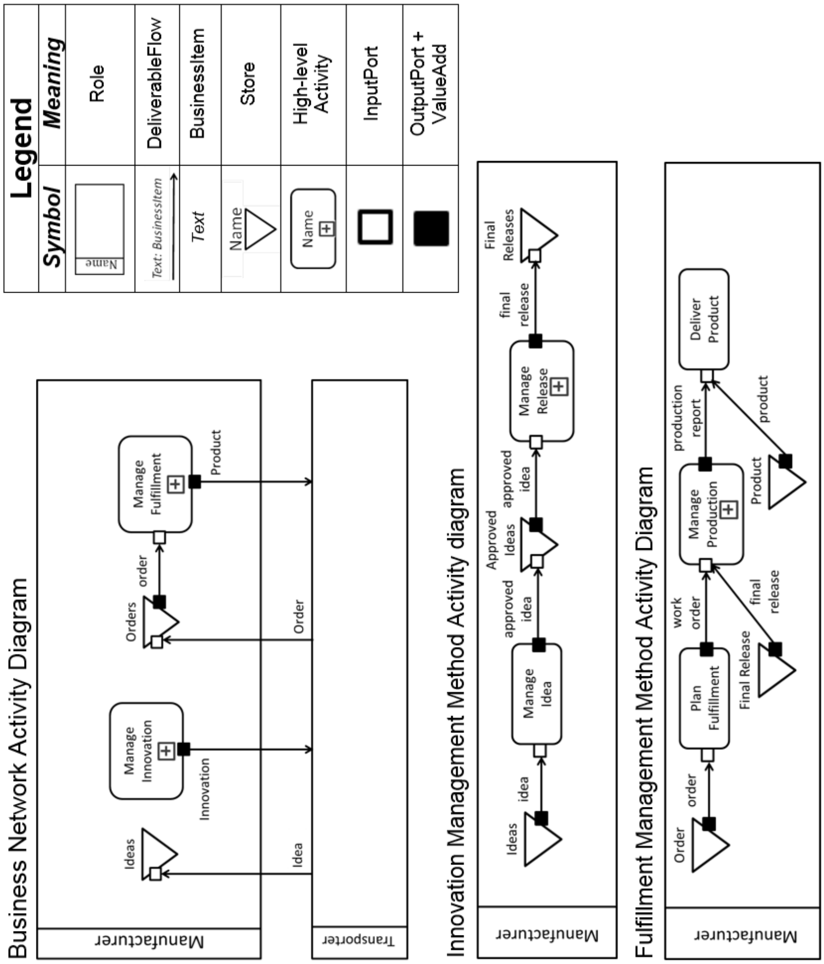

Figure A.13: Activity Diagram for the Manufacturing Case (OMG, 2012c)

VDML Business Model Viewpoint

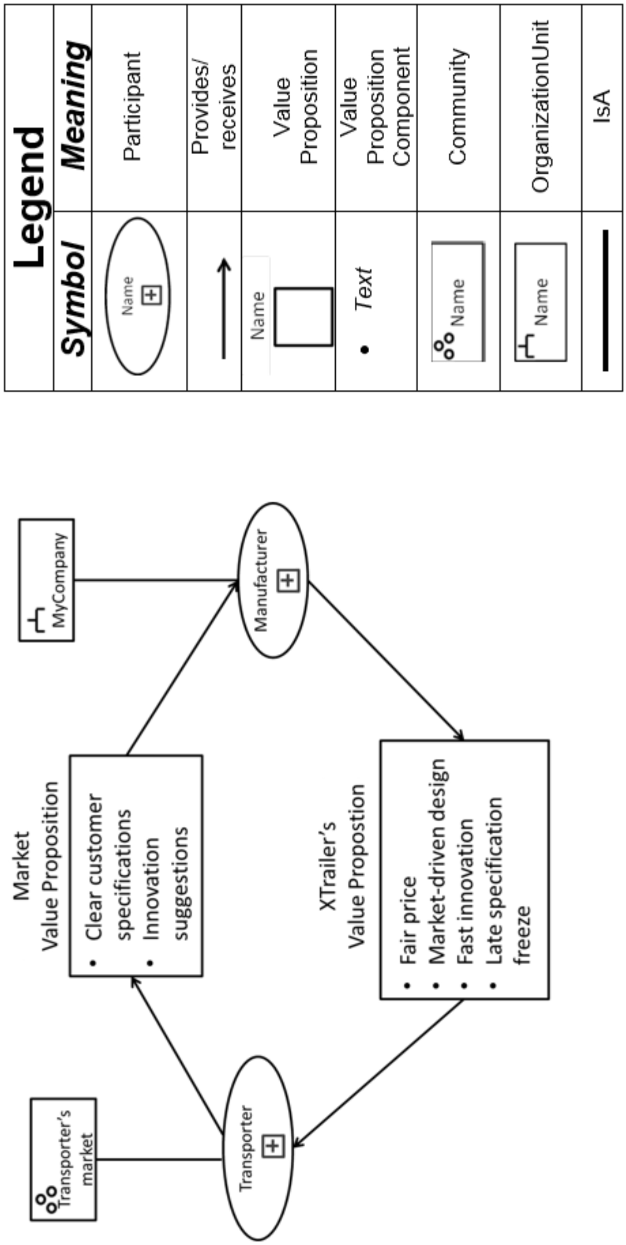

Figure A.14: Business Network Diagram for the Manufacturing Case

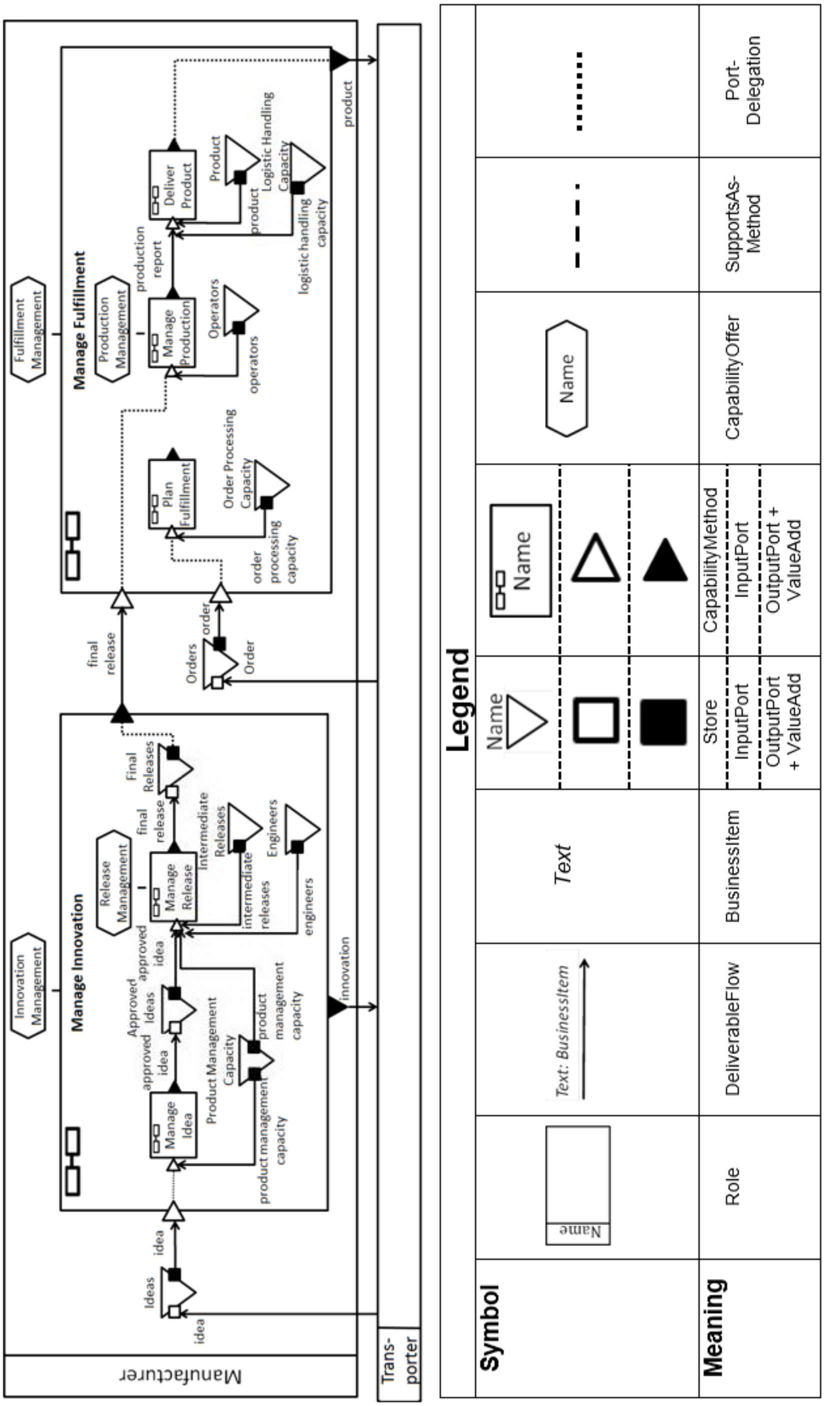

Figure A.15: Value Stream Diagram for the Manufacturing Case

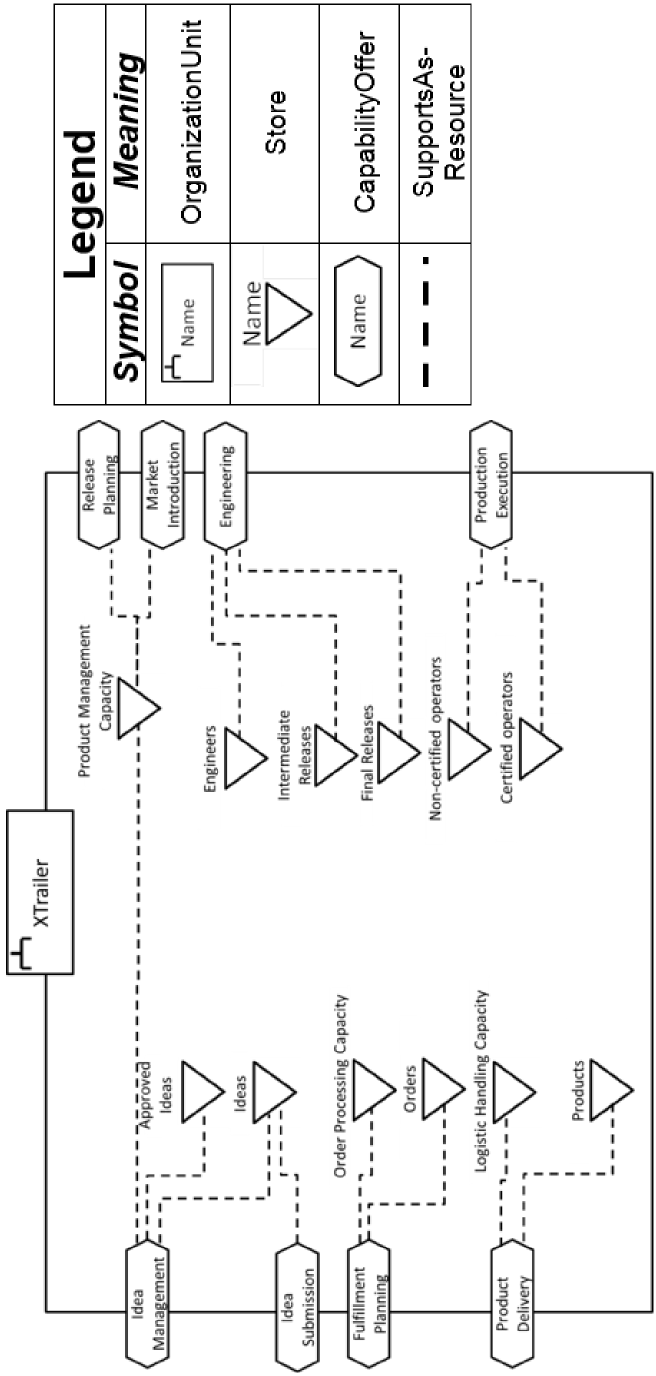

Figure A.16: Low-level Capability Diagram for the Manufacturing Case

Solution Comprehension Questions

Healthcare Case (25p)

1. Monitoring, Emergency care, Maternity care[5], Admissions, Maternity ward, Operating room, Recovery[6] , Patient recovery, Child recovery (/8)
2. Community (1p)
3. Obstetrics nurse, Obstetrician, Pediatrician, Operating room, Anesthesiologist, (Patient)[7] (5p)
4. Recourse-intensive maternity care service, Continuous monitoring of the gestation, Reduced physical efforts, Reduced risk of death of mother, Reduced risk of death of unborn child, Reduced cost of maternity healthcare (6p)
5. Emergency, Admissions, Maternity ward, Operating room, Recovery (5p)

Manufacturing Case (20p)

1. Manage innovation, Manage idea, Manage release, Manage fulfillment, Plan fulfillment, Manage production, Deliver product (7p)
2. Community (1p)
3. Approved idea, Product management capacity, Engineers, Intermediate releases (4p)
4. Fair price, Market-driven design, Fast innovation, Late specification freeze (4p)
5. Innovation management, Fulfillment management, Release management, Production management (4p)

[5] Due to a small error in information equivalence, Maternity Care is the right answer for the existing VDML diagrams.
[6] Due to a small error in information equivalence, Recovery is the right answer for the VDML business model viewpoint.
[7] Although a patient is strictly not provided by a Store, it is not wrong to consider it as an input resource based on the provided diagrams. As a result no points were deducted when a participant provided this answer.

Statistical Analysis: Interaction Effects

	Effect of VDML business model viewpoint	F value	df value	p-value[8]
H_{c1}	+ 10.53%	19.573	176	$< 10^{-3}$
H_{c2}	- 140s	13.822	176	$< 10^{-3}$
H_{c3}	+ 0.0318%/s	14.651	177	$< 10^{-3}$
H_{p1}	+ 0,422pt	0.479	177	0,490
H_{p2}	-17.96s	1.693	176	0.195
H_{p3}	+<10^{-3} pt/s	0.331	176	0.566

Table A.2: Results of the hypothesis tests (with interaction effects)

	Significant effect	Effect	F value	df value	p-value
H_{c1}	Case: healthcare	+ 9.87%	3.687	176	0.056
H_{c2}	Order: learning effect Gender: male	- 306s + 68s	100.554 5.128	176 176	$< 10^{-3}$ 0.025
H_{c3}	Order: learning effect	+ 0.0368%/s	35.750	177	$< 10^{-3}$
H_{p1}	Case: healthcare Curriculum: regular Gender: male	+ 4.11pt + 2.23pt + 1.09pt	71.472 11.172 6.065	177 177 177	$< 10^{-3}$ 0.001 0.015
H_{p2}	Order: learning effect Gender: male Treatment_1* Case_healthcare	- 227s + 49s -90s	111.825 5.361 4.764	176 176 176	$< 10^{-3}$ 0.022 0.030
H_{p3}	Order: learning effect	+ 0.001pt/s	69.387	176	$< 10^{-3}$

Treatment 1: existing VDML diagrams

Table A.3: Results of the post-tests (with interaction effects)

[8] For one-sided hypotheses (i.e., H_{c1}, H_{c2}, and H_{c3}), the reported values are the p-values of the two-sided test divided by two.

B

Appendix Chapter 4

PGA Tool support

To enable the development of user-defined meta-models, the ADOxx meta[2]-model defines a meta-model as a set of model types, which consist of classes, relationclasses, data types, and attributes. In this section, the FDMM formalism (Fill et al., 2013) (i.e., the Formalism for Describing ADOxx Meta models and Models) is used to provide an exact description of the refined PGA meta-model, which is the result of the ADR adaptations.

Only one model type ($\boldsymbol{MT}_{PGA}$) is used in the proposed technique, which is further decomposed in a set of object types ($\boldsymbol{O}_{PGA}^{T}$), data types ($\boldsymbol{D}_{PGA}^{T}$), and attributes ($\boldsymbol{A}_{PGA}$) (formula 1).

$$\boldsymbol{MT}_{PGA} = < \boldsymbol{O}_{PGA}^{T}, \boldsymbol{D}_{PGA}^{T}, \boldsymbol{A}_{PGA} > \tag{1}$$

$$\begin{aligned}\boldsymbol{O}_{\boldsymbol{PGA}}^{\boldsymbol{T}} = \{&Element, Goal, FinancialGoal, CustomerGoal, InternalGoal,\\ &FinancialStructure, ValueProposition, CoreCompetence,\\ &ValueChain, Activity, valueStream, matrix\}\end{aligned} \tag{2}$$

Object types (formula 2) refer to the classes and the relationclasses that are used in the meta-model (see figure 4.1). The business architecture elements are implemented as a set of different classes ($\boldsymbol{O}_{PGA}^{T}[1-10]$), which are defined as subtypes of an *Element* (see formula 3) to facilitate the implementation of the attributes and relations that are identified in the meta-model. Furthermore a relationclass is added for the *valueStream* relation between these elements. The *matrix* object type refers to a record class, which is a collection of attributes that is represented in a table-based structure (Fill and Karagiannis, 2013). This object is needed to build the comparison matrix as input for the AHP (see figure 4.4).

$$\begin{aligned}&FinancialGoal \preccurlyeq Element\\ &CustomerGoal \preccurlyeq Element\\ &InternalGoal \preccurlyeq Element\\ &FinancialStructure \preccurlyeq Element\\ &ValueProposition \preccurlyeq Element\\ &CoreCompetence \preccurlyeq Element\\ &ValueChain \preccurlyeq Element\\ &Activity \preccurlyeq Element\end{aligned} \tag{3}$$

Five different data types are used in the PGA technique (formula 4). While a String can be used to represent text, Float data are related to decimal numbers. The other data types are pre-defined enumerations (Enum), which allow users to hide or visualize valueStream relations ($\boldsymbol{Enum}_{Make\ visible}$), to choose the type of performance indicator ($\boldsymbol{Enum}_{Measure\ type}$) , or to compare the importance of two elements according to the AHP scale ($\boldsymbol{Enum}_{Importance}$) as proposed by Saaty (1990).

$$\boldsymbol{D}_{\boldsymbol{PGA}}^{\boldsymbol{T}} = \{String, Float, \boldsymbol{Enum}_{\boldsymbol{Make\ visible}}, \boldsymbol{Enum}_{\boldsymbol{Measure\ type}}, \boldsymbol{Enum}_{\boldsymbol{Importance}}\}$$

$$\boldsymbol{Enum}_{\boldsymbol{Make\ visible}} = \{\ Yes, No\}$$

$$\boldsymbol{Enum}_{\boldsymbol{Measure\ type}} = \{\ None, Positive, Negative, Qualitative\}$$

$$\boldsymbol{Enum}_{\boldsymbol{Importance}} = \{0.111\ Y\ has\ absolute\ importance\ over\ X, 0.125, 0.143\ Y\ has\ demonstrated\ importance\ over\ X, 0.167, 0.2\ Y\ has\ essential\ or\ strong\ importance\ over\ X, 0.25, 0.333\ Y\ has\ slight\ importance\ over\ X, 0.5, 1\ X\ and\ Y\ have\ equal\ importance, 2, 3\ X\ has\ slight\ importance\ over\ Y, 4, 5\ X\ has\ essential\ or\ strong\ importance\ over\ Y, 6, 7\ X\ has\ demonstrated\ importance\ over\ Y, 8, 9\ X\ has\ absolute\ importance\ over\ Y\} \quad (4)$$

All attributes that are used in figure 4.1, are elements of $\boldsymbol{A}_{PGA}$ (formula 5). However, it is important to link this set of attributes to the object and data types of the meta-model. This is done by specifying the domain of an attribute (i.e., the object to which the attribute is attached), the range of an attribute (i.e., a data type or an object type from the PGA model type in the context of the proposed technique), and the card function which constrains the (minimum and maximum) number of attribute values an object can have (Fill et al., 2013). An overview for the attributes is given by formula 6-22.

$$\boldsymbol{A}_{\boldsymbol{PGA}} = \{Name, Preference\ matrix, Consistency\ ratio, Measure\ type, Measure\ description, Performance\ goal, Allowed\ deviation\ (\%), Actual\ performance, Deviation\ from\ measure, valueStream_{from}, valueStream_{to}, Importance, Make\ visible, Element\ Xi, Element\ Xj, Compared\ importance\} \quad (5)$$

The textual *Name* attribute (formula 6) is connected to an *Element* object and has exactly one value as it is used as the primary key in the underlying ADOxx database. This also holds for the $\boldsymbol{Enum}_{\boldsymbol{Make\ visible}}$ (formula 7) of *valueStream* relations as the end-user is obliged to choose between yes or no.

$$domain(Name) = \{Element\}$$
$$range(Name) = \{String\}$$
$$card(Element, Name) = \ <1,1> \tag{6}$$

$$domain(Make\ visible) = \{valueStream\}$$
$$range(Make\ visible) = \ \{\boldsymbol{Enum_{Make\ visible}}\}$$
$$card(valueStream, Make\ visible) = \ <1,1> \tag{7}$$

$$domain(Measure\ type) = \{Element\}$$
$$range(Measure\ type) = \{\boldsymbol{Enum_{Measure\ type}}\}$$
$$card(Element, Measure\ type) = \ <1,1> \tag{8}$$

$$domain(Importance) = \{valueStream\}$$
$$range(Importance) = \{Float\}$$
$$card(valueStream, Importance) = \ <1,1> \tag{9}$$

An obligatory minimum is not applicable to the *Performance goal* attribute (formula 10). Indeed it is possible that end-users still have to define this numerical element attribute at a certain moment during the application of the technique.

$$domain(Performance\ goal) = \{Element\}$$
$$range(Performance\ goal) = \{Float\}$$
$$card(Element, Performance\ goal) = < 0,1 > \tag{10}$$

$$domain(Consistency\ ratio) = \{Element\}$$
$$range(Consistency\ ratio) = \{Float\}$$
$$card(Element, Consistency\ ratio) = \ <0,1> \tag{11}$$

$$domain(Measure\ description) = \{Element\}$$
$$range(Measure\ description) = \{String\}$$
$$card(Element, Measure\ description) = \ <0,1> \tag{12}$$

$$domain(Performance\ goal) = \{Element\}$$
$$range(Performance\ goal) = \{Float\}$$
$$card(Element, Performance\ goal) = \ <0,1> \tag{13}$$

$$domain(Allowed\ Deviation\ (\%)) = \{Element\}$$
$$range(Allowed\ Deviation\ (\%)) = \{Float\}$$
$$card(Element, Allowed\ Deviation\ (\%)) = \ <0,1> \tag{14}$$

$$domain(Actual\ performance) = \{Element\}$$
$$range(Actual\ performance) = \{Float\}$$
$$card(Element, Actual\ perfomance) = \ <0,1> \tag{15}$$

$$domain(Deviation\ from\ measure) = \{Element\}$$
$$range(Deviation\ from\ measure) = \{Float\}$$
$$card(Element, Deviation\ from\ measure) = \ <0,1> \tag{16}$$

In case of the attributes of a record class (formula 17), the maximum number of attributes is not limited as the resulting table can contain multiple values for its attributes.

$$
\begin{aligned}
&domain(Element\ Xi) = \{matrix\}\\
&range(Element\ Xi) = \{String\}\\
&card(matrix, element\ Xi) = <0, \infty>
\end{aligned}
\tag{17}
$$

$$
\begin{aligned}
&domain(Element\ Xj) = \{matrix\}\\
&range(Element\ Xj) = \{String\}\\
&card(matrix, Element\ Xj) = <0, \infty>
\end{aligned}
\tag{18}
$$

$$
\begin{aligned}
&domain(Compared\ importance) = \{matrix\}\\
&range(Compared\ importance) = \{\boldsymbol{Enum_{Importance}}\}\\
&card(matrix, Compared\ importance) = <0, \infty>
\end{aligned}
\tag{19}
$$

The *valueStream* relationclass can be formalized by its from and to attributes (formula 20-21). These attributes differ from the above as their range is not a data type, but exactly one object type (i.e., another *Element*) within the PGA model type.

$$
\begin{aligned}
&domain(valueStream_{from}) = \{valueStream\}\\
&range(valueStream_{from}) = \{Element, \boldsymbol{MT_{PGA}}\}\\
&card(valueStream, valueStream_{from}) = <1, 1>
\end{aligned}
\tag{20}
$$

$$
\begin{aligned}
&domain(valueStream_{to}) = \{valueStream\}\\
&range(valueStream_{to}) = \{Element, \boldsymbol{MT_{PGA}}\}\\
&card(valueStream, valueStream_{to}) = <1, 1>
\end{aligned}
\tag{21}
$$

$$
\begin{aligned}
&domain(Preference\ matrix) = \{Element\}\\
&range(Preference\ matrix) = \{matrix, \boldsymbol{MT_{PGA}}\}\\
&card(Element, Preference\ matrix) = <1, 1>
\end{aligned}
\tag{22}
$$

This meta-model is augmented by the proposed graphical notation (see table 4.2) for the business architecture elements and the connecting valueStream relations. This includes an automated adaptation of the color coding based on the results of the AHP and the performance measurement, which requires coding the GRAPHREP class attribute for these elements by means of the ADOxx Library Language.

Further refinements are needed to adhere to the proposed design. A first refinement includes a limitation of the possible valueStream relations between business architecture elements (see figure 4.1). Furthermore it is needed to specify the values that are allowed for the different attributes. This can be implemented by the external coupling component in the ADOxx platform. This component is also used to provide the functionality to fully automate the AHP. This includes the development of AdoScript files, which realize the connection to a java file that calculates the resulting priorities and consistency ratio. Furthermore these files ensure that the comparison matrix (which was realized by adding a record class) remains valid in case valueStream relations are added or deleted, and when the name of elements is changed by end-users. External coupling is finally used to incorporate the strategic fit improvement analysis by automatically hiding those valueStream relations that are not part of the relative or absolute importance interval.

Evaluation Questionnaire Results

Item	Case 1	Case 2	Case 3
SF_1	6	6	6
SF_2	6	7	6
SF_3	4	6	7
SF_4	6	4	5
PU_1	6	6	6
PU_2*	4*	6*	6*
PU_3	5	5	7
PU_4	6	6	7
PU_5*	6*	6*	6*
PU_6*	6*	6*	6*
PU_7	6	6	5
PU_8	6	6	7
PEU_1*	6*	6*	6*
PEU_2*	6*	6*	4*
PEU_3	6	6	6
PEU_4*	6*	2*	7*
PEU_5	6	6	5
PEU_6*	3*	6*	4*

Table B.1: Evaluation questionnaire results

* To facilitate comparison between the questions, the scales were inversed for negatively formulated questions:

1 = strongly disagree
2 = disagree
3 = slightly disagree
4 = neutral
5 = slightly agree
6 = agree
7 = strongly agree

1* = strongly agree
2* = agree
3* = slightly agree
4* = neutral
5* = slightly disagree
6* = disagree
7* = strongly disagree