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THEME SECTION PAPER

From enterprise architecture to business models and back

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Abstract In this study, we argue that important IT change processes affecting an organization's enterprise architecture are also mirrored by a change in the organization's business model. An analysis of the business model may establish whether the architecture change has value for the business. Therefore, in order to facilitate such analyses, we propose an approach to relate enterprise models specified in ArchiMate to business models, modeled using Osterwalder's Business Model Canvas. Our approach is accompanied by a method that supports business model-driven migration from a baseline architecture to a target architecture and is demonstrated by means of a case study.

Keywords Business modeling · Enterprise architecture · Business Model Canvas · ArchiMate · Business Model Ontology · Cost/revenue analysis

1 Introduction

Many expensive IT innovation projects suffer from the fact that the technical solutions they propose never materialize. Considerable research and investments go into specification and development of yet another information system or prototype proving a novel concept that, eventually, fails to be absorbed into real life settings. We argue that such projects fail because they are merely the result of yet another technology push and are initiated without a proper analysis of the problem in its enterprise context. Changes in systems often do not consider the financial impacts. Usually, questions such as "who benefits from the product?", and "who will pay for it?" are not included in the design of new system. Yet, they may have a huge impact on the system requirements. Especially when the answers to the above questions may concern multiple stakeholders, the chance that the product is adopted and implemented is severely limited. In order to avoid such situations, any architecture change (i.e., any new IT project) should be first judged from the perspective of its business fitness. Therefore, we advocate that first a business model should be explicitly built and analyzed before any implementation decision is made about the (new) architecture design. To make this possible, a technique is necessary for relating enterprise architectures to business models. Of course, the statement above rests on the assumption that such an enterprise architecture does exist. Indeed, since IT innovation projects are often triggered by (consortia of) well-established organizations, they rarely occur in a green field situation (the latter is probably only the case for start-ups). Therefore, the main goal and contribution of this paper are to explore the relationships between two modeling formalisms used to specify enterprise architectures and business models, respectively: The Open Group's enterprise architecture modeling standard, ArchiMate [19] and Osterwalder's Business Model Canvas (BMC) [33,34]. The first one is the modeling language and open standard for the specification of enterprise architectures (going from business to technology infrastructure) and of their motivation. The second one is

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nowadays probably the most popular business model specification framework. The choice for these specific modeling approaches is justified by their representativeness and wide acceptance in the academic and practitioner communities in their respective application domains. A discussion of their limitations and their comparison with similar approaches will follow in the following section.

Before going into further technical details about how to relate enterprise architecture (EA) to business models (BM), we first explain what motivated us to tackle this problem and why we consider that a solution to it would be beneficial. Many organizations undergo expensive architectural changes without having a clear idea of how efficient and effective their investments in these changes are. Moreover, many enterprise architects have difficulties in demonstrating and quantifying the value of architecture changes for the business. We argue that this could be accomplished if an approach would exist to relate EAs and BMs. With such an approach, it becomes possible to assess, at strategic level, the global balance between costs involved in the architecture change and the benefits one may expect from it. Hence, the architecture change could be mirrored by a business model change, and thus, the impact of architecture change for the business becomes explicit.

In the enterprise architecture field, several methods exist to assess the gap between an enterprise architecture's current situation and some desired situation in design terms (see for e.g., [39]). Although research has been done concerning the development of EA model-based cost analysis techniques (e.g., [24]), these enterprise approaches do not aim to assess what such a gap means in terms of costs and revenues at a business strategy level. In order to accomplish this, one should be able to relate the results of EA-based cost analyses to business model-based costs/revenues analyses. Hence, business models must be elicited from an organization's current and future architectures. These business models can take the results of architecture-based cost analysis calculations as quantitative input. This input already incorporates detailed fixed and variable cost components, propagating throughout the architecture layers, from the bottom (e.g., infrastructure costs) up to the top (e.g., business process costs). Thus, business model frameworks, such as the BMC, can produce a more accurate and realistic cost/revenue analysis of the target architecture, which can be used to motivate implementation decisions concerning new innovation projects, and to consolidate the business requirements for such architecture change projects. At this stage, business requirements are critical because they are refined into design and technical requirements driving, and constraining the architecture change.

The need for this refinement step has been also recognized by Tom Graves, who wrote (in a rather informal, yet expressive fashion) [16]: *"And who would want to go from BMC to ArchiMate, anyway? […] People like building business models. It's wonderfully abstract, and it's fun—like playing with model-trains, where the passengers are only imaginary and the trains really can run on time. Unfortunately (or fortunately?) the real world is a bit different from that… Real-world detail can break the best-looking business-model without even breaking out a sweat. We need to know that detail—or at least have a better sense of that detail—before committing ourselves and others to a lot of hard work and ultimate heartache."*

He pinpoints that crafting an instance of the BMC is not enough. Before attempting to design a business model, more details have to be filled in. However, in our view, many of these details can be found in the enterprise architecture and must be "translated" into BMC terms. This can only be realized if (a) we can relate architecture and business models at the modeling language level and (b) if we have a method to guide the migration from a current situation to a desired situation in which the architecture change is motivated by a new or improved business model. Summarizing the above arguments, we conclude with the formulation of our research goals:

1. To relate enterprise architecture to business models through their modeling formalisms.
2. To explore the chaining of architecture-based cost analysis and business model-based revenue analysis techniques such that a realistic cost/benefit analysis can be made.
3. To develop a method for migrating from an as-is to a to-be architecture, resting on the relationship between enterprise architecture models and business models in which business requirements and business fitness (embedded into a business model) justify the migration process.

The remainder of the article is organized as follows. Section 2 covers some background information on ArchiMate and BMC. Then, in Sect. 2.3, we present the proposed approach for relating the two modeling formalisms. We compare the (definitions of) concepts and relationships as defined by the ArchiMate meta-model to the concepts and relationships defined by the BMC. Furthermore, in Sect. 4, we explain how architecture-based cost analysis can be used to provide the necessary quantitative input for the BM-based cost/revenue analysis. This is followed (Sect. 5) by the presentation of the migration method that is positioned with respect to TOGAF [39]. To demonstrate both the method and how we relate enterprise architecture and business models, in Sect. 6, we consider (and elaborate) a new scenario for an example often used in the enterprise architecture domain, the ArchiSurance case. We conclude the article with a discussion of the related work (Sect. 7), a summary of our contribution and with some pointers to future work (Sect. 8).

2 Background

As we aim to explore the relationships between ArchiMate and Osterwalder's BMC, we first motivate our choice for these two formalisms and then introduce their concepts and their underlying meta-models separately.

2.1 Why ArchiMate and BMO?

As we said in the Introduction (Sect. 1), one of the most important arguments to choose for these two modeling approaches is that each of them is leading in their own area. In this section, we will take a closer look at each of them and position them with respect to existing alternatives.

Many frameworks, reference architectures and methodologies are relevant for the field of enterprise architecture (see [19,39] for an overview). However, in the last decade, in the scientific community, two schools of thought have been recognized as dominating EA modeling:

- the ArchiMate language and framework [23], which has become for EA design what UML is for software design with its own international open standard ([19]; a detailed description of ArchiMate is provided in Sect. 2.2), and
- the Design and Engineering Methodology for Organizations (DEMO), which is a predominantly academic approach that emerged in the nineties as a methodology for describing business processes and evolved into an enterprise engineering ontology and method, which includes several types of models for the description of organizations. DEMO takes a language–action perspective and looks at organizations at an ontological, an infological and a datalogical level. Central to DEMO is the basic pattern of a business transaction. DEMO further distinguishes the construction, process, state, and action aspects [7]. Results have been reported with respect to the usage of DEMO for organizational composition and decomposition modeling [32].

More recently, the TOGAF standard proposed the Content Framework, which emerged in the consultancy world, and which categorizes architecture artifacts according to the TOGAF development phases [39]. The Content Framework constitutes a kind of conceptual map of the EA domain, but lacks both a formal meta-model and a graphical notation. Therefore, it cannot be considered a modeling language.

ArchiMate and DEMO are hardly comparable as concluded by [9], which attempted to do that. However, besides expressive power, an important advantage of ArchiMate over DEMO is its rapid acceptance in the industrial community as well. This motivates our choice for ArchiMate.

Many business model frameworks exist that aim at facilitating and guiding business modeling, e.g., *Activity system* by Zott and Amit [45], *e3-value* by Gordijn [13], *RCOV* by Demil and Lecocq [6], *The BM concept* by Hedman and Kalling [17], *Entrepreneur's BM* by Morris et al. [31], *The social BM* by Yunus et al. [44], *The BM guide* by Kim and Mauborgne [26], 4*C* by Wirtz et al. [43], *Internet BM* by Lumpkin and Dess [29], and *BMO* by Osterwalder [33]. Some of them have a strong link to information systems, others are closely related to strategic management or industrial organization. Most of the business model frameworks mentioned above have been published in the top 25 MIS journals. However, a systematic literature review we carried out recently resulted in an initial set of 171 journal articles and conference papers relevant for the topic of business modeling. After filtering this set of publications, we ended up with 76 articles presenting some 43 different business model frameworks. Furthermore, five articles in the reviewed literature present a review of business model literature and aim to compare some existing frameworks: Pateli and Giaglis [36], Gordijn et al. [35], Lambert [27], Al-Debei and Avison [1], Zott and Avison [46]. A common trait of most of these frameworks is that they lack the level of formality, which is necessary to relate a business model to its supporting enterprise architecture at the model level. However, of the reviewed frameworks, two stand out as having, from the modeling point of view, a sufficient formal foundation: e3-value [13] and BMO [33]. An extensive comparison of these two formalisms is presented in [15]. There are quite some differences between the two approaches. In terms of the scope covered, BMC is focused on a single element of a value chain and its direct relations with customers and suppliers, while e3-value takes a network perspective, in order to provide more insight into value generation, outside the formal boundary of a single organization. Also, at the conceptual level, they are quite different: the BMO puts emphasis on resources needed to create a certain value proposition, while in e3-value, the modeling of value streams in a business network is central. An approximate mapping between BMO and e3-value concepts is proposed in Gordijn et al. [35], which clearly reveals these differences. When considering the level of formality, although both e3-value and BMO have been found to be "light weight" ontologies [15], e3-value is more formal than BMO since it comes with a meta-model [14] and a graphical notation, for which reason it is a modeling language. The fact that BMC is widely accepted is partly due to its simplicity and ease of use, which come at the cost of formality. Our decision to choose in our study BMO over e3-value is not only because of its popularity but also due to the fact that the relationship between e3-value and ArchiMate has been addressed in [22].

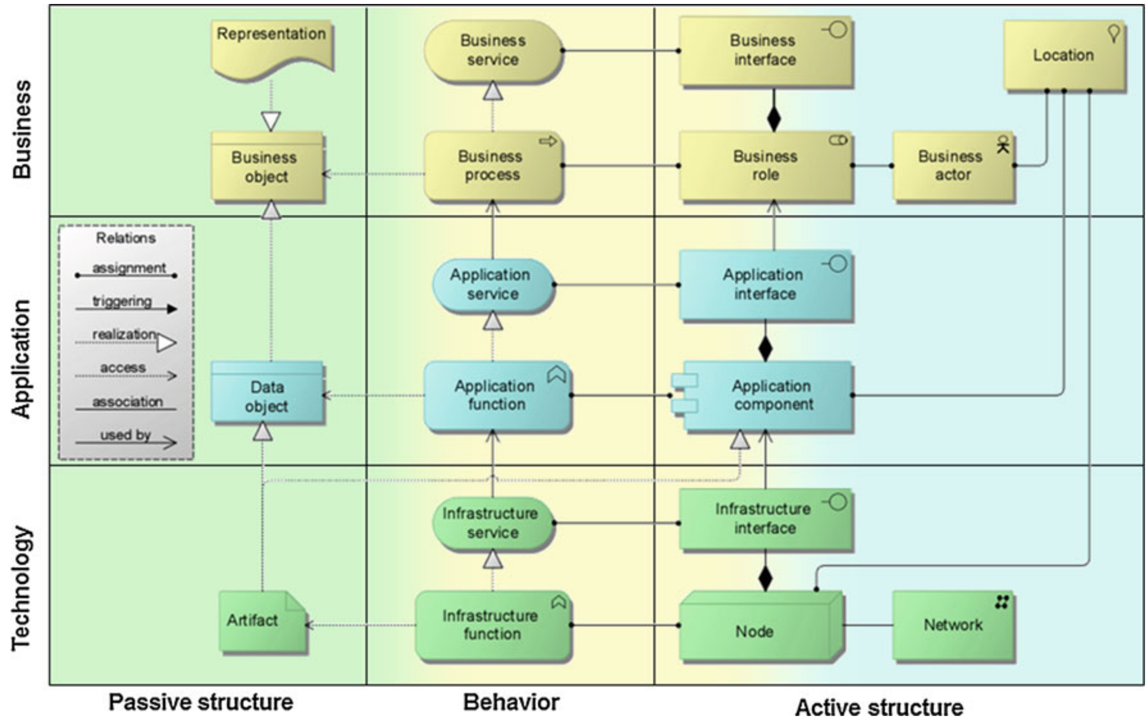

Fig. 1 Simplified ArchiMate meta-model

2.2 ArchiMate

In this section, we briefly describe ArchiMate 2.0 (Sects. 2.2.1 and 2.2.2) and its extension with value-related concepts (Sect. 2.2.3).

2.2.1 The ArchiMate 2.0 core

Figure 1 shows a simplified version of ArchiMate's meta-model. The language distinguishes between three layers: the business layer, the application layer, and the infrastructure layer. In addition, the language considers the structural, behavioral, and informational aspects within each layer. It also identifies relationships between and within the layers. For a full description of the language, we refer to [19]. Figure 1, however, does not show all permitted relationships: every element in the language can have composition and aggregation relationships with elements of the same type; furthermore, there are indirect relationships that can be derived through a relationship composition mechanism [4].

To facilitate architecture-based (quantitative) analysis, ArchiMate model elements could be annotated with attributes, which quantify measures associated with the concepts and relationships. The nature of these measures may vary depending on the purpose of the concrete analysis technique used. For example, one may associate core elements with costs, performance measures, KPIs, etc., which then can be used as input for quantitative analysis techniques (for quantitative attributes and performance analysis technique, see [18]). Attributes can be defined for both input parameters and analyses results, although the distinction may not always be sharp: the result of one analysis technique may be the input of another analysis technique. In our approach, the specific quantitative attributes are related to costs and revenues as defined in the BMO.

2.2.2 Motivation extension

A proposal for extending ArchiMate with motivation concepts has first been made in [8]. This extension is now part of the official ArchiMate 2.0 standard specification and is described briefly in the sequel. The motivation extension facilitates the identification, description, analysis and validation of requirements and their realization in enterprise architecture models. A motivational element is defined as an element that provides the context or reason behind the architecture of a system or behind architecture decisions.

Intentions are pursued by people, called stakeholders, which can be some individual human being or some group of human beings, such as a project team, enterprise or society. In addition, intentions may be organized into certain areas of interest, called drivers such as customer satisfaction, compliance to legislation or profitability. Drivers represent internal or external factors, which influence the plans and aims of an enterprise. Assessments of these drivers are needed to

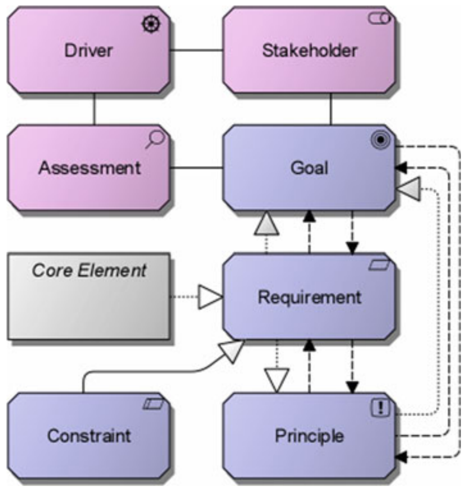

Fig. 2 Motivation extension meta-model

decide whether existing intentions need to be adjusted or not. The actual intentions are represented by goals, principles and requirements. Goals represent some intended result—or end—that a stakeholder wants to achieve (for e.g., increasing customer satisfaction with 10 %). Principles and requirements represent intended properties of solutions—or means—to realize the goals. Principles represent intended properties that are required from all possible solutions in a given context. For example, the principle "Data must be stored only once" represents a means to achieve the goal of "Data consistency" and applies to all possible designs of the organization's architecture. Instead, requirements represent intended properties of specific solutions. For example, the requirement "Use a single CRM system" is a specialization of the aforementioned principle by applying it to the current organization's architecture in the context of the management of customer data. For a more detailed description of this extension, we refer to [19]. Figure 2 shows the complete meta-model of the motivation extension, and Fig. 3 shows an example of a motivation model.

2.2.3 Value-related concepts

We have recently completed research concerning several additional concepts that make the modeling of value and value-related concepts possible. This research [20] aims at supporting architecture-based IT valuation models and portfolio management techniques. We have identified concepts such as value, risk, constraint, resource and capability, which make it possible to use ArchiMate in conjunction with portfolio management techniques, such as Financial and Economic Models, Constrained Optimization Models, Multi-criteria Decision Making Models, Checklists, Scoring models, Relevance Trees, etc. Furthermore, these concepts are linked with the existing ArchiMate concepts and aligned with the ArchiMate meta-model. In the remainder of this section, we describe them briefly without going into technical details concerning the motivation of their underlying meta-model (which can be found in [20]).

ArchiMate's *value* concept, although limiting, fits in the general definition of value as assumed by most valuation techniques (see [20] for a survey of valuation techniques). There are two problems with the current definition of value in ArchiMate. The first one is related to its semantic overload. Value is now defined as the relative worth, utility, or importance of a business service or product. This coincides to a certain extent with the view expressed in the service science literature [40]. However, Vargo and Lusch argue that value is not intrinsic to goods or services, but is established by the customer of that good or service as value-in-use and, therefore, firms can only make value propositions. This is in line with the BMO [33]. This distinction between value as "value-in-use" and value as "value proposition" is not made in ArchiMate. For the sake of (models') simplicity, we choose to allow both these interpretation of values. The second problem is related to the fact that, in ArchiMate 2.0, value is only associated to business services and products and, thus, confined to the business layer of the architecture. We argue that value should not only be considered in relation to a firm's environment (i.e., its customers) but also internally. Thus, any architectural element (or project) has value (as value-in-use) for its users. For this reason, we chose to broaden its definition to cover a broader range of values. Thus, value is defined as the relative worth, utility, or importance of a core architectural element (business service, process, application component, etc.) or of a (IT) project.

For the concept of *risk*, we adopt the definition of The Open Group [38]: "the frequency and magnitude of loss that arises from a threat (whether human, animal, or natural event)." The most common risk calculation formula is that of the threat's probability multiplied with the size of its effect (i.e., the size of the value loss).

The *constraint* concept has been defined in the motivation extension as being a restriction on the way in which a system is realized and does not cover operational constraints (e.g., control flow constraints). We use it in relation to value-related concepts as well.

The *resource* concept is prominently present in most valuation techniques, and especially in constraint optimization models in which they are defined mathematically and constrained. We defined a resource as a person, (information) asset, material, and/or capital owned or controlled by an organization. We relate the resource concept to the motivation extension, in particular to goals. We have to stress that a resource is realized by structure elements, and as such we can regard it as an abstraction of structure elements.

Similar to resource, we introduce the *capability* concept as an abstraction of behavior elements. More precisely,

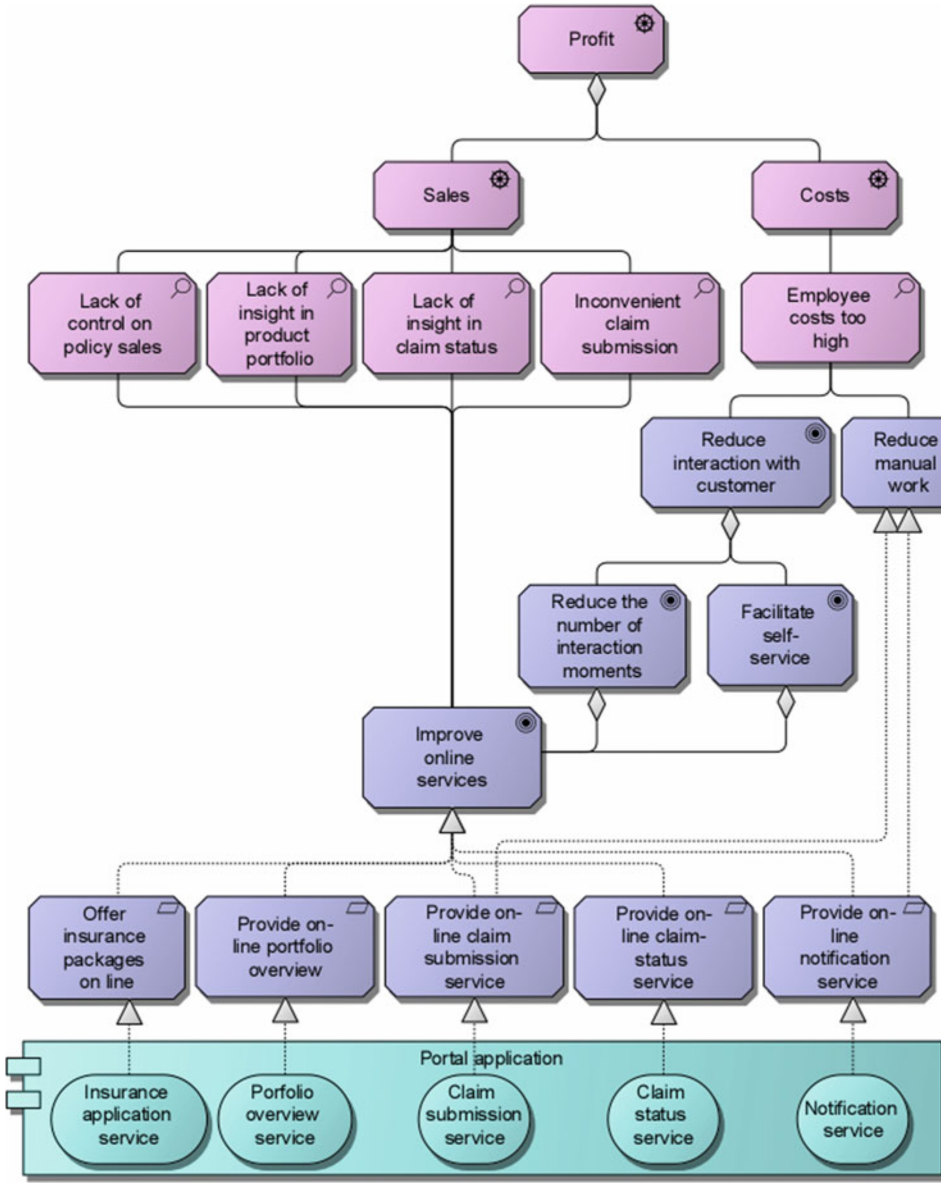

Fig. 3 Motivation model example

capability is defined as the ability of an entity (department, organization, person, system, etc., i.e., a static structure element) to perform activities that would contribute to the achievement of its objectives, especially in relation to its overall mission. This definition suggests that capability can indeed be seen as an abstraction of the behavior that the entity is able to perform in order to achieve its goals.

The above concepts of resource and capability are from the semantic point of view similar to those of operand and operant resources respectively, as introduced by Constantin and Lusch [5] in the marketing literature, and then incorporated in service science [40]. Operant resources are employed to act on other resources to create an effect, usually some benefit, while operand resources are resources on which an operation or act is performed in order to be beneficial (e.g., natural resources, goods, data, or money). According to Vargo and Lusch [40], operant resources are usually intangible (e.g., core competencies and organizational and business processes), they are dynamic and infinite as opposed to operand resources, which are static and finite. This is in also agreement with our idea to introduce resource and capability in ArchiMate as abstractions of structure and behavior, respectively.

Figure 4 depicts the meta-model and notation for the extension with value-related concepts and their alignment with the core meta-model. In Fig. 5, we also give an example of a model that uses concepts from this extension.

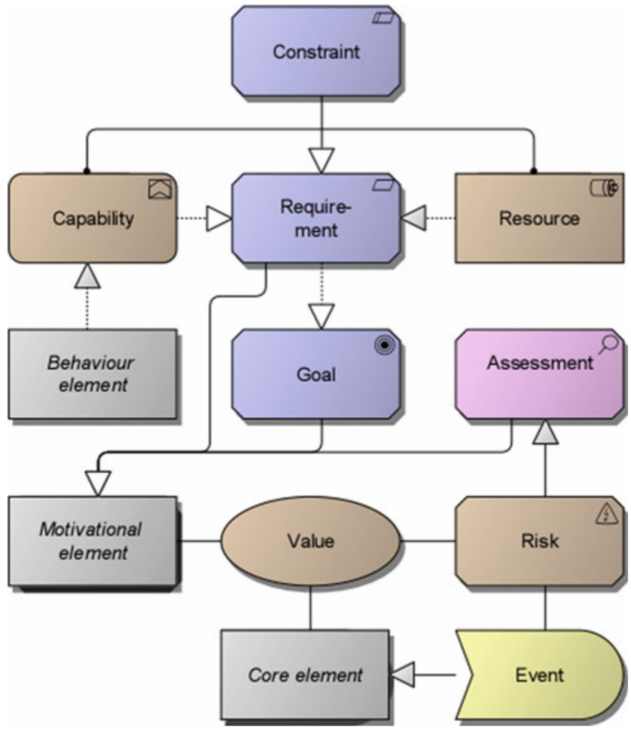

Fig. 4 Meta-model and notation for value-related concepts

2.3 Business model ontology

Osterwalder's PhD thesis provides the formal foundation for the BMC in the form of the Business Model Ontology (BMO) [33,34]. The ontology is based on previous research as its key concepts come from the balanced score card [25], value chains [37], and stakeholder analysis [11].

As we use Osterwalder's BMO, we adopt his definition of a business model [33]: *"A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing a company's logic of earning money. It is a description of the value a company offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing and delivering this value and relationship capital, in order to generate profitable and sustainable revenue streams."*

In [33], nine so-called "building blocks" are identified (see Fig. 21, p. 44): Value Proposition, Target Customer, Distribution Channel, Relationship, Value Configuration, Capability, Partnership, Cost structure, and Revenue Model. They map to four general areas, similar to the balanced score card [25]: product (the value a company offers), customer interface (one or several segments of customers), infrastructure management (the architecture of the firm and its network of partners), and financial aspects (profitable and sustainable revenue streams). Each of these building blocks is decomposed into sub-elements. For example, a value proposition may consist of multiple offerings. Besides that, the elements may have attributes, e.g., the sub-element "account" may take a name and a percentage of the total costs as attributes. Figure 6 shows all the elements included in the BMO and their relationships. For a precise description of each element (by means of tables), its attributes, and its relationships, we refer to [33]. Using this source, we have been able to "mine" the BMO meta-model as shown in Fig. 6.

While in [33], the BMO consists of 20 concepts, later versions include only 9 concepts (i.e., the original building blocks, see [34]). These form the BMC (BMC) [34], name which gives a clear hint on the intended use and practical relevance of BMO, namely that of a tool to design and specify business models. The main reduction of concepts comes from combining the elements with their sub-elements, which has significantly contributed to BMC's parsimonious character, and most probably, to its quick success. For example, from the two pairs, Value Proposition and Offering, and Capability and Resource, only Value Proposition and Resource remain.

In the BMC, the concepts of Profit and Actor have been eliminated. Profit might have been considered superfluous, as it is simply the difference between Revenue and Cost. In the meta-model, profit has no relationships to any other elements either. As far as the Actor concept is concerned, we assume that it was merged with Partnership and Agreement to form Key Partners. Considering all of the above, we may assume that the BMC meta-model can be derived from the BMO meta-model by considering that the relationships between BMC elements are inherited from BMO (as former relationships between the BMO building blocks, see Fig. 6), as shown in Fig. 7 (NB: at this time, the reader should disregard the dashed arrows, as they do not belong to original definition of the BMO; they represent proposed extensions and are explained below).

In our opinion, the resulting BMC meta-model reveals a few issues with the meta-model definition of the BMC and of the BMO, from which we have derived it. For example, there is no explicit relationship defined between the cost structure building block and any other building blocks. To compensate this, we propose the extension of the BMC meta-model with the following relationships:

- A "has" relationship from the key activities to the cost structure. Key activities require the usage/consumption of resources, which generate costs.
- A "has" relationship from key resources to cost structure. We argue that key resources must be connected to costs, as the costs of all activities can be seen as resulting from the consumption/usage of resources during their execution.

Another problem (also related to costs) is that the creation and maintenance of customer relationships may also generate significant costs (e.g., through creation and distrib-

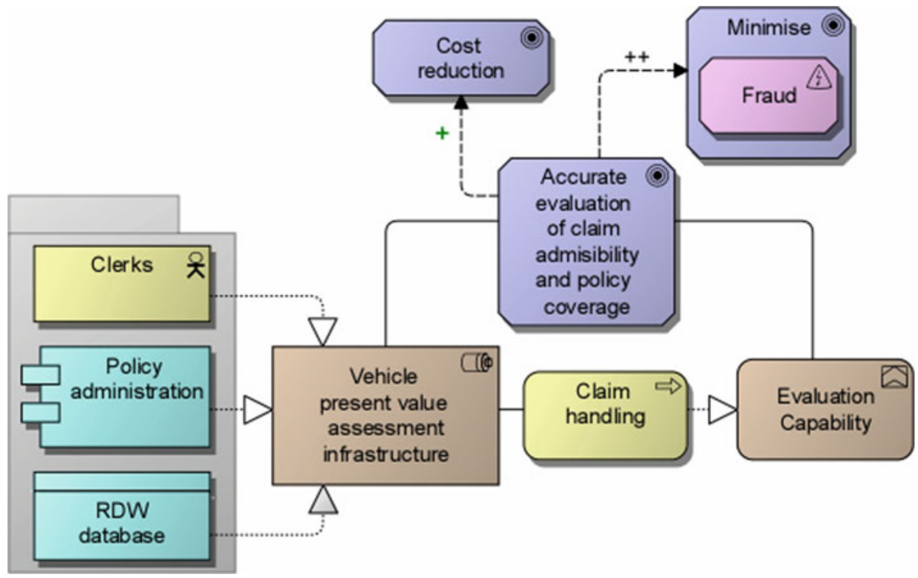

Fig. 5 Example of resource and capability use

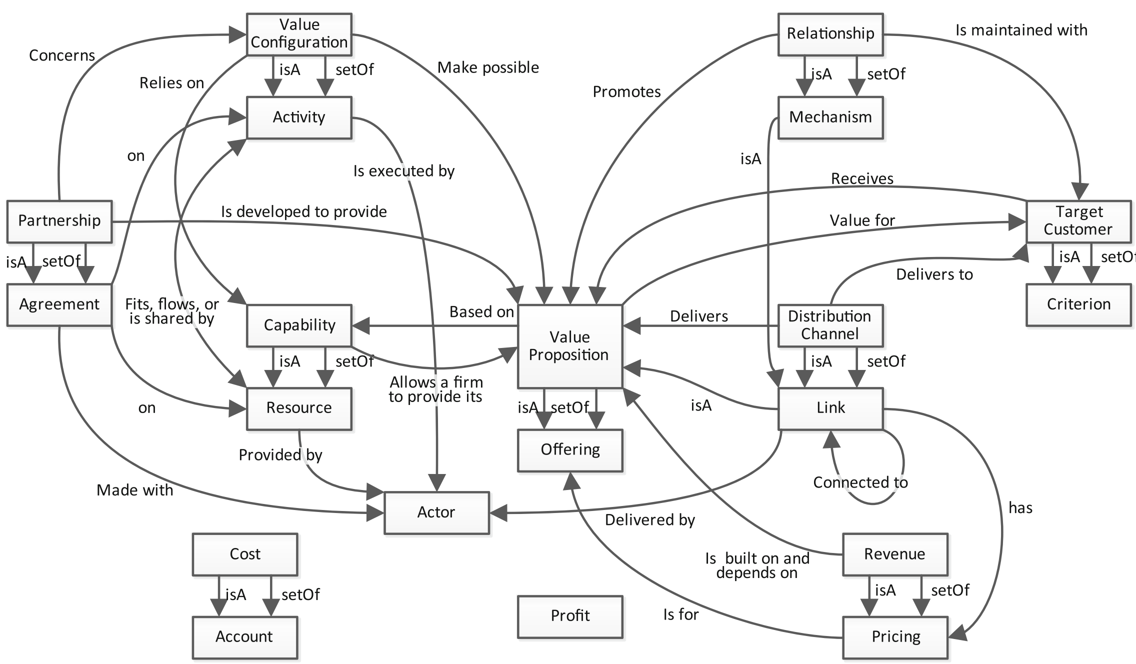

Fig. 6 The BMO meta-model

ution of marketing materials), as they can also be seen as a type of activity during which resources are used/consumed. However, no direct (or indirect) relationship in the BMO is defined between the customer relationship building block and cost structure. We solve this issue by adding an "is a" relationship from customer relationship building block to the key activity building block. A similar situation occurs with the channels, which can be seen as resources that cost money. Take, for example, the portal application of a web shop, which is the channel through which the business is done and, hence, a key resource. The solution is to add a "is a" relationship from channels to key resources. Additionally, we may also consider extending BMC with a bidirectional "fits, flows to, or it is shared by" from the customer relationship building block to the channels building block in order to make explicit the resources (i.e., channels) assigned to the customer relationships. Finally, we also miss a "delivers" relationship from channels to value proposition, since channels are also the means through which the value proposition reaches the customers. The proposed additional

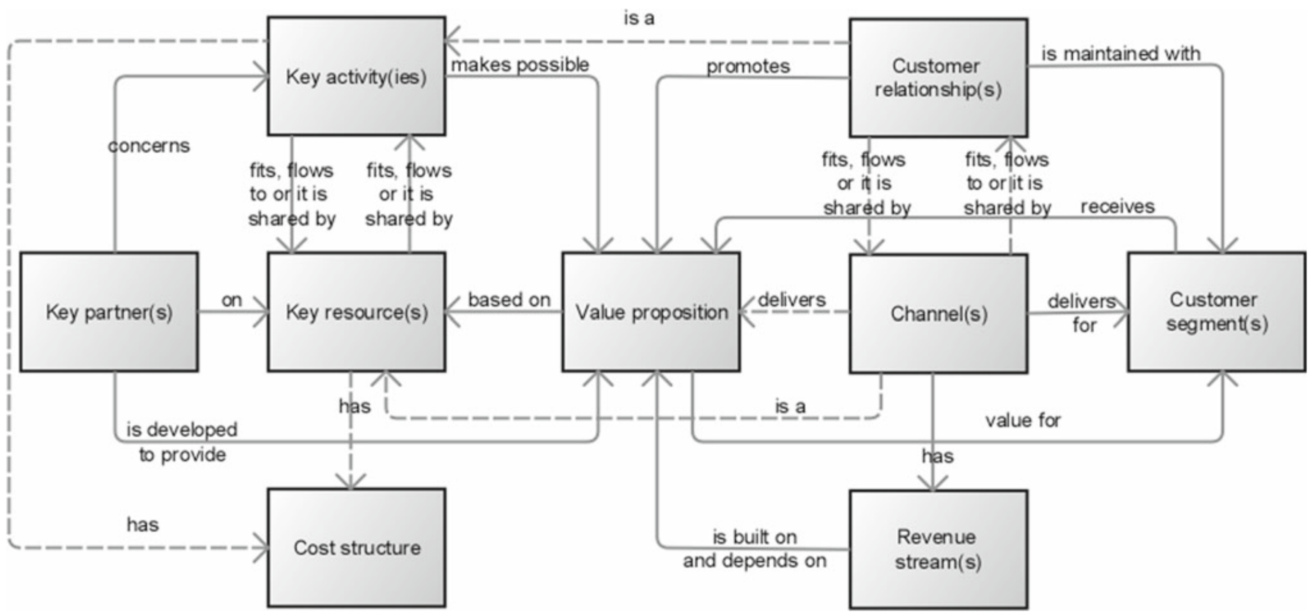

Fig. 7 BMC meta-model and proposed extensions

relationships are shown in Fig. 7 with dashed lines and they do not belong to the original BMO meta-model definition.

Another, more fundamental issue with the BMO definition is the inclusion of capabilities in the Key resources building block. Osterwalder's capability definition is that of "ability to execute a repeatable pattern of actions that is necessary in order to create value for the customer" [33]. On the other hand, Osterwalder defines the activity concept (which forms the core of the key activity building block) as "an action a company performs to do business and achieve its goals." As can be easily seen, not only are the two definitions semantically very much related, but also they suggest that capability (as ability of performing activities) and activity should better belong together to the same building block (i.e., the key activities building block) as they have the same nature: they both express behavior. Instead, the key resources building block should only focus on the specification of tangible assets (e.g., plants, equipment, information systems and cash reserves), intangible assets (e.g., patents, copyrights, reputation, brands and trade secrets) and human assets (i.e., the people a firm needs in order to create value with tangible and intangible resources), i.e., on the assets an organization owns or controls. In the BMC, this problem somehow disappears, since the capability concept has been eliminated, and the only remaining elements are, simply, key activities and key resources. Nevertheless, we must stress that (contrary to the BMO meta-model definition) we followed our argument that capabilities must belong to key activities, when relating the BMC's key activities building block with the architecture capability concept, as it will be explained later in the article.

3 Relating ArchiMate and BMC

We argue that the ArchiMate concepts suitable to be related to the BMC concepts are those from the motivation extension, the resource and capability concepts and, most likely, some of the business layer concepts. This statement rests on the observation that business models and architecture models aim to represent different abstraction levels of an organization. Thus, the former captures mostly the strategic aspects, while the latter is mostly concerned with operational aspects. Therefore, business models rarely concern other aspects of the enterprise than those mentioned earlier, which are obviously closer to an organization's strategy than the deeper architecture layers. Furthermore, even if BMC elements would refer to operational entities described in the architecture, one can use more abstract architecture concepts instead, such as, capability and resource, to abstract from them. Such abstractions (i.e., resources and capabilities) can then be further refined and operationalized in terms of business, application and infrastructure layer concepts. This idea is suggested in Fig. 8, which also shows the correspondences between BMC and ArchiMate concepts. To define correspondences, we first compared concepts defined by BMC (also called "building blocks", [34]) to the concepts defined by the ArchiMate. Table 1 shows and motivates the proposed correspondence that resulted from this comparison. As can be seen, often, concepts from Osterwalder's meta-model can be matched with multiple concepts in ArchiMate. This is logical, as ArchiMate is richer than the BMC.

After the most suitable matching between BMC and ArchiMate concepts has been found, we attempted to do

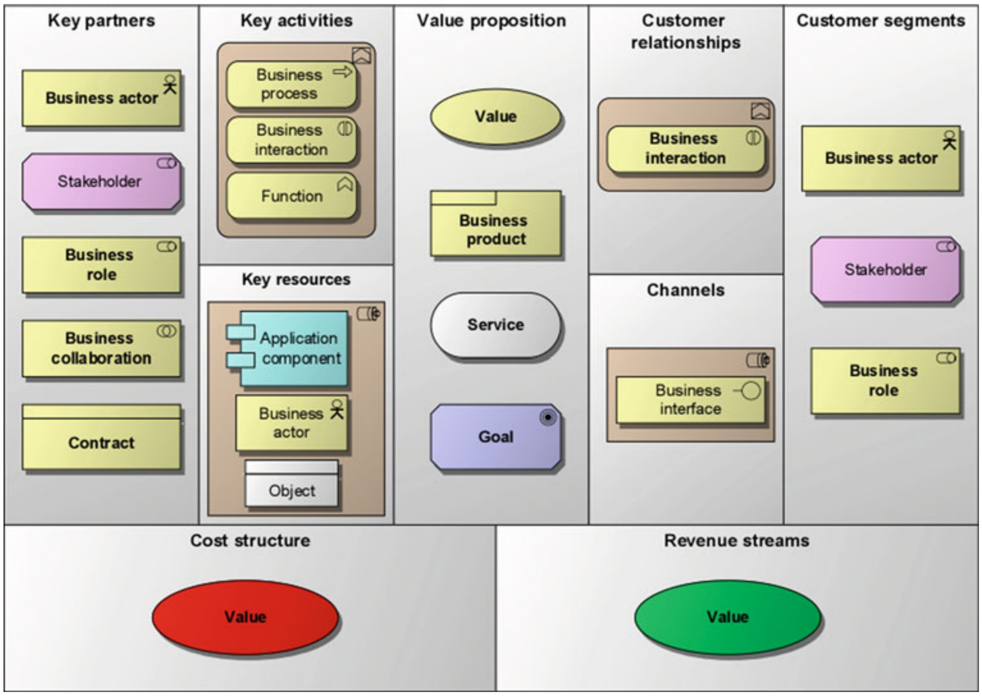

Fig. 8 Relating ArchiMate and BMC

the same for the relationships defined in BMC meta-model (Fig. 7) and ArchiMate relationships. The result of our relationship matching is presented in Table 2 and it was obtained as follows: for each pair of BMC concepts among which a BMC relationship exists, we analyzed the ArchiMate meta-model and selected the most suitable relationship that is allowed between the corresponding ArchiMate concepts.

4 Chaining architecture-based cost analysis technique with BM-based cost/revenue analysis

Next to showing how a business "works", an equally important goal of a business model is to demonstrate that the business indeed does work, i.e., that it generates profit. This is mostly done by a cost/revenue analysis in which both costs and revenues are estimated as accurate as possible based on the expected size of the market share. Thus, the accuracy of the result of this type of analysis very much depends on the quality of the input estimations. This accuracy can be significantly improved if these estimations are the result of detailed architecture-based cost calculations that, in turn, are based on real resource costs, processing times and processing volume (also known as throughput). For architecture models, such a technique exists [24] and it is briefly described below.

Architectures can be described from different viewpoints, which result in different views on architectural models ISO [21]. These views are aimed at different *stakeholders* that have an interest in the modeled architectures. Also for the cost aspects of an enterprise, a number of viewpoints can be discerned, resulting in different (but related) cost measures:

- **User/customer view** (stakeholders:customer; user of the offered service/product): *cost per use/price* of a service/product. This type of costs can be seen as *revenues* for the providing enterprise.
- **Resource view** (stakeholder:resource manager; capacity planner): *resource variable cost* (or *tariff*), the cost per (time) unit for using or consuming the resource and a *resource fixed cost*, i.e., the cost per usage. Recall that a resource is any type of asset used or consumed (e.g., human resources, information resources and systems, money, materials, buildings, etc.). In ArchiMate, resources are realized by active or passive structure elements (such as actors, application components, interfaces, objects).
- **Process view** (stakeholders:process owner; operational manager): *cost per completion* of a process. This cost can be calculated as the sum of all costs incurred as result of all resources consumed/used during the execution of that process instance.
- **Product/service view** (stakeholders:product manager; operational manager): *cost per completion* of one product/service. This cost is the sum of all completion costs of all business processes that together realize the product or service.

Table 1 Defining the correspondence between BMC and ArchiMate

BMC	ArchiMate	Justification
Segments	Business actor, Business role, Stakeholder	"The Customer Segments Building Block [in the BMC] defines the different groups of people or organizations an enterprise aims to reach and serve". In ArchiMate such organizations, departments are modeled as actors, stakeholders or roles.
Propositions	Business service Value, product Goal	"The Value Propositions Building Block [in the BMC] describes the bundle of products and services that create Value for a specific Customer Segment". A very simple lexical analysis of the definition above already gives a clear indication of the ArchiMate concepts that are suitable to model the value proposition. Besides products, business services and value, we also included the goal concept because most goals are formulated in terms of the aim of increasing some sort of value, and thus, they give a more accurate view on the value proposition by showing why the Product or Service is useful.
Channels	Business interface, Resource	"The Channels Building Block [in the BMC] describes how a company communicates with and reaches its Customer Segments to deliver a Value Proposition". Considering that, in the ArchiMate specification [5], "a business interface is defined as a point of access where a business service is made available to the environment", we may conclude that the channels building block contains a specification of all business interfaces. It should be noted that business interface is an active structure element that fits in the definition of resource and, as such, can be abstracted from by means of the resource concept.
Customer relationships	Business interaction, Capability	"The Customer Relationships Building Block [in the BMC] describes the types of relationships a company establishes with specific Customer Segments. In ArchiMate, the most suitable choice to describe such relationships is the concept of business interaction defined as "a behavior element that describes the behavior of a business collaboration." It should be noted that business interaction is an behavior element that fits in the definition of capability, and, as such, can be abstracted from by means of the capability concept.
Revenue streams	Value	"The Revenue Streams Building Block [in the BMC] represents the cash a company generates from each Customer Segment (costs must be subtracted from revenues to create earnings)". The only ArchiMate concept that can be used to model revenue is value. Another option is to specify the revenue as an attribute of the architectural element generating it (e.g., a product or business service). However, in such case (as opposed to modeling revenue as value), the modeling of revenue sources is explicit, while that of revenues themselves is implicit.
Key resources	Resource	"The Key Resources Building Block [in the BMC] describes the most important assets required to make a business model work." This definition reproduces almost literally the definition of resource.
Key activities	Capability	"The Key Activities Building Block [in the BMC] describes the most important things a company must do to make its business model work." As mentioned earlier, in the architecture domain, capability is defined as the ability of an entity (department, organization, person, system) to perform activities that would contribute to the achievement of its objectives, especially in relation to its overall mission, which is that of making its business model work.

In addition, if necessary, all the above cost measures can be divided further into fixed and variable cost components. In [24], the EA-based cost calculation technique uses the above cost measures and assigns them to the different model elements. Applying the algorithm (based on a recursive formula) results in calculated cost values for each behavior

Table 1 continued

BMC	ArchiMate	Justification
Key Partnerships	"Business actor, business role, Stakeholder, business collaboration, Contract	"The Key Partnerships Building Block [in the BMC] describes the network of suppliers and partners that make the business model work". This definition suggests that this building block specifies both the nodes of the network, i.e., the parties invoked in partnerships (actors, roles, and stakeholders) and the relationships and interactions between them. Similar to the customer relationship building block, such relationships/interactions can be described in ArchiMate by means of business collaborations, business interactions and contracts.
Cost Structure	Value	"The Cost Structure [in the BMC] describes all costs incurred to operate a business model". Similar to the case of the revenue streams building block, the only ArchiMate concept that can be used to model cost is value. Another option is to specify the costs as an attribute of the architectural elements generating them (e.g., a human, technical or informational resource). However, in such case (as opposed to modeling cost as value), the modeling of cost sources is explicit, while that of costs themselves is implicit.

element (including services). The algorithm essentially collects, in a bottom–up fashion (from the technology infrastructure to the business layer), all resource usage costs caused by the completion of an instance of that behavior element, where any active and passive structure elements are seen as a resource. This technique leads to an objective and precise estimation of the cost structure in an architecture. In particular, the calculated costs associated with the business services offered directly to the customer, as part of the value proposition, can be copied directly into the cost structure building block of that architecture's BMC. These calculated service costs include already the costs of resources and activities needed for their realization. Thus, realistic business cases and accurate cost/revenue calculations become possible. This idea, of chaining the two cost analysis techniques will be demonstrated by means of the ArchiSurance case later.

Table 2 Relationship matching

BMC relationship	ArchiMate relationship
Is a	Specialization
Fits, flows or it is shared by	Assignment access, used by
Concerns, is maintained with	Assignment
Make possible, promotes, deliver, based on	Realization
Is developed to provide, on, has, is built on and depends on receives	Association
Delivers for	Used by

5 A method for business model-driven architecture change

As interesting as it may be, relating the BMC framework with ArchiMate has by itself no immediate practical value without a method to guide the migration from a current situation to a desired situation, in which a new or improved business model motivates the architecture change. In this section, we propose such a method. Before we go into detail regarding this method, we set the applicability scope of our approach. Our method applies to architecture change projects. By an architecture change, we mean any change that may affect any of an enterprise architecture's layers (i.e., business, application and technology infrastructure layers). Examples of such change projects are projects that involve change of one or more business processes, acquisition, outsourcing, or upgrading of information systems, replacing infrastructural components, such as computing equipment. Also, it should be noted that the BMC business model formalism may not be entirely suitable for non-profit organizations, in which case funding models may be used as well [10], but we did not investigate this possibility in this study.

In the remainder of this section, we present our migration method. In the enterprise architecture domain, we rely on the most widely accepted development method, The Open Group Architecture Framework (TOGAF) [39]. We further elaborate on TOGAF and explain how business models can be incorporated in TOGAF and how they intervene in the development of the target (business) architecture.

TOGAF originated as a framework and methodology for the development of technical architectures, but has evolved into a generic EA framework and method. The core of TOGAF is formed by the *Architecture Development Method (ADM)*, a step-wise iterative approach for the development and implementation of an enterprise architecture (see Fig. 9). In this section, we will focus on the Phases B, C, and D (see the highlighted area of Fig. 9), as they are concerned with the actual development of the four architectures that TOGAF distinguishes: business architecture, application architecture, data architecture and technology architecture, for both the

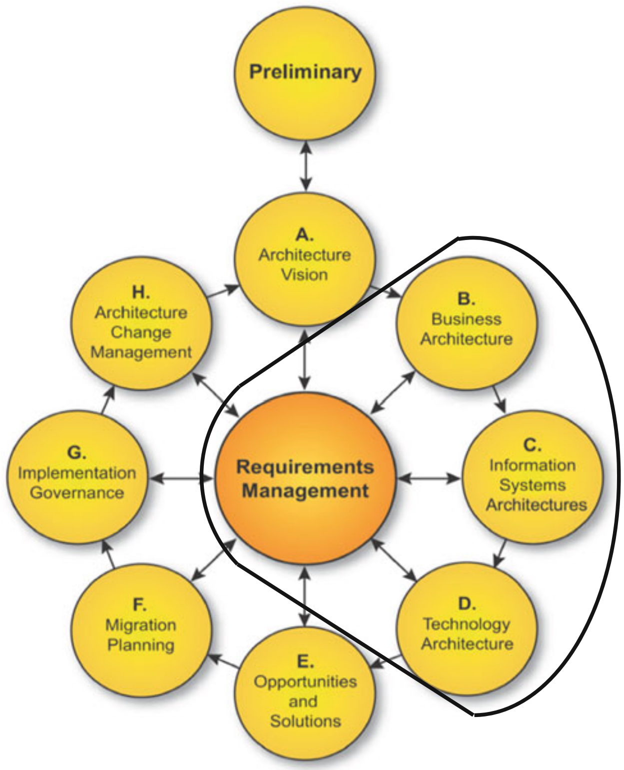

Fig. 9 TOGAF ADM

current (i.e., "baseline") and desired (i.e., "target") situations. For these phases, ArchiMate 2.0 provides suitable modeling support and viewpoints. In addition, we will explain the role of the requirements management step during these phases, because this is precisely where the role of a business model becomes critical for justifying the EA change.

It should be noted that TOGAF does not prescribe a particular sequence in which the Phases B, C, and D are to be carried out, although the arrows in Fig. 9 may suggest otherwise. This is important for our method, which takes the complete set of baseline architectures as starting point. This assumption is justified by the fact that rarely the need for architecture change arises in a green field situation and, thus, a complete baseline architecture indeed exists. Start-ups may constitute an exception, in which case the method starts with the design of a target architecture and of its business model and continues from there.

Phase B "Business Architecture" is particularly relevant because, as indicated in the ADM specification [39], this is the phase in which business principles, business goals and business drivers included in the request for architecture work are explicitly mentioned as inputs for the design of the target architecture (see the overview of overview of TOGAF's Phase B given in Fig. 10). Business principles, goals and drivers are the foundation on which business requirements rest and which will be leading the target architecture design.

Therefore, before the design of the target business architecture can begin, a critical requirements management activity must take place, which will have as a result the consolidation of business requirements to be included in the request for architecture work. Some of these business requirements can be incorporated in a target business model. Although this line of thinking is acknowledged in TOGAF as well, as proven by the bidirectional arrows linking the middle Requirements Management circle with each of the other phases, the meaning and methodical content of these double arrows are some of the most scarcely described and least understood areas of the TOGAF ADM. This is precisely where our method contributes and fits in. More exactly, it clarifies the meaning of the bidirectional arrow between Phase B and Requirements Management.

Of course, the following question may be raised: why is the definition and communication of business requirements linked specifically to Phase B (and not so much to Phases C and D)? As we mentioned earlier, we argue that it is unlikely that a business model concerns and directly drives the design of the application, data and technology architectures, due to the abstraction level gap between business models and architecture models. Any business requirements built in the business model (including those that concern to some limited extent the application and infrastructure layers) can be first captured by means of resources and capabilities (in the sense of ArchiMate). Afterward, these can be further linked to the target business, application, data and technology architecture descriptions, for which the usual steps prescribed by TOGAF ADM's Phases B, C, and D should be followed. Therefore, in the case of Phases C and D, the bidirectional arrows in Fig. 9 concern the elicitation of specific technical requirements for the respective architectures and not that of business requirements (as indicated in the TOGAF ADM specifications [39]).

The main idea of the proposed method (worked out in detail in Fig. 11, left) is that, once the baseline architecture has been specified (following the Phases B, C, D), its corresponding baseline business model can be derived from it, based on the relationships established between ArchiMate and BMC earlier in this study. Since the conceptual gap between EA and BM is significant, one may consider, as an intermediary step, the synthesis (from the EA model) of a resource–capability model, which can be related easily to the baseline BM. As explained in the previous section, at this time, an EA-based cost analysis chained with a BM-based cost/revenue analysis of the baseline situation can be carried out. Such an analysis may reveal problems with the financial health of the current business model and may trigger the architecture change process. The first step of this process is the design of a so-called "motivation model" that captures the goals and requirements of the architecture change. This model may already indicate which part of the baseline architecture is subject to change.

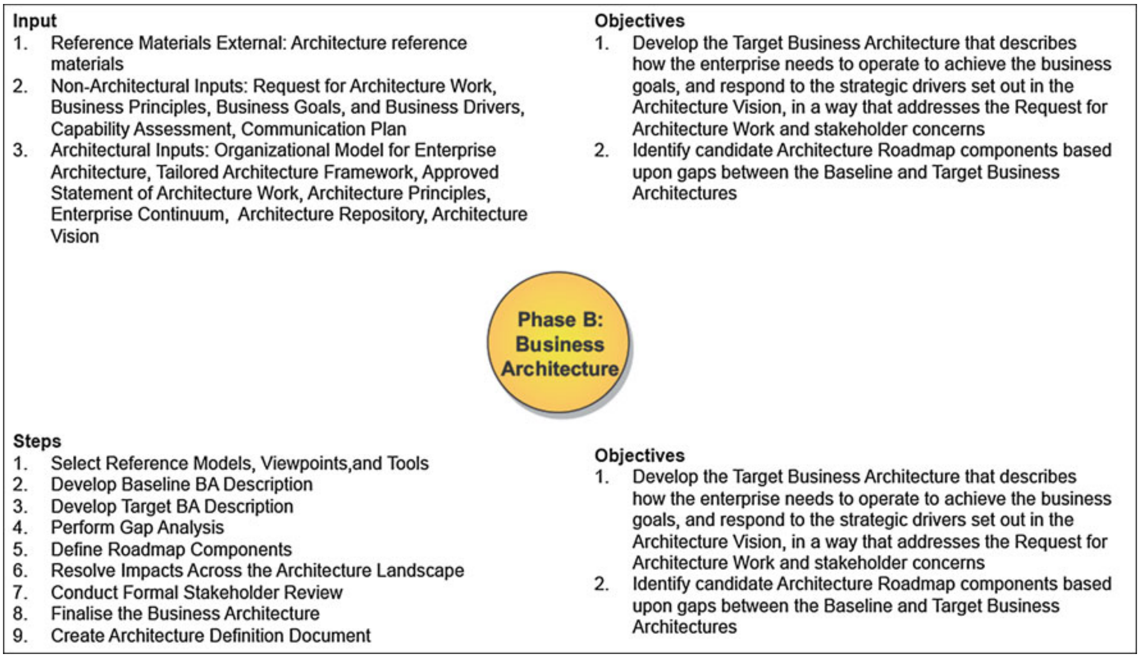

Fig. 10 Overview of the Phase B in the TOGAF ADM

However, the complete and detailed specification of the target architecture will be carried out by following, again, the Phases B, C, and D. Similar to the baseline situation, a target resource–capability model and a target business model must be devised from the target enterprise architecture. A second round of EA-based cost analysis chained with a BM-based cost/revenue analysis must be executed, this time for the target situation. The comparison of the results of the two cost/revenue analyses will indicate whether the architecture change is justified from the business point of view. Moreover, the comparison of the two business models will reveal the impact of the architecture change on the baseline business model. Consequently, a decision with respect to the implementation of the target architecture can be made. If the decision is negative (i.e., the cost/revenue analysis of the target situation shows no significant profit increase), one may consider going back to the motivation model and reconsider the drivers and goals of the architecture change. A change of the motivation model may lead to an alternative target architecture and, thus, to a re-iteration of the right half of the method (Fig. 11, left).

The baseline and target architectures developed during the Phases B, C, D can also be used to develop a series of *Transition Architectures* that show how to move gradually from the Baseline Architecture to the Target Architecture, in all the architectural domains [39]. If the risk and impact of the envisaged change are small, it might be possible to move from the baseline to the target in one step. However, migration often requires consideration of a number of business and complex technical issues related to the change of operational systems. In such a case, the change is better to be carried out in an incremental fashion and each step is described by a so-called Transition Architecture. Of course, it may be necessary to devise and evaluate the intermediary business models of the Transition Architectures as well.

To summarize, in our method, models evolve on two "orthogonal" dimensions: the horizontal dimension, which concerns the change occurring within a modeling domain (e.g., the *architecture* change from baseline to target) and the vertical dimension (going from the EA domain to the BM domain), which consists of a two-step abstraction transformation and expresses the process of creating a BM for a given EA. The relationship between the models occurring in the vertical dimension (and also between their underlying modeling formalisms) is depicted in Fig. 11 (right). Once the baseline and target BMs have been created, analyzed and compared with each other, a decision can be made with respect to the actual implementation of the target EA (in case the costs/benefits balance is favorable).

6 Case study: ArchiSurance

To demonstrate the usage of the method described in the previous section, we use an example case often used in the enterprise architecture community: the ArchiSurance case (a case description for ArchiSurance is presented in [28]). This case has the advantage of being realistic and of manageable size without being overly simplistic.

ArchiSurance is a fictitious company that provides home, travel, and car insurances. It sells its services through a

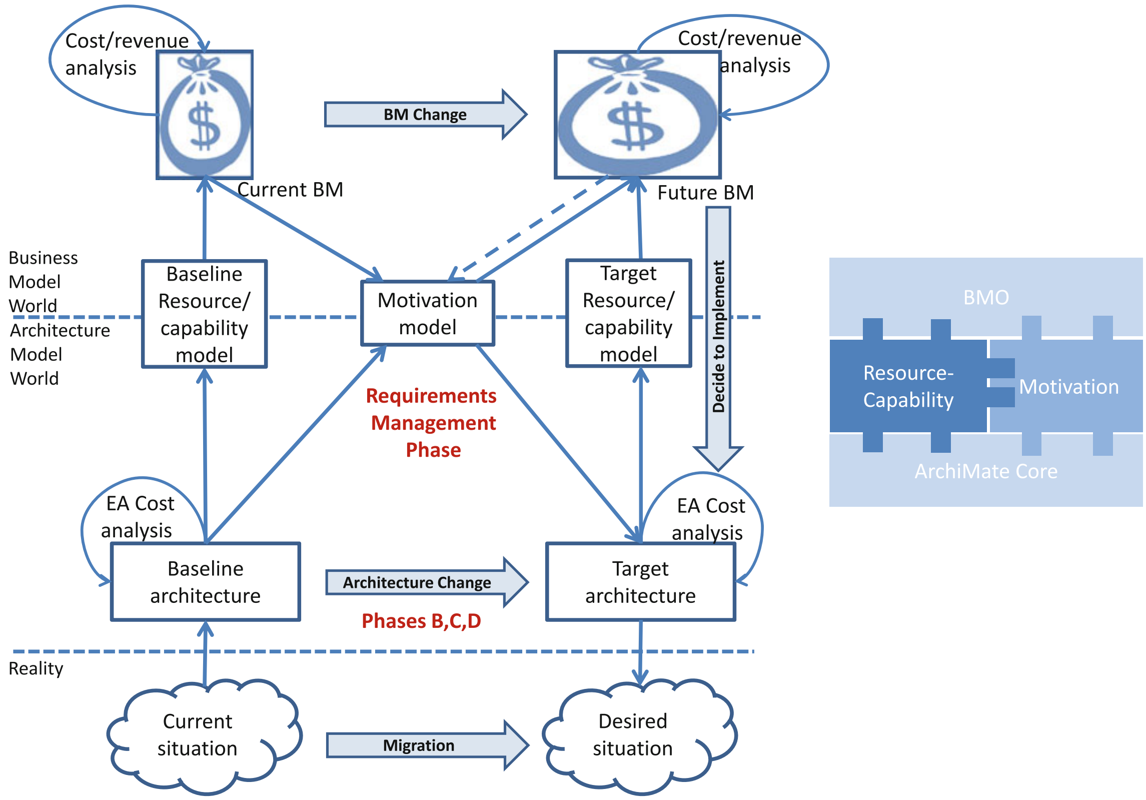

Fig. 11 Going from enterprise architecture to business models and back

network of intermediaries. ArchiSurance's primary operations are (1) maintaining customer relationships and intermediary relationships, (2) contracting, (3) claims handling, (4) financial handling, and (5) asset management. These operations are similar for most insurance companies. To support these operations, the company has several departments and is running a collection of applications on various hardware platforms.

As for all insurance companies, ArchiSurance offers "security" in the form of risk reduction to its customers. In return for a premium, customers are covered in the case of incidents. The goal of the customers is to "be insured". Insurance can be considered as a case of the upside-down business model freemium pattern [34]; many paying customers cover the costs of a few claimants. Next to the premiums paid, ArchiSurance also tries to make a profit on its assets by investing them in stocks and bonds. This is common practice for most financial companies. This aspect, however, will not be handled in the models presented next, as it falls outside the scope of the architecture change we address, and thus, it is not directly relevant.

The problem ArchiSurance is facing is that lately the customer support at ArchiSurance was confronted with more complaints than usual. Customers complain about almost everything: lack of clarity of their claim status, the inconvenient manner for submitting claims, long waiting times when calling customer support, claims take forever to be processed and paid, etc. Moreover, as a result, they are leaving. ArchiSurance has seen the number of policies dropping with 8 % over the past 12 months. Although the situation is not yet critical, management sees this trend as disturbing, considering that it coincides with turbulent developments on the stock market, where ArchiSurance's investments also significantly dropped in value lately.

In the remainder of this section, we will go step by step through the method described in the previous section and shown in Fig. 11. During the process, we will make use of the proposed approach for relating EA and business models and of the combination of cost analysis techniques mentioned earlier in the paper.

1. ArchiSurance's current enterprise architecture is documented and specified using ArchiMate (Fig. 12).
   To create insight into ArchiSurance's primary operations, the company is described in terms of its main business processes, services and products (i.e., the business architecture), application services and components (i.e., the application architecture) and networks, devices and artifacts (i.e., the technology architecture). Since most reported problems are related to claim handling, the

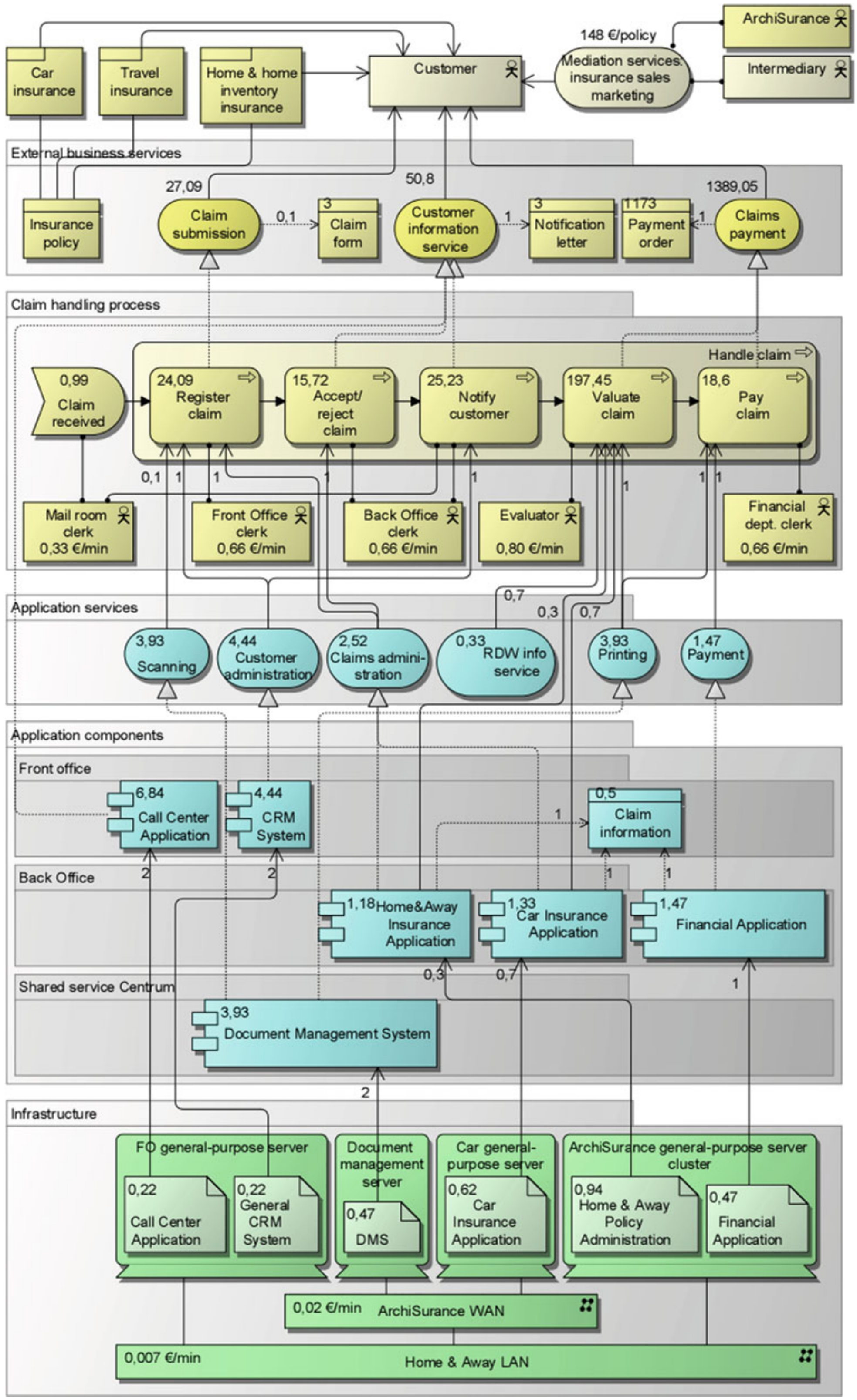

Fig. 12 ArchiSurance's baseline architecture

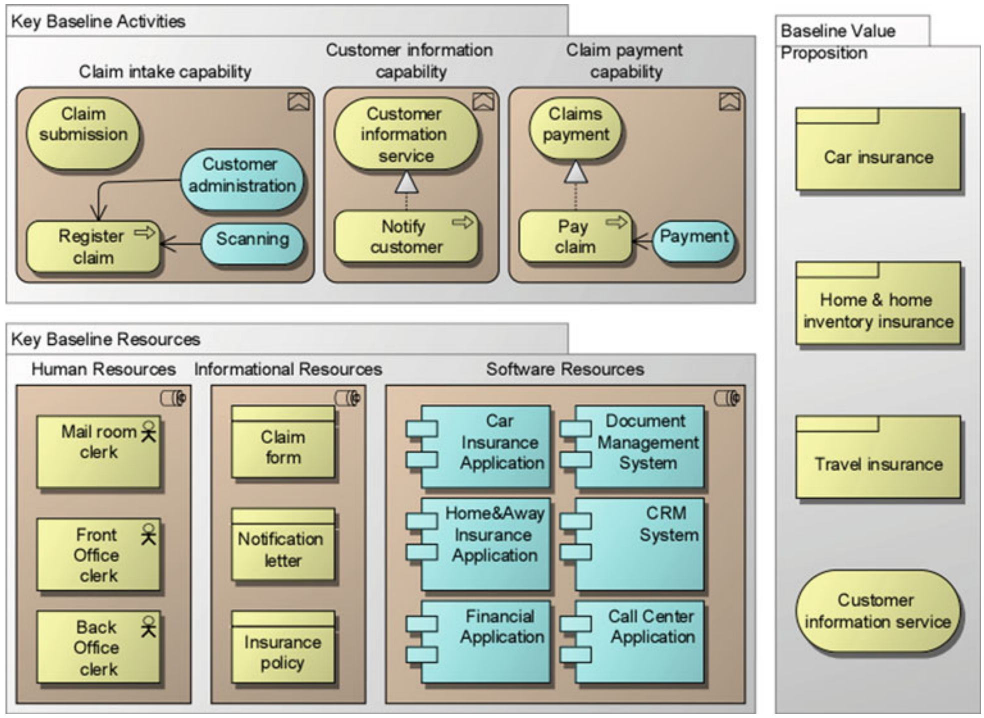

Fig. 13 ArchiSurance baseline resource–capability model

baseline EA specification focuses on the claim handling process and on the business services it supports. ArchiSurance offers essentially three services to the customer: *claim submission* for which regular mail is used (incoming claims are first sorted by the mail room employee and then scanned and registered in the Document Management System), *customer information service* that is used to inform customers about the status of their claims (again via regular mail or by telephone via the call center), and *claim payment* to compensate damages suffered by customers whose claims have been accepted. ArchiSurance has no control over the sales of insurance products. They work with intermediaries, who mediate the sales and marketing activities, on ArchiSurance's behalf, against a commission. The model in Fig. 12 also shows the actors involved in the claim handling process. The numbers shown on the model represent either the cost associated with the execution of one instance of a behavior element or the tariff/time unit associated with the used resources. The former constitute the calculated cost values using the EA-based cost analysis technique from [24], while the latter is given input data.

2. In order to specify ArchiSurance's current business model, we first extract from the baseline EA the key activities, key resources and main business services and products offered directly to the customer. All these elements are included in the resource–capability model shown in Fig. 13.

   Based on this model, a baseline BM can be created (Fig. 14). Note that, in the cost structure building block, the cost values resulting from the EA-based cost analysis are used as input. Another necessary input is that related to the current transaction volumes (e.g., total number of claims/month; average number of new policies/month). Based on this quantitative input, a total cost is calculated. ArchiSurance's monthly revenue is calculated as the average monthly premium multiplied with the average number of policies.

As we said before, customers are complaining about the lack of insight into the status of their claims and about inconvenience of the claim submission. The ArchiSurance management team is aware that a few competitors offer new Internet-based solutions where customers can access all kinds of information about their insurance portfolios. Therefore, they believe that adopting this new technology may solve ArchiSurance's problems. They want to explore the possibility of developing an online ArchiSurance portal that should offer such services, i.e., information services, claim submission service, etc. in the form of a customized "my ArchiSurance" web application (protected by the Id and Password), etc. They have documented their business requirements with respect to this IT project (i.e., architecture change) into the motivation models shown in Fig. 4, which is the starting point for the specification of the target architecture shown in Fig. 15. All new architecture elements have been highlighted with dashed border.

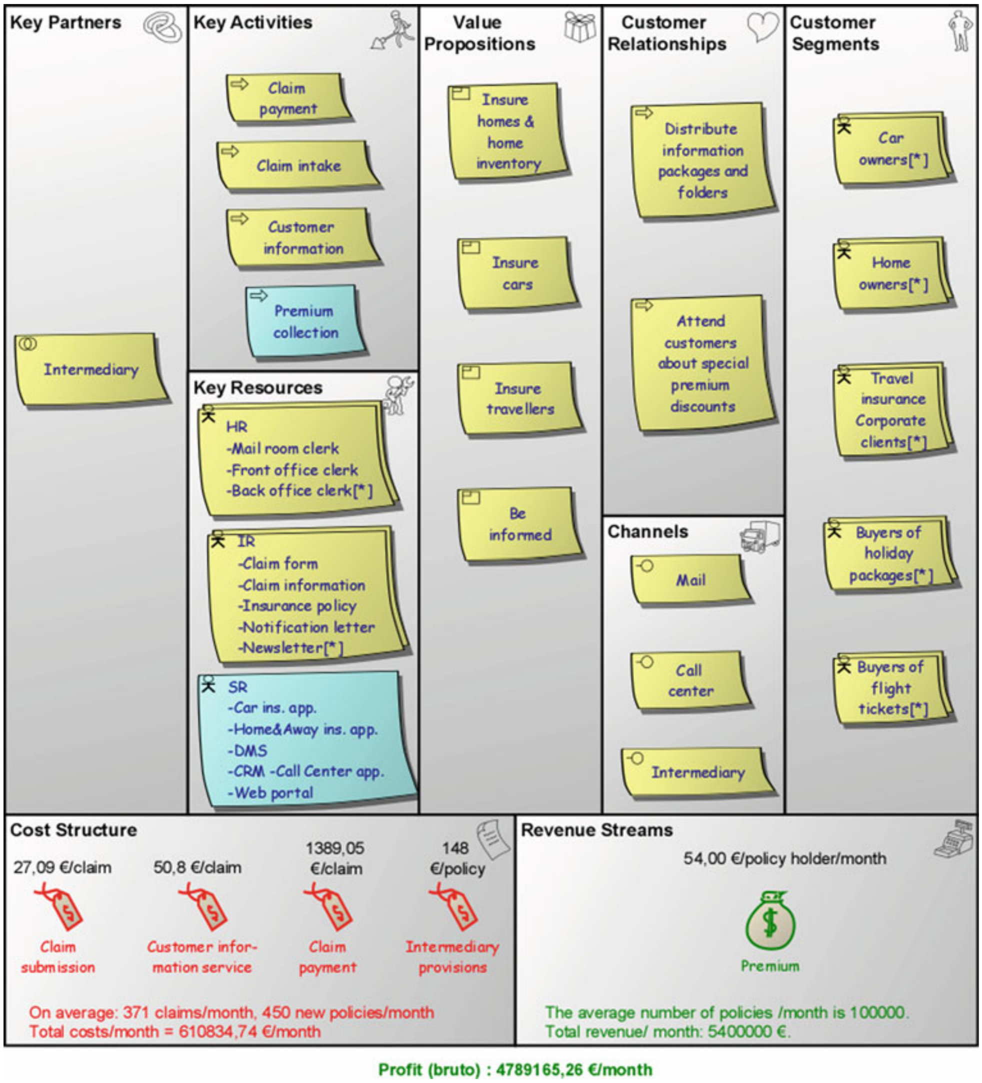

Fig. 14 The ArchiSurance baseline BM

As it can be seen in Fig. 15, the new web portal application and its corresponding infrastructure have been added to the EA. This results in several new services offered to customers (e.g., the possibility to request insurance packages on line, on-line marketing, newsletters) and old services being offered through a new channel, i.e., the new portal. This is expected to reduce manual labor and handling costs. For example, in the case of handling of incoming claims, it is expected that, within a year, 90 % of the incoming claims will be received on line, thus paperless. This assumption seems realistic to us considering the wide spread and ease-of-use of Internet nowadays. Consequently, the mailroom employee will have to sort 90 % less claims than in the current situation. Also scanning of paper forms will be no longer needed since for 90 % of claims e-forms are stored directly into the system. The new portal can also automate the customer information service.

As indicated in the method, in order to calculate the costs associated with all business processes and services, we run the EA-based cost analysis algorithm [24] on the target architecture as well. The results of the cost calculations are indicated in the model.

3. Similar to the baseline situation, the next steps are the design of the target resource–capability model and of the target BM. They are shown in Figs. 16 and 17, respectively.

As it can be seen, a new sales capability and new informational and software resources have been added. In addition, the cost/revenue analysis of the target BM has been done under the assumptions in Table 3.

This leads us to the following conclusions:

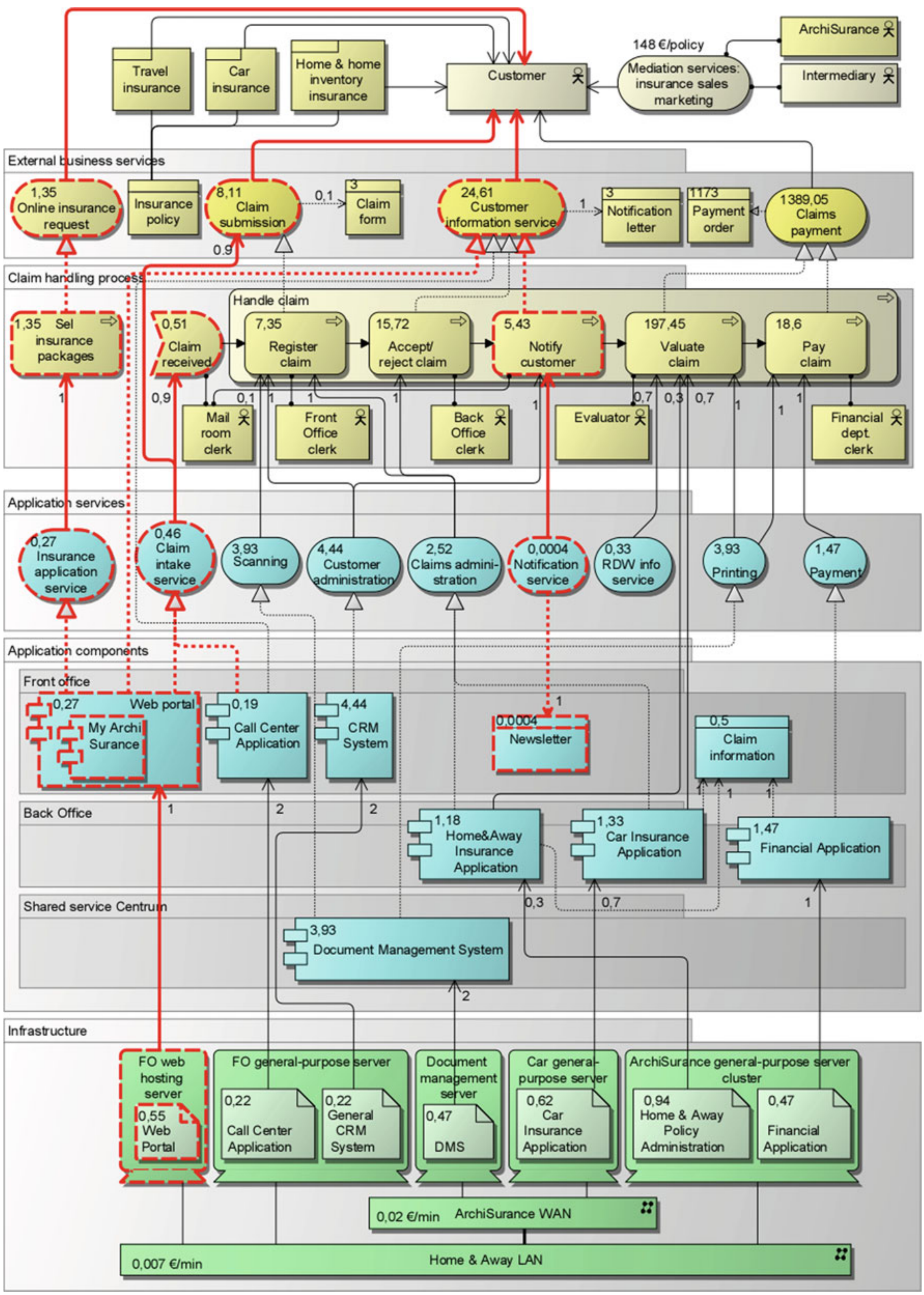

Fig. 15 ArchiSurance's target situation (color figure online)

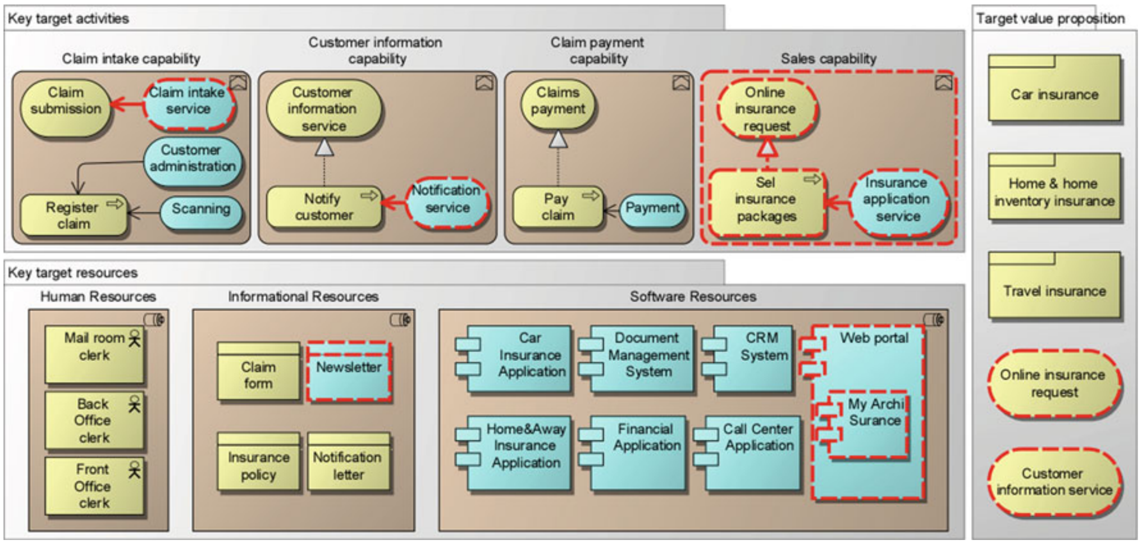

Fig. 16 The target resource–capability model

- the new portal will lead to a significant decrease in costs for some of the old services (i.e., the claim submission service and customer information service);
- new costs are generated by the new on line policy sales service, while the commission costs for the intermediaries drop significantly;
- the total costs remain approximately unchanged;
- the important gain is the increase in revenues due to the expected increase of the customer base.

Considering all of the above, the management decides that the investment in the new portal is beneficial with an estimated profit increase of 7.6 % per month and, therefore, initiates the implementation of the target EA.

7 Discussion

Although new, the idea of relating enterprise architectures and business models seems to be quite powerful and justified, as it has emerged recently in both the EA and BM communities simultaneously. Recently, [12] published their view on the relation between business models, enterprise architecture and IT services. They also used the BMC and ArchiMate, in addition to a classification and objectives of IT Services [41,42]. They focus on connecting business models to the IT infrastructure level and using ArchiMate as visualization. While their work also emphasizes the importance of relating business modeling to enterprise architecture, their study does not go into technical details regarding concept and relationship mappings. It is a rather global mapping and comparison of the three frameworks. In contrast with Fritscher and Pigneur's work, we take as starting point the enterprise architecture. Our motivation is that it is possible to extract the business model from the architecture model, by leaving out application, technology details and even business process details. BMs are about the "key" elements of the business, i.e., key business services, key resources and activities, distribution channels, customers and partners. Trying to relate these highly generic and strategic elements of the BMC to the very concrete and operational business, application and infrastructure layers of ArchiMate directly are hard, if not impossible. Fritscher and Pigneur confirm this, as they have to add the IT Services for it. By making use of the ArchiMate extensions, we are able to insure a smooth transition from operational architecture descriptions to strategic business models using motivation and resource–capability models. In addition, we specify a method supporting this process, position it with respect to the TOGAF ADM, and show how to apply cost analysis to the combination EA–BM. We agree with them that, in future work, the relation between BM patterns [34] and EA design patterns [2,3] should be investigated.

Another related work is presented in one of our earlier papers [30]. These early ideas have been extended and greatly improved in this study. The recently improved version of ArchiMate and its extensions and new insights have led us to a better understanding and better justification of the relation between business modeling and enterprise architecture.

8 Conclusions

The main contribution of this article is threefold:

- First, we have related the BMO building blocks to ArchiMate concepts. Because the BMO is not a standard and

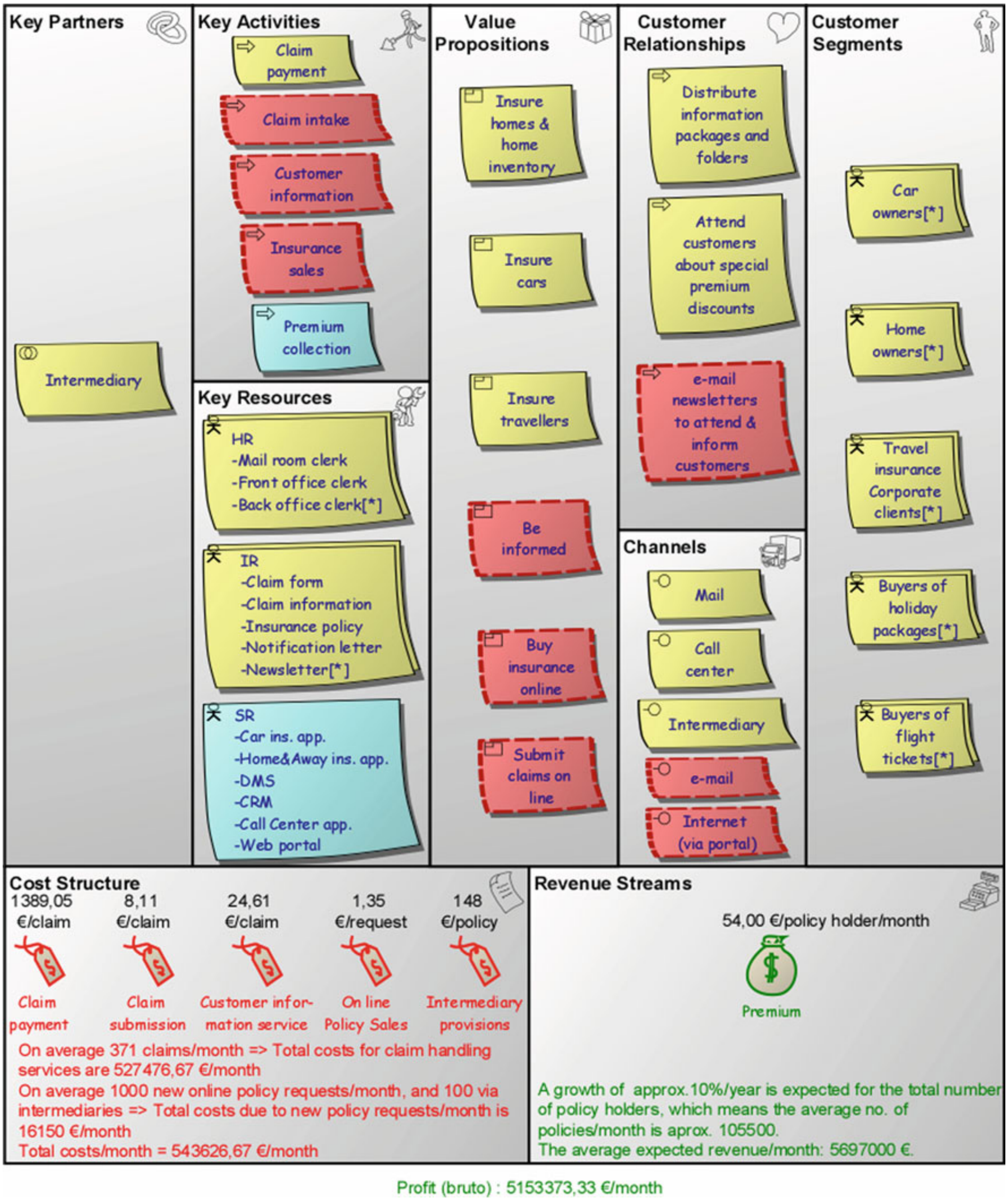

Fig. 17 Target BM

Table 3 Assumptions for a new portal

Volumes	Baseline	Target
Average number of claims/month	371	371
Average number of new requests/month	450	1,100[a]
Average number of policy holders/month	1,00,000	1,05,500 (approx.)

[a] 1,000 new online requests + 100 via intermediaries. It should be noted that not all these requests will lead to new policies. We assume a growth of 10 % on yearly basis of the total number of policies

no official or complete meta-model exists, we had to create one. We took Osterwalder's thesis [33] as the main reference, as this is the most extensive work on the BMO. However, we used the concepts from the BMC, as this is the version most often used and allows for a more intuitive mapping. As the BMC does not provide relations, we took those from the BMO and included them in our derived version of the BMC meta-model. This meta-modeling exercise also resulted in a critical analysis of the definition of the BMO, which revealed some missing relationships. We also used ArchiMate extended with motivation and value-related concepts. This was necessary in order to find good semantic correspondences for the BMC building blocks in ArchiMate and to bridge the abstraction level gap between the two.
- Second, we have demonstrated the practical value of the proposed BMO–ArchiMate relation by showing how cost analysis techniques defined for the two formalisms can be composed such that the output of one can be used as input for the other, having as result more accurate and realistic calculations.
- Third, we have elaborated methodological support that complements the TOGAF ADM and clarifies the role of business models for business requirements management and for architecture change. Our approach facilitates the tracing of business requirements captured by motivation and business models down to the design specifications, expressed as enterprise architecture models. Furthermore, it may be used the other way around, to assess the impact of an architectural change on the underlying business model.

We foresee several possibilities to extend this research. Future work may concern the following:

- One interesting aspect to be investigated is the extent to which automated transformations are possible for a model-driven generation of business models.
- Additional types of financial analysis are conceivable at the BMC level, e.g., break-even analysis. On the other hand, at the architectural level, several other quantitative and qualitative modeling techniques exist [3,18] (e.g., performance analysis, portfolio management and valuation techniques). Similar to the composition of cost analysis techniques, one can explore which other combinations may be realized.
- Although we have addressed the (mapping of) relationships between the concepts of the two formalisms, the focus in this study was rather on relating the ArchiMate and BMC concepts and not their relationships. This is because, in the BMC, relationships are not explicitly modeled and do not play any role. A more extensive investigation and discussion of possible benefits of relationship mapping between the two languages, for example, for analysis techniques or for BM generation, must be still carried out.
- In this study, we describe an extension of ArchiMate with value-related concepts [20], which we use to bridge the semantic gap between ArchiMate and the BMO. This extension and its underlying meta-model have been motivated in [20] in relation to portfolio management approaches. Furthermore, this new language fragment has been aligned with the ArchiMate 2.0 meta-model. Part of our ongoing research is an ontological analysis of the new concepts, which will further insure their semantic interoperability with ArchiMate concepts, and will strengthen their validation. In addition, we are currently applying the approach proposed in a real-life case, which aims at establishing whether technological innovations (in the form of a software service platform) will have a positive impact on the business model for elderly care in Dutch nursing homes. The preliminary results will be available at the end of 2012.
- Through our choice for the BMC, we have narrowed down the scope of our approach to a single organization. Extending this scope to a supply-chain perspective could be a very interesting extension of this study. This would require, however, the usage of another BM framework, such as e3-value, which takes a network perspective to business modeling.
- Lately, there is a trend in the literature concerning a broader interpretation (than just costs) of IT/EA's value contribution to the business, both internally and towards the environment. However, once again our choice for BMC implicitly shifted the focus of this research toward the profitability of some architecture change evaluated, as suggested by the BMC, as difference between estimated costs and revenues. In future research, we will attempt replacing cost analysis with other types of quantitative analyses in the EA domain and relate that not just to profit (in the BM domain), but also to other types of business values or risks. This could help us understand the impact of other such IT/EA non-functional properties on business values and risks.
- Finally, as it can be seen, all the models presented in this study have been realized using an existing modeling tool, that supports the BMC, and the ArchiMate 2.0 meta-model extended with the newly proposed value-related concepts, thus providing an integrated modeling environment. However, integrating and chaining the used analysis techniques (and possibly of other techniques) in this modeling tool is still work in progress.

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