A Viewpoint for Representing Costs in Enterprise Architectures

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***Abstract*—Costs are fundamental in any organization, but Enterprise Architecture(EA) lacks a viewpoint for costs despite being widely used to cover many other stakeholders concerns. In this paper we propose a viewpoint for ArchiMate to represent costs based on the Time-Driven Activity Based Costing (TDABC) method. The proposed viewpoint includes the concepts, relationships and attributes that represent costs according to TDABC in the context of an enterprise architecture. The proposal was evaluated using a demonstration based on Harvard case study about a pharmacy. We conclude that representing costs in the architecture enables a higher degree of transparency and better decisions based on costs.**

***Index Terms*—ArchiMate, Costing, Enterprise Architecture, TDABC, Viewpoint**

I. Introduction

Enterprise Architecture (EA) is a practice that has been gaining popularity in recent years, being widely adopted by several organizations [4] [21] [27]. EA was originally created to understand and manage the complex and chaotic real-world of enterprise-wide IT systems [22]. However, with its evolution it actually serves a bigger purpose, being used as a map with information of the current situation and strategies for future directions of the organization [22] [27], not only on the IT level.

This evolution was mainly focused on functional properties (functions that a system provides and the way in which it performs these functions) [28]. In contrast quantitative aspects (qualities of these functions), like cost or performance measures, have received less attention [22] [28], specially EA costs analysis, which is a subject where few research was made.

One of the most important concerns, regarding EA quantitative analyses, that the main stakeholders of EA would like to see addressed is the EA costs concern [22]. This concern is a priority because costs are fundamental in any organization [1]–[3] and according stakeholders' opinion, by addressing this concern it could help them to decrease the costs related to the business organisation [22]. This is relevant because in order to reduce costs, managers need to know the principal determinants of cost, which are not always obvious, and that if poorly understood can comprise the total cost estimation, affecting the quality of the organization' cost information. According to Kaplan and Cooper [7] poor cost information about the organization' cost objects, leads to a bad competitive strategy, which may affect the organisation performance, having direct impact on its results.

ArchiMate is an EA modelling language that covers a broad range of aspects, from the technological layer (e.g. hardware), through applications running on top of it, to business processes supported by these applications, allowing to represent EAs, costs and also the relation between those costs and their sources (EA elements).

In this paper we present an approach to estimate, manage and represent the cost analysis of EAs. This approach is based on a mapping between ArchiMate and Time-Driven Activity-Based Costing (TDABC) [12], which allowed us to create an ArchiMate viewpoint framing a set of concerns, for supporting EA cost analysis concern. The solution has one major objective: a specification of the concepts, relationships and attributes that capture the fundamental information for representing and reasoning upon costs of an EA description.

The remainder of this paper is structured as follows. Research Methodology describes the method used to guide our research. Then, Research Problem presents the problem that this proposal intends to address, as well the motivation to solve it. Section IV covers some background information about the problem domains. section V presents the existing literature regarding the problem domain. In section VI, we detail our proposal, as well the main objectives that we want to achieve with its use. To demonstrate our work, in Section VII the application of our proposal to a case study is presented, followed by the evaluation of that demonstration in section VIII. Lastly, some concluding remarks are given in section IX.

II. Research Methodology

Design Science Research Methodology (DSRM) [5] was chosen as the research methodology to be used throughout this research. This methodology aims at developing solutions (artifacts) to important business problems overcoming traditional research methods whose final result was most of the times merely explanatory and theoretical, not being applicable to the problem found. Such artifacts

include constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices) and instantiations (implemented and prototype systems) [5]. This IS methodology is widely-adopted by researchers due to its appropriateness to researches that intend to create, evaluate and improve innovative IT artifacts, which is the case of our proposal. DSRM, according Peffers [5] is an iterative cycle composed of six steps:

- **Problem Identification:** present and explain the research problem together with its importance to the relevant community;
- **Objectives Definition:** describe the solution' objectives inferred from the problem definition, in order to solve the identified problem;
- **Design and Development:** describe the functionality of the artifact that will be developed as well the models and methods applied to create it;
- **Demonstration:** demonstrates both the feasibility and the utility of the artifact to solve one or more instances of the problem. Examples of demonstrations are experimentations, simulations, cases studies, proofs, or other appropriate activity;
- **Evaluation:** measure and classify the usefulness, quality and the effectiveness of the artifact. It can be done according to several methods (observational, analytical, experimental, testing or descriptive);
- **Communication:** communicates the problem and its relevance, the research proposal (artifact developed), and the utility of the artifact to researchers and other relevant audiences.

III. Research Problem

EA is a powerful tool, one of its main purposes being to assist managers in the process of decision making by offering an insight into cross-domain architecture relations, typically through projections and intersections of underlying models [6]. In order to provide such support, EA models should be amenable to quantitative analyses of various properties (e.g. performance, availability, cost, etc.), thus providing a basis for fact-based EA-related decision-making. According a survey [22], several Chief Information Officers (CIO) (corresponding to the EA primary stakeholder) declared that their major expectation is to use EA to decide about organizational costs. However, even though costs are fundamental for an organization to guide their decision making process [1]–[3] and EA being a crucial instrument to help and guide stakeholders in this process, there is little or no explicit support to include cost information in EA, thereby allowing better decisions.

Although ArchiMate be used for modelling EA descriptions and allows to model costs through the motivation element "Value" [16] it is not possible to fully address the EA costs concern. The main reason for this limitation is because it does not exists a selection of a relevant subset of the ArchiMate concepts and their relationships that allow to model this concern with the necessary level of detail regarding all the necessary cost information (how much a resource costs or what is the capacity of a resource), so that is possible to apply a cost method while modelling an EA, adorning the relevant entities, like resources or cost objects with pertinent cost information. So there is a challenge that has to be overcome, which is: **the lack of a solution to integrate the knowledge from EA models with cost models**. Otherwise EA will continue to lack an important aspect regarding decision support, that would enable cost transparency [12] by tracking the total cost of a cost object to all its cost determinants (EA elements), allowing to view where money is actually being spent. This would also aid stakeholders, like managers or CIOs, to perform EA-related decision based on costs more easily. An example where such a feature would be useful was to quantify the cost of alternative design choices, allowing to have cost-based criteria for the decision, as well to improve the degree of transparency when informing other relevant stakeholders about the decision taken.

IV. Theoretical Background

This section intends to give a brief overview of the context where this work is inserted. To do this we start by explaining the main concepts related to identified problem and also the ones that are going to be used to address it.

A. Enterprise Architecture

Enterprise Architecture (EA) allows to describe, design and control several parts of an organisation's structure (business processes, applications, technology) by applying architecture principles and practices to guide organisations to fulfil their organisational objectives [6]. This way it provides an holistic view of the organisations, based on views that allows to see the relationship between artifacts and architectures, as also the existent dependencies between the various layers of the enterprise [6]. The alignment between the organisation' layers allow to have a blueprint of the organization, which is used to manage and align assets, people, operations and projects to support business goals and strategies, improving the governance of its processes and systems [9] [10].

B. ArchiMate

ArchiMate graphical modelling language is a standard from The Open Group used by scholars and practitioners worldwide [31] to describe, analyse and visualize an architecture representation in its several domains [6].

The objective of ArchiMate is to help and guide the stakeholders designing, assessing and communicating the consequences of decisions and changes within and between the several business domains by providing a graphical notation to represent EA over time [6].

The central part of this language (Core) defines the elements (concepts and relationships) that are necessary to model an EA [6]. ArchiMate core has a layered look due to its division in layers: business, application and infrastructure. Regarding the aspects ArchiMate distinguishes in each layer the several elements in three groups according to its characteristics: Active, behaviour or passive structure.

Respecting visualization and according with the Zachman Framework [8], ArchiMate allows to have a separation of concerns through the use of views. These views are defined by viewpoints, which is a sub-set of concepts and relations that allows to model and focus on a certain aspect of the EA. The main purpose of viewpoints is to serve as a mean of communication about certain aspects of an architecture. The aspects and the viewpoint content are based on the stakeholders' concerns. So, even though there is only a single EA for an organization, all of its stakeholders can benefit from it, since through viewpoints, each stakeholder can view the EA according to its needs, ignoring the irrelevant aspects to him, but that may be relevant to other stakeholders.

1) Extending ArchiMate: ArchiMate is one of the most expressive modelling notations in the EA domain. Therefore the language' core, embedded in the ArchiMate metamodel, contains only the basic concepts and relationships that serve general EA modelling purposes. However, the language should also be able to facilitate, through extension mechanisms, specialized, or domain-specific purposes.

For this purpose ArchiMate provides an extension mechanism that allows to extend its core by adding attributes to ArchiMate concepts and relationships. For example when interested in performing detailed quantitative analysis using key performance indicators [11].

Since one of the goals of the ArchiMate language [6] is the integration of detailed design models, together with the characteristics presented before, it is perfectly suited to address the problem previously identified.

C. Costing Method

Generally, there are two possible approaches of estimating costs: bottom-up or top-down [33]. Top-down approaches are based on resource's use estimates, being their results dependent on the quality of the estimate used. Bottom-up approaches such as activity-based costing (ABC), quantify the amount of each resource that is used to produce a service and apportion costs accordingly to to estimate unit costs [33]. Therefore, the results of these approaches are more feasible, however, comparing with the top-down, they require more effort to implement [33]. In spite of its advantages, it has been difficult for many organizations to implement ABC due to problems related with its implementation and collection of data [12].

1) Time-Driven Activity Based Costing: Due to several criticisms of the ABC, its authors without fully abandoning the concept (after all it helped many companies identifying important costs [13]) came up with a newer and refined ABC. This method was the Time-Driven Activity Based Costing (TDABC), that was simpler, more flexible and easier to implement.

TDABC only requires two estimates: (1) capacity cost rate (CCR) of a resource (calculated by dividing the total expenses related to a resource by its practical capacity (amount of time that a resource is available to work)), and (2) time needed to execute each activity. With these two measures it is possible to determine the cost of an activity, by multiplying the time taken by its unit cost.

To solve the ABC low flexibility problem, due to fact that a small variation in an activity originated a new activity in the ABC method, TDABC introduced the concept of time-equation, that is a linear equation that represents costs in function of the time and resources it consumes, allowing to represent conditions and cycles.

An example of this, is the case of the activity "Process Order" in a logistics department, that for special needs, extra time is needed to finish. In ABC this would result in two activities, "process normal order" and "process special order". In TDABC its simpler because this variation can be expressed in the same equation (eq. 1), reducing the number of existing activities in comparison with ABC. This equation means that processing an order consumes 5 time units of the logistics department for every order, plus 3 additional time units for each special order. This way it is possible to consider a greater complexity of the reality avoiding an exponential growth of the number of activities by grouping all the activity' variations in a single time equation.

$$\text{Order processing} = 5 + 3 * [\text{ If special }] \tag{1}$$

Another advantage of the TDABC is the possibility of measuring the unused capacity that can give the ability to perform capacity and predictive analysis [12].

We decided to focus on Activity-Based methods, like TDABC, since our objective is to calculate the cost of a service or product, and some of the other existent costing methods are outdated (e.g. direct costing) or are focused on value (e.g. Lean) or on quality (e.g. Just-In-Time), and so on. Also, there is a clear parallelism between the activities defined in Activity-Based methods and Business Processes in ArchiMate, which will make the connection between the diagrams and the costing template easier.

V. Related Work

The related work consists of contributions dealing with EA cost analysis. One of the first initiatives where this non-functional EA aspect was addressed was [32], where associated to a possible EA scenario was its probable cost. This way stakeholders would have a criteria to decide about the best scenario to choose. However this cost may not be entirely representative, since it was estimated based on unfounded assumptions instead of its absolute value.

In the case of [31] even if it is presented an ArchiMate costs viewpoint to address the EA costs concern, the way

costs are calculated is based on simplistic traditional cost methods, which may distort the real value of a cost object.

Similar to [31], in [24] ArchiMate is used to model EA' costs, however even being a viable solution to represent costs, the cost analysis method used in this work in some cases may lead to incorrectly estimates due to the way how the resources' cost is allocated. For example the cost of a behaviour element (e.g. business process) is the sum of the cost of all resources used by that element, however in case we are considering a resource that is used by more than one business process at the same time, its cost cannot be considered twice, instead it as to be divided between them according an adequate criteria (e.g. if two business processes are being performed at the same time, in the same facility, but in different rooms, the facility cost has to be divided by the two business processes, using as criteria the space occupied by each one of them). Furthermore, this proposal does not consider all the relevant kind of resources, not allowing to address all the possible cost analysis scenarios. For example, in case of a human resource, it can be modelled either by a business actor (the only option considered in [24], which is the most common) or by a business role (in some organizations an employee can have different costs according the role performed).

In [23] ArchiMate is used to represent the business models of an organization using Business Model Canvas (BMC), serving a bigger purpose than only to address the EA costs concern. The cost analysis method used in this work is an updated version of [24], overcoming one of its predecessor limitations by considering all the resources concepts necessary to model all the possible scenarios. However in BMC only the key resources are considered, leaving aside indirect resources, which even if not directly linked to a cost object are necessary to run the business and may have a considerable impact in its final cost.

All approaches previously mentioned, although being a valid option to represent costs have some issues regarding the way costs are calculated. This is mainly due to the absence of the use of an appropriate costing method. However according our literature review there are two approaches [14], [15], where EA' costs are calculated according an appropriate costing method. In these proposal the authors present a method to apply TDABC in a business process (modelled in Business Process Model and Notation). Both proposals are valid options to estimate organisation' costs, however, even if considering all the different cost sources, they allocate all those costs to human resources, making difficult to know what are the resources necessary to realize a certain product or service and also to distinguish their impact on its the final cost.

All the existing solutions although related to the identified problem do not solve it entirely, because none of them considers all the relevant aspects necessary to solve the problem. Some of the key aspects that a solution for the problem identified in this paper should take into account are: allow cost analysis according an appropriate cost model (like TDABC, which we believe, that in addition to its advantages is the costing method most appropriate to use in case like this), based on the organisation' EA (in order to benefit of its advantages) and easy to analyse and understand (in order to facilitate its use as also to communicate effectively and clearly - with transparency - its results and conclusions to relevant stakeholders).

VI. Proposal

This section presents an ArchiMate viewpoint that allows to apply a costing method (TDABC) while modelling an EA, making possible to verify the costs associated to an EA. The aim is to support communication and decision-making amongst stakeholders during the cost analysis process. The viewpoint specifies the concepts, relationships and attributes that must be taken into account when considering the cost analyses of a certain cost object.

A. Objectives

The main objectives that we intend to fulfil with the use of this proposal by **improving cost representation in the EA** are:

- Express and reason upon the underlying elements regarding EA costs concern;
- Enable stakeholders to know their EA real costs;
- Aid in the communication and decision-making towards EA costs;

B. The viewpoint

Our proposal is based on two artifacts: a mapping (between TDABC and ArchiMate) and an ArchiMate viewpoint (based on the previous mapping, with the purpose of explaining how to use ArchiMate in order to make possible to apply TDABC while modelling an EA).

The first step to reach our viewpoint was to identify the TDABC main concepts and only then map them in the possible ArchiMate elements (first column of Table 1).

The ArchiMate concepts suitable to be related with the TDABC concepts, are not in a single layer, once a cost model in order to be useful needs several types of information from the various layers [12].

To define a valid correspondence between the two we started by comparing the concepts existing in TDABC with the (definitions of) concepts specified by ArchiMate.

Table 1 shows and motivates the proposed correspondence that resulted from this comparison. Remind that this is a unilateral mapping relation and not bilateral one.

As can be seen, not all the TDABC concepts have a correspondent ArchiMate element (these being modelled as other ArchiMate elements attributes), even being ArchiMate a very rich language. This is due to ArchiMate not consider the time, which is a vital concept for TDABC (time is used to describe the resources' capacity and the unit time estimate of an activity). Thus, the only way to model time is extending ArchiMate using for that purpose the attributes of an element. In our case, those elements

will be the elements that represent a resource and the ones that represent an activity.

Besides modelling time through an attribute we opted to model other concepts this way, like "Cost of capacity supplied", "CCR" and "Activity Cost". These cost related concepts could have been both modelled by the concept "Value" (implicitly), just like the "Total Cost" element, however, there was another option to model this concept (explicitly), like it is described in [16]. The reason behind this option was merely to simplify the diagram visualization, allowing to keep it simpler and easier to read.

"Final cost" was the only cost related concept that was modelled implicitly because there is only one cost for a cost object (what does not have a big impact on the diagram complexity) and because it is the main result that we aim to check with the use of this viewpoint.

Regarding TDABC-ArchiMate resources mapping, we based on Technology Business Management (TBM) framework[1] to name the different types of resources (as can be observed on Fig. 1). The main reason why we did this was that the TBM framework provides a standard taxonomy to describe cost sources, and also due to one of its stakeholder be the CIO (same as ours). Thus, by using this taxonomy we are assuring that the terms used are understood and mean the same thing for everyone, allowing to create a basis for costs transparency and providing a standard taxonomy for reporting costs. Another aspect worth mentioning is that in case of a Facility we represent in parentheses the facility' space where the activity takes place (see fig.3). Otherwise in case we have two parallel activities being performed on the same facility in different rooms, we would be considering the facility's cost twice, instead of dividing its cost by the two rooms.

After the most suitable matches for TDABC were found in ArchiMate, we analysed the relationships between them in order to match TDABC relationships with ArchiMate relationships. The result of this step is presented in Table 2 and it was obtained as follows: for each pair of TDABC concepts among which a TDABC relationship exists, we

[1]https://www.tbmcouncil.org/learn-tbm/tbm-taxonomy

Table 1
Defining the correspondence between TDABC and ArchiMate

TDABC	ArchiMate	Justification
Activity	Business Process	An activity [in the TDABC] is defined as any event, unit of work or task with a specific goal. This definition conforms to the ArchiMate definition of Business Process, once both define it as something with an objective, which this case is to realize a cost object.
Resource Pool (Labour, hardware, software...)	(Resource) - Business Actor - Business Role - Application Component - Node - Facility - Business Service	A resource [in the TDABC] is defined as a factor required to complete an activity. This definition reproduces almost literally the definition of "Resource" ArchiMate element. Due to this and according with [6], the particular cases of a Resource are: Business Actor; Business Role; Application Component; Node. Besides these we considered also the "Business Service" to represent outside resources (e.g. electricity, security, maintenance, etc.), which are not directly involved in the production of a cost object, but without which it would not be possible obtain one. These types of resource are usually used to serve other resources, assuring their normal usage. ArchiMate [6] does not consider it as a resource, but according TDABC [12] and other authors [17], it clearly is one.
Practical capacity (min)	Resource Attribute	Practical capacity [in TDABC] refers to how much a resource can really do within a given period, being less than its theoretical capacity. ArchiMate cannot model or express time, remaining as the only solution to represent it through an attribute, in this case a resource attribute.
Cost of capacity supplied (€)	Resource Attribute	This equivalence was already presented and established in another work. "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 modelling cost as value), the modelling of cost sources is explicit, while that of costs themselves is implicit" [16].
Capacity Cost Rate (€/min)	Resource Attribute	The resource's capacity cost rate [in the TDABC] is calculated by dividing its cost by its capacity, usually expressed as a cost per hour. So, this measure is a cost per unit of time, thus it is still a cost. So it can be explained by the same reason presented in the row above.
Cost Object	- Business Service - Business Product - Stakeholder	A cost object [in the TDABC] is an item for which costs are separately measured. There are two types of cost objects: Output (internal to the organisation (e.g. product, service), allowing to know the cost of its output) or Business relationship (external to the organisation (e.g. customer), to determine the cost of dealing with that entity). The first type has a direct match to ArchiMate concepts. The last one is a particular case of the concept "Stakeholder" [6].
Time Driver	Business Object	A time driver [in the TDABC] is a factor that influences the duration of activities. In ArchiMate the element that can be associated to an activity (represented by a "Business Process" according our mapping) and that can influence its duration due to its information content is the "Business Object" (e.g. the time necessary to process an order is proportional to the number of items ordered, that are described in an order, which in ArchiMate is represented as a Business Object).
Unity Time Estimate (min)	Business Process Attribute	Same reason as "Practical capacity".
Time equation	Business Process Attribute	TDABC estimates the resources demand by a time-equation [12]. Just like "Practical Capacity" this concept is also related with time, intending to model the time that an activities took to be performed. By the same reason given for "Practical Capacity" we choose an attribute to model this concept.
Final Cost (€)	Value	Same reason as "Cost of capacity supplied".
Activity Cost (€)	Business Process Attribute	Same reason as "Cost of capacity supplied" and "Final Cost".

analysed the ArchiMate meta-model and selected the most suitable relationship that is allowed between the corresponding ArchiMate concepts.

Table 2
Relationship matching

TDABC relationship	ArchiMate relationship
is a	Specialization
associate	Association
is realized	Realization
assigned	Assignment
serve	Serving
has	Element attribute

After completing all the necessary mapping both for concepts and relations we were able to create the second artifact mentioned in the beginning of this section, the costs viewpoint (Figure 1).

C. Viewpoint Classification

This viewpoint represents the costs of an organisation's cost object, according to the EA that supports it, allowing to depict the resources necessary to create it and the cost of each one of them, and also the cost and unit time estimate of the activities that are executed to create it. This viewpoint could benefit many management processes where cost analyses are needed, like price setting, budgeting or planning, facilitating processes and helping managers to inform relevant stakeholders easily.

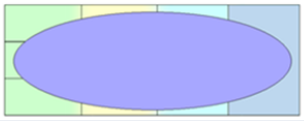
Costs Viewpoint		
Stakeholders	Managers, CEO, CIO, others	
Concerns	Cost information, resources, activities and costs objects of an organization	
Purpose	Deciding, informing	
Abstraction level	Coherence, overview	
Layer	Business, application, technology, physical	
Aspects	Passive structure, behaviour, active structure, motivational	

Fig. 2: Costs Viewpoint Description. Adapted from [29]

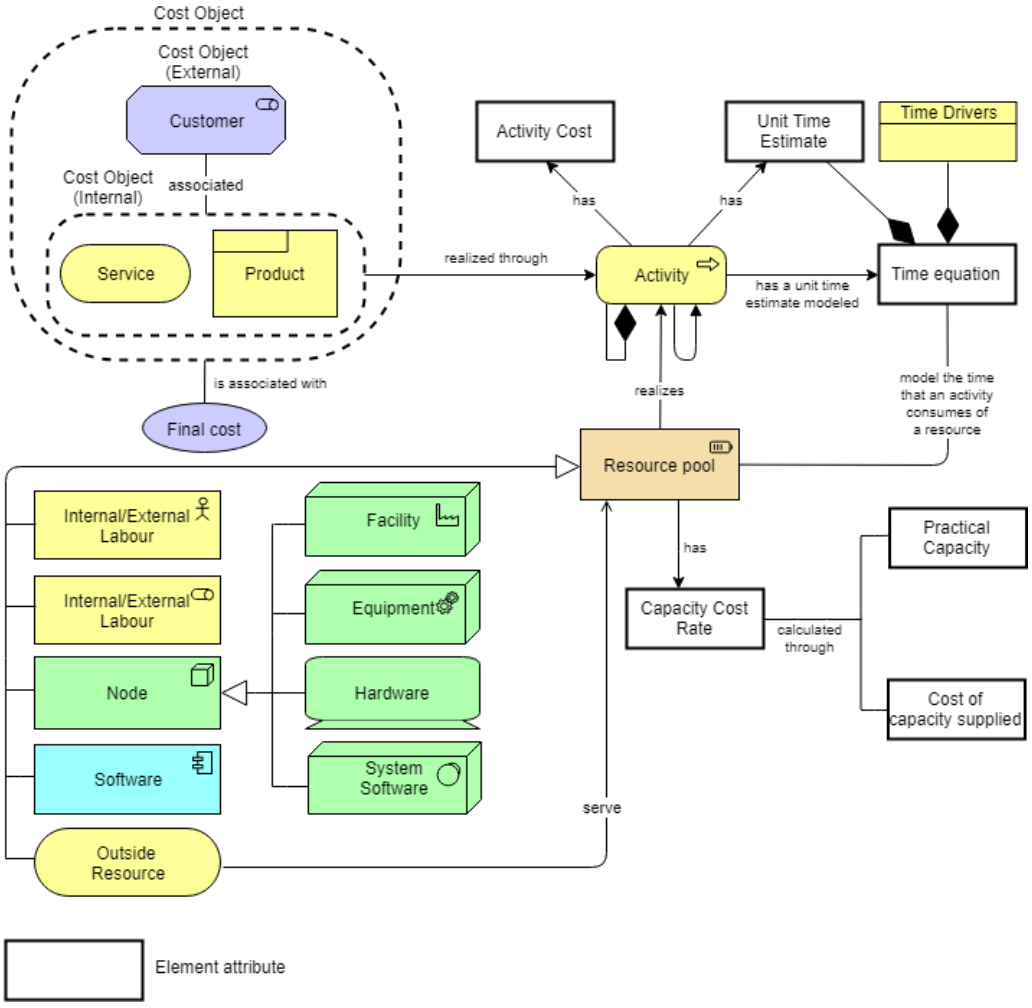


Fig. 1: ArchiMate costs viewpoint

VII. Demonstration

This section presents an application of our viewpoint towards representing the costs of an EA. To demonstrate the utility of our proposal we chose pharmacies due to the crisis that is affecting this sector and that has brought a new necessity to pharmacy managers to gain a deeper understanding of their business costs through real-world evidence instead of assumptions, so that they could gauge their potential impact on pharmacy management [17]–[19].

Regarding this worrisome situation, we applied our proposal to this problem in order to aid pharmacy managers to have a better view of their costs, specially the ones related with their major service, script fulfilment [17].

For that purpose a well-known Harvard case study [20] was used to model the EA that was supporting the prescription fulfilment service (cost object under analyses). In this case study [20], the current prescription fulfilment process on CVS pharmacies is described. CVS is one of America's largest retail drugstores with over 4,000 stores and revenue of $24.2 billion per year. Even though the CVS pharmacy' EA wasn't modelled in this case study, with the description (process flow, main activities, resources involved) presented on it we were able to model the EA that was supporting the prescription fulfilment service, so that we could apply our proposal.

After modelling the EA (Fig. 3) according our viewpoint, it was only missing to add the attributes, first to resources and then to the activities.

In the case of the resources their practical capacity was estimated according Kaplan approach [12], considering 365 days of a year, subtracting weekends (104 days), holidays (10 days), vacation days (20) and expected days not worked for personal and sick leave (3 days), totalling 19 days available per month. To calculate the available hours, an 8-h shift workday was considered and then multiplied by 90%, so that we can consider the time for breaks, training, education, or repairs and maintenance, to obtain the available capacity of the resource. A simplifying choice was made to consider this available capacity of resources equal for every resource, from human resources to space and hardware, since a pharmacy cannot operate without a pharmacist being present.

Having the practical capacity in every resource was missing to add the cost of capacity supplied to each one. Though this case study is well detailed, it lacks this information. So, in order to overcome this limitation we used the cost information obtained from a field study carried out in a Portuguese pharmacy, where we interviewed the pharmacy manager and consulted the pharmacy' accountant sheets of that month.

Having all the resources' attributes filled, the only remaining thing was to add the ones related with the activities (unit time, Activity Cost Rate (ACR) and activity cost) (Table 3). The first one was obtained from the case study description. The ACR was calculated using equation 2, by adding the different CCR's of each one of the resources that are assigned to that activity.

$$\text{Activity Cost Rate (ACR)} = CCR_1 + ... + CCR_n \quad (2)$$

With all the ACR's calculated, it is now possible to find the cost of each activity (Table 3), using equation 3, multiplying its unit time (obtained from the case study) by its ACR (sum of the CCRs that realize the activity). Therefore, it is now possible to find the cost of a specific service by adding the several activities' cost using the equation 3, where t1 is the time spent with the first activity and so forth.

$$\text{Service cost} = \underbrace{(t_1 * ACR_1)}_{\text{Activity-1 Cost}} + ... + \underbrace{(t_n * ACR_n)}_{\text{Activity-n Cost}} \quad (3)$$

Table 3
Activities Cost rates

Cost rates for the activities	Unit Time Estimate (m)	Activity Cost rates (€/h)	Cost (€)
Drop-Off	1	22.32	0.37
Data Entry	1.5	39.60	0.99
Production	2	30.24	1.01
Quality Assurance	1	31.32	0.52
Pickup	2	39.60	1.29

As seen in Fig.3, not all the elements modelled in this view have the same size, since resource's size is proportional to its CCR and the activities' are proportional to their cost. This way we can easily verify which are the most expensive activities and resources, facilitating the perception of the main cost determinants of a cost object.

The resources and activities' attributes (e.g. practical capacity or activity' cost) cannot be seen in the diagram, but they are "inside" of each element (e.g. resources and business processes) as attributes (see Fig. 4).

Moreover, we refer that the average cost obtained for the prescription fulfilment service was 4.18€.

VIII. Evaluation

To evaluate our proposal and its application we performed both qualitative and quantitative evaluations. First, we obtained feedback about our work with the staff of a Portuguese pharmacy where we obtained the cost information used in the demonstration. For this purpose we interviewed the pharmacy staff (2 pharmaceutical techniques and 3 pharmacists, one of whom was the pharmacy manager). The interviews were conducted by one author over a period of two days and each one lasted on average about 20 minutes. To support and conduct the interviews we developed a questionnaire with both open and closed response questions about accountancy, EA and the use of our proposal for integrating costs on the EA.

According the first part of the interviews results, where we tried to characterize our interviewees, all of them had little or no knowledge about EA, as was expected in a pharmacy, however two of them had knowledge about

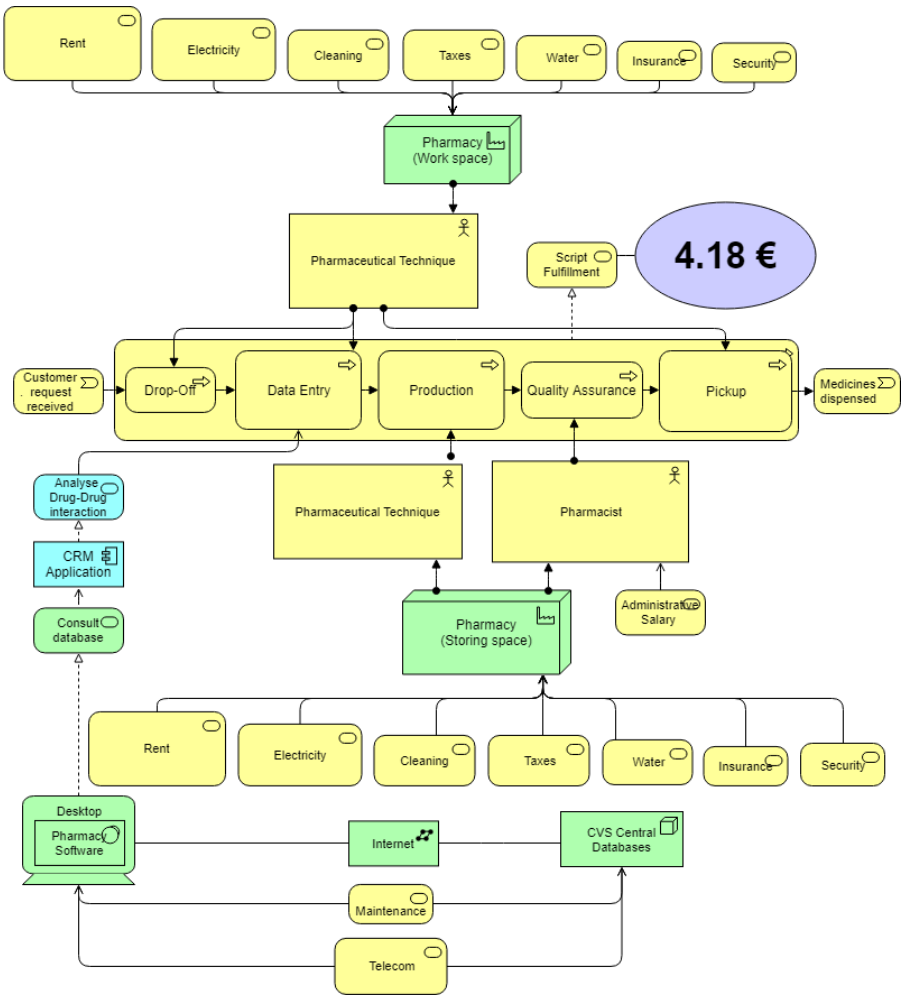


Fig. 3: Prescription fulfilment service supporting EA for CVS Pharmacy

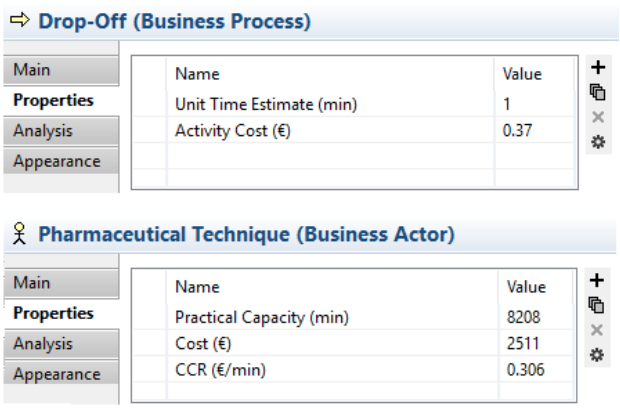


Fig. 4: Activity (Drop-Off) and resource (Pharmaceutical Technique) attributes

costs, those interviewees were the pharmacy manager and another pharmacist who helped him in pharmacy management subjects. These two were our main focus, since they were the ones whose feedback could help us the most. The second part of the interview was mainly focused on our proposal and the demonstration presented on section VII, and it had as main objective to understand if they were able to comprehend it, if they review on it and also what were the advantages/disadvantages that they saw in it.

The feedback was rather positive since: 1) we were able to validate the importance of our research problem, since we were told that there was a huge lack of knowledge about the business cost and specially its source. Pharmacy manager stated that: "We have no idea about how much cost to have a prescription dispensed, the only thing we know is that many prescriptions generate losses due to the low profit margin that we get. The pharmacy financial sustainability is mainly due to the sales of non-medical products". Another relevant aspect highlighted was that analyses like the one we did were too expensive; 2) there is a need for implementing costing models in organisations, however the cost associated to this kind of processes, generally, is not affordable; 3) the results presented by us were considered useful; 4) our proposal was easy to understand even by someone with little knowledge of accountancy

and EA experience and; 5) there is no equivalent solution available at a similar price, at least that they know.

Besides this, the two pharmacists with cost experience said: "we already tried to implement a costing method by our own, but it was too complex and time requiring". However they found our proposal much easier to implement and comprehend than a normal costing method. An aspect they would like to see in a future iteration of our work was to take advantage of their IS to transfer the necessary data to our solution, in order to allow a more detailed and deep analyses.

Regarding quantitative evaluation we used a framework [30], which despite being specific to evaluate software architecture viewpoints, it can also be used to evaluate EA viewpoints. So, we evaluated our viewpoint respecting its language precision, assessing its abstract syntax, concrete syntax, static semantics and semantics (Fig. 5 & 6).

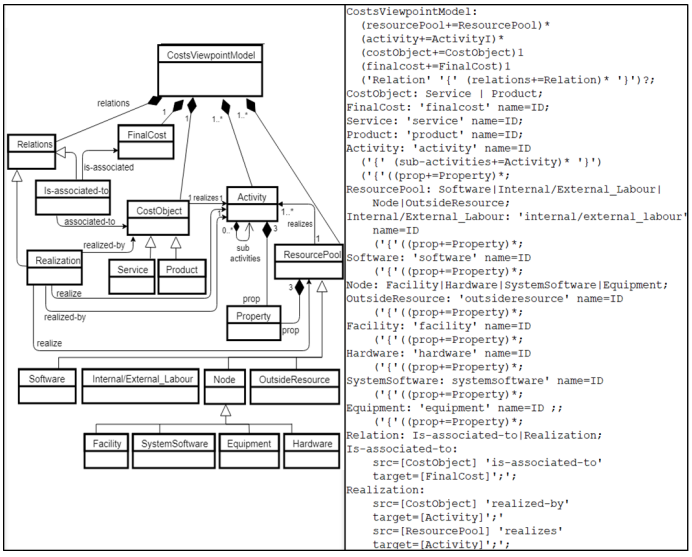


Fig. 5: Abstract Syntax and Grammar

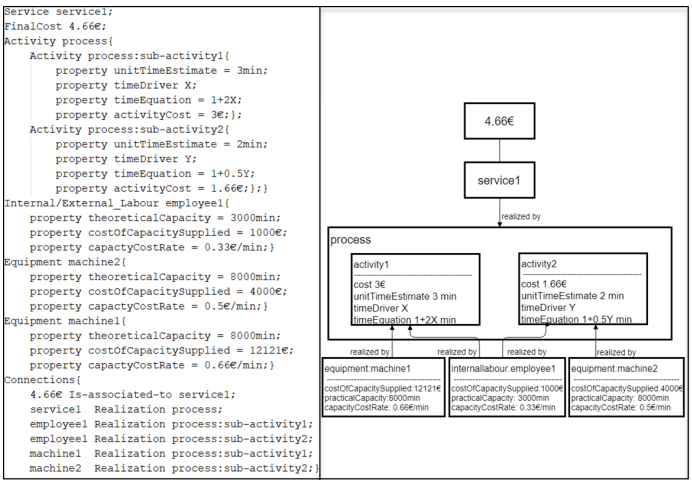


Fig. 6: Textual and Visual Concrete Syntax

Regarding abstract syntax definition (Fig.5), our viewpoint falls into level L2 of the evaluation framework. The concepts to be used are defined textually, textual description is clear; it can be easily translated to a formal model. Concrete syntax can be considered at level L3, Since both informal and semi-formal notations are provided (Fig. 6). Regarding static semantics, we did not specified any rules beyond those ArchiMate has, however there are some rules missing (e.g. a support resource can serve another resource, however that resource cannot be a support resource). So we consider this at level L1. Finally, regarding the semantics we consider it at level L2. The concepts used are sufficiently explained in natural language but not formally defined. The above results show that we can map our viewpoint to a domain specific language that can be used to define executable models (model that has everything required to produce the desired functionality) and also provides insight of the degree of formal precision of the viewpoint description.

IX. Conclusion

Costs are fundamental in any organization and according EA stakeholders, estimating and managing costs is one of the major concerns they pretend to address with the use of EA, because in their opinion, it can help them to decrease the costs related with business organization. However, so far EA does not support such concern, since there is

The EA costs viewpoint presented in this paper intends to address this concern by improving cost representation in the EA, allowing managers to know the costs of their business, offering them a way to trace the costs of the organisation outputs to each one of the organisation' resources. This way our viewpoint will allow to support organisation' strategy in a better way, enabling an higher degree of transparency regarding costs, helping them in the pricing process and allowing fact-based EA-related decision-making.

An application of the viewpoint was demonstrated by applying it to a pharmaceutical service.

One of the limitations of our proposal inferred from our demonstration is the scalability. As we can see, for a simple service like the one modelled in our demonstration we have more than 30 ArchiMate elements, which according to Horton [25] is the maximum number of elements that a diagram should have in order to be easily understood. So when considering a more complex scenario, it will raise the level of complexity to the point that eventually becomes unreasonable to comprehend and analyse the view.

Finally we believe the next steps are to obtain feedback from the scientific community through submission of papers to conferences, resume the development of the solution, and then carry a series of case-studies in order to demonstrate and validate the instantiation of our proposal.

Regarding future work, we foresee several possibilities to extend our research in the next iteration. First we will take

advantage of time equations in order to add to our solution a way of measuring the unused capacity that can give the ability to perform capacity and predictive analysis. Besides this, in order to deal with the complexity problem we will take advantage of ArchiMate views and also of Buuren' work [26], so that we can keep our approach in line with the ArchiMate specification, but reducing the complexity of the models, facilitating stakeholder-specific visualisations. After implementing and receive feedback about these new aspects of our proposal we will apply it to a more complex field study, in order to understand its appropriateness to deal with more complex cost objects than the one under analyses in this paper. Lastly our ultimate goal is to implement our proposal in a commercial Enterprise Architecture Management Tool.

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