doi: 10.36689/uhk/hed/2019-01-043

Activity Based Costing and Process Simulations

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Abstract. The article is focused on the usage of Activity Based Costing (ABC) and process modelling, Business Process Model and Notation (BPMN) to be precise for simulation modelling. This connection is applied to the predictive simulation of costs of Alzheimer's Disease (AD). The aim of the article is to describe the application of these two methods in a new problem domain and in doing so possibly outlay a new way of use. The article builds on the already existing applications of the combination of ABC and BPMN on specific processes and elaborates it in a more abstract process which operates with a high rate of coincidence.

Keywords: Activity Based Costing, BPMN, Business Process Management, Simulation, Model.

1 Introduction

At present time, there have been trends of percepting businesses in a more complex way. This holistic view of businesses then leads to a much bigger interconnectedness of individual parts of the business. This article focuses on the Activity Based Costing method (ABC) and process perception of a business. ABC is an accounting and calculation method which assigns the business's costs to individual activities. These activities are the basic building component in analysing and modelling processes.

The article explores the connection of ABC and modelling processes with the help of Business Process Model and Notation (BPMN) with the goal of predicting costs of the Alzheimer's Disease. Prediction is realized with the help of a modelled process and simulations of its course. Connecting ABC and BPMN is not a frequent connection and therefore opens possibilities of interesting expansion of well-known BPMN notation in economic sector. BPMN and Time Driven Activity Based Costing were used in the article [17] where the testing and evaluation of abilities of chosen BPM tools in relation to the model of costs based on TD ABC were presented. The article [2] demonstrated the use of TD ABC when analysing the proposed system with the help of BPMN for state universities. Articles [8,9] show detailed process model of business sources and administering the costs inspired by the accounting principles based on the activity (ABC).

2 Activity Based Costing

The advantage of this method when compared with others is the effort of evaluating each single activity instead of an evaluation based on allocation bases. [12,13] This primarily demands a total change in the business perception and in the approach to the costs calculation, e.g. the separation of costs to fixed and variable is redundant. On the other hand, thanks to this method, it is possible to evaluate the products in areas where the classic calculation methods do not apply, or the conditions are specific, for example, a small lot production and the costs of machine adjustments. Typically, it is a fixed cost, but in case of a small lot production where the machine has to be adjusted for each product, otherwise, it would be a variable cost. The second area is work sharing, e.g. a group of experts which influences the functioning of nearly the whole business.

ABC method is based on assigning costs to particular activities which are furthermore grouped into a process where the costs of the whole process are aggregated. Especially the determination of indirect and overhead costs of particular activities is problematic. That can be in practice solved in different ways, for example, the principle of causal link or the principle of tolerability [4,5].

We shall define the basic terms which are bound to the costs' allocation (according to [2,8]):

- Activity – primary elementary component
- Function – an alternative to activity, it is possible to group them, both can define inputs and optionally outputs
- Process – grouping of activities which with the help of the inputs create outputs, their further division into main and supporting is possible
- Sources – inputs into process or activity, using them creates costs
- Costing object – they are the reason for source usage, they are valuable for business
- Quantity of reference – once again an alternative to the costing object, the reason of source usage

If the costs are defined this way, it is then very easy to use it in the area of process modelling where it is possible to predict how the costs will change when altering particular parts of the process.

3 Process Model and Simulation

At first, we need to define what process is, and the following definition serves that purpose: „… a collection of inter-related events, activities, and decision points that involve a number of actors and objects and that collectively lead to an outcome that is of value to at least one customer." [10]. The similarity of process outlook on costs area is visible in the definition.

A relatively young but plentifully used Business Process Model and Notation (BPMN) is used in the article. "The Business Process Model and Notation (BPMN) is a graphical notation that depicts the steps in a business process. BPMN depicts the end to end flow of a business process. The notation has been specifically designed to

coordinate the sequence of processes and the messages that flow between different process participants in a related set of activities." [6]. BPMN was chosen mainly because of the possibility of wider usage of usable elements which allow to accurately capture reality and to work with different abstraction.

Primary elements of BPMN notation used in the presented model are defined in the following part.

- Activity (rectangle) is the primary part of the process, work is done in the activity, takes a certain amount of time and can use sources and produce outcomes
- Events (circle) – show an impulse or execution of an event in the process, do not take any time and serve to show the change of state and dynamics in a process
- Gateways (rhomb) – manage the flow of the process and show its logical branching and merging
- Artefacts – show reports, documents and other additional elements of different importance. For this article, the key element is the one according to which the simulation is managed

4 Process Model of Alzheimer's Disease

The possibility of abstracting away particular parts of the process that BPMN allows was crucial for creating the model of Alzheimer's disease. Due to its complexity, the exact depiction of the disease's process including all the details would be an enormously complicated process. That is the reason why this model was simplified and reduced only to the aspects of the disease that generate costs.

This article is focused on the application of Enterprise Architect tool, since it is a widely used tool to model SW and it works inherently with the BMPN notation and its simulation. To be able to convey a simulation of the process with regard to the costs, it was needed to add BPSim [3,7] complement to EA which allows specifying simulation details more into depth and provides better outputs with the possibility of specification of its own markers of the process performance.

Alzheimer's disease process has its specifics and that is the reason why it is suitable to use simulation methods when predicting the costs of the process. It is mostly for situations when particular progress of Alzheimer's disease might differ in fundamental points, whether it comes to the duration of the process or different drug dosage based on the progress of the disease. All of these facts might be reflected in the size of costs or in their structure.

This model and its simulation, therefore, combine determining of simulation by time as well as data. Decision making on the basis of data is solved here with the help of Minimal Mental State Examination (MMSE) value, which shows the gravity of the disease. In practice, this value is determined on the basis of examination [15]. In this process, it is a generated variable when initiating each instance of the process. Time viewpoint is then logically used for the duration of the illness and the periodicity of particular operations such as medical check-ups and costs of drugs [14,16].

4.1 Disease Model and Costs Calculation

The model is focused on the activities which generate costs in the duration of the disease. It is mainly three groups of activities, medical examinations, costs of drugs and other professional care. This distribution is shown in the **Fig.1.** Phase I. These overall categories (in the model represents by sub processes) are then divided into individual atomic activities. Other specific examples are found in the process.

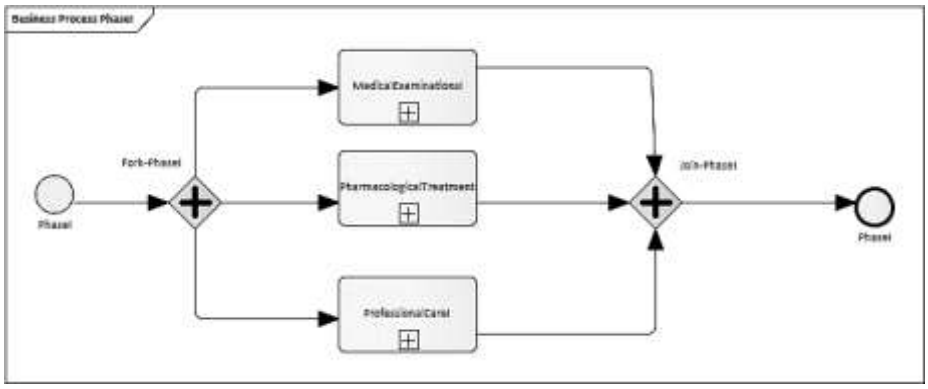

Fig.1. Phase I.

Furthermore, the course of the disease in time intervals is shown. Because of these reasons, the disease is divided into three phases, since each requires a different approach towards the patient – as shown in **Fig. 2.** Alzheimer Disease. Individual phases are then divided into sub-processes according to the logic described above. An example of a subprocess of a disease, which is managed by the MMSE score, is the subprocess of pharmacological treatment in **Fig. 3**. Pharmacological Treatment. The decision making about the choice of drugs takes place in the subprocess and the subprocess is terminated if the drop of the score is too fast.

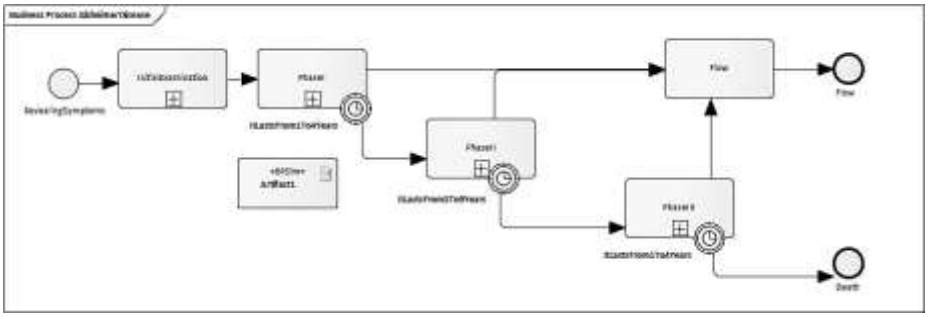

Fig. 2. Alzheimer Disease.

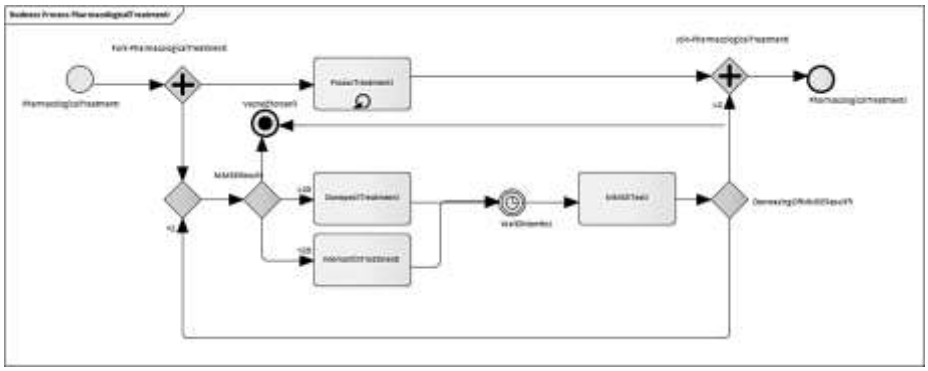

Fig. 3. Pharmacological Treatment.

5 Results

The goal of the simulation was not to calculate the real costs of the disease but to verify the connectedness of BPMN and ABC on an unusual practical problem. The results of the simulation are presented as constituent sums of individual activities and the sum of costs. These costs were then divided into individual constituent parts with the help of ABC principles. ABC method can be, thanks to its nature, used for better transformation of costs information taken from regular accounting data. It is therefore not a factual implementation, since a factual implementation of ABC is a very costly and complicated matter. The following Table 1 - simulation results in BPSim module shows chosen results of the simulation that was carried out. It is about the activity of Memantin application in the Alzheimer's Disease process. It depicts the activity in the first phase of the disease which is often repeated in the other phases, particular phases are differentiated by Roman numerals in the name of the activity.

Table 1 - simulation results in BPSim module

Category	Element	Parametr	Result
Control	AlzheimerDisease	Number Of Processes Completed	100
Control	AlzheimerDisease	Number Of Processes Started	100
Control	AplikaceMemantinuI	Number Of Tokens Arrived	900
Control	AplikaceMemantinuI	Number Of Tokens Compensated	0
Control	AplikaceMemantinuI	Number Of Tokens Completed	800
Control	AplikaceMemantinuI	Number Of Tokens Started	900
Control	AplikaceMemantinuI	Number Of Tokens Terminated	100
Cost	AplikaceMemantinuI	Total Completion Cost	2025000
Cost	AplikaceMemantinuI	Total Time Cost	0
Control	AplikaceMemantinuII	Number Of Tokens Arrived	1900
Control	AplikaceMemantinuII	Number Of Tokens Compensated	0

Control	AplikaceMemantinuII	Number Of Tokens Completed	1800
Control	AplikaceMemantinuII	Number Of Tokens Started	1900
Control	AplikaceMemantinuII	Number Of Tokens Terminated	100
Cost	AplikaceMemantinuII	Total Completion Cost	4275000
Control	AplikaceMemantinuIII	Number Of Tokens Arrived	700
Control	AplikaceMemantinuIII	Number Of Tokens Compensated	0
Control	AplikaceMemantinuIII	Number Of Tokens Completed	700
Control	AplikaceMemantinuIII	Number Of Tokens Started	700
Control	AplikaceMemantinuIII	Number Of Tokens Terminated	0
Cost	AplikaceMemantinuIII	Total Completion Cost	1575000
Cost	AplikaceMemantinuIII	Total Time Cost	0

From the results shown above it is clear that the simulation took place 100 times (Number of Processes Started) and all the simulations were finished. The activity of Memantin application examined here was initiated in total of 900 times in the first phase and 100 activities were forcefully terminated. The sum total of the activities was 8,370,000 CZK and the value of Total Time Cost that equals zero shows that no variable costs were entered, and everything was calculated with fixed costs. Fixed costs within the simulation are always calculated at the initiation of the activity. In this process, this setting shows the state when each time a package of drugs is opened, which is paid for at one time. Those are only chosen data which deliver results based on the simulation setting. It is similar in other phases. Phase three is specific because all the activities were finished successfully, and this phase was finished correctly.

5.1 Application of the Simulation Results on ABC

The template for costs assigning according to the ABC method was taken from [11] and was adjusted to the needs of the simulation. The final chart is too extensive to be shown wholly in the article; therefore, only parts which are connected to the aforementioned activity are depicted.

Table 2. Phase cost allocation shows the sum total of costs of pharmacological treatments in individual parts of AD in lines 3.1.x. Allocate lines then show the division of costs of Memantin application activity to individual phases of pharmacological treatment. Table 3. Conversion based on unit costs shows the sum total of costs based on unit costs and count.

Table 2. Phase cost allocation.

Pharmacological treatment					
3.1.1	3 274 840	< - - - - - - - - - - - - - - - - Allocation of Costs to Activity 4.2 - - - - - - - - - - - - - -			
3.1.2	14 925 480	Allocation	Allocation		
3.1.3	5 365 500	Percent	Amount		Activity Name
Allocate 3.1.1 >		62%	2 025 000	Memantin	
Allocate 3.1.2 >		29%	4 275 000	Memantin	
Allocate 3.1.3 >		29%	1 575 000	Memantin	
		Sub Totals	7 875 000		

Table 3. Conversion based on unit costs.

		Total	Unit	Total
Activities per Tab 4	Output Metric (Activity Driver)	**Units**	**Cost**	**Cost**
Memantin	Count of activities	3500	2 250	7 875 000

6 Conclusion

Creation of our own ABC model for the article brought several problems. One of those is the problem of price determination of individual operations in medical and pharmacological treatments. The second problem is the fact that AD is not precisely described in medical literature and the exact process definition is therefore unknown. Because of the aforementioned reasons it is not possible to consider the data gathered thanks to the simulation to be true, but the article still serves as an illustration of the way which may be taken.

The article shows a possible way of using the process simulation when simulating costs. Unlike already published articles, this article is focused on the abstract process of the Alzheimer's Disease which requires work with the probability rate mainly due to the fact that the disease cannot be perfectly described.

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