Realizing Strategic Fit within the Business Architecture: the Design of a Process-Goal Alignment Modeling and Analysis Technique

Abstract. The realization of strategic fit within the business architecture is an important challenge for organizations. Research in the field of Enterprise 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 only provide partial solutions for the issue of realizing strategic fit, the Process-Goal Alignment (PGA) technique is presented in this paper. This technique combines the visual expressiveness of heat mapping techniques with the analytical capabilities of performance measurement and Strategic Management frameworks to provide a comprehensible and well-informed modeling language for the realization of strategic fit within an organization's business architecture. The paper reports on the design of the proposed technique by means of Action Design Research, which included iterative cycles of building, intervention, and evaluation through case studies. To support the application of the technique, a software tool was developed using the ADOxx meta-modeling platform.

Keywords: Strategic fit, Business architecture, Enterprise modeling, Process-Goal Alignment, Heat map

1 Introduction

The realization of strategic fit within the business architecture remains an important challenge in practice [82, 90]. Strategic fit entails the alignment of the strategic positioning of the company with the design of activities that support this organizational strategy [60]. Within the business architecture, the infrastructure perspective is considered as the key intermediate layer to align the strategy and process perspectives of an organization [60]. As such, 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) [69].

Previous research has identified three main drivers that are crucial for the realization of strategic fit:

#1. The alignment of the strategy, the infrastructure, and the process perspectives of the enterprise [20, 42, 82].

#2. The use of a performance measurement system that guides process outcomes towards the intended strategic objectives by setting clear performance targets and by keeping track of the actual performance to provide incentives for possible improvements [20, 82].

#3. A clear communication of the organizational strategy to ensure its understanding and acceptance by business stakeholders [13, 20, 82].

Strategic fit within the business architecture is an object of study in the discipline of Enterprise Modeling, which addresses different aspects of the construction and analysis of organizational models [17]. Within this research area, different *enterprise modeling languages* are used to provide visual representations of the three aforementioned business architecture perspectives. Goal modeling languages (e.g., i* [95], KAOS [18], the Business Motivation Model (BMM) [70]) 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 [47]. As they largely abstract from the infrastructure needed to implement a strategy and decisions regarding process design, we position goal models at the highest level of abstraction of the business architecture. Consistent with the view taken by the BMM [70], we consider goals as ends describing a desired state or development of the company as derived from the organizational vision [76]. For instance, if the vision is to be the premier company in industry (in a given sector and geographical area), then a goal could be to strengthen the market position of the company (in that sector and area).

At a lower level of abstraction of the business architecture, value modeling techniques (e.g., the Value Delivery Modeling Language [71], the Resource-Event-Agent ontology [61], e^3-value [34], Value Network Analysis [2]) 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 [4, 71]. As such, value models are considered as offering a detailed representation of the business model of a company, which operationalizes the company's strategy.

Finally, models developed using process modeling languages (e.g., Business Process Model and Notation (BPMN) [68], UML Activity Diagrams [67], the Web Service Business Process Execution Language (WS-BPEL) [66], Role Activity Diagrams [74]) are situated at the lowest abstraction level of the business architecture as they describe in detail the interlinked organizational processes that are needed to execute the organizational value creation/delivery activities that were identified at the higher abstraction level. Processes are described in process models in terms of operational aspects such as events and activities; the sequencing of activities; data, information or other object flows; roles and their assignment of responsibilities; exception handling; and resource use or consumption [23, 49, 58].

Apart from modeling languages, Enterprise Modeling research has also proposed techniques that contribute to the achievement of the drivers of strategic fit. A first group of techniques are *model-based alignment techniques*, which address the alignment of the different business architecture perspectives by creating a fit between the modeling languages that are used to represent these different perspectives (i.e., driver #1). These 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 models at lower abstraction levels from models at higher abstraction levels. Bottom-up approaches annotate models with information of models found at higher abstraction levels, while hybrid techniques align the models that are used for the different business architecture perspectives by combining top-down and bottom-up approaches. A last subgroup achieves strategic fit in an integrative manner through the use of newly designed modeling languages, which include constructs that are relevant to two or all three of the strategy, infrastructure, and process perspectives of the business architecture. As a result, this fourth subgroup provides the flexibility to align models at different abstraction levels 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. Within this wide range of model-based alignment techniques, some proposals [29, 30, 43, 52] build on appropriate frameworks in the field of Strategic Management to provide modeling concepts that are explicitly oriented towards business stakeholders instead of IT professionals. This business orientation increases the comprehensibility of the enterprise models and is intended to result in a better understanding by and communication to business people (i.e., driver #3), who are usually not familiar with the use of more formal modeling languages [10].

Capability heat mapping techniques [40, 62] form a second group of enterprise modeling techniques, which focus specifically on the infrastructure perspective of the enterprise as they specify what needs to be done in the organization to support the creation of value [62]. These techniques address strategic fit by making use of performance measurement to guide the organizational operation of capabilities towards the intended strategic objectives (i.e., driver #2). 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 perceived 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 [48]. As such, these techniques contribute to the realization of strategic fit by visually helping strategic fit analysis. Their ability to reduce the size of models through prioritization allows creating intuitive visualizations that facilitate understanding by and communication to business stakeholders (i.e., driver #3).

However, as none of the current model-based alignment and capability heat mapping techniques simultaneously addresses all three drivers of strategic fit (for a detailed analysis see section 4 – Related Work), we formulated the following research question:

RQ. How can we realize strategic fit within the business architecture by means of an enterprise modeling technique, which builds on the strengths of existing techniques by simultaneously addressing all three drivers of strategic fit?

This paper presents the Process-Goal Alignment (PGA) technique, which uniquely combines existing partial solutions into a single approach to realize strategic fit within the business architecture. PGA consists of an integrative modeling language (i.e., addressing driver #1) based on concepts taken from Strategic Management frameworks (i.e., addressing driver #3), a system for setting and measuring performance goals (i.e., addressing driver #2), and a heat mapping visualization based on the performance measurement system and augmented with a prioritization mechanism (i.e., addressing driver #3). The design of the technique included the development of a new enterprise modeling language that is used 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 frameworks in the field of Strategic Management, which make use of a terminology that is meaningful to business users [31], intending to result in a better understanding and communication of the organizational strategy as it is formulated and as it is or should be implemented. To enable the application of heat mapping, the modeling language constructs were extended with appropriate performance measurement attributes. Furthermore, the Analytic Hierarchy Process (AHP) [79] was incorporated to implement a prioritization mechanism. The visualization of the performance measurement and prioritization outcomes was developed in the form of business architecture heat maps. The newly developed language is accompanied by a modeling procedure that guides the proper application of the PGA technique.

As the development of appropriate tool support for designing and analyzing models is an important requirement for enterprise modeling techniques [32], we developed a software tool for the PGA technique, which supports the creation of model instantiations and the execution of the strategic fit modeling and analysis procedure (i.e., the development of a prioritized business architecture hierarchy, the execution of the performance measurement, and the automation of the strategic fit improvement analysis). Since these functionalities are closely related (e.g., deleting an element in the model needs to be implemented in the other mechanisms to preserve the consistency), the tool requirements became highly complex. To manage this complexity, the ADOxx meta-modeling platform [27] was chosen. This industry-proven platform allowed a visual definition of the PGA modeling language (i.e., meta-model and notation) which resulted in an automatic creation of the modeling editor [27]. Furthermore, this editor could easily be extended with extra functionalities for executing the modeling and analysis procedure by using the ADOScript programming language. Although the ADOxx platform is not built on the MetaObject Facility (MOF) [72] as meta²-model, its low technical complexity is a significant advantage compared to alternatives such as the Eclipse Modeling Framework (EMF) [25] and the Eclipse Graphical Modeling Framework (GMF) [24]. The use of these frameworks, which are based on Ecore (i.e., an equivalent of (E)MOF), is characterized by a steep learning curve as they require more extensive programming and is more susceptible to errors in case of increasingly complex tool requirements [51].

The research presented in this paper contributes to the study of software and systems modeling in several aspects. First, it proposes a new *domain-specific modeling language* for representing and visualizing in an integrative manner an organization's system of interrelated business architectural elements across strategy, infrastructure and process perspectives. Second, it shows how AHP prioritization, performance measurement, and heat mapping can be incorporated into the modeling procedure for the proposed language to allow for *model-based analysis* of the strategic fit within an organization's business architecture. Third, it demonstrates how the ADOxx meta-modeling platform can be used to create a *model development tool* that integrates functionalities for performing the strategic fit analysis.

The rest of this paper is structured as follows. Section 2 describes the Action Design Research (ADR) methodology, which was used for the design of the PGA technique. This included a gradual refinement of the technique through intervention and evaluation in a real-life enterprise context [83]. The results of the ADR are presented in section 3, which also provides more details about the developed ADOxx tool support. Section 4 presents a comparison between the PGA technique and the related work that provided the basis for our approach, while the research contributions and the opportunities for future research are discussed in section 5.

2 Methodology

Action Design Research (abbreviated as ADR) is a specific type of Design Science Research methodology for the design of research artifacts that explicitly provide theoretical contributions to the academic knowledge base, while solving a practical organizational problem [83]. 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 [31]. This section reports on the four stages of the ADR methodology as we applied them to the design of the PGA technique: problem formulation (section 2.1), building, intervention, and evaluation (section 2.2), reflection and learning (section 2.3), and formalization of learning (section 2.4).

2.1 Problem Formulation

The problem of unrealized strategic fit was already described in the introduction (section 1), which clarifies its practical relevance and further explains how this issue is conceived by academic research. Furthermore, we also discussed how existing enterprise 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 is further explained in section 4, which shows that the individual related work research efforts do not address all three drivers of strategic fit.

2.2 Building, Intervention, and Evaluation

The second phase of the ADR took place in the context of three real-life case studies in a single organization and included the iterative process of building the PGA technique (section 2.2.1), intervention in the organization (section 2.2.2), and evaluation (section 2.2.3) [83].

2.2.1 Building the PGA Technique

To ensure a rigorous design, building the PGA technique (see sections 3.1 and 3.2 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 Strategic Management to ensure that the modeling constructs of the PGA technique are meaningful to business stakeholders. These frameworks were considered as analysis theories, which aim to describe a certain domain of interest [38].

The Balanced Scorecard [44, 45] addresses the strategic perspective of the business architecture by organizing the formulation of organizational goals according to four organizational performance dimensions (i.e., effectiveness and efficiency of the internal organization, customer focus, financial performance, and innovation and learning). In line with the BMM [70], these Balanced Scorecard dimensions allow expressing the organizational vision through goals that address stakeholder concerns, which are inherently captured by these dimensions (e.g., the financial performance dimension allows thinking about strategic goals in terms of shareholder or owner satisfaction, the customer dimension triggers thinking about strategic goals related to satisfying customer needs, etc.). Other management instruments and frameworks (e.g., SWOT analysis [6], Blue Ocean strategy [14]) are useful to support the formulation of the strategy, but are not capturing the actual strategic goals. Therefore, these frameworks were not included in the PGA technique.

For the infrastructure perspective, the Business Model concept was used as it operationalizes the strategy that is formulated for achieving the organizational performance goals and hence describes what is needed for strategy implementation [84]. Following Osterwalder's Business Model Ontology [73], we think about a business model as a set of interlinked components addressing structural and behavioral elements of an organization (e.g., value propositions, capabilities, key activities) rather than a general characterization of some type or pattern of business model. Business model types are more relevant to the strategic perspective of the business architecture as they provide context and meaning to organizational goals and strategies (e.g., a goal of convincing free users of a service to become paying users by providing attractive additional services on top of a bundle of free services makes sense in case of a 'freemium' business model [73]). To identify the relevant business model components for the PGA technique, we built on our previous research [8], which presents an integrative business model component framework that provides a common conceptual basis for the business model concept.

Finally, the process perspective of the business architecture was based on Porter's Value Chain concept Porter [77], which considers the operational activities that are performed in a company as a key source of competitive advantage.

For the application of a heat mapping technique, we 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 3.1.1 for more details). Prioritization was implemented by making use of the Analytical Hierarchy Process (AHP), which is based on pairwise comparisons of alternatives [80]. 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 [79]. Moreover, this mechanism measures the inconsistency that is inherent to subjective judgments [40]. 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., [62]), the mechanism we developed is able to discriminate between an excellent, an expected, and a bad performance. In this respect, it would have been possible to integrate the performance measurement with the prioritization mechanism by using absolute measurement within the AHP [79]. However, this would result in a single score for the priority of a business architecture element in creating value on a higher level in the business architecture and the actual performance of that business architecture element. Consequently, it would be impossible to identify those elements that are characterized by both a high priority and a bad performance, which is of particular interest to improve the strategic fit within the business architecture (see also section 3.1.2).

The visual representation of the PGA modeling language was informed by the Physics of Notations [64], 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.

2.2.2 Intervention in the Organization

To investigate how the PGA modeling technique needed to be designed to support the analysis and improvement of strategic fit in a real-life organizational context, we conducted an intervention study in a large-scale company that is a global IT solution provider.[1] The organization employs over 120.000 people to offer a product portfolio that ranges from on-premises applications to cloud-based IT solutions, which sustain the different aspects in a client organization. These clients include more than 400.000 companies worldwide. A total of three case studies were performed in this organization. Each case study presented a particular organizational context that was a relevant unit of analysis for the intervention. This research design, which resulted in the development of three different PGA models (i.e., one for each case study), made it possible to reflect on how the PGA technique could be iteratively improved (see also section 2.3). More specifically, the proposed adaptations of each application were tested and analyzed during the subsequent case studies (see figure 1). The ADR team was composed of two researchers, an external strategy consultant temporarily engaged by the company, and three managers employed by the company, where each manager acted as an end-user for one of the case-studies. Hence, during each case-study the team consisted of four members, where only the end-user role rotated between managers. The researchers provided theoretical input for (re)building and evaluating the PGA technique, which was informed by seven forms of evidence that were collected during each of the case studies: interviews, direct observations, documentation, archival records, participant observations, end-user evaluation survey results and physical artifacts [94] (see also section 3.2.1). The strategy consultant collected these different types of evidence. This strategy consultant was trained by the researchers to create the PGA models through interventions with the end-users, which was important to introduce practical hypotheses and knowledge of organizational work practices into the application of the PGA technique [83]. Furthermore, the strategy consultant was responsible for the qualitative analysis of the complexity, applicability, and comprehensibility of the PGA

[1] We are not allowed to reveal the identity of this company.

technique. The end-users included two product managers (i.e., case study 1 and 3) and one regional manager (i.e., case study 2), who provided the necessary input to enable the application of the PGA technique by the strategy consultant. Finally, the end-users also executed both a quantitative evaluation (i.e., filling out an evaluation questionnaire) and qualitative evaluation (i.e., open feedback) to validate the PGA models and the modeling and analysis procedure. Irrespective of the managerial position of the end-users in the different case studies, we believe that a representative end-user of the PGA technique can be any organizational stakeholder that has the interest of improving strategic fit and that has access to the necessary internal information.

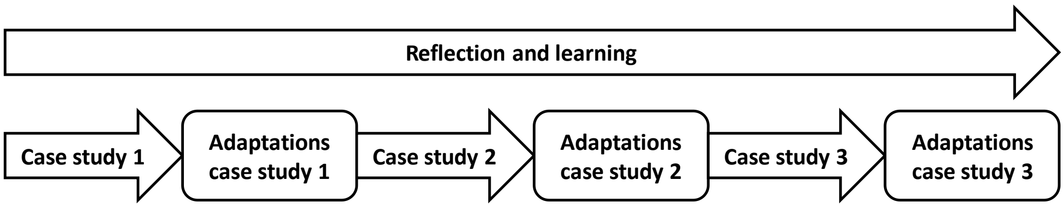


Figure 1: Research design

The IT applications that are offered by the business unit in the first case study focus on supporting and increasing the efficiency of business performance management. The objective of this management field is to increase the visibility of operations in the whole enterprise. Practically, this means that these applications focus on supporting business planning and forecasting operations. Within this context, changing conditions in the product market were the problem of interest. Although it was sufficient for the business unit to focus merely on functional product requirements in the past, they now faced an increasing importance of offering integrative solutions and developing partnerships with customers. This evolution required an analysis whether the current business architecture was suited to address the changing market conditions.

The second case study was conducted in collaboration with a senior regional manager, who is responsible for all strategic initiatives of the constituent product groups. The main task of this manager is to align the higher-level management with the lower-level operational business units. The application of the PGA technique provided insights about how to improve strategic fit to sustain the future growth of the company and how to better communicate the high-level vision on the business architecture to the operational business units.

The third case study was executed in collaboration with a product group, which focuses on supporting and increasing the efficiency of human resource management through the use of techniques that are supported by software. As the product market of this business unit already largely shifted to cloud-based applications, the main focus was oriented towards securing the sales to these new customers. However, the product manager experienced a gap between this new strategic focus and the operational processes of its business unit. 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 new strategy.

The first case study provides the input for the running example that we use in the paper to illustrate the application of the PGA technique (see figures 4 to 10 in section 3). 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 [27]. This tool support was crucial for the creation and analysis of PGA model instantiations during the case studies. More details about the technical implementation of the software tool can be found in sections 3.1.3 and 3.2.2.3.

2.2.3 Evaluation

The intervention in the company allowed an evaluation of the proposed technique by both the external strategy consultant and the company managers involved in the case studies. The evaluation by the consultant (see section 3.2) was based on a qualitative analysis of the complexity, applicability, and comprehensibility of the different mechanisms in the PGA technique [59]. The end-user evaluation by the managers (see section 3.3) employed a questionnaire to quantitatively assess how well the technique supports the three drivers of strategic fit: #1 the alignment of the strategy, infrastructure, and process perspectives of the business architecture in a top-down manner (i.e., $SF_{top\text{-}down}$ table 1) and bottom-up manner (i.e., $SF_{bottom\text{-}up}$ in table 1), #2 the use of performance measurement to guide process outcomes towards the intended strategic goals by setting clear performance targets (i.e., $SF_{perf\text{-}meas1}$ in table 1) and by keeping track of the actual performance to provide incentives for possible improvements (i.e., $SF_{perf\text{-}meas2}$ in table 1), and #3 a clear communication of the organizational strategy to ensure its understanding and acceptance by business stakeholders. This last element, which is a basic requirement for enterprise models [32], was evaluated by means of the Technology Acceptance Model (TAM) [19]. This measurement framework for the user acceptance of IT artifacts has proven to be useful for a wide range of technologies [56]. 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, have proven their applicability in more recent technology acceptance frameworks [89]. 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 [31]. The evaluation questions for perceived usefulness (i.e., PU_{1-8} in table 1) and perceived ease of use (i.e., PEU_{1-6} in table 1) were based on the refined item scales of the TAM [63], worded in terms of the PGA technique. Each of the items in table 1 was measured on a seven-point scale, ranging from strongly disagree to strongly agree.

Table 1: Evaluation questionnaire

Item	Question
$SF_{top-down}$	The PGA technique improves the realization of strategic goals by identifying the appropriate business processes that sustain these goals [5, 65].
$SF_{bottom-up}$	The PGA technique improves the effectiveness of business processes by ensuring that these processes help achieve a strategic goal [5, 65].
$SF_{perf-meas1}$	The PGA technique improves the efficiency of processes by identifying performance targets based on appropriate quality measures [5, 65].
$SF_{perf-meas2}$	The PGA technique improves monitoring within the organization to ensure that desired results are achieved over time [5, 65].
PU_1	I believe the PGA technique would reduce the effort required to take strategic decisions [63].
PU_2	Understanding strategic decisions using the PGA technique would be more difficult for users [63].
PU_3	The PGA technique would make it easier for users to verify whether strategic decisions are correct [63].
PU_4	Overall, I found it useful to apply the PGA technique [63].
PU_5	Using the PGA technique would make it more difficult to take strategic decisions [63].
PU_6	Overall, I think the PGA technique does not provide an effective solution to take strategic decisions [63].
PU_7	Overall, I think the PGA technique is an improvement to the existing strategic decision mechanisms [63].
PU_8	Using the PGA technique would make it easier to communicate strategic decisions to other stakeholders [63].
PEU_1	I found the procedure for applying the PGA technique complex and difficult to follow [63].
PEU_2	Overall, I found the PGA technique difficult to use [63].
PEU_3	I found the PGA technique easy to learn [63].
PEU_4	I found it difficult to apply the PGA technique in the context of the organization [63].
PEU_5	I found the rules of the PGA technique clear and easy to understand [63].
PEU_6	I am not confident that I am now competent to apply the PGA technique in practice [63].

2.3 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 (see figure 1). Adaptations to the technique are then the result of the organizational use and the concurrent evaluation of the technique [83]. To identify possible improvements, the role of the researchers in 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 3.2).

2.4 Formalization of Learning

Formalization of learning includes the development of the situational learning into a generic solution for the addressed problem [83]. This includes the generalizability of the ADR improvements for the modeling language (see section 3.4.1) and the modeling and analysis procedure (see section 3.4.2). However, this step needs to be performed with caution as it is not straightforward to generalize results from case study research. Therefore, formalization of learning also involved evaluating different threats to validity (see section 3.4.3).

3 PGA Technique

3.1 Building the Initial Version

The PGA technique consists of a modeling language (section 3.1.1), which is defined by its syntax, semantics, and visual notation. Besides this, a modeling and analysis procedure (section 3.1.2) guides the actual creation of model instantiations [46]. Furthermore, the developed software tool that supports this initial PGA technique is discussed in section 3.1.3.

3.1.1 Modeling Language

The initial meta-model of the PGA modeling language[2] is given in figure 2 (i.e., with the exception of the valueStream* relation and the Make visible attribute, which are the result of refinements explained in section 3.2.2). The corresponding definitions can be found in table 2. In the remainder of this paper, the meta-model elements are underlined to preserve the clarity of the text.

This PGA modeling language is oriented towards visualizing the creation of value throughout the business architecture. This is implemented by the identification of valueStream relations between relevant business architecture elements. The value stream represents the hierarchical structure through which value is created at the strategic, infrastructure and process business architecture perspectives. The idea of valueStream relations is based on our previous research [8], which identified how value is created throughout a hierarchical structure of value model elements (i.e., the infrastructure perspective of the business architecture) by means of a business model component framework. In this paper, this hierarchy is extended by the Value Chain [77] and Balanced Scorecard [44] frameworks from the Strategic Management field to also cover the process

[2] The initial version of the meta-model was presented in [9].

and strategic perspectives (see also section 2.2.1). As such, the valueStream concept can be considered as an extension of how it is used within Value Stream Mapping, which is a part of Lean thinking [93]. In this context, the concept is employed to focus on value-adding and to remove non-value-adding activities within processes.

Each Element supports the creation of value at a certain hierarchical level (see L.X in table 2) of the business architecture and is characterized by a Name attribute (i.e., a String value) to provide them with a meaningful label .The process perspective is addressed by the concept of Activity (i.e., L1) [77], which enables end-users to decide on low-level operations that are required for realizing organizational goals. These activities are aggregated in the value stream to an overview of the constituting Process (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 [8]. To establish the link with the organizational goals (i.e., L.6), Kaplan and Norton [44] differentiate between the internal, customer, financial, and innovation and learning perspectives. This results in the identification of a valueStream relation between a Competence 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 this perspective includes strategic initiatives that go beyond the boundaries of the existing business architecture, such as the introduction of entirely new products, the penetration of new customer markets, the development of new business capabilities [43], etc. As these changes are characterized by a larger degree of risk, companies are confronted with implementation barriers (e.g., managerial resistance, lower margins, a misfit with existing organizational assets) [16]. Therefore, specific innovation programs are needed to realize successful innovation, which have been thoroughly investigated (e.g., the Open Innovation Paradigm [15]), but clearly differ from the effective implementation of strategic initiatives within the boundary of the existing business architecture. Consequently, we chose to leave out the innovation and learning perspective of the intended scope of the PGA technique.

The meta-model was extended with additional entities to convert a business architecture model, which is obtained by instantiating these meta-model constructs, into a business architecture heat map. Two kinds of extensions were made.

First, the result of the AHP prioritization mechanism is captured by the Importance attribute (i.e., a float value) of the valueStream relations. This attribute measures the extent to which an Element on some level of the business architecture hierarchy supports the creation of value on the next higher level in the hierarchical structure. To facilitate the calculation of this Importance attribute, each Element has a Comparison matrix attribute, which enables the end-users to choose a Comparison value to relatively weigh the importance of two connected Elements at a lower hierarchical level (i.e., Element X_i and Element X_j) (see section 3.1.2 for more details). To preserve the clarity of figure 2, the AHP comparison scale was not further specified in the meta-model, but can be consulted in table 3 of section 3.1.2. The Consistency ratio attribute (i.e., a float value) captures the degree to which the subjective choices of the end-users in the Comparison matrix contain disproportions.

Second, the performance measurement mechanism of the heat maps is realized by adding appropriate Measure attributes to the different Elements. These attributes include a Measure type to account for 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 (i.e., a String value) provides a textual definition of the performance indicators. The remaining attributes are numerical float values, which specify a Performance goal with an Allowed deviation (%) interval. Such interval is useful when there is uncertainty about the desired value of a quantitative performance goal (e.g., the higher this uncertainty, the larger this interval should be). By comparing these values with the Actual performance value, it can be calculated whether this performance is excellent, as expected or bad (see section 3.1.2). These numerical attributes can also be used in the context of qualitative measures (see also table 4). In this case, the Performance goal can be considered as having a value 1 without an Allowed deviation (%) (i.e., value 0). Depending on the Actual performance, this attribute will be either 0 (i.e., bad performance) or 1 (i.e., excellent performance).

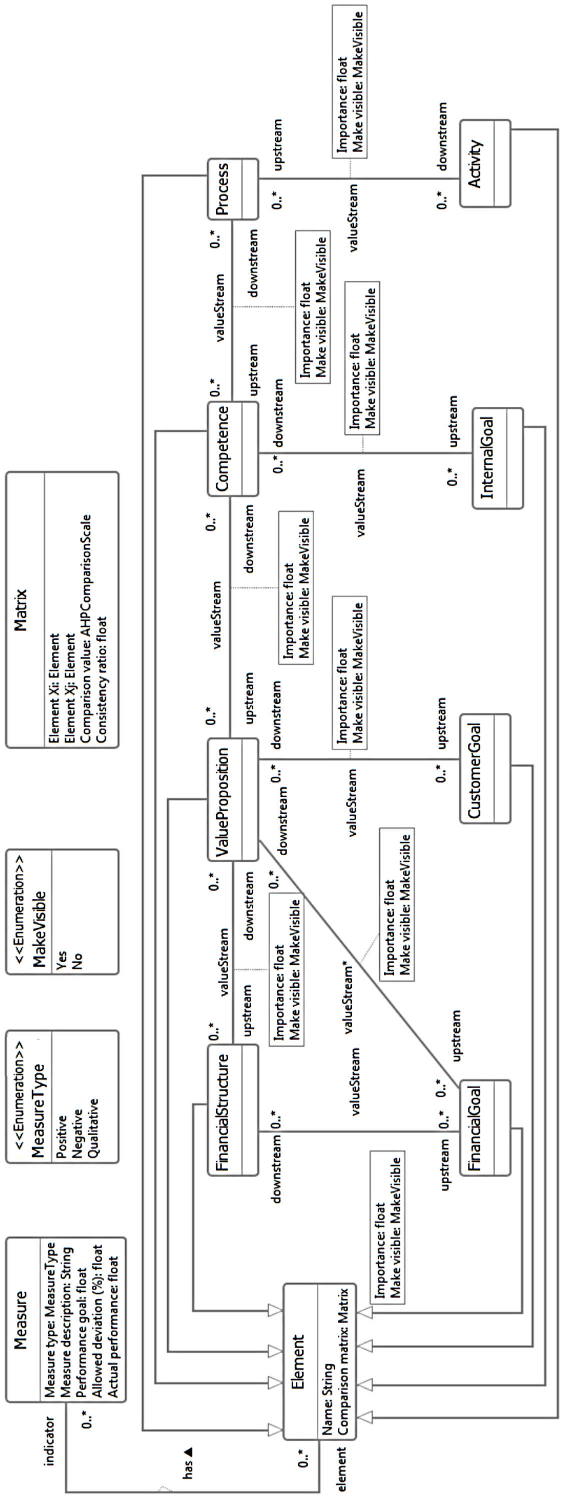
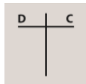
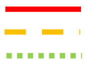
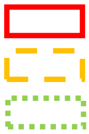


Figure 2: Meta-model of the PGA modeling language

The design of the notation of the PGA modeling language (see table 2) was guided by the Physics of Notations [64]. 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 3.1.2 for more details about how these values are obtained). This choice of colors is inspired by existing heat mapping techniques [62] to further ensure semantic transparency.

Table 2: Definition and notation of the PGA modeling constructs

Hierarchy level	**Modeling construct**	**Definition**	**Notation**
L.6	Goal	Strategic objective that describes a desired state or development of the company [76]. Relevant categories are financial (upper notation), customer (middle notation), and internal objectives (bottom notation) [44].	
L.5	Financial Structure	Representation of the costs resulting from acquiring resources, and the revenues in return for the offered value proposition [73].	
L.4	Value Proposition	Offered set of products and/or services that provides value to the customers and other partners, and competes in the overall value network [1, 73, 88].	
L.3	Competence	An integrated and holistic set of knowledge, skills, and abilities, related to a specific set of resources, which is coordinated through processes to realize the intended value proposition [55, 78, 81].	
L.2	Process	A structured set of activities that uses and/or consumes resources to create the organizational competences [22, 88].	
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 [55].	
-	valueStream	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 [43, 76].	

3.1.2 *Modeling and Analysis Procedure*

The initially designed modeling and analysis 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. A visual aid (see figure 3) was developed for this interview, which could be used by the strategy consultant to assist the end-users in identifying valid business architecture elements.

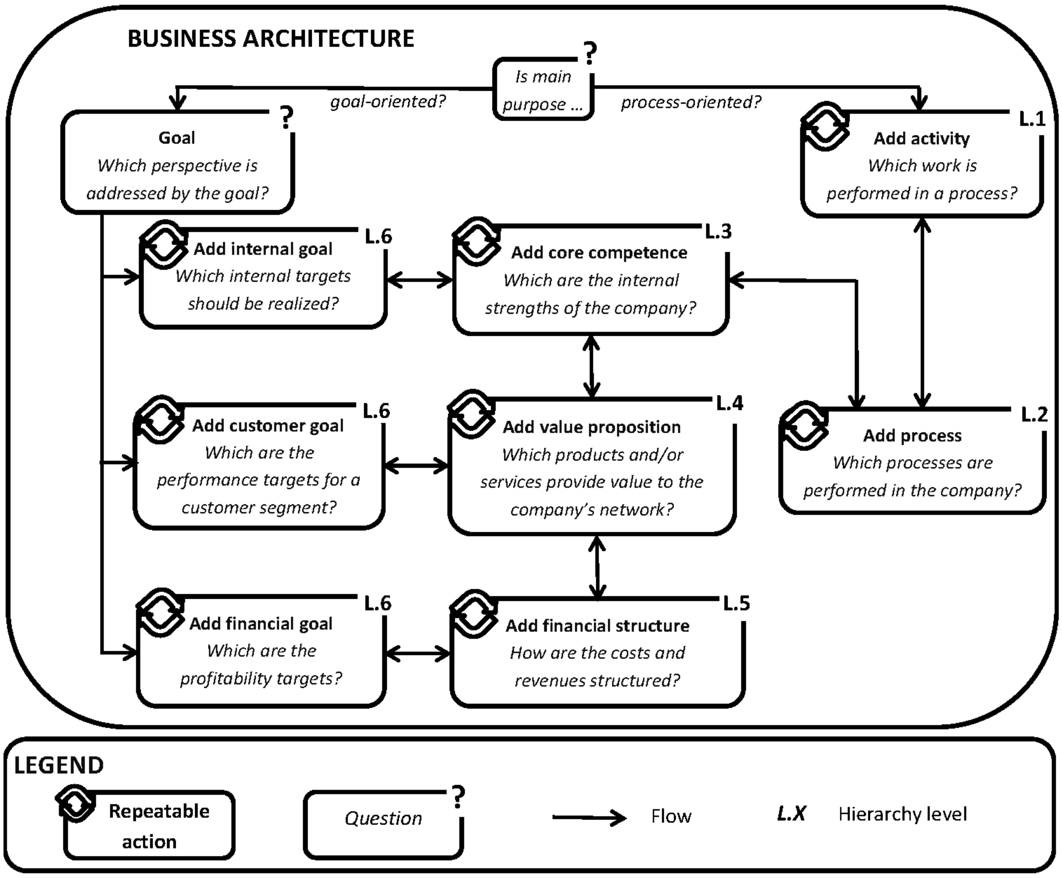


Figure 3: Visual aid for the creation of the business architecture hierarchy

The first question in this visual aid was whether the analysis of 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), this includes for instance adding 'Defend market position' as a <u>CustomerGoal</u> (i.e., in a goal-oriented approach) or 'Close customer deals' as an <u>Activity</u> (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 3) and adding elements of another type, which can be reached via the flow arrows. 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 <u>Activity</u> on the same horizontal level or adding 'Sales process' as a <u>Process</u> 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 3) [59]. After the identification of the elements, the business architecture hierarchy was completed by adding the relevant valueStream relations between these elements. This was done by questioning whether business architecture elements add value to other elements at a higher abstraction level (i.e., bottom-up) or whether the value of an element is sustained by elements at a lower (i.e., top-down) abstraction level. In the running example (from our first case study), 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., 'Sales process', '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 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 CustomerGoal), as well as to generate sufficient revenues (i.e., a FinancialGoal). To generate these revenues, the FinancialStructure should be oriented towards realizing a higher sales volume within the business unit. In this respect, three different ValuePropositions are offered to customers. Apart from meeting the functional requirements for their IT products, the company also needs to offer integrative solutions and partnership support to their customers. To further support these ValuePropositions, the following Competences are identified: 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., 'Sales process', 'Marketing process', 'Financial management process', and 'Technology research and development'). The sales process 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.

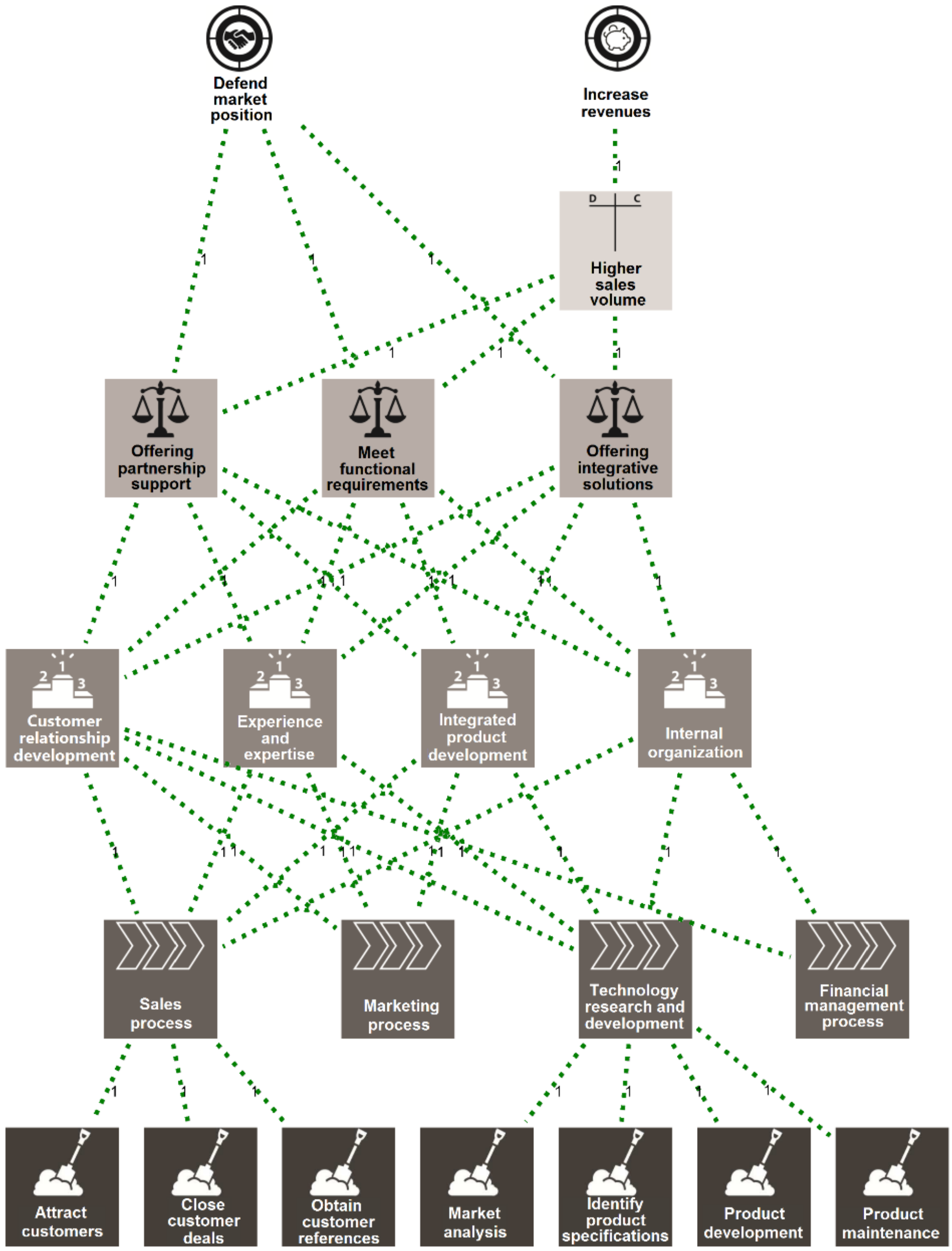


Figure 4: Business architecture hierarchy for the running example

Afterwards, the AHP was applied to determine the Importance of the valueStream relations. In figure 5, an illustration of this prioritization process is provided for the running example. This included the pairwise comparison of all different elements X_i and X_j (e.g., the Competences 'Customer relationship development', 'Experience and expertise', 'Integrated product development', and 'Internal organization'), which are related to the same higher-level element Y (e.g., the ValueProposition 'Offering integrative solutions') by valueStream relations. 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 extreme importance compared to X_j), as well as the reciprocal values in case X_j is more important than X_i [79] (for more details, see table 3).

Table 3: AHP comparison scale (based on [79])

Importance scale	Definition
1	X_i and X_j have equal importance
3	X_i has moderate importance compared to X_j
5	X_i has essential or strong importance compared to X_j
7	X_i has very strong importance compared to X_j
9	X_i has extreme importance compared to X_j
2,4,6,8	Intermediate values between two adjacent judgments
Reciprocal values (e.g., 0.111 is the reciprocal value of 9, i.e., 1/9; 0.333 is the reciprocal value of 3, i.e., 1/3)	If X_i has one of the above numbers assigned to it when compared to X_j, then X_j has the reciprocal value when compared to X_i

For the running example, this results in a list of six pairwise comparisons , which 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 principal right Eigenvector represents the priorities of the considered set of elements [79] (see formula 1). In the original AHP proposal of Saaty [79], this Eigenvector is normalized (see formula 2) such that the sum of the priorities is equal to 1, which enables the user to consider these priorities as absolute percentages.

Comparison matrix:
$$\begin{bmatrix} 1 & 0.333 & 0.143 & 0.5 \\ 3 & 1 & 0.2 & 0.333 \\ 7 & 5 & 1 & 3 \\ 2 & 3 & 0.333 & 1 \end{bmatrix} \quad (1)$$

Normalized Eigenvector:
$$\begin{bmatrix} 0.074 \\ 0.128 \\ 0.572 \\ 0.225 \end{bmatrix} \quad (2)$$

For the application of the AHP in the context of the PGA technique, this normalization implies that the higher the number of elements X that are related to a higher-level element Y, the lower their average priorities will be. This is a problem as the user should be able to compare priorities throughout the complete business architecture hierarchy. Therefore, we changed the original AHP by rescaling (see formula 3) the resulting priorities relatively to the lowest value (i.e., 0.074). This ensures that the priorities can be compared independently from the number of elements X to be compared. This change does not pose any problems for the mathematical foundations underlying the AHP as it is allowed to multiply an Eigenvector by any non-zero scalar.

Rescaled Eigenvector PGA:
$$\begin{bmatrix} 1 \\ 1{,}73 \\ 7{,}74 \\ 3{,}05 \end{bmatrix} \quad (3)$$

Based on these rescaled priorities, the color of the valueStream relations was changed to (solid) red for a high importance (i.e., ≥ 5), (dashed) orange for a medium importance (i.e., ≥ 3 and < 5), or (dotted) green for a low importance (i.e., < 3). These threshold values were chosen as they correspond with a moderate (i.e., 3) and strong (i.e., 5) importance difference in the AHP comparison scale (see table 3).

Finally, it was also possible to calculate a Consistency ratio, which is an AHP measure for the degree to which the subjective judgments in the Comparison matrix contain disproportions. If the value of this ratio is over 10%, appropriate actions should be undertaken to improve the consistency of the judgments [79]. A possible action includes a re-evaluation of the judgments in the pairwise comparison matrix by the end-user [40]. The figures that are provided for the running example result in a Consistency ratio of 7.85% (see figure 5), which means that the inconsistency of these comparisons, as provided by the end-user, is at an acceptable level. This process was completely automated in the software tool (see section 3.1.3) and results in the screenshots that are provided by figure 5.

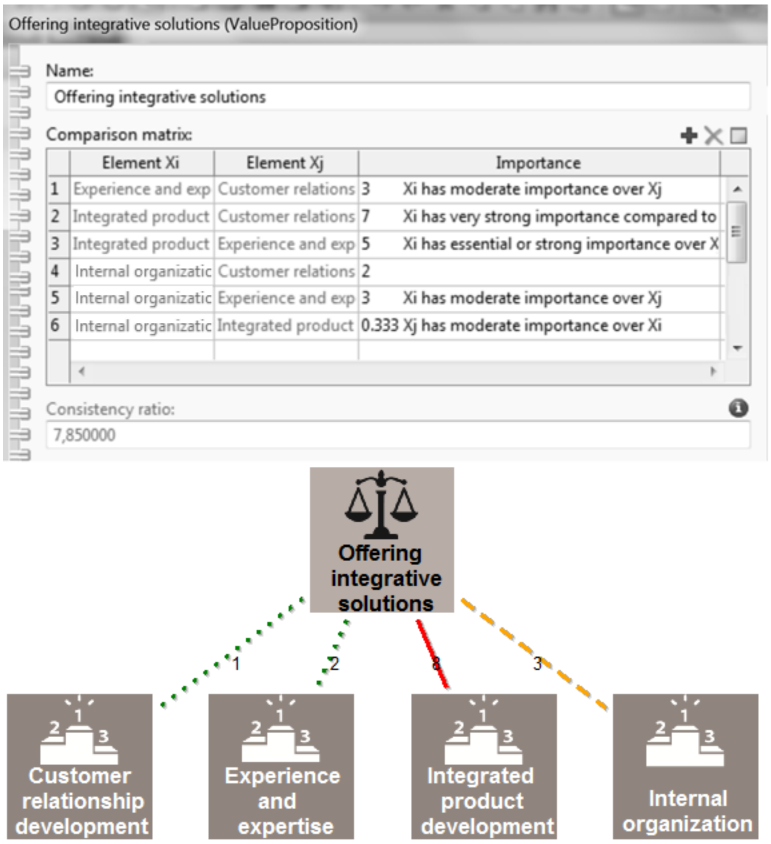


Figure 5: AHP tool implementation for the running example

Activity (ii): executing the performance measurement

The performance measurement activity aims at collecting information 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 excellent, as expected or bad (see table 4). An excellent performance was visualized by a (dotted) green, an expected performance by an (dashed) orange, and a bad performance by a (solid) red border color of the elements. Figure 6 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 (100% + Allowed deviation (%)) (i.e., 50% x (100% + 5%) = 52.5%), a (dotted) green color was used for the border of this element (see right-hand side of figure 6).

Table 4: Performance measurement interpretation of the different measure types

Measure type	Actual performance	Interpretation
Positive	≥ Performance goal x (100% + Allowed deviation (%))	Excellent
	≥ Performance goal x (100% – Allowed deviation (%)) and < Performance goal x (100% + Allowed deviation (%))	As expected
	< Performance goal x (100% – Allowed deviation (%))	Bad
Negative	≤ Performance goal x (100% – Allowed deviation (%))	Excellent
	> Performance goal x (100% – Allowed deviation (%)) and ≤ Performance goal x (100% + Allowed deviation (%))	As expected
	> Performance goal x (100% + Allowed deviation (%))	Bad
Qualitative	= 1	Excellent
	= 0	Bad

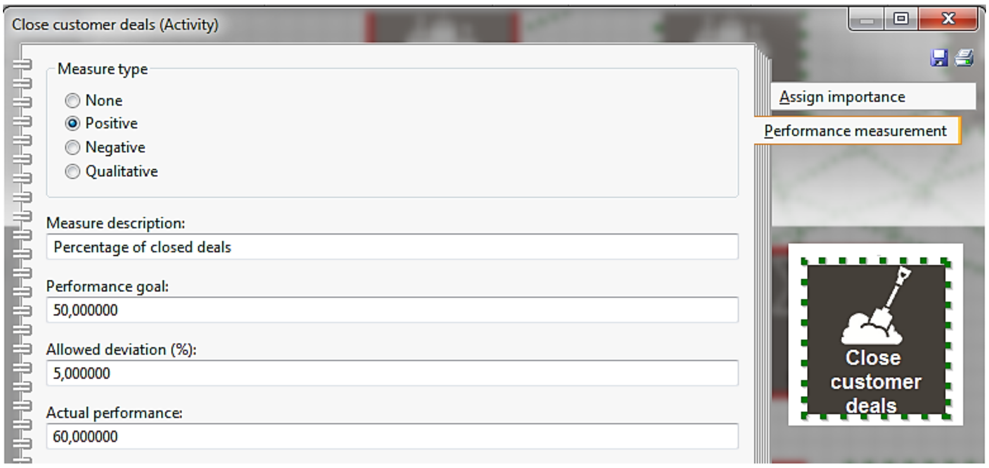


Figure 6: Performance measurement for the running example

Activity (iii): performing the strategic fit improvement analysis

The first two activities in the modeling procedure result in the creation of a business architecture heat map (see figure 7 for the running example), which can then further be used to perform a strategic fit improvement analysis. This analysis includes the identification of goals that are characterized by a bad performance and the identification of critical paths through the business architecture. Starting from a goal with a bad performance, a critical path is a chain of downstream valueStream relations that mostly have a high or medium importance[3] and that connect business architecture elements on different hierarchical levels of which the performance can be possibly improved. As such, the critical path leads to the identification of Activities to which adjustments are needed. It is assumed that a better performance of these Activities will improve the performance of the other elements on such a critical path to better realize the targeted organizational goals. In the running example, an example of such critical path is highlighted by a grey color (see figure 7). 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 sales process, which can be improved by focusing on the Activity of obtaining customer references in the new market reality. These two examples are an illustration that the notion of a critical path can provide different insights about how strategic fit can be improved within the business architecture. As the identification of a critical path is dependent on the particular organizational context, we deliberately chose not to automate this in the software tool. In our experience, it is better to informally perform a visual analysis of the business architecture heat map with the end-users to identify possible improvements. This flexibility avoids that possible opportunities would be ignored because they do not fit in a more formal definition of the critical path concept.

[3] In figure 7, the valueStream relation between the Financial Structure 'Higher sales volume' and the Goal 'Increase revenues' is dotted and green, which normally indicates a low priority. This is purely a result of the prioritization mechanism applied as it is the only valueStream relation leading to the goal. Hence, we consider it as part of the critical path of valueStream relations leading to 'Increase revenues'.

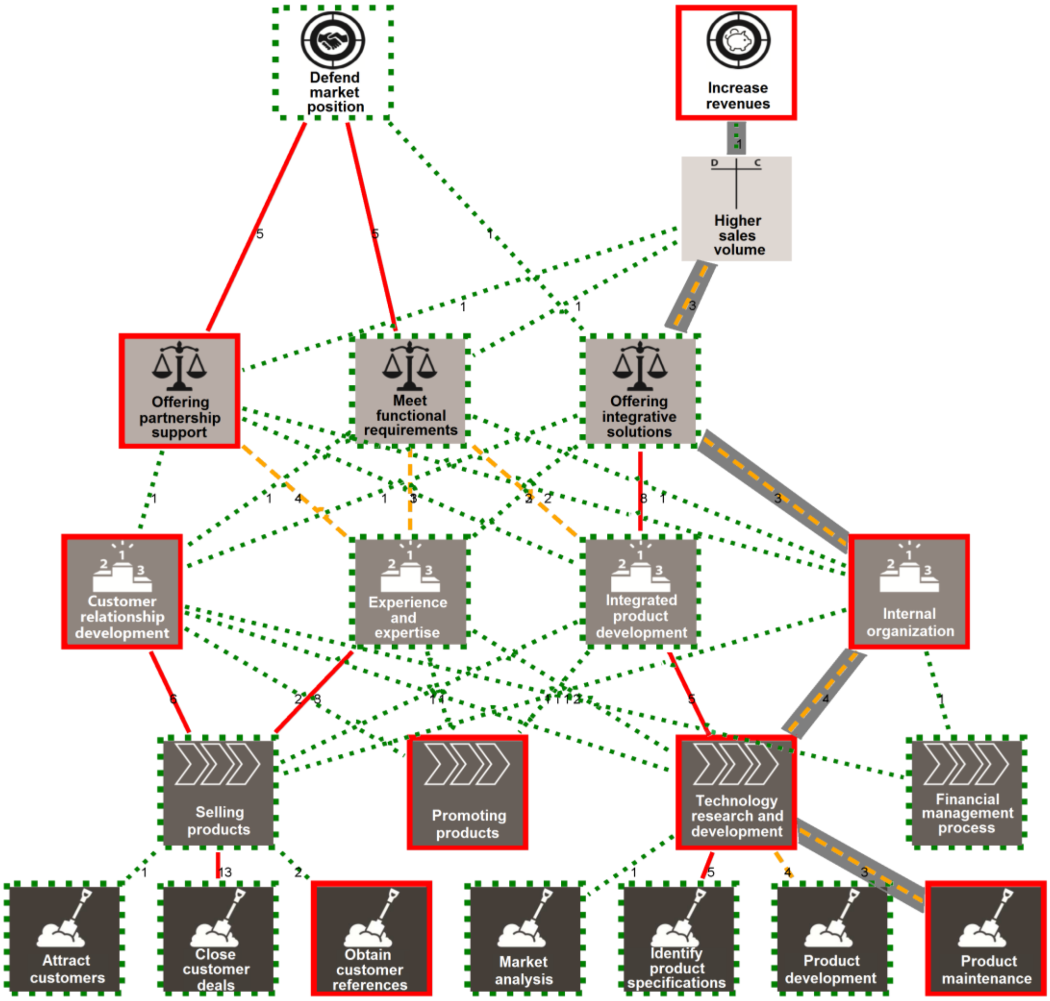


Figure 7: Business architecture heat map for the running example

3.1.3 *Tool Support*

(i) The creation of model instantiations

The FDMM formalism [28] (i.e., the Formalism for Describing ADOxx Meta models and Models) is used in this section to provide an exact description of how the initial PGA meta-model (see section 3.1.1) was implemented in the ADOxx software tool. To this end, the ADOxx meta[2]-model defines a meta-model as a set of model types, which consist of classes, relationclasses, data types, and attributes.

Only one model type ($\boldsymbol{MT}_{PGA}$) is used in the PGA 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 4).

$$\boldsymbol{MT}_{PGA} = < \boldsymbol{O}_{PGA}^{T}, \boldsymbol{D}_{PGA}^{T}, \boldsymbol{A}_{PGA} > \quad (4)$$

Object types (formula 5) refer to the classes and the relationclasses (except of Enumerations) that are part of the meta-model (see figure 2). The business architecture elements are implemented as a set of classes, which are defined as subtypes of an Element (see formula 6). 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 [27]. This object is needed to build the comparison matrix as input for the AHP (see formula 1). Finally, the Measure class and the has relation between Measure and Element of the meta-model were omitted and the measure attributes were added to the abstract Element class during the implementation of the software tool to enable an easy visualization of these attributes in a separate tab (see figure 6).

$$\boldsymbol{O^T_{PGA}} = \{Element, FinancialGoal, CustomerGoal, InternalGoal, FinancialStructure, ValueProposition, CoreCompetence, ValueChain, Activity, valueStream, Matrix\} \tag{5}$$

$$\begin{aligned} &FinancialGoal \preccurlyeq Element \\ &CustomerGoal \preccurlyeq Element \\ &InternalGoal \preccurlyeq Element \\ &FinancialStructure \preccurlyeq Element \\ &ValueProposition \preccurlyeq Element \\ &CoreCompetence \preccurlyeq Element \\ &ValueChain \preccurlyeq Element \\ &Activity \preccurlyeq Element \end{aligned} \tag{6}$$

Four different data types are used in the PGA technique (formula 7a). While a String can represent text, Float data are related to decimal numbers. The other data types are pre-defined enumerations, which allow end-users to choose the type of performance indicator (i.e., $\boldsymbol{Enum}_{Measure\ type}$), or to perform the pairwise comparison of two elements according to the AHP comparison scale (i.e., $\boldsymbol{Enum}_{AHPComparisonScale}$) (see table 3).

$$\boldsymbol{D^T_{PGA}} = \{\boldsymbol{String}, \boldsymbol{Float}, \boldsymbol{Enum_{Measure\ type}}, \boldsymbol{Enum_{AHPComparisonScale}}\}$$

$$\boldsymbol{Enum_{Measure\ type}} = \{\ Positive, Negative, Qualitative\}$$

$$\boldsymbol{Enum_{AHPComparisonScale}} = \{0.111\ Xj\ has\ extreme\ importance\ compared\ to\ Xi, 0.125, 0.143\ Xj\ has\ very\ strong\ importance\ compared\ to\ Xi, 0.167, 0.2\ Xj\ has\ essential\ or\ strong\ importance\ compared\ to\ Xi, 0.25, 0.333\ Xj\ has\ moderate\ importance\ compared\ to\ Xi, 0.5, 1\ Xi\ and\ Xj\ have\ equal\ importance, 2, 3\ Xi\ has\ moderate\ importance\ compared\ to\ Xj, 4, 5\ Xi\ has\ essential\ or\ strong\ importance\ compared\ to\ Xj, 6, 7\ Xi\ has\ very\ strong\ importance\ compared\ to\ Xj, 8, 9\ Xi\ has\ extreme\ importance\ compared\ to\ Xj\} \tag{7a}$$

All attributes that are used in figure 2, are elements of $\boldsymbol{A}_{PGA}$ (formula 8a). 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 [28]. An overview for the attributes is given by formulas 9 to 22.

$$\boldsymbol{A_{PGA}} = \{Name, Comparison\ matrix, Measure\ type, Measure\ description, Performance\ goal, Allowed\ deviation\ (\%), Actual\ performance, valueStream_{from}, valueStream_{to}, Importance, Element\ Xi, Element\ Xj, Comparison\ value, Consistency\ ratio\} \qquad (8a)$$

The textual Name attribute (formula 9) 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 enumeration attribute Measure type (formula 10) as each measure is characterized by a specific value for this attribute. Finally, as the Importance attribute of a valueStream relation (formula 11) and the Consistency ratio attribute of a Matrix (formula 12) are automatically calculated in the tool based on the relevant Comparison matrix, these attributes will exactly have one Float value.

$$\begin{aligned} &domain(Name) = \{Element\} \\ &range(Name) = \{String\} \\ &card(Element, Name) = \ <1, 1> \end{aligned} \qquad (9)$$

$$\begin{aligned} &domain(Measure\ type) = \{Element\} \\ &range(Measure\ type) = \{\boldsymbol{Enum_{Measure\ type}}\} \\ &card(Element, Measure\ type) = \ <1, 1> \end{aligned} \qquad (10)$$

$$\begin{aligned} &domain(Importance) = \{valueStream\} \\ &range(Importance) = \{Float\} \\ &card(valueStream, Importance) = \ <1, 1> \end{aligned} \qquad (11)$$

$$\begin{aligned} &domain(Consistency\ ratio) = \{Matrix\} \\ &range(Consistency\ ratio) = \{Float\} \\ &card(Matrix, Consistency\ ratio) = \ <1, 1> \end{aligned} \qquad (12)$$

An obligatory minimum is not applicable to the Measure description attribute (formula 13). This also holds for the other numerical measure attributes such as the Performance goal (formula 14), the Allowed deviation (%) (formula 15), and the Actual performance (formula 16). Indeed, it is possible that end-users still have to define values for these attributes at a certain moment during the application of the technique.

$$\begin{aligned} &domain(Measure\ description) = \{Element\} \\ &range(Measure\ description) = \{String\} \\ &card(Element, Measure\ description) = \ <0, 1> \end{aligned} \qquad (13)$$

$$\begin{aligned} &domain(Performance\ goal) = \{Element\} \\ &range(Performance\ goal) = \{Float\} \\ &card(Element, Performance\ goal) = <0, 1> \end{aligned} \qquad (14)$$

$$\begin{aligned} &domain(Allowed\ deviation\ (\%)) = \{Element\} \\ &range(Allowed\ Deviation\ (\%)) = \{Float\} \\ &card(Element, Allowed\ Deviation\ (\%)) = \ <0, 1> \end{aligned} \qquad (15)$$

$$domain(Actual\ performance) = \{Element\}$$
$$range(Actual\ performance) = \{Float\}$$
$$card(Element, Actual\ perfomance) = \ <0, 1> \quad (16)$$

The number of values is not limited for some of the attributes of the Matrix record class. Indeed, it can contain multiple values for the Element X_i (formula 17), Element X_j (formula 18), and Comparison value (formula 19) attributes (e.g., see screenshot of the matrix in figure 5).

$$domain(Element\ Xi) \ = \{Matrix\}$$
$$range(Element\ Xi) = \{String\}$$
$$card(matrix, element\ Xi) \ = < 0, \infty > \quad (17)$$

$$domain(Element\ Xj) = \{Matrix\}$$
$$range(Element\ Xj) = \{String\}$$
$$card(matrix, Element\ Xj) = \ < 0, \infty > \quad (18)$$

$$domain(Comparison\ value) = \{Matrix\}$$
$$range(Comparison\ value) = \left\{\boldsymbol{Enum_{AHPComparisonScaleImportance}}\right\}$$
$$card(matrix, Compared\ importance) = \ < 0, \infty > \quad (19)$$

The valueStream relationclass can be formalized within ADOxx by its from and to attributes[4] (formula 20 to 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. As such, a valueStream is implemented as a recursive relation between two Elements, which was needed to only use one type of valueStream relation to visualize the creation of value within the whole business architecture. To only allow those relations that are defined in the PGA meta-model (see figure 2), extra constraints were added to the external coupling component of ADOxx.

$$domain\left(valueStream_{from}\right) = \{valueStream\}$$
$$range\left(valueStream_{from}\right) = \{Element, \boldsymbol{MT_{PGA}}\}$$
$$card\left(valueStream, valueStream_{from}\right) = \ <1, 1> \quad (20)$$

$$domain(valueStream_{to}) = \{valueStream\}$$
$$range(valueStream_{to}) = \{Element, \boldsymbol{MT_{PGA}}\}$$
$$card(valueStream, valueStream_{to}) = \ <1, 1> \quad (21)$$

The Comparison matrix attribute (formula 22), which is attached to exactly one Element in the PGA meta-model, has a range that is a Matrix object type.

$$domain(Comparison\ matrix) = \{Element\}$$
$$range(Comparison\ matrix) = \{Matrix, \boldsymbol{MT_{PGA}}\}$$
$$card(Element, Comparison\ matrix) = \ <1, 1> \quad (22)$$

The specification of the meta-model was augmented by the proposed graphical notation (see table 2) to enable a visual representation of the business architecture elements and the

[4] To enable the development of the business architecture hierarchy in a top-down and bottom-up manner, a valueStream relation can be instantiated from downstream to upstream and vice versa.

connecting valueStream relations. This required coding the GRAPHREP class attribute for these elements by means of the ADOxx Library Language.

(ii) Functionalities for the modeling and analysis procedure

The development of a prioritized business architecture hierarchy is supported by the full automation of the AHP. This was accomplished by ADOScript files that establish the coupling with a Java application that calculates the Importance attribute of a valueStream relation and the Consistency ratio of a Matrix based on the user input in the Comparison matrix. Based on the value of the Importance attribute, the visualization of the valueStream relations is automatically adapted (see screenshot in figure 5). This was realized by the specification of appropriate conditional formatting in the GRAPHREP attribute of the valueStream class. Moreover, an explicit warning is provided to the end-user in case the Consistency ratio of the Comparison matrix is out of bound (i.e., > 10%). Finally, external coupling is also used to ensure that the Comparison matrix remains valid in case valueStream relations are added or deleted, and when the Name of an Element is changed by end-users.

The execution of the performance measurement mechanism entails the dynamic visualization of the border color of a certain Element, based on its measure attributes (see screenshot in figure 6). More specifically, the performance measurement interpretation of the different measure types is implemented as specified in table 4. This was done by adding the relevant formatting rules to the GRAPHREP attribute of the Element class. Furthermore, it was needed to specify the range of values that are allowed for the different measure attributes. This is supported by the external coupling component in the ADOxx platform.

3.2 Intervention in the Organization

3.2.1 Case Study Evidence

A summary of the types of evidence that were collected during the case study activities can be found in table 5. The interviews between the strategy consultant and the involved managers (as end-users) were the main source of information. Although one interview was used to develop the prioritized business architecture hierarchy in case study 1, this interview was split in two for the subsequent case studies to separate the development of the business architecture hierarchy from the execution of the AHP (see also section 3.2.2.2). These in-depth interviews also served to identify elements of the PGA technique that could be improved. During all case studies, another interview was held to perform the strategic fit improvement analysis and the evaluation of the technique. While the first part of this interview was also an in-depth interview, the last part was more strictly structured according to the evaluation questionnaire (see table 1). This quantitative evaluation was supplemented by open questions to obtain qualitative feedback about the perceived strengths and weaknesses of the technique (see section 3.3). Furthermore, the strategy consultant was also able to make direct observations of the decision-making process as he was allowed to attend strategic meetings within the company. These meetings further informed him about the main managerial views on the strategy of the organization. During the case studies, different forms of documentation (e.g., product development roadmap, sales targets, customer market information) and archival records (e.g., balance sheets, evaluation forms) were consulted to collect the appropriate performance measurement data. This choice was originally preferred as one of the main advantages of this type of evidence is its precise and quantitative nature [94]. However, as this information was difficult to access, other performance measurement data were obtained through the interactions of the strategy consultant with the managers. In this context, the consultant also had an active role in the organization. Consequently, this form of evidence can be classified as a participant observation [94]. The execution of the modeling and analysis procedure eventually led to the construction of three PGA models, which are physical artifacts that incorporate a large amount of the information and insights that were obtained during the case study research. These artifacts were important to facilitate the evaluation of the PGA technique by the managers in their role of end-users.

Table 5: Relevant types of case study evidence

<table>
<tr><th rowspan="2">Activity
Case study</th><th colspan="3">PGA modeling and analysis procedure</th><th rowspan="2">End-user evaluation</th></tr>
<tr><th>Development of the prioritized business architecture hierarchy</th><th>Execution of the performance measurement</th><th>Performing the strategic fit improvement analysis</th></tr>
<tr><td>1</td><td>- One in-depth interview
- Direct observations</td><td rowspan="3">- Documentation
- Archival records
- Participant observation</td><td rowspan="3">- One in-depth interview
- Direct observations</td><td rowspan="3">- One in-depth interview
- Evaluation survey
- Physical artifacts</td></tr>
<tr><td>2</td><td rowspan="2">- Two in-depth interviews
- Direct observations</td></tr>
<tr><td>3</td></tr>
</table>

3.2.2 ADR Adaptations

3.2.2.1 Modeling Language

The first in-depth interview of case study 1 revealed the need to increase the understanding of the different business architecture concepts used by the PGA technique by making them more clearly distinguishable in the models (i.e., the principle of perceptual discriminability [64]). This was improved for case studies 2 and 3 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. For the clarity of the running example, this background color was already added to the visualization of table 2 and consistently used in figures 4 to 9.

The applicability of the FinancialStructure element was questioned during the first in-depth interview of case study 1. 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 2). This resulted in omitting the FinancialStructure element (together with the valueStream relation that connected this element with a FinancialGoal) in the first case study model. For the running example (see figure 8), this change was implemented by allowing valueStream relations between the FinancialGoal 'Generate Revenues' and the respective ValuePropositions 'Offering partnership support' and 'Offering integrative solutions'. Also in case study 3, a direct valueStream relation between a FinancialGoal and a ValueProposition was included in the PGA model.

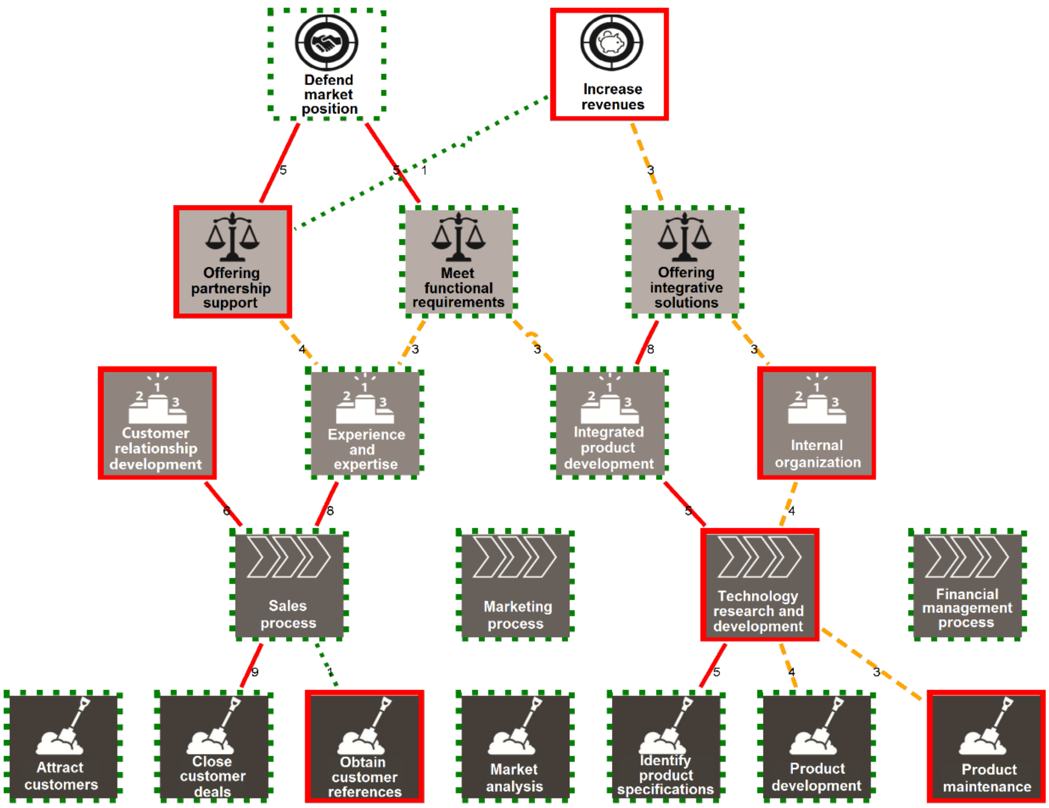


Figure 8: Refined business architecture heat map for the running example

3.2.2.2 Modeling and Analysis Procedure

Activity (i): developing a prioritized business architecture hierarchy

In the first in-depth interview of case study 1, the end-user preferred to build the business architecture hierarchy layer per layer. 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 in case studies 2 and 3. As such, an end-user could apply adaptations without having to repeat the AHP for the modified Comparison matrices afterwards.

An adaptation to the minimal cycles was the result of the first in-depth interview of case study 2. 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 Activities were not relevant for the strategic fit analysis performed in this case study, it was allowed to consider a Process as the element at the lowest hierarchical level in the business architecture. This does not endanger the realization of strategic fit as the Process element still provides insights in possible operational improvements to better realize the organizational goals. Although not directly applicable in the other case studies, this adaptation can also be understood in the context of the running example (figure 8) by considering 'Marketing process' 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 adapted based on the first in-depth interview of case study 1. To increase the understanding of the end-users in case studies 2 and 3, the choice of a Comparison value between two elements (i.e., Element X_i and Element X_j) was 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 (see table 3) 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 7a in section 3.1.3) was not adapted.

The first in-depth interview of case study 1 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-user, 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.[5] In this case, it was decided to remove the least important valueStream relation (i.e., with an importance of 1) from the resulting models. This change resulted in the removal of two out of the remaining 38 valueStream relations in the first case study to resolve the inconsistencies. This adaptation was also applied after the second interview of case study 2, after which nine out of 32 valueStream relations were removed in the PGA model (see table 6). Although this action solves the issue of the inconsistency of these models, it comes at the expense of their completeness. However, this is not a problem in the scope of the PGA technique, which has an important focus on increasing the understanding about the essence of the business architecture by the end-users. Indeed, the removed valueStream relations (i.e., with importance 1) would not be found on critical paths leading to goals with bad performance. Consequently, the resulting models just become simpler without consequences for the strategic fit improvement analysis.

Figure 9 provides an example of this mechanism for the running example. In the Comparison matrix, it can be seen that the Comparison value of ‘Obtain customer references’ to ‘Close customer deals’ is 0.111 and to ‘Attract customers’ is 3 (see top of figure 9). To obtain a comparison without any inconsistency, the Comparison value of ‘Attracting 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 comparison scale, it is decided to remove the relation between ‘Sales process’ and ‘Attract customers’. This results in the situation, which is depicted at the bottom of figure 9.

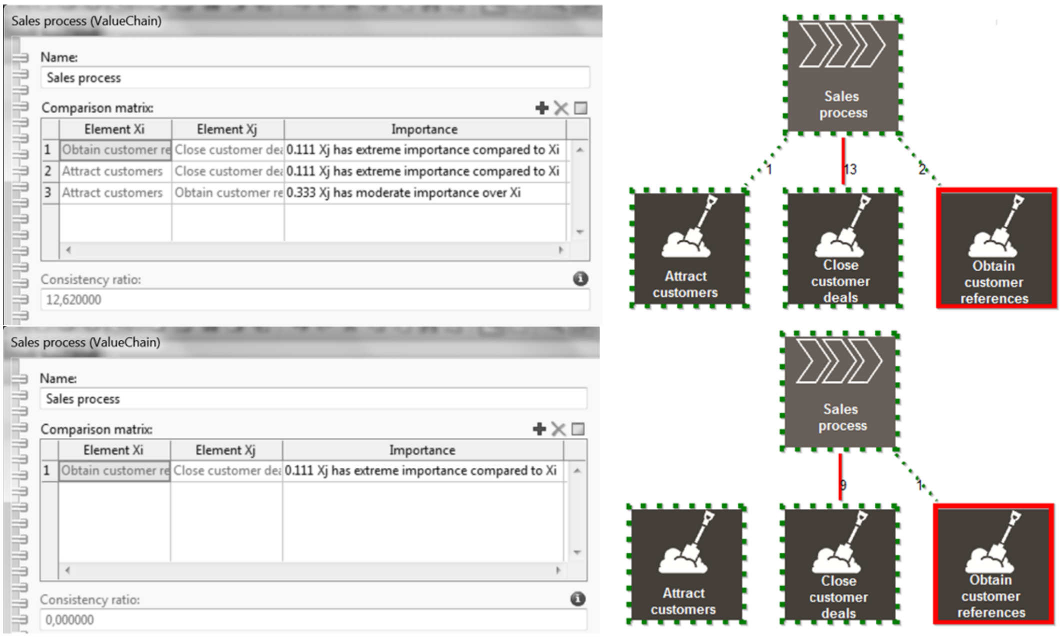


Figure 9: Mechanism to remove unimportant relations for the running example

The second in-depth interview of case study 3 led to the introduction of a mechanism to reduce the total number of comparisons. This was the result of the finding that during the

[5] This can only occur when at least three lower-level elements are pairwise compared

development of the business architecture hierarchy, end-users do not yet discriminate between unimportant and important valueStream relations. To limit the complexity of the prioritization process, the end-user was asked upfront whether a relation should be further included in the application of the AHP. 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 6). As this change of the modeling procedure resulted from insights obtained during the last case study (see figure 1), the need for this change will have to be evaluated in the further application of the PGA technique.

Table 6: Model size for the different case studies

Model elements	case study 1	case study 2	case study 3
# initial business architecture elements	21	13	32
# initial valueStream relations	39	32	94
# refined business architecture elements	20	13	32
# refined valueStream relations	36	23	79
Strategic fit improvement analysis	50%	50%	4-9

Activity (ii): executing the performance measurement

The application of the performance measurement was refined based on experience gained during the first case study. When collecting the relevant information based on documentation and archival records, it turned out that quantitative measures were not always available (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 extra information that was obtained through participant observations (see section 3.2.1) during each of the three case studies. 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 identification of critical paths during the strategic fit improvement analysis, which was performed during the second in-depth interview of case study 1, 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 only show a subset of the valueStream relations, of which the Importance is within a certain interval that is specified by a lower and upper bound percentage. To calculate whether a valueStream relation is within this interval, all relations were ranked from a high to a low Importance (e.g., four valueStream relations with Importance values 9, 7, 7, and 5). Afterwards, the relative ranks were calculated for each group of valueStream relations with the same Importance (e.g., 9: 0% - 25%, 7: 25%-75%, 5: 75%-100%). If these ranks were within the specified lower (e.g., 0%) and upper (e.g., 50%) bound percentages of the importance interval (e.g., if end-users wish to focus on the 50% most important valueStream relations), this group of valueStream relations (i.e., importance value 9) was eventually made visible. Therefore, it was needed to add the Make visible attribute to all valueStream relations of the PGA meta-model (see figure 2). The analysis of the running example (see figure 8), which is based on the first case study, resulted in the visualization of the 50% most important relations (see figure 10 for the implementation of this mechanism in the software tool). During the third interview of case study 2, this mechanism was also applied to visualize 50% of the most important valueStream relations in order to capture the essence of the business architecture heat map (see table 6). Even if an importance interval is specified, we allowed the end-user to visualize extra valueStream relations that are not part of the visual importance interval to complete a critical path in the business architecture. For the running example (figure 8), this principle is applied to complete the critical path analysis by the individual visualization of the valueStream relations between ‘Increase revenues’ and ‘Offering partnership support’ and between ‘Sales process’ and ‘Obtain customer references’.

The analysis during the third in-depth interview of case study 3 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 6). 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 the lower and upper bound percentages for the visual importance interval. Therefore, it was decided to enable the specification of absolute boundaries for this interval. For the third case, this resulted in the visualization of the valueStream relations that have an importance between 4 (i.e., the lower bound) and 9 (i.e., the upper bound). As case study 3 was the last in our sequence (see figure 1), this adaptation has yet to be tested in other contexts.

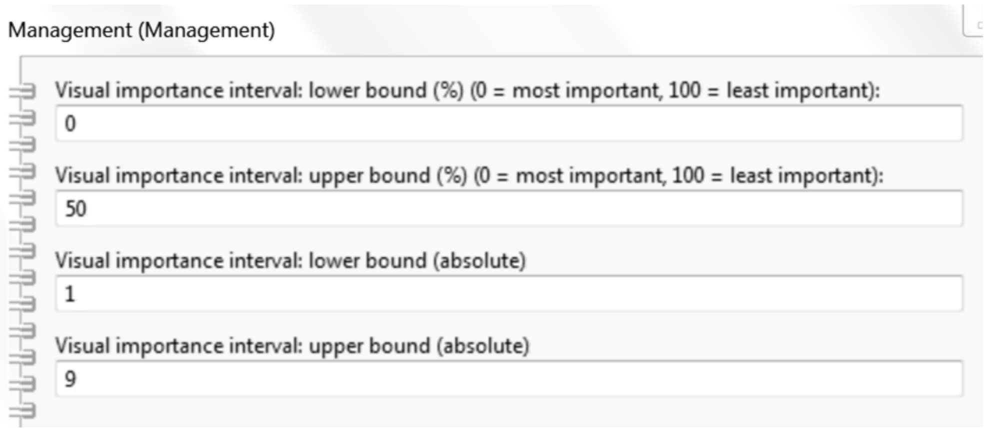


Figure 10: Mechanism to facilitate the strategic fit improvement analysis for the running example

3.2.2.3 Tool Support

(i) The creation of model instantiations

A first refinement to the PGA modeling language was the use of brightness as an extra variable to the visualization of the business architecture elements. This was done by a redesign of the original notation, which was inserted in the software tool by updating the GRAPHREP class attribute of the different elements. The second ADR adaptation entailed adding a direct valueStream relation between a FinancialGoal and a ValueProposition in the meta-model. This has been implemented by loosening the constraints that specify the allowed valueStream relations in the external coupling component of the ADOxx platform. A last refinement to the meta-model specification was needed to enable the end-user to visualize or hide valueStream relations in the model instantiations, which supports the strategic fit improvement analysis by creating simplified views on the model. In this respect, it was needed to add an extra data type (i.e., $\boldsymbol{Enum_{Make\ visible}}$), which is a pre-defined enumeration that can either be Yes or No (formula 7b). By linking this enumeration to a new attribute Make visible (formula 8b), it is possible to hide or visualize valueStream relations (formula 23) based on user-defined values.

$$\boldsymbol{D^T_{PGA}} = \{String, Float, \boldsymbol{Enum_{Make\ visible}}, \boldsymbol{Enum_{Measure\ type}}, \boldsymbol{Enum_{Importance}}\}$$

$$\boldsymbol{Enum_{Make\ visible}} = \{\, Yes, No\} \tag{7b}$$

$$\boldsymbol{A_{PGA}} = \{Name, Preference\ matrix, Consistency\ ratio, Measure\ type, Measure\ description, Performance\ goal, Allowed\ deviation\ (\%), Actual\ performance, Deviation\ from\ measure, valueStream_{from}, valueStream_{to}, Importance, Make\ visible, Element\ Xi, Element\ Xj, Compared\ importance\} \tag{8b}$$

$$domain(Make\ visible) = \{valueStream\}$$
$$range(Make\ visible) = \{\boldsymbol{Enum_{Make\ visible}}\},$$
$$card(valueStream, Make\ visible) = <1, 1> \tag{23}$$

(ii) Functionalities for the modeling and analysis procedure

External coupling is used to further incorporate the strategic fit improvement analysis into the software tool by explicitly showing those valueStream relations that are part of the relevant importance interval. In this case, the end-user can choose to define either absolute or relative boundaries for this visible interval (see screenshot in figure 10). Finally, the end-user is able to manually adapt the Make visible attribute in the PGA models.

3.3 End-User Evaluation

Table 7 gives an overview of the end-user evaluation scores for the PGA support of the drivers of strategic fit. All items were measured on a seven-point scale, ranging from strongly disagree to strongly agree. To facilitate the comparison between questions, this scale was inversed for negatively formulated questions (see asterisk in table 7 and in its legend). For the perceived usefulness and perceived ease of use, the average of the individual item scores is provided, as well as the detailed values for the individual items. Besides this quantitative evaluation, the strategy consultant also asked the users to provide qualitative feedback about the perceived strengths and weaknesses of the technique.

Table 7: End-user evaluation results

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

<u>Legend:</u>

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

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 and clarifies existing intuitive ideas about how elements are aligned (or misaligned) in the organizational context. 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. Furthermore, it is important to create a long-term engagement with the stakeholders in the organization to update the models over time. These issues have to be taken into account in the further application of the technique.

On average, users more than slightly agree with the usefulness of the PGA technique to support strategic decision-making. 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 overcome opposite interests and information asymmetry between stakeholders. This is useful 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. Moreover, it is 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.

3.4 Formalization of Learning

3.4.1 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 [64]. The understanding of the definitions of the model elements, which is supported by clarifying questions in the visual aid (figure 3), 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 [64]. The adaptation that improves the applicability of the FinancialStructure element (see section 3.2.2.1), shows that the modeling language needed extra flexibility in the proposed hierarchical structure of the business architecture.

3.4.2 Modeling and Analysis 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 and analysis procedure can be kept manageable. In this context (see section 3.2.2.2), the main refinements consist of building the business architecture layer per layer, the introduction of an upfront evaluation of the importance and subsequent selection of the valueStream relations before the actual AHP application, and facilitating the strategic fit improvement analysis by the specification of an importance interval to explicitly visualize valueStream relations in the model instantiations. Furthermore, the understanding of the reciprocal values in the AHP comparison scale (see table 3) was improved by first asking which of the elements is the most important in the pairwise comparison. Finally, it was analyzed how the modeling and analysis 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 consistency of the AHP application, and the use of qualitative measures in case quantitative indicators were not available during the case studies.

3.4.3 Validity criteria

Four different criteria are used to judge the quality of case study research: (i) construct validity, (ii) internal validity, (iii) external validity, and (iv) reliability [94]. The remainder of this paragraph discusses these criteria as applied to our research.

Construct validity is concerned with *establishing correct operational measures for the concepts being studied* [94]. This form of validity was mainly assured by using multiple sources of evidence during the different case study activities (see table 5). For the development of the prioritized business architecture hierarchy and the analysis of the strategic fit improvements, the direct observations of the strategy consultant were found to be useful as additional information to guide the in-depth interviews with the end-users. For the execution of the performance measurement, the available documentation and archival records within the company were insufficient to collect the relevant data. Therefore this evidence was further complemented by data that was collected by the strategy consultant in the form of participant observations. The end-user evaluation included a quantitative evaluation of the perceived usefulness and the perceived ease of use of the PGA technique, which was based on refined item scales of the TAM. The construct validity of these scales is demonstrated in the work of Moody [63]. Furthermore, this evaluation survey was combined with an in-depth interview with the end-users to obtain qualitative feedback about the perceived strengths and weaknesses of the PGA technique.

Internal validity is a main concern for causal studies as it is about *establishing causal relationships, whereby certain conditions lead to certain outcomes* [94]. The case studies that were performed have, however, an exploratory character as their main purpose is to investigate how the PGA technique can be designed to support strategic fit in a real-life organizational context. Consequently, internal validity is little relevant as no explicit causal statements are proposed in this research.

External validity is about generalizing the findings beyond a particular case study context [94]. The type of generalization we perform in the formalization of learning is analytic generalization, *in which a previously developed theoretical proposition is used as a template, with which to compare the empirical results of a case study* [94]. To assure external validity, the PGA technique was applied in three separate case studies. This allowed us to test whether the refined design of the PGA technique, which resulted from case studies 1 and 2, was relevant to realize strategic fit in the subsequent cases (i.e., literal replication [94]). However, it is important to also test the applicability of the proposed adaptations in case study 3 by performing follow-up case studies. As the end-user evaluations yield similar results across the different case studies (see table 7), the generalizability of the findings is further strengthened. However, the limited number of cases, all pertaining to the same organization, does not allow to statistically generalize the case study findings [94].

Finally, reliability is relevant to *demonstrate that the operations of a case study are documented to ensure that same findings can be obtained by other investigators* [94]. The reliability of the research was ensured in two different ways. As the ADR team consisted of six members (i.e., four in each case study, with the fourth member a different manager in the end-user role), a protocol ensured that there was a shared understanding about the project, the case study questions, and the field procedures that needed to be followed. Besides this, all sources of evidence (i.e., in the form of transcripts, notes, and the PGA models) were carefully saved in a case study database. A limitation to the replicability of our research is that this database is protected by a non-disclosure agreement between the ADR team and the involved company.

4 Related Work

In this section we compare the PGA technique to existing enterprise modeling techniques, which are applied in the context of realizing model-based alignment (section 4.1) and providing capability heat mapping techniques (section 4.2). The overview of this section partly builds on previous research [7], which reviewed efforts that align goal modeling languages and process modeling languages by adopting a top-down and/or bottom approach.

4.1 Model-based alignment techniques

As explained in the introduction (section 1), model-based alignment techniques approach the alignment of models for the different business architecture perspectives in a top-down (section 4.1.1), bottom-up (section 4.1.2), hybrid (section 4.1.3), or integrative (section 4.1.4) manner (i.e., driver #1). However, most alignment techniques do not incorporate a performance measurement mechanism to guide operational process outcomes towards the intended strategic objectives by setting both appropriate performance targets and monitoring the actual organizational performance (i.e., driver #2). Furthermore, these techniques (with the exception of [29, 30, 32, 43, 52, 87]) make use of models for specifying precise, complete, and business-aligned requirements for developing and implementing effective IT systems [57]. 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 [10, 31] (i.e., driver #3). A more detailed overview of the different drivers of strategic fit that are addressed by model-based alignment techniques is given below and is summarized at the end of this section in table 8.

4.1.1 Top-down Approaches

Gordijn et al. [36] developed transformation rules to realize a top-down alignment between the strategy and the infrastructure perspectives, which results in iterative cycles of goal modeling (with i*) and value modeling (with e3-value). Andersson et al. [4] use similar transformation rules to develop a top-down method, which enables the identification of 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. [21] provide a top-down method to align ArchiMate models (i.e., an Enterprise Architecture (EA) modeling language) with e^3-value models via the transaction modeling pattern of the DEMO methodology for Enterprise Engineering (i.e., the Design & Engineering Methodology for Organizations). Another top-down technique [3] allows to derive process models (i.e., UML activity diagrams) from e^3-value diagrams by making use of pre-defined patterns. Similar methods employ (an extended variant of) e^3-value as a starting point to align value models with BPMN process models by means of transformation rules [26, 91, 92]. Other researchers directly align goal models with process models (see review in [7]). Their efforts use of (a variant of) i* goal models and various kinds of process models, such as WS-BPEL [33, 54] and Role Activity Diagrams [11]. Although, all these approaches contribute to the realization of strategic fit by aligning models for the different business architecture perspectives in a top-down manner (i.e., driver #1), the other two drivers of strategic fit are not addressed.

Kudryavtsev et al. [52] deploy the Quality Function Deployment (QFD) methodology to realize a top-down alignment of the different perspectives in the business architecture (i.e., driver #1). To identify business architecture concepts that are meaningful for business stakeholders (i.e., driver #3), this technique consulted frameworks from the Strategic Management literature. Although QFD makes use of prioritization to capture the essence of the resulting models, Kudryavtsev et al. [52] do not take into account the actual organizational performance of business architecture elements (i.e., driver #2).

4.1.2 Bottom-up Approaches

Gordijn et al. [35] 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 [12], 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. [37] employs Script Modeling to develop business process models, from which i* goal models can be derived in a prescriptive and systematic way. In the context of realizing strategic fit, it can be concluded that the use of these techniques is restricted to the alignment of models for the different business architecture perspectives in a bottom-up manner (i.e., driver #1).

4.1.3 Hybrid Approaches

Zlatev and Wobacher [97] 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 [85] 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. The e^3-alignment framework [75] is proposed to realize inter-organizational business-IT alignment between the business architecture perspectives and information systems. 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. The alignment technique of Koliadis et al. [50] directly aligns goal models with process models. This technique employs construct mappings and transformation rules to convert Formal Tropos goal models (i.e., an extended variant of i*) into BPMN diagrams and vice versa. The advantage of these hybrid techniques is that they enable to align models for different business architecture perspectives in both a top-down and bottom-up manner (i.e., driver #1). Nevertheless, the use of a performance measurement system (i.e., driver #2) and the support of a clear communication to business stakeholders (i.e., driver #3) is not addressed.

Guizzardi and Nunes Reis [39] also make use of Tropos and BPMN to design a model-based alignment method, which includes an analysis of how activities (i.e., top-down) or goals (i.e., bottom-up) could be better aligned within the organization. Furthermore, this method defines impact and satisfaction values to investigate the degree to which process performance contributes to the accomplishment of goals. In this way, the proposed method both realizes the top-down and bottom-up model alignment of business architecture perspectives (i.e., driver #1) and introduces the use of a performance measurement system to guide process outcomes towards the intended strategic objectives (i.e., driver #2).

4.1.4 Integrative Approaches

The Business Intelligence Model (BIM) [43] 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 provides insights into how operations can be aligned with the strategic objectives of an organization (i.e., driver #1). 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 (i.e., driver #2). Since the early version of this technique did not cover the infrastructure perspective, this was addressed by the Tactical Business Intelligence Model (TBIM) [29], which augments the BIM modeling language with some concepts of the Business Model Ontology [73]. This ontology clarifies business models by providing a shared terminology for the concept. By using this terminology, TBIM enables a better understanding and communication of the infrastructure perspective by business stakeholders (i.e., driver #3).

The Multi-perspective Enterprise Modeling (MEMO) approach was originally developed to support the design of business information systems by integrating this design with the operational strategy and business process organization [30]. To this end, the methodology enables the development of a consistent set of enterprise models, which comprises a strategic, organizational, and information system view. As such, the approach supports the integrative alignment of the strategy, infrastructure, and process perspectives within the business architecture (i.e., driver #1). Moreover, as it is built upon the Value Chain concept of Porter [77], which originates in the Strategic Management literature, the methodology helps to improve the communication between the involved business stakeholders [30] (i.e., driver #3). However, the original approach only allows to set performance measure benchmarks for a certain business architecture element (e.g., an activity), but neglects the actual performance of that element within the organization (i.e., driver #2).

The use of different enterprise perspectives has evolved during the development of the MEMO approach. In its current form [32], this approach supports the design of modeling techniques that are explicitly oriented towards the background of prospective business users. This is implemented by the development of domain-specific modeling techniques, which are relevant in the domain of discourse of a particular enterprise. In this way, the MEMO approach potentially results in the development of a DSML accompanied by a modeling procedure, which is specifically tailored to support a clear communication to business stakeholders (i.e., driver #3). Although the domain specificity of a DSML does not necessarily restrain a possible application of these languages in other organizations [32], unrealized strategic fit is a generic problem within the business architecture of any company. This requires another approach than the creation of a DSML that is driven by the requirements of a specific organizational context.

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, information systems, and information technology infrastructure [53]. To deal with the increasing size and complexity of the EA process, Zachman [96] 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 realization of strategic fit contributes to a better aligned conceptual enterprise system 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 enterprise architecture development process [86]. The ADM is accompanied by guidelines and techniques to facilitate its application in practice. Moreover, it is fully aligned with ArchiMate, a graphical EA modeling language that integrates concepts of the business, application, and technology architectural layers to construct visual representations of the enterprise architecture [87]. As such, this modeling language provides graphical models that can be employed to align the different business architecture perspectives in an integrative manner (i.e., driver #1). Although ArchiMate also ensures the understanding of modeling concepts by the development of viewpoints that are tailored to specific stakeholders (i.e., driver #3), it does not support the use of performance measurement (i.e., driver #2).

4.2 Capability Heat Mapping techniques

Capability heat mapping techniques [40, 62] combine the use of performance measurement (i.e., driver #2) with a prioritization mechanism to assess the organizational performance and strategic value of capabilities. In this context, capabilities are defined as the ability to perform a particular skillset, which is a function, process or service [55]. 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 [48]. Although a capability heat map is not oriented towards aligning the strategy, infrastructure and process perspectives of business architecture (i.e., driver #1), it provides an intuitive visualization that can easily be understood by business stakeholders (driver #3).

Table 8: Application context of the related work

Category	Reference (Driver of strategic fit →)	#1 Alignment of business architecture perspectives: Top-down	#1 Alignment of business architecture perspectives: Bottom-up	#2 Use of a performance measurement system	#3 Understanding by and communication to business stakeholders: Concepts	#3 Understanding by and communication to business stakeholders: Visualization
4.1 Model-based alignment techniques	Andersson et al. [3] Andersson et al. [4] Bleistein et al. [11] de Kinderen et al. [21] Edirisurija and Johannesson [26] Frankova et al. [33] Gordijn et al. [36] Lapouchnian et al. [54] Weigand et al. [91] Weigand et al. [92]	x				
	Kudryavtsev et al. [52]	x			x	
	Buder and Felden [12] Gordijn et al. [35] Grau et al. [37]		x			
	Koliadis et al. [50] Pijpers et al. [75] Solaimani and Bouwman [85] Zlatev and Wobacher [97]	x	x			
	Guizzardi and Nunes Reis [39]	x	x	x		
	Francesconi et al. [29] Horkoff et al. [43]	x	x	x	x	
	Frank [30]	x	x		x	
	Frank [32]				x	x
	The Open Group [86] The Open Group [87] Zachman [96]	x	x		x	
4.2 Capability heat mapping techniques	Microsoft [62] Hafeez et al. [40]			x		x

It can be concluded from table 8 that none of the above techniques fully supports all three drivers of strategic fit. However, the BIM approach is best suited to address this issue as it provides insights into how operations can be aligned with the strategic objectives of an organization (i.e., driver #1) and makes use of performance measures for the evaluation of alternative design options (i.e., driver #2). Furthermore, it is extended with elements from the Business Model Ontology to provide concepts that are familiar to business stakeholders (i.e., concepts column of driver #3). Nevertheless, it lacks a prioritization mechanism and a consistent use of performance measurement (i.e., performance indicators only measure process outcomes), which prevents the development of an intuitive visualization that provides insights into the strategic value and the actual performance of business architecture elements (i.e., visualization column of driver #3). This flaw can be solved by applying the prioritization and performance measurement mechanisms of capability heat mapping techniques, which are visualized by using appropriate color coding in heat maps. Furthermore, the prioritization mechanism can be used to reduce the size of model instantiations. In other words, these techniques contribute to the realization of strategic fit by providing an intuitive visualization that can be easily understood by and communicated to business stakeholders (i.e., visualization column of driver #3). This resulted in the development of the PGA modeling technique, which makes use of a unique combination of mechanisms to address the different drivers of strategic fit: an integrative modeling language (i.e., addressing driver #1), a performance measurement system (i.e., addressing driver #2), Strategic Management frameworks (i.e., addressing the concepts column of driver #3), and a heat mapping mechanism (i.e., addressing the visualization column of driver #3).

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 uses an integrative enterprise modeling approach to describe hierarchies of business architecture elements covering different perspectives (strategic, infrastructural, operational) and presents these hierarchies in heat maps that indicate the critical paths of valueStream relations between elements at different hierarchical levels, which then allows identifying opportunities for strategic fit improvement. The ADR methodology was used to build and evaluate the technique in a real-life organizational context. Refinements of the technique were based on reflection and learning during iterative cycles, which consisted of building or further adapting the technique, applying and testing it in three consecutive case studies in the organization, and evaluating the case study results. The adaptations of the initial version of PGA were mainly 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 performance measurement component of the technique. The end-users also seem to agree with the usefulness of the technique and its perceived ease of use. In the future, follow-up case studies will be performed to further show the relevance of the proposed PGA adaptations.

As case studies do not allow to obtain a statistical generalization of the findings [94], a controlled experiment with practitioners could be considered. Given a sufficient number of participants, such an experiment will allow to statistically evaluate the degree to which the different elements of the PGA technique contribute to the three drivers of realizing strategic fit. More specifically, the impact of the following mechanisms could be tested: the use of the business model as an intermediate business architecture perspective in between strategy and processes, the prioritization mechanism for better focusing on the most promising initiative(s) for realizing strategic fit, the performance measurement mechanism for better analyzing strategic fit, and the use of the business architecture heat mapping technique to visualize the results of the modeling, prioritization and performance measurement. This design could be operationalized by giving each participant a specific variant of the method, which is characterized by a specific combination of mechanisms, to interpret the same problem situation and to propose a solution for this problem. For example, the impact of the performance measurement mechanism could be tested by comparing the complete PGA technique to a partial variant that employs the business model, the prioritization, and the heat mapping mechanisms. Alternatively, the complete PGA technique can be compared against the use of a combination of existing model-based alignment and heat mapping techniques that, taken together, also address all drivers of strategic fit. This way we can test the working hypothesis underlying our research question, which assumes that an integrated approach performs better than a combination of different approaches.

As PGA has just passed its early development phase, a limitation of this paper includes its mere focus on the isolated application of the technique. However, this does not mean that we present it as a 'one size fits all' solution, which could replace all techniques that are currently used within an organization. Therefore, future case study research will need to examine whether extra benefits can be realized by applying the PGA modeling in conjunction with existing techniques such as business analytics systems (i.e., to gather the relevant performance measurement data), business process improvement programs (e.g., Lean thinking [93], Six Sigma [41]), etc. This will enable to analyze how the use of the PGA technique could supplement current management practices, which will enable a stronger positioning within the organization.

The insights of the proposed technique can also provide input for approaches that enable a more formal evaluation of alternative designs (e.g., the BIM modeling language in section 4.1.4). As these approaches developed 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.

Another challenge for the PGA technique is ensuring consistency between the business architecture elements and the performance indicators that are used to measure them, as this can be an important threat for the validity of the resulting insights. Possible improvements can be based on the work of Popova and Sharpanskykh [76] as they developed a methodology to formulate consistent performance indicators in the context of strategic goals. Furthermore, it should be investigated whether the development of predefined libraries can provide recommendations for the formulation of appropriate performance indicators. These functionalities will impose extra requirements on the supporting software tool. Therefore, it also needs to be examined whether the ADOxx meta-modeling platform is able to implement these extensions or whether other alternatives (e.g., EMF [25] or GMF [24]) are more suitable for this purpose.

The timing of the activities in the modeling and analysis 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. These opportunities for future research will be investigated by the further application of the PGA technique in organizations.

Acknowledgements

The authors would like to thank the managers of the company for their collaboration during the case studies.

References

1. Al-Debei M and Avison D (2010) Developing a Unified Framework of the Business Model Concept. European Journal of Information Systems 19, 359-76.
2. Allee V (2008) Value Network Analysis and Value Conversion of Tangible and Intangible Assets. Journal of Intellectual Capital 9(1), 5-24.
3. Andersson B, Bergholtz M, Grégoire B, Johannesson P, Schmitt M, and Zdravkovic J (2006) From Business to Process Models – a Chaining Methodology. In BUSITAL '06. Pigneur Y and Woo C (eds.), CEUR-WS, vol.237, pp. 211-8.
4. Andersson B, Johannesson P, and Zdravkovic J (2009) Aligning Goals and Services through Goal and Business Modelling. Information Systems and e-Business Management 7(2), 143-69.
5. Andolson A (2007) Does Your RIM Program Need a Strategic Alignment. Information Management Journal 41(4), 35-40.
6. Andrews K (1980) The Concept of Corporate Strategy. 2nd Edition. Irwin, Homewood, IL.
7. Anonymous (2013) Research Review: Investigating Goal-oriented Requirements Engineering for Business Processes. Journal of Database Management 24(2), 35-71.
8. Anonymous (2013) Towards an Integrative Component Framework for Business Models: Identifying the Common Elements Between the Current Business Model Views. In CAiSE'13 Forum. Deneckère R and Proper H (eds.), CEUR-WS, vol. 998, pp. 114-21, Valencia, Spain.
9. Anonymous (2014) The Creation of Business Architecture Heat Maps to Support Strategy-aligned Organizational Decisions. In ECIME '14. Devos J and De Haes S (eds.), Proceedings of the European Conference on Information Management and Evaluation, pp. 388-92, Acad. Conferences Ltd.
10. Balabko P and Wegmann A (2006) Systemic Classification of Concern-based Design Methods in the Context of Enterprise Architecture. Information System Frontiers 8(2), 115-31.
11. Bleistein S, Cox K, Verner J, and Phalp K (2006) B-SCP: A Requirements Analysis Framework for Validating Strategic Alignment of Organizational IT based on Strategy, Context, and Process. Information and Software Technology 48(9), 846-68.
12. Buder J and Felden C (2012) Towards a Reference Model of Business Model & Business Process Management Alignment. In VMBO '12. Vienna, Austria.
13. Burton B and Allega P (2011) Enterprise Architects: Know Thy Business Strategy. Gartner Insight, Technical Report
14. Chan KW and Mauborgne R (2005) Blue Ocean Strategy: How to Create Uncontested Market Space and Make the Competition Irrelevant Harvard Business Press, Boston, MA.

15. Chesbrough H (2003) Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business School Press, Boston, MA.
16. Chesbrough H (2010) Business Model Innovation: Opportunities and Barriers. Long Range Planning 43, 354-63.
17. Clark T, Matthes F, Barn B, and Brown A (2014) Guest Editorial to the Theme Section on Enterprise Modelling. Software & Systems Modeling 13(3), 909-12.
18. Dardenne A, Van Lamsweerde A, and Fickas S (1993) Goal-directed Requirements Acquisition. Science of computer programming 20(1-2), 3-50.
19. Davis F (1989) Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. MIS Quarterly 13(3), 319-40.
20. De Bruin T and Rosemann M (2006) Towards Understanding Strategic Alignment of Business Process Management. In ACIS '06. Spencer S and Jenkins A (eds.), Adelaide, Australia.
21. de Kinderen S, Gaaloul K, and Proper H (2014) Bridging Value Modelling to ArchiMate via Transaction Modelling. Software & Systems Modeling 13(3), 1043-57.
22. Demil B and Lecocq X (2010) Business Model Evolution: In Search of Dynamic Consistency. Long Range Planning 43, 227-46.
23. Dumas M, La Rosa M, Mendling J, and Reijers H (2013) Fundamentals of Business Process Management. Springer, Heidelberg.
24. Eclipse. (2015). Eclipse Graphical Modeling Framework (GMF), from http://www.eclipse.org/modeling/gmp/.
25. Eclipse. (2015). Eclipse Modeling Framework (EMF), from https://eclipse.org/modeling/emf/.
26. Edirisurija A and Johannesson P (2009) On the Alignment of Business Models and Process Models. In BPM '08 Workshops. Ardagna D, et al. (eds.), LNBIP, vol. 17, pp. 68-79, Springer, Heidelberg.
27. Fill H and Karagiannis D (2013) On the Conceptualisation of Modelling Methods Using the ADOxx Meta Modelling Platform. Enterprise Modelling and Information Systems Architectures 1(8), 4-25.
28. Fill H, Redmond T, and Karagiannis D (2013) Formalizing Meta Models with FDMM: The ADOxx Case. In ICEIS '12. Cordeiro J, et al. (eds.), LNBIP, vol. 141, pp. 429-51, Springer, Heidelberg.
29. Francesconi, F., Dalpiaz F, and Mylopoulos J (2013) TBIM: A Language for Modeling and Reasoning about Business Plans. In ER '13 Ng W, et al. (eds.), LNCS, vol. 8217, pp. 33-46, Springer, Heidelberg.
30. Frank U (1994) MEMO: A Tool Supported Methodology for Analyzing and (Re-) Designing Business Information Systems. In TOOLS '94. Ege R, et al. (eds.), 367-80, Englewood Cliffs, NJ.
31. Frank U (1998) Evaluating Modelling Languages: Relevant Issues, Epistemological Challenges and a Preliminary Research Framework In Technical Report 15, Arbetsberichte des Instituts fuer Wirtshaftsinformatik. Universität Koblenz-Landau.
32. Frank U (2014) Multi-perspective Enterprise Modeling: Foundational Concepts, Prospects, and Future Research Challenges. Software & Systems Modeling 13(3), 941-62.
33. Frankova G, Massacci F, and Seguran M (2007) From Early Requirements Analysis towards Secure Workflows. In Trust Management. Etalle S and Marsh S (eds.), IFIP, vol. 238, pp. 407-10, Springer, US.
34. Gordijn J and Akkermans H (2003) Value-based Requirements Engineering: Exploring Innovative e-Commerce Ideas. Requirements Engineering 8(2), 114-34.
35. Gordijn J, Petit M, and Wieringa R (2006) Understanding Business Strategies of Networked Value Constellations Using Goal- and Value Modeling. In RE'06. Minneapolis/st Paul, Minnesota.
36. Gordijn J, Yu E, and van der Raadt B (2006) E-service Design Using i* and e3value Modeling. IEEE Software 23(3), 26-33.
37. Grau G, Franch X, and Maiden N (2008) PRiM: An i*-based Process Reengineering Method for Information Systems Specification. Information and Software Technology 50(1-2), 76-100.
38. Gregor S (2006) The Nature of Theory in Information Systems. MIS Quarterly 30(3), 611-42.
39. Guizzardi R and Nunes Reis A (2015) A Method to Align Goals and Business Processes. In ER '15. Johannesson P, et al. (eds.), LNCS, vol. 9381, pp. 79-93, Springer, Switzerland.
40. Hafeez K, Zhang Y, and Malak N (2002) Determining Key Capabilities of a Firm Using Analytic Hierarchy Process. International Journal of Production Economics 76(1), 39-51.
41. Harry M (1998) Six Sigma: a Breakthrough Strategy for Profitability. Quality Progress 31(5), 60-4.
42. Henderson J and Venkatraman N (1999) Strategic Alignment: Leveraging Information Technology for Transforming Organizations. IBM Systems Journal 38(2-3), 472-84.
43. Horkoff J, Barone D, Jiang L, Yu E, Amyot D, Borgida A et al. (2014) Strategic Business Modeling: Representation and Reasoning. Software & Systems Modeling 13(3), 1015-41.
44. Kaplan R and Norton D (1992) The Balanced Scorecard - Measures that Drive Performance. Harvard Business Review Jan-Feb, 71-9.
45. Kaplan R and Norton D (2004) Strategy Maps: Converting Intangible Assets into Tangible Outcomes. Harvard Business School Publishing, Cambridge.
46. Karagiannis D and Kühn H (2002) Metamodelling Platforms. In EC-Web '02 – Dexa '02. Bauknecht K, et al. (eds.), LNCS, vol. 2455, pp. 182-95, Springer, Heidelberg.
47. Kavakli E and Loucopoulos P (2005) Goal Modeling in Requirements Engineering: Analysis and Critique of Current Methods. In Information Modeling Methods and Methodologies: Advanced Topics of Database Research. Krogstie J, et al. (eds.), pp. 102-24. IGI Publishing, London.
48. Keller W (2009) Using Capabilities in Enterprise Architecture Management. Object Architects.
49. Ko R, Lee S, and Lee E (2009) Business Process Management (BPM) Standards: a Survey. Business Process Management Journal 15(5), 744-91.

50. Koliadis G, Vranesevic A, Bhuiyan M, Krishna A, and Ghose A (2006) Combining i* and BPMN for Business Process Model Lifecycle Management. In BPM '06 Workshops. Eder J and Dustdar S (eds.), LNCS, vol. 4103, pp. 416-27, Springer, Heidelberg.
51. Kolovos D, Rose L, Paige R, and Polack F (2009) Raising the Level of Abstraction in the Development of GMF-based Graphical Model Editors. In MiSE '09. IEEE, Vancouver, Canada.
52. Kudryavtsev D, Grigoriev L, and Koryshev I (2014) Applying Quality Function Deployment Method for Business Architecture Alignment. In ECIME '14. Devos J and De Haes S (eds.), Gent, Belgium.
53. Lankhorst M (2013) Enterprise Architecture at Work: Modelling, Communication and Analysis. Springer, New York.
54. Lapouchnian A, Yu Y, and Mylopoulos J (2007) Requirements-driven Design and Configuration Management of Business Processes. In BPM '06. Alonso G, et al. (eds.), LNCS, vol. 4714, pp. 246-61, Springer, Heidelberg.
55. LEADing Practice. (2015). The LEADing Practice Meta Object Taxonomy. <http://www.leadingpractice.com/wp-content/uploads/Enterprise-Modelling-Reference-Content-Meta-Object-Taxonomy.pdf>.
56. Lee Y, Kozar K, and Larsen K (2003) The Technology Acceptance Model: Past, Present, and Future. Communications of the Association for Information Systems 12, Article 50, 752-80.
57. Li F, Horkoff J, Borgida A, Guizzardi G, Liu L, and Mylopoulos J (2015) From Stakeholder Requirements to Formal Specifications through Refinement. In REFSQ '15. Essen, Germany, to appear.
58. List B and Korherr B (2006) An Evaluation of Conceptual Business Process Modelling Languages. In Proceedings of the 2006 ACM symposium on Applied computing. Dijon, France.
59. Lüftenegger E (2014) Service-Dominant Business Design. BOXPress.
60. Maes R (2007) An Integrative Perspective on Information Management. In Information Management: Setting the Scene. Huizing A and De Vries E (eds.), Perspectives on Information Management,vol. 1, pp. 11-28. Elsevier Science, Oxford.
61. McCarthy W (1982) The REA Accounting Model: A Generalized Framework for Accounting Systems in a Shared Data Environment. Accounting Review 57, 554-78.
62. Microsoft (2006) Microsoft Motion: Heat Mapping Tool. Microsoft Services <blogs.microsoft.co.il/files/folders/2034/download.aspx>.
63. Moody D (2003) The Method Evaluation Model: a Theoretical Model for Validating Information Systems Design Methods. In ECIS '03. Naples, Italy.
64. Moody D (2009) The "Physics" of Notations: Toward a Scientific Basis for Constructing Visual Notations in Software Engineering. IEEE Transactions on Software Engineering 35(6), 756-79.
65. Morrison E, Ghose A, Dam H, Hinge K, and Hoesch-Klohe K (2012) Strategic Alignment of Business Processes. In ICSOC '11. Pallis G, et al. (eds.), LNCS, vol. 7221, pp. 9-21, Springer, Heidelberg.
66. OASIS (2007) Business Process Execution Language specification. Version 2.0 <http://docs.oasis-open.org/wsbpel/2.0/OS/wsbpel-v2.0-OS.html>.
67. OMG (2004) UML 2.0 Infrastructure (ptc/2004-10-14).
68. OMG (2010) Business Process Model and Notation (BPMN) (version 2.0).
69. OMG (2012) Business Architecture Body of Knowledge Handbook 2.0.
70. OMG (2014) Business Motivation Model (BMM) (version 1.2).
71. OMG (2014) Value Delivery Modeling Language (VDML) (dtc/2014-04-05).
72. OMG (2015) Meta Object Facility (MOF) (Version 2.5).
73. Osterwalder A (2004) The Business Model Ontology: a Proposition in a Design Science Approach [Thesis]. l'Université de Lausanne, Lausanne.
74. Ould M (1995) Business Processes: Modelling and Analysis for Re-Engineering and Improvement. Wiley, Chichester, New York.
75. Pijpers V, de Leenheer P, Gordijn J, and Akkermans H (2012) Using Conceptual Models to Explore Business-ICT Alignment in Networked Value Constellations. Requirements Engineering 17(3), 203-26.
76. Popova V and Sharpanskykh A (2011) Formal Modelling of Organisational Goals Based on Performance Indicators. Data & Knowledge Engineering 70(4), 335-64.
77. Porter M (1985) Competitive Advantage: Creating and Sustaining Superior Performance. The Free Press, New York.
78. Prahalad C and Hamel G (1990) The Core Competency of the Corporation. Harvard Business Review 68(3), 79-91.
79. Saaty T (1990) How to Make a Decision: The Analytic Hierarchy Process. European Journal of Operational Research 48(1), 9-26.
80. Saaty T (2008) Decision Making with the Analytic Hierarchy Process. International Journal of Service Sciences 1(1), 83-98.
81. Sanchez R (1996) Strategic Product Creation: Managing New Interactions of Technology, Markets, and Organizations. European Management Journal 14(2), 121-38.
82. Schieman W (2009) Aligning Performance Measurement with Organizational Strategy, Values, and Goals. In Performance Measurement: Putting Research into Action. Smither J and London M (eds.), pp. 45-88. Wiley & Sons, Inc., San Francisco.
83. Sein M, Henfridsson O, Purao S, Rossi M, and Lindgren R (2011) Action Design Research. MIS Quarterly 35(1), 37-56.
84. Shafer S, Smith J, and Linder J (2005) The Power of Business Models. Business Horizons 48, 199-207.

85. Solaimani S and Bouwman H (2012) A Framework for the Alignment of Business Model and Business Processes: a Generic Model for Trans-sector Innovation. Business Process Management Journal 18(4), 655-79.
86. The Open Group (2011) TOGAF (version 9.1).
87. The Open Group (2013) ArchiMate® 2.1 Specification.
88. Tikkanen H, Lamberg J, Parvinen P, and Kallunki J (2005) Managerial Cognition, Action and the Business Model of the Firm. Management Decision 43(6), 789-809.
89. Venkatesh V, Morris M, Davis G, and Davis F (2003) User Acceptance of Information Technology: Toward a Unified View. MIS Quarterly 27(3), 425-78.
90. Verweire K (2014) Strategy Implementation. Routledge.
91. Weigand H, Johannesson P, Andersson B, Bergholtz M, Edirisuriya A, and Ilayperuma T (2006) On the Notion of Value Object. In CAiSE '06. Dubois E and Pohl K (eds.), LNCS, vol. 4001, pp. 321-35, Springer, Heidelberg.
92. Weigand H, Johannesson P, Andersson B, Bergholtz M, Edirisuriya A, and Ilayperuma T (2007) Value Object Analysis and the Transformation from Value Model to Process Model. In I-ESA'06. Doumeingts G, et al. (eds.), Bordeaux, France.
93. Womack J and Jones D (2010) Lean Thinking: Banish Waste and Create Wealth in Your Corporation. Simon and Schuster, New York.
94. Yin R (2009) Case Study Research: Design and Methods. Sage publications Inc., London.
95. Yu E, Giorgini P, Maiden N, and Mylopoulos J (2011) Social Modeling for Requirements Engineering., MIT Press, Boston.
96. Zachman J (1987) A Framework for Information Systems Architecture. IBM Systems Journal 26(3), 276-92.
97. Zlatev Z and Wobacher A (2005) Consistency Between e3value Models and Activity Diagrams in a Multi-perspective Development Method. In CoopIS, DOA, and ODBASE '05. Meersman R and Tari Z (eds.), LNCS, vol. 3760, pp. 520-38, Springer, Heidelberg.