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A method to infer the need to update situations in business process adaptation

Juliana do Espírito Santo Carvalho, Flávia Maria Santoro *, Kate Revoredo

Postgraduate Information Systems Program, Federal University of the State of Rio de Janeiro, Avenida Pasteur, 458, CEP 22290-240 Rio de Janeiro, RJ, Brazil

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ABSTRACT

Contextual knowledge is an essential resource for adapting business processes in order to keep them aligned with its goals. A context-based adaptation environment should learn from the dynamism of the context as well as the decisions made, and continuously identify new unforeseen situations. Data mining is a possibility to maintain the analysis of the processes updated. This paper presents a method that infers the need to learn new situations that influence a business process execution. The method is based on the results of the Apriori algorithm application. Case studies were conducted to evaluate the proposal. We observed evidences of context changes over time and the potential to learn with this dynamics through the method proposed.

1. Introduction

Business process is the set of coordinated activities aiming at achieving a business goal within an organizational environment [34]. Business Process Management (BPM) is the art and science of monitoring how the work is performed to ensure consistent results and opportunities for improvement. BPM is not just about improving the way single activities are performed; but somewhat, it is about managing the entire chain of events, activities and decisions that add value to the organization and its customers [7].

Mapping and deploying processes, in a correct, timely, and effective manner, are still a major priority and a challenging task for executives [12]. However, day-to-day work is subject to frequent changes, and not considering these possible deviations might cause non-expected results [25]. The economic success of an organization is highly dependent on its flexibility, i.e., the ability to react to changes in the operating environment [29]. Flexibility in business processes is related to the ability of a process to adapt while maintaining its stability and alignment with the policies, culture and goals [20,26].

However, according to Bider [3], it is not realistic to predict everything that can occur during the execution of a process, since new scenarios can arise. Moreover, describing all possible paths in a process model can harm its understanding, due to the high degree of complexity [3,15]. Thus, Nunes et al. [19] argue that mechanisms should be set to enable the dynamic adaptation, including the definition of adaptation rules that considers the context of a particular instance of the process. Context is defined here as the minimum set of variables that contain all the relevant information that impacts the design and implementation of a business process [28].

In order to illustrate the problem, let us consider the Air Traffic Control scenario, specifically the aircraft takeoff process. Some elements can interfere in this process, such as airspace availability and weather condition. These elements are called here contextual elements, and they are specified along with the possible values they can assume, e.g., airspace availability can be "operational", "not operational" or "operational with restrictions". Combining these contextual elements, we can identify situations which capture the potential problems for normal process flow. For example, the Situation A = {airspace availability = "operational with restrictions" AND weather = "unfavorable"}. As a result, Situation A is recognized when the contextual element "airspace availability" assumes the value "operational with restrictions", and simultaneously, the contextual element "weather condition" assumes the value "unfavorable". In view of that, an adaptation rule "Alfa" (a suggestion for a decision to be made in this case) should be activated to solve this situation. For instance, the rule due to Situation A takes place is "delaying the takeoff for a period of at least one hour".

* Corresponding author. Tel.: +55 21 999813618; fax: +55 21 25308047.
E-mail addresses: juliana.carvalho@uniriotec.br (J.d.E.S. Carvalho), flavia.santoro@uniriotec.br (F.M. Santoro), katerevoredo@uniriotec.br (K. Revoredo).

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On the other hand, if the weather continues unfavorable, after a certain time, the takeoff is really not going to be performed, and so the process goal will not be reached. If this case happens frequently, i.e., a situation is identified, an adaptation decision is made, but the goal of the process is not reached, it could mean that the environment has evolved, and the adaptation assumptions – situations and rules – are not valid anymore. Therefore, it is crucial to continuously investigate whether the contextual elements that interfere are really only those that led to the Situation A, and in addition, learn the most appropriate actions to avoid that situation.

We argue that a dynamic process adaptation environment based on context must learn from decisions made, as well as identify new unforeseen situations. For this, it is important to maintain a historical database that contains context information associated to instances of activities performed and results of process adaptations. Thus, the research problem to be addressed here is: since context is dynamic, situations and adaptation rules become obsolete over time.

The solution proposed is a method and a decision support system based on data mining techniques that infers and suggests the necessity of updating situations, adaptation rules and/or contextual elements. Our premise is the existence of a process log that contains information about each process instance, including: information about the activities performed; situations that interfere in each activity; adaptation rules used to adapt the process instance in those given situations; and, results obtained after every execution of the process instance (the achievement of the goals).

This paper is organized as follows: Section 2 describes the theoretical background; Section 3 presents the proposal: the method and the implementation; Section 4 discusses the evaluation of the proposal in two case studies; Section 5 presents related work; and Section 6 concludes the paper and presents future perspectives of the research.

2. Background

In this section, we briefly review the concepts of Business Process Adaptation and Knowledge Discovery in Database, both relevant to a complete understanding of our approach.

2.1. Business process adaptation

Flexibility has been recognized as a critical quality for organizations to adapt to business variations [29], as such, process adaptation is the customization necessary to make it applicable to a specific context [23]. Moreover, dynamic adaptations in business process encompass procedures and technologies which detect variations in process instances without compromising its execution, support the effective and necessary changes and reduce associated costs [17].

Process flexibility is the ability to handle both predictable as unpredictable variations, adapting business process parts affected by these variations while maintaining the essential form unaffected. In other words, flexibility is both about what should remain and what should be allowed to change [29]. Therefore, business processes must be designed to respond to different events and their specificities, and to variations in the environment conditions. This information defines what literature calls context [28,31,33,22].

The contextual knowledge is present in experience shared among participants, artifacts, joint and individual activities and conditions and events occurred during process execution [4,21]. Its importance lies in the fact that it provides a strong cause–effect relationship between the need for flexibility and the impacts on the adaptation process [20]. In this work, we use the definition of context presented in [16]: context is a set of instantiated and combined contextual elements (Situation), which provides support to an activity in a business process. Furthermore, since a contextual entity manipulates contextual information (e.g., person, place, object, user and application), then a contextual element is defined as the basic unity of the model, identified by a set of attributes and relations associated to an entity.

Mattos et al. [16] present a formal description to characterize the context of a business process activity in a domain. The approach is based on conceptual models structured in 3 layers: Context, Business Process and Domain. The first describes concepts and relationships related to context; the second describes the basic elements, which must be presented in a business process model; and, the third includes the definition of the data structure, functions, relationships and restrictions of a specific knowledge area (Fig. 1).

Moreover, in [16], relations between the context and the business process layers are described in a form of rules (restrictions). Among these rules, there is one, which relates contextual elements with situation, as described as follows:

> Let CE be the set of contextual elements.
> For all contextual element $ce_i \in CE$, where $1 \leq i \leq n$ and $n = |CE|$, a domain ($Dom(ce_i)$) is associated indicating the possible values the contextual element may assume.
> Let $Dom(ce_i) = \{d_{i1}, d_{i2}, \ldots, d_{iMi}\}$, where $Mi = |(Dom(ce_i)|$, the set E is defined as the set of all contextual elements with their instanced values:
> $E = \{ce_1 = d_{11}, \ldots, ce_1 = d_{1M1}, ce_2 = d_{21}, \ldots, ce_2 = d_{2M2}, \ldots, ce_n = d_{n1}, \ldots, ce_n = d_{nMn}\}$
> A situation S is defined as a subset of E ($S \subseteq E$), where a certain contextual element can only be considered once.

A situation is formally defined as: Situation $A = \{ce_1 = d_1, ce_2 = d_2, \ldots, ce_n = d_n\}$, where ce_i, $\forall i\ 1 \leq i \leq n$, are contextual elements, d_i the value which ce_i assumes in a certain time, and situation A is the definition of a condition. The occurrence of a situation may require a process adaptation. On the other hand, the adaptation based on the context requires decisions about which adaptation rule apply [16]. Therefore, rules for process dynamic adaptation may be defined based on the situations, and they have the form IF <*condition*> THEN <*action*>; where <*condition*> is the Situation and <*action*> is the decision to be made in order to keep the process aligned with its goals [19–21].

So, in a business processes scenario, adaptations needs are caused by changes in context, activating an adaptation rule. However, this model should evolve constantly, because of the dynamism of context. Analyzing the historical execution of process instances is important, since situations and adaptation rules are initially defined based on the know-how of specialists. Moreover, after several executions of the process, due to the large volume of data generated, it becomes increasingly difficult to manually figure out whether the current situations and adaptation rules are still consistent by the time of a new instance is executing.

2.2. Knowledge discovery in databases

The huge amount of data accumulated in databases may hide valuable and useful knowledge for decision making. The knowledge discovery in database process (KDD) [4,14] encompasses a set of iterative steps, aiming at finding new and useful knowledge. Each step may be repeated in order to accomplish a better result. The first three steps aim at preparing the data. In these steps, the