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Specification and automated design-time analysis of the business process human resource perspective ☆

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ABSTRACT

The human resource perspective of a business process is concerned with the relation between the activities of a process and the actors who take part in them. Unlike other process perspectives, such as control flow, for which many different types of analyses have been proposed, such as finding deadlocks, there is an important gap regarding the human resource perspective. Resource analysis in business processes has not been defined, and only a few analysis operations can be glimpsed in previous approaches. In this paper, we identify and formally define seven design-time analysis operations related to how resources are involved in process activities. Furthermore, we demonstrate that for a wide variety of resource-aware BP models, those analysis operations can be automated by leveraging Description Logic (DL) off-the-shelf reasoners. To this end, we rely on Resource Assignment Language (RAL), a domain-specific language that enables the definition of conditions to select the candidates to participate in a process activity. We provide a complete formal semantics for RAL based on DLs and extend it to address the operations, for which the control flow of the process must also be taken into consideration. A proof-of-concept implementation has been developed and integrated in a system called CRISTAL. As a result, we can give an automatic answer to different questions related to the management of resources in business processes at design time.

1. Introduction

The human resource perspective of a Business Process (BP) [1] (also known as the organisational perspective [2]) is concerned with the relation between the activities of a process and the human resources[1] that take part in them. The management of resources in Business Process Management (BPM) encompasses several tasks, typically divided into two groups. *Resource assignment* is the design-time definition of the conditions (resource selection conditions from now on) that must be fulfilled by the company members to become candidates to work on the process activities. The outcome is a *resource-aware BP model*, i.e., a process model annotated with resource

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[1] For the sake of simplicity, in the rest of the paper we use *resource* to refer to *human resources*.

selection conditions. *Resource allocation* is the time designation of the actual performers of the activities before their execution, which includes, for instance, mechanisms for resource prioritisation that may ease the distribution of work.

Like in other BP perspectives (e.g., the control flow), analysis of the resource perspective may provide insights that are relevant for the execution of the process. For instance, both assignment and allocation must guarantee a deadlock-free execution. Therefore, it is of utmost importance to ensure that the resource-aware process model is consistent, i.e., that there are candidates for all the activities. It is also helpful to know beforehand the workload a resource may have during the execution of a specific process, i.e., which activities of the process may be allocated to her.

Resource management in Business Processes (BPs) in general and analysis in particular have not yet reached the degree of maturity of other BP perspectives, such as control flow. Specifically, the following gaps have been found. First, to the best of our knowledge, only two analysis operations have been identified and tackled in the literature so far, namely, determining the candidates to execute a process activity given a set of selection conditions (i.e., the *potential participants* in a BP activity) and checking whether a resource-aware BP model is consistent. Second, there are very few software prototypes that implement these operations, and only a subset of them is independent of any BP modelling language used to specify the process. Finally, a paradigm that underpins the analysis of this BP perspective similar to the one provided by Petri nets for the control flow perspective is missing. Therefore, the efforts necessary to formally define these operations will take more time to converge.

We focus on increasing the degree of maturity of analysis in the BP resource perspective, specifically with regard to resources. In particular,

- We define a catalogue of seven *person–activity operations* related to how resources are involved in activities. The catalogue is divided into three categories: basic, consistency checking, and criticality checking operations. Five of the seven operations are novel.
- We propose a way to define resource-aware BP models by using Resource Assignment Language (RAL) [3], a language to define resource selection conditions that is independent of any process modelling notation.
- We propose Description Logics (DLs) as a paradigm to underpin the analysis of resource-aware BP models based on RAL, and we show that for the R3C-processes, a term we coin to denote a class of resource-aware BP models that meet certain conditions (cf. Section 5), it is possible to interpret the entire set of analysis operations in terms of DLs.
- We offer a proof-of-concept implementation of the catalogue of analysis operations. This catalog is integrated into a larger system called Collection of Resource-centrIc 47 Supporting Tools And Languages (CRISTAL) [4], which provides several tools for the management of the BP resource perspective. The core of the prototype is a DL reasoner, which reduces the development effort and the likelihood of failure.

A preliminary version of RAL and its semantics have been presented in previous publications [3,5]. In this paper, we extend them as follows. First, we revisited the RAL specification and separated the RAL expressions into different modules. We also added support to define resource assignments for different degrees of involvement in the process activities, also called *task duties*. For instance, RAL allows defining selection conditions for the person in charge of carrying out the work, the person who must approve the work performed and the person who must receive notifications related to an activity. These and other duties have been identified and used in a few approaches, such as BPEL4People [6] and RACI [7]. Second, we adapted and extended the RAL semantics originally defined in DLs. The extension takes into account specific features required for the automation of the seven analysis operations mentioned above. The overall idea of the extension is to include in the DL-based Knowledge Base (KB) required information about other BP resource perspectives [8], specifically the control flow of the process. Finally, we provide the DL formulas dealing with the automated resolution of the analysis operations at design time based on the extended KB.

The rest of this paper is structured as follows. Section 2 describes a running scenario that is used throughout this paper. Section 3 defines automated resource analysis in BPs and the person–activity analysis operations, which constitute the main goal of this work. Section 4 presents the current version of RAL. Section 5 introduces the conditions a resource-aware BP model must fulfil to be an R3C-process and the characteristics that make it amenable to automatic analysis using DLs. Section 6 describes the semantics of the BP resource perspective using RAL for resource assignment. Section 7 describes the content of a KB to address the analysis operations at design time, and it presents the DL expressions for the implementation of the operations. Section 8 presents an evaluation of RAL expressiveness and describes an implementation of the analysis operations and its integration into CRISTAL [4]. Finally, Section 9 summarises the revision of the state of the art on the design-time analysis of resources in BPs, and Section 10 closes the paper by drawing several conclusions and outlining potential future work.

2. Running example

In the following, we describe a scenario that will be used as a running example throughout this paper. We highlight some concepts that we elaborate later on.

Let us assume that we belong to the ISA research group of the University of Seville and that we take part in a hypothetical research project called Human Resource Management 83 System (HRMS). The model shown in Fig. 1 represents the hierarchy of organisational *positions* that are involved in the *organisational unit* HRMS.[2] Seven positions (Project Coordinator, Account Delegate, Technician, Administrative Assistant, Work Package Leader, PhD Student and Post-Doc Researcher) *are members of* this unit, and eight *persons* (Anthony, Betty, Daniel, Anna, Charles,

[2] Note that this model is inspired by reality, but the values (roles, positions, persons, *etcetera*) have been modified due to confidentiality issues.