ORGANIZATION OF A KNOWLEDGE BASE TO REUSE WORKFLOW TEMPLATES: AN ONTOLOGICAL APPROACH

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Abstract - Nowadays, business process models have been used in a wide range of enterprise applications. As a result, it is necessary to take interest in how to create business processes correctly in terms of semantics and syntax. Moreover, attention needs to be paid to the acceleration of the efficiency of reusing the existing models. In this paper, we introduce a knowledge base established to assist the choice of appropriate workflow templates for the development of a new business workflow template. We describe a repository that contains business workflow templates whose syntactic and semantic correctness has been checked. The repository provides an organizational mechanism for control flow-based business workflow templates to guarantee an effective search for necessary workflow templates. In addition, we also propose a process for developing workflow templates in the paper.

Key words - business process; knowledge base; ontology; SPARQL; reuse; workflow template.

1. Introduction

The design of business workflow management systems (WfMSs) is generally independent from the concrete business area of employing enterprises. Consequently, this workflow technology follows a generic approach. Therefore, IT experts play an important role in implementing business processes of the enterprise and establishing its software infrastructure. It is important to note that business workflows are aimed at automating and optimizing an organization's processes in an administrative context to reduce costs (e.g., human resources) and increase revenue. Up to now, there have been more than a hundred business WfMSs, such as FileNet, SAP, JBPM and Spiff Workflow. Insurance, banking and health industries, for example, are domains using business workflows.

However, the specification of a real-world business process is generally manual and is thus vulnerable to human errors. An incorrectly designed workflow may lead to failed workflow processes, execution errors or not meet the requirements of customers, etc. There is an inherent problem regarding the problem of modelling semantically rich business workflow templates[1], workflow templates sharing and subsequently their reuse need to be considered.

Continuing our previous work [9, 10, 11], which focus on how to model semantically rich business workflow templates and check their correctness at the syntactic and semantic level, in this paper we introduce a solution to the reuse of workflow templates.

Let us consider the following scenario. A person plans to create an ordering process for his own purpose. He has either some experience in working on it or none at all. The question is how he can create his process model in the most effective way without developing it from scratch.

In fact, the different existing workflow templates extracted from a set of process models can support modellers to create new workflows or process models by providing the knowledge about potential and suitable workflow activities. We are interested in the organization of a knowledge base which guides the search for suitable workflow templates in order to reuse them. Users can adapt the resulting workflow templates for each specific use case. This is the knowledge on how to model a business process reusing control flow-based business workflow templates (CBWTs). Hence, the annotation and storage of workflow templates play a very important role in the success of reusable CBWTs, which guarantee an effective search for modelling a business process.

The rest of this paper is structured as follows: In Section 2 we present related works. We then propose an organization of the knowledge base of CBWTs in Section 3. We also indicate that the SPARQL [13] query language is used to retrieve a list of workflow templates from the CBWT repository we have proposed. In Section 4, we introduce a process for developing workflow templates. Finally, Section 5 concludes the paper with an outlook on future research.

2. Related Works

Up to now, the problem of reusing process models or workflows is mentioned in some existing approaches. In general, workflows can be reused manually or semi-automatically [4, 6, 7]. Moreover, modellers can partly or fully reuse a workflow [1, 3, 4, 8].

The authors in [8] specify a method for business process design via view integration which takes two process views as input. At first, semantic relationships between elements of different process models are formalized. On this basis, the integrated process model applying the merge operator is calculated. [1] also presents a formal approach for constructing customized process views on structured process models to improve effective cross-organizational collaborations. Each customized process is constructed by hiding and/or omitting activities not requested by the process consumer. However, neither of them considers content-based reuse. In order to overcome that issue, the authors in [4] introduce a set of Domain Process Patterns (DPPs) that capture process model parts.

A DPP represents a specific business function of a

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[1] In our work, we define a definition for business workflow template: **A business workflow** template is a **generic business workflow** that can be customized according to the application.

process model part in a modelling domain. DPPs facilitate reuse from a content perspective by focusing on domain-centered reuse of process model content. Nevertheless, DPPs do not provide any syntactic needs for modelling business processes. However, by capturing process model parts with a particular structure, DPPs do not support syntactic checks which are supported in our approach. In our approach, a workflow template is stored in the repository if and only if it is checked at the syntactic and semantic level, and no errors exist.

In [2], the authors propose a framework to enable ontology-driven process modelling. By utilizing the framework, users can define, analyze and re-engineer their process models in complex and dynamic contexts with semantically enriched processes. But they are mainly interested in structuring and exploiting design knowledge. They do not focus on the meaning of all the concepts and relationships in the knowledge base, this is in contrast with our approach.

3. Organization of the Knowledge Base of Control Flow-based Workflow Templates

In literature, the main goals of workflow reuse are to improve workflow template quality and to increase its development productivity [5]. In other words, the more workflow templates are available, the more difficult they are to be suitable in a specific reuse case. It is worth noting that the reuse of workflow templates is only beneficial if the cost to find and adapt an existing workflow template is smaller than the cost needed to develop a new one from scratch.

After finding suitable workflow templates, it is important for users to understand what the workflow templates actually do. Thus, there is a strong need that the knowledge base of workflow templates could provide enough information for modellers to be able to determine which template is suitable for the reuse case at hand.

In [9, 10], we introduce an approach to develop a workflow template relying on a set of semantic constraints and the structure of CPNs. The workflow template is formalized via an RDF [13] graph in which the dependencies between its activities are expressed.

In this paper, we propose a method to semantically annotate workflow templates. Their retrieval through meta-workflow templates will model expert knowledge and guide the use of existing workflow templates. The idea of using content which characterizes workflow templates is not original. Indeed, it seems reasonable to use explicit information to find suitable templates to build a business workflow. This is particularly important for workflow modellers to be able to deal with the great number of workflow templates.

Based on the analysis of the state-of-the-art concerning the organization and reuse of workflow templates, we annotate workflow templates by the following properties as follows:

- *templateName*: Description of the main task being enacted by the template.
- *description*: Description of the template.
- *keywords*: List of words that characterizes the template. It also includes the words that name the template.
- *listOfActivityLabels*: The labels are extracted from activity labels in the template.
- *creationDate*: The date when the template is created.
- *modificationDate*: The date the template is last modified.
- *relatedTemplates*: List of related templates (if any). The related templates can be predecessors and successors of the template.
- *bpOnt*: Indicating the business process ontology used to develop the template.

The properties *templateName*, *description*, *keywords* and *relatedTemplates* are determined by using expert knowledge. In contrast, the values of the properties *creationDate* and *modificationData* are automatically captured at the moment of storing the template. Depending on all the activity labels in the template, the value of the property *listOfActivityLabels* is automatically retrieved. For example, to get all activity labels of the template *http://WFTemplate#Payment_Processing*, the following SPARQL[2] query is first executed to get all IDs of its transitions:

SELECT distinct ?trans WHERE

{k:Payment_Processing h:hasTrans ?trans}

Then the labels of these transitions are cut from their IDs and added to the list of activity labels.

The property *bpOnt* captures the names (or URLs) of the business process ontology file. This property leads us to the representation of additional knowledge that facilitates modellers to search for suitable templates, which can be used to design a new one.

An ontology is thus developed to annotate workflow templates. The ontology describes the main classes and properties for RDF annotations of workflow templates (see Figure 2).

In fact, the semantic annotations of workflow templates have been inspired by this idea: the knowledge added to these annotations will be helpful for the (re-)use of workflow templates. Those meta-workflow templates allow retrieving a list of workflow templates that correspond to different criteria. For example, to acquire all existing workflow templates relating to payment by credit card, two criteria are used: (i) one keyword of such template is *credit card*; (ii) description of such template contains *payment procecss*. This can be performed by the SPARQL[3] query as follows:

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[2] SPARQL is a query language, inspired by SQL for querying RDF data. It is adapted to the specific structure of RDF and relies on the triplets that constitute them. SPARQL allows adding, removing, searching and/or modifying data in RDF format. SPARQL can also be used to query RDFS or OWL vocabularies (written in RDF).
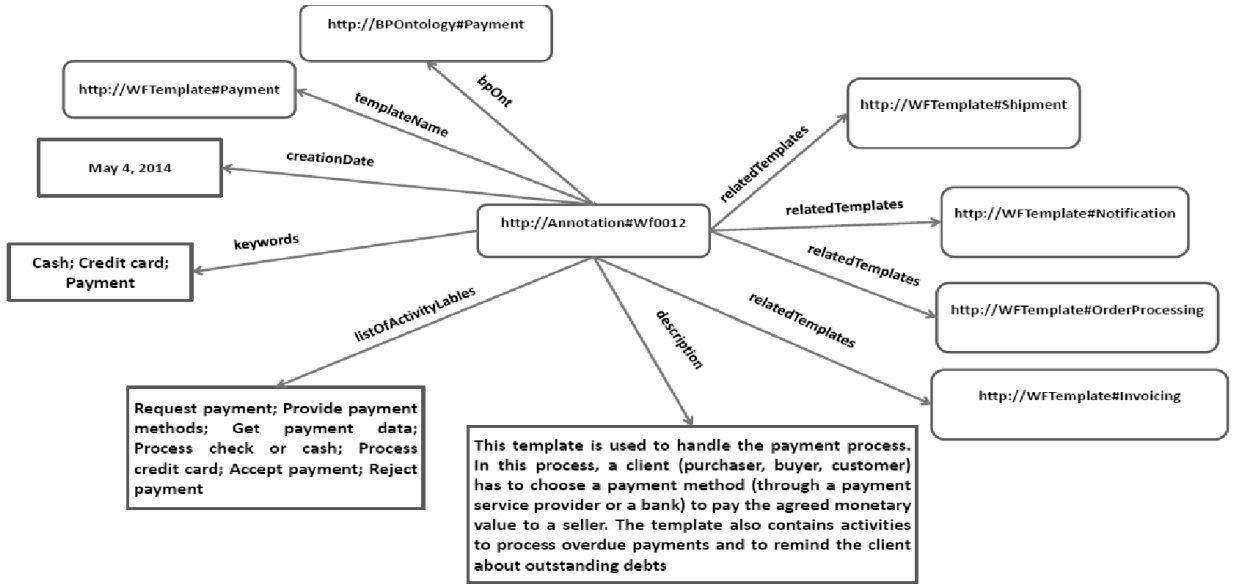
[3] PREFIX anno:<http://ontWFTemplateAnnotationsURI.owl#>

Figure 1: Example of the semantic annotation of Payment workflow template

SELECT * WHERE
{ ?workflow anno:keywords ?keyword
 FILTER (?keyword ~ "credit card"^^xsd:string)
 ?workflow anno:description ?descr
 FILTER (?descr ~ "payment process"^^xsd:string)
 ?workflow anno:templateName ?name;
            anno:listOfActivityLabels ?actLabel;
            anno:relatedTemplates ?relatedTemp;
            anno:creationDate ?crtDate;
            anno:modificationDate ?modDate }

As a result, a semantic annotation of workflow templates which expresses knowledge relative to their properties is proposed here. The expert knowledge is captured as RDF annotations to conduct users to model new business processes. Figure 1 illustrates a simplified example of such semantic annotation.
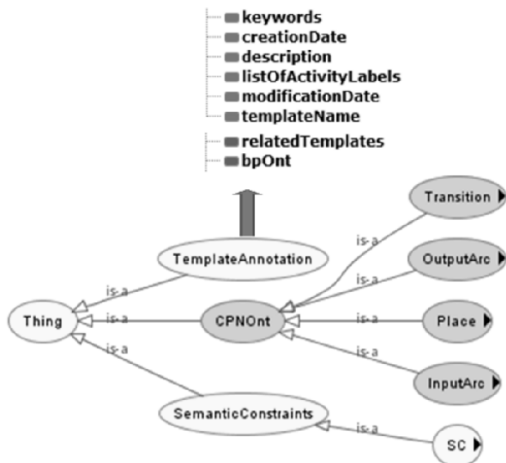

Figure 2: Extract of the annotation ontology used to annotate workflow templates

It is important to emphasize that those meta-workflow templates allow retrieving workflow templates, which are annotated with additional expert knowledge formalized with the help of the CPN ontology (for more details please see [10]) and the BP ontology (for more details please see [9]). In the following we introduce an excerpt of the RDF annotation related to the workflow template *http://WFTemplate#Payment* depicted in Figure 1.

    <rdf:RDF
    xmlns ="http://ontWFTemplateAnnotationsURI.owl#"
    xmlns:wf="http://WFTemplate#"
    xmlns:rule="http://ECARule#"
    ... >
      <TemplateAnnotation rdf:ID="wf0012">
      <templateName
rdf:resource="http://WFTemplate#Payment"/>
      <keywords>Cash;Credit card; Payment; Payment processing </keywords>
        <listOfActivityLables>Request payment; Provide payment methods; Get payment data; Process check or cash; Process credit card; Accept payment; Reject payment </listOfActivityLables>
      <description>Template payment processing is used to handle the payment process...</description>
      <relatedTemplates
rdf:resource="http://WFTemplate#Invoicing"/>
      <relatedTemplates rdf:resource= "http://WFTemplate#OrderProcessing"/>
        ...
      <bpOnt rdf:resource="http://BPOntology# Payment"/>
    ...
      </TemplateAnnotation>
    </rdf:RDF>

4. Process for Developing Workflow Template

In this section, we introduce a process for developing workflow templates, which is regarded as part of a process for developing an encompassing workflow application. The process consists of the main following phases (see Figure 3):

- **Search for reusable workflow templates**: An analysis of the process(es) is performed before implementing it. This results in a set of requirement descriptions as well as a business process model. The information is then used to start the process for developing workflow templates which may involve the search for reusable workflow templates.

- **Understand and select potential, suitable templates**: In this phase, modellers have to carefully consider the found workflow templates. They try to understand them to decide which ones are (partly or fully) reused for their application.

- **Modify selected templates**: If the selected templates do not comply with all the requirements, they have to be modified accordingly. For example, some new activities can be added into a selected template.

- **Create new sub-workflow templates**: Besides reusing part or all of the existing templates, modellers might have to create new sub-workflow templates to meet all the requirements. However, the creation of a new sub-workflow template is only necessary if no existing templates can be reused instead for the same purpose.

- **Complete workflow templates**: The last phase is to complete a new workflow template. The existing unmodified, modified and new sub-workflow templates are integrated into a new workflow template for a specific use case. Each of these workflow templates is considered as a sub-workflow of the new workflow template. It is then verified at the syntactic and semantic level. In case of errors, the errors have to be solved. The new workflow template is stored in the CBWT repository if and only if there exist neither syntactic errors nor semantic errors.

Figure 3: *Development of reuse-based workflow template*

To find suitable workflow templates, users can define their criteria via keyword, description or activity labels. If the search process returns only one template, users can easily make their decision that the template is selected or not selected. Otherwise, the value of the property *RelatedTemplates* can be used to provide more information for users to make their decision.

To sum up, the semantic annotations of workflow templates integrating expert domain knowledge formalized via an RDF graph are used to organize and retrieve workflow templates and their business process ontologies. The resulting templates and their rules can be used in a process for implementing software components or in a process for developing workflow templates.

5. Conclusion

In this paper, we have presented a process for developing workflow templates, which specially emphasizes the different phases of workflow template reuse comprising the tasks of searching, understanding and modifying workflow templates. Each phase provides useful support to facilitate the reuse of workflow templates.

Moreover, in order to better support the search for suitable workflow templates, the annotation ontology has been developed to annotate workflow templates. The ontology provides adequate information about the workflow templates for workflow modellers to determine whether a workflow template is able to be reused.

At the moment, only build-time is supported and we know that verifying workflow templates at the build-time is not sufficient to guarantee that workflows can be executed correctly. The correctness of workflow execution must also be checked. Therefore, in future work, we plan to develop a run-time environment for validating concrete workflows.

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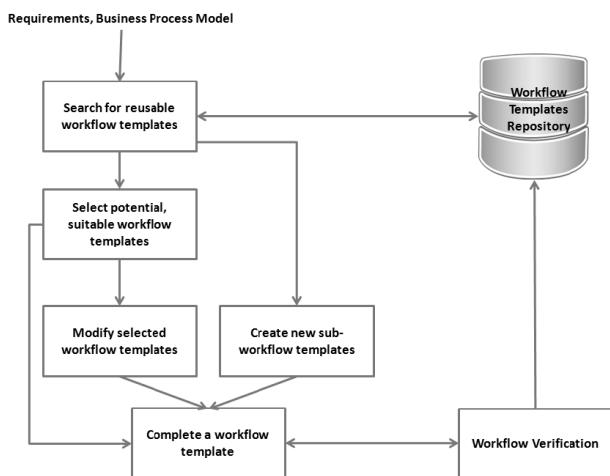
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(The Board of Editors received the paper on 12/04/2016, its review was completed on 20/04/2016)