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A semantic framework for configurable business process as a service in the cloud

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ABSTRACT

With the advent of Cloud Computing, new opportunities for Business Process Outsourcing services have emerged. Business Process as a Service (BPaaS), a new cloud service model, has recently gained a great importance for outsourcing cloud-based business processes constructed for *multi-tenancy*. In such a multi-tenant environment, using *configurable business process models* enables the sharing of a reference process among different tenants that can be customized according to specific needs. With a large choice of configurable process modeling languages, different providers may deliver configurable processes with common functionalities but different representations which makes the process discovery and configuration a manual tedious task. This in turn creates cloud silos and vendors lock-in with non-reusable configurable BPaaS models. Therefore, with the aim of enabling the interoperability between multiple BPaaS providers, we propose in this paper a semantic framework for BPaaS configurable models. Taking advantage of Semantic Web technologies and data mining techniques, our framework allows for (1) an ontology-based high level abstract representation of BPaaS configurable models enriched with configuration guidelines and (2) an automated approach for extracting the configuration guidelines from existing process repositories. To show the feasibility and effectiveness of our approach, we extend Signavio with our semantic framework and conduct experiments on a dataset from SAP reference model.

1. Introduction

With the emergence of Business Process Outsourcing, enterprises are looking for available business processes outside of their organizations to quickly adapt to new business requirements and Q4 also reduce process development and maintenance costs. The new paradigm Cloud Computing (Weiss, 2007) has recently received a great attention for delivering shared ICT services over the internet. According to the National Institute of Standards and Technology (NIST),[1] Cloud Computing is a model that enables providers sharing their computing resources (e.g., networks, servers, storage, applications, and services) and users accessing them in an ubiquitous, convenient and on-demand way with a minimal management effort (Mell and Grance, 2011). Cloud Computing is inherently emerging as a new trend for enabling a green IT approach by allowing resource and energy efficiency (Berl et al., 2010). A recent study conducted by the Carbon Disclosure Project (Reeve and Stuart, 2011) states that “*by 2020, large U.S. companies that use cloud computing can achieve annual energy savings of 12.3 billion and annual carbon reductions equivalent to 200 million barrels of oil – enough to power 5.7 million cars for one year*”.

Business Process as a Service (Wang et al., 2010) (BPaaS), a cloud-based business process model, has recently gained a great importance for adopting cost-effective business process solutions. A recent study from Gratner states that BPaaS is the biggest segment with 77% of the market and predicts that BPaaS will grow from $84.1*B* in 2012 to $144.7*B* in 2016, generating a global compound annual growth rate of 15% (Gartner, 2012). According to the traditional cloud service models (Bohn et al., 2011), the Infrastructure as a service (IaaS), the Platform as a service (PaaS) and the Software as a service (SaaS), the new service model BPaaS does not have a unique and standard definition yet. It is considered as a special instance of SaaS in some approaches (Accorsi, 2011), and in others as a fourth service model placed on top of the cloud service stack (http://www.ibm.com/developerworks/websphere/library/techarticles/1203_lau/1203_lau.html). Examples of BPaaS solutions are Wipro's Human Resources and Procurement processes and OVUM Business Process Outsourcing.

The BPaaS model allows cloud providers to model flexible and energy-efficient service-based business processes constructed for multi-tenancy. These processes are accessed, customized according to specific needs and remotely executed by cloud tenants. Since traditional process modeling languages do not allow for variability modeling and controlled customization, using *configurable process models* (Rosemann and van der Aalst; Gottschalk et al.) enable the sharing of a reference process with a

[1] http://www.nist.gov/

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configuration facility among different tenants (van der Aalst, 2011). A configurable process model is a generic model that integrates multiple process variants of a same business process in a given domain through variation points. These points are referred to as *configurable elements* and allow for multiple design options in the process model. A configurable process model needs to be configured according to a specific need by selecting a design option for each configurable element. In this way, an individual process variant is derived via customization without an extra design effort.

With such an increasing popularity of cloud process services, a serious challenge that prevents fostering their widespread adoption is that of *interoperability* (Petcu, 2011). Interoperability is defined as the ability of ICT systems and the business processes they support to exchange information and to use the information that has been exchanged (IEEE, 1990; European Commission). As Cloud Computing is relatively a new paradigm, the interoperability issue is being increasingly addressed at different levels of traditional cloud service models (IaaS, PaaS and SaaS) (Lewis, 2012; Gonidis et al., 2013; Parameswaran and Chaddha; Wang et al.; Buyya et al.; Rezaei et al.). Existing approaches tackle this problem from ICT system perspective. That is, they propose interoperability frameworks based on cloud brokers (Bohn et al., 2011) which act as intermediaries between cloud consumers and cloud providers, in order to allow resources (at the IaaS level), platforms (at the PaaS level) and softwares (at the SaaS level), within the same or different clouds, communicating with each other.

However, from a business process perspective (i.e. at the BPaaS level), the interoperability remains poorly managed. In essence, a key challenge for enabling interoperability between different BPaaS providers is to *unify the common understanding of different service-based process models*. In fact, different BPaaS process models may be defined with different configurable modeling languages such as Configurable Event-Driven Process Chain (C-EPC), Configurable Business Process Model and Notation (C-BPMN), and Configurable Unified Modeling Language (C-UML), making the cloud-based business processes heterogeneous and diverse. On the one hand, at the cloud user side, a user chooses a BPaaS provider and customizes the service-based configurable process model according to his specific requirements. If he needs to migrate to another BPaaS provider or to integrate a configurable process model from another BPaaS provider, he should learn about the new provider's specific technical details, customize the new configurable process model and adapt it with the current one. Therefore, an extra effort and IT resources are needed for process development and adaptation step. On the other hand, at the cloud provider side, the process modeling from scratch is a well know complex and difficult task (Fettke and Loos). A BPaaS provider may need to reuse configurable process models from other BPaaS providers in order to develop his processes. However, with different configurable modeling languages and customization techniques, this task is impossible without an extra effort of transformation and adaptation.

In order to overcome these issues, we propose in this paper a *semantic framework for BPaaS configurable models*. Our framework takes advantage of semantic web technology in order to formalize and unify the description of BPaaS configurable models in a machine understandable way. The framework allows for (1) an ontology-based high-level abstract representation of BPaaS configurable models enriched with configuration guidelines and (2) an automated approach for extracting the configuration guidelines from existing BPaaS repositories.

Concretely, we define the Configurable business Process Modeling Ontology (CBPMO) an extension of Business Process Modeling Ontology (BPMO) (Cabral et al., 2009) which is an abstract representation of different process modeling languages developed by the European project SUPER[2] (Semantics Utilized for Process Management within and between Enterprises). CBPMO formalizes and unifies the representation of different configurable modeling languages and customization constraints. Then, we enhance our framework with a domain ontology that will be used to formalize the business understanding of BPaaS solutions in a given domain. Afterwards, we define a set of configuration guidelines using Semantic Web Rule Language (SWRL). Configuration guidelines reveal the association between the configuration (i.e. customization) decisions taken for different variation points in a configurable process model (Assy and Gaaloul, 2014). They assist the end users during the BPaaS customization phase. As experiences show that manually defining the configuration guidelines for a configurable process model is a tedious and complex task (Rosa et al., 2009; Huang et al., 2013), we propose an automatic approach for extracting configuration guidelines from existing cloud-based business processes using data mining techniques (Witten and Frank, 2005), in particular, association rule mining. In order to show the feasibility of our approach, we extend the Signavio process editor with a semantic layer implementing our semantic framework and conduct experiments to evaluate our automatic approach for extracting configuration guidelines.

The remainder of this paper is organized as follows: In Section 2 we present a running example used throughout the paper to illustrate our approach and the overview of our approach. In Section 3, some preliminary concepts on configurable process models and semantic process models are discussed. We detail the proposed semantic framework in Sections 4 and 5. The approach validation through the extension of Signavio platform and the corresponding experiments is then depicted in Section 6. In Section 7, we present the related work. Finally, in Section 8, the paper closes with conclusions and future works.

2. Objective

In this section we present a motivation example used throughout the paper to illustrate our approach (see Section 2.1) and an overview of the proposed approach (see Section 2.2).

2.1. Motivation example

In this section, we present a motivating example used throughout the paper to illustrate our approach. Let us consider two clouds *cloud* 1 and *cloud* 2 providing "order processing" BPaaS solutions (see Fig. 1). In Fig. 1, we present a scenario of a BPaaS usage. A cloud user chooses the BPaaS$_1$ from *cloud* 1. The first step consists of customizing the corresponding BPaaS process model according to the cloud user's needs. Once customized, a new variant $BPaaS_1-variant$ is derived and executed by the user in the cloud. The BPaaS customized variant is then stored in the cloud provider datastore.

The BPaaS$_1$ and BPaaS$_3$ models offered by *cloud* 1 and *cloud* 2 in Fig. 1 are illustrated in Figs. 2 and 3 respectively. The BPaaS$_1$ in Fig. 2 is a business process model for invoicing inspired from SAP reference model (Keller and Teufel, 1998). It is modeled with the configurable EPC notation. The EPC notation consists of three elements: event, function and connector. An event can be seen as a pre- and/or post-condition that triggers a function. A function is the active element that describes an activity. Three types of connectors, OR ($\vee$), exclusive OR (XOR $\times$) and AND ($\wedge$) are used to model the splits and joins. In a configurable EPC, the

[2] http://projects.kmi.open.ac.uk/super/

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