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Rule- and context-based dynamic business process modelling and simulation

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ABSTRACT

The traditional approach used to implement a business process (BP) in today's information systems (IS) no longer covers the actual needs of the dynamically changing business. Therefore, a necessity for a new approach of dynamic business process (DBP) modelling and simulation has arisen. To date, existing approaches to DBP modelling and simulation have been incomplete, i.e. they lack theory or a case study or both. Furthermore, there is no commonly accepted definition of BDP. Current BP modelling tools are suitable almost solely for the modelling and simulation of a static BP that strictly prescribes which activities, and in which sequence, to execute. Usually, a DBP is not defined strictly at the beginning of its execution, and it changes under new conditions at runtime. In our paper, we propose six requirements of DBP and an approach for rule- and context-based DBP modelling and simulation. The approach is based on changing BP rules, BP actions and their sequences at process instance runtime, according to the new business system context. Based on the proposed approach, a reference architecture and prototype of a DBP simulation tool were developed. Modelling and simulation were carried out using this prototype, and the case study shows correspondence to the needs of dynamically changing business, as well as possibilities for modelling and simulating DBP.

1. Introduction

Nowadays business processes (BPs) are dynamic by nature and affected by a dynamically changing environment. Examples of such dynamic changes of environment include regulatory adaptations (e.g. change in raw material prices), market evolution (e.g. stock price change), changes in customer behaviour (e.g. rapid change in customer needs), process improvement, policy shifts and exceptions.

Traditional approaches used to model, simulate and implement BP no longer cover the actual needs of business, which should be more dynamic in order to be able to compete. There is thus a necessity to conduct research in the field of DBP modelling, simulation and their automation in information systems (IS), and to propose new solutions that correspond to a dynamic business's needs. Moreover, a business needs tools which support such DBP and allow it to find answers for the question of what-if.

Consequently, these business needs can be transformed into the requirements for research as follows:

- proposing a DBP modelling approach,
- proposing a DBP simulation approach,
- proposing an architecture and implementing it into a BP simulation engine.

Existing approaches to DBP modelling and simulation are incomplete because they are lacking in theory and in terms of implementation. Furthermore, there is no commonly accepted definition of DBP. Current BP modelling and simulation tools are suitable for modelling and simulation of a static BP that strictly predicts which activities, and in which sequence, to execute (e.g. Simprocess or ARIS 9.7). In the best case, today's tools and proposed methods allow for changing BP by executing different configurations of the BP, as in Xiao et al. (2011), or using templates for modifying BP activity sequences, as in Eijndhoven et al. (2008). This means that the majority of existing tools and approaches require strict specification of a BP, and unexpected sequences of BP activities cannot be included during a BP execution. Therefore, modelling and simulation of a dynamically changing BP, e.g. dynamic processes, is a topical, relevant and challenging task.

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As advocated in a number of papers (e.g. in Mejia Bernal et al., 2010; Hermosillo et al., 2010a; Milanovic et al., 2011), business rules are applicable for ensuring the dynamicity of BP.

The main opportunities of using business rules to ensure dynamicity of BP lie in the following: each activity in a process is selected according to the defined conditions at BP runtime; choice of activity content; and representing the changing DBP context. However, as presented in the works related to this paper, there is no complete approach or tool for rule- and context-based DBP modelling and simulation – i.e. none of the analysed tools (IBM Websphere (v.7.0 2014),[1] Simprocess (v 2015),[2] Simul8,[3] AccuProcess[4] and ARIS 9.7[5]), which are widely used for BP modelling and simulation, supports changing business rules during the simulation of DBP. Some approaches, like Hermosillo et al. (2010b), describe BP dynamicity using BP pointcuts, where adaptations can be made, or changes of BP are available in new instances of the BP, but not at the same instance, like in Xiao et al. (2011).

In our paper, we propose an approach for rule- and context-based DBP modelling and simulation. We define DBP as a process with a not-fixed sequence of activities, i.e. activities for execution in the BP are selected according to the rule conditions and changing context of the environment. Moreover, activities can be changed at the same BP instance runtime. We propose an approach for changing a sequence of BP activities, their content, rules for selecting activities in DBP and the context of a DBP at process runtime. Based on the proposed approach, the reference architecture and a prototype of a DBP simulation tool was developed. A case study was carried out using this prototype, and it shows correspondence between the obtained results and needs of the dynamically changing business, as well as possibilities for DBP modelling and simulating.

The balance of this paper is organized as follows. Section 2 presents related works on DBP. Section 3 presents our proposed requirements of rule- and context-based DBP. Section 4 describes our approach for rule- and context-based DBP modelling and simulation and reference architecture for the rule- and context-based DBP modelling and simulation system (DRBP-Simul). Section 5 presents a case study of an ordering system. Section 6 presents results and discussion. Finally, Section 7 concludes the paper.

2. Related works

In our research, we emphasize DBP where content and the sequence of activities depends on the context of the environment and can be changed at runtime. In contrast to DBP, static BP has a strict specification, i.e. the content and sequence of activities are defined before BP instance execution and cannot be changed at runtime. The remaining part of the work discusses four main aspects of a DBP. They are: existing definitions, models, realizations and simulation of a DBP.

2.1. Concept of a dynamic business process

However, there is a range of approaches within DBP modelling and simulation, the difference of these approaches lies in the understanding of the concept of dynamicity. Therefore, we start our analysis with the concept of BP dynamicity. The analysis of the related works shows that four main concepts are popular for defining the ability of a BP to adapt to the changing environment. They are as follows: dynamicity, flexibility, agility and adaptability. Gong and Janssen (2012) state that the concept of flexibility is more appropriate in comparison to agility within the context of a BP. According to them, the concepts of agility and flexibility overlap and represent a system's ability to respond to changes in the environment. *Agility* in this case has a stronger emphasis on the speed aspect than on flexibility. According to Pucher (2010), *dynamic* BP is a variant of agile process and enables a business user to make changes in the process at runtime, for example, by selecting a different sub-process at predefined decision points. Another kind of a flexible BP is an *ad-hoc* BP that has no underlying process definition and consists of a set of activities relating to possible contents (Pucher, 2010; Dustdar et al., 2005; Bizagi, 2015). In an ad-hoc process, a user decides what to do and when to do it. The most flexible BP, according to Pucher (2010), is *adaptive* BP, which is a process that changes according to the environmental conditions at runtime. Moreover, the execution of adaptive BP instance influences execution of the next BP instance, e.g. real-time knowledge from the last process execution can influence the execution of the next one.

In spite of the above, in many cases BP dynamicity, flexibility, agility and adaptability are used as synonyms. For example, organizations like (Wikipedia,[6] Gartner, Inc.,[7] WhatIs.com[8]) and research papers, like Adams (2010) and Pesic and van der Aalst (2006) define the *dynamicity* of BP as: the ability to react to changing conditions (internal and/or external) of operation, according to the client's individual needs, in an appropriate and timely manner at process instance runtime without having a negative impact on the process essence or its expected completion. Management of such DBP is understood as the ability to support process change by any role, at any time, with very low latency.[7]

The differences in DBP definitions and modelling and simulation approaches can be found by analysing the level of dynamicity of BP. As proposed by WhatIs.com,[9] there are three levels of DBP. The first, and lowest, level of dynamicity is described as using decision points, in which a human or an automated system decides what to do next according to predefined rules. Almost all of today's approaches and tools implement this level of dynamicity.

The second, and middle, level of dynamicity allows for automatic configurations of a BP, like choosing an alternative template for processing activities or changing the order of activities in a process if conditions change. A number of approaches, proposing dynamic adaptation using variability models, are presented. They are, like Hallerbach et al. (2009), Alférez et al. (2014), Milani et al. (2016), etc. However, all those methods are based on the idea that business process consists of variable and not variable segments and only variable segments of a process could be changed, in some cases, like in Alférez et al. (2014), at runtime.

Approaches presented by Eijndhoven et al. (2008) and Hermosillo et al. (2010a, b) fall into this level of dynamicity, since their main idea is to define decision points in a process and describe those decisions through business rules. The approach, presented in Xiao et al. (2011), also falls into this level of dynamicity. Although Xiao et al. (2011) suggest constructing a process from a number of reusable fragments, new process schemas generated according to the new conditions are applicable only at the next process instance execution (Berkane et al., 2012). In their approach (Hildebrandt and Mukkamala, 2011), the authors propose a Dynamic Condition Response Graphs (DCRGraphs) model based on

[1] http://www-03.ibm.com/software/products/en/modeler-advanced.
[2] http://simprocess.com.
[3] http://www.simul8.com.
[4] http://bpmgeek.com/accuprocess-business-process-modeler.
[5] http://www.softwareag.com/corporate/products/new_releases/aris9/more_capabilities/default.asp.
[6] http://en.wikipedia.org/wiki/Dynamic_business_process_management.
[7] http://www.gartner.com/it-glossary/dynamic-business-process-management-bpm.
[8] http://whatis.techtarget.com/definition/dynamic-BPM-business-process-management.