Workflow Modelling Assistance by Means of Process-oriented Case-based Reasoning

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In recent years, workflows have become an important paradigm to represent processes in many application areas. Traditionally known from the field of business processes, workflows are "the automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules" [25]. Today, their application has extended towards various other domains such as healthcare [7], or the analysis of large data sets employing so called scientific workflows [24]. Moreover, they are considered as a novel programming paradigm [14] and can also be used to represent simple processes like cooking instructions [22].

In all these domains, the creation of workflows (also refered to as workflow modelling) is a complex and time consuming task. Consequently, in order to ease their creation, reuse becomes an important key to the successful application of the workflow paradigm. Workflow reuse is usually supported by search methods capturing the current needs and requirements in a query or a partial workflow. Based on this, a previously modelled workflow is identified which at best matches the current scenario. Thus, the workflow does not have to be modelled from scratch. Various approaches already exist for such search-based workflow reuse (e.g., [5,8,2,3]).

However, workflow adaptations are required more often due to an increased individuality demand of workflows, i.e., workflows need to be tailored to the particular needs or scenario more frequently. Manual workflow adaptation may become an elaborate task. Thus, methods supporting workflow adaptations are of high relevance. In this regard, Process-oriented Case-based Reasoning (POCBR) [13] can be a means to support the creation and adaptation of processes that are, e.g., represented as workflows. Although, POCBR is of high relevance little research exists so far, in particular addressing workflow adaptation (e.g., [12]).

The presented approach addresses workflow modelling assistance by means of POCBR, in particular focussing on the adaptation of workflows. Adaptation requires knowledge, e.g., in the form of adaptation rules. The modelling of such domain specific adaptation knowledge, however, is expensive and requires a deep understanding of the adaptation methods. This results in an acquisition bottleneck for adaptation knowledge [9]. Thus, the approach includes automated learning of adaptation knowledge to prevent limited adaptation capabilities.

1 Approach

The overall approach for workflow modelling support by means of Process-Oriented Case-based Reasoning is illustrated in Figure 1. In order to determine the requirements and needs on the workflow to be modelled, the query language POQL [19] basically captures workflow elements or subworkflows that are desired or undesired. Thus, the best matching workflow from a case base (or workflow repository respectively) of previously modelled workflows can be identified. Next, workflow adaptations are executed in order to increase the fulfilment of the adapted workflow w.r.t. the POQL query. Hence, the retrieved workflow W is transformed into an adapted workflow W_n by chaining various adaptation steps $W \overset{s_1}{\to} W_1 \overset{s_2}{\to} \ldots \overset{s_n}{\to} W_n$. This process can in principle be considered a search process towards an optimal solution w.r.t. the query.

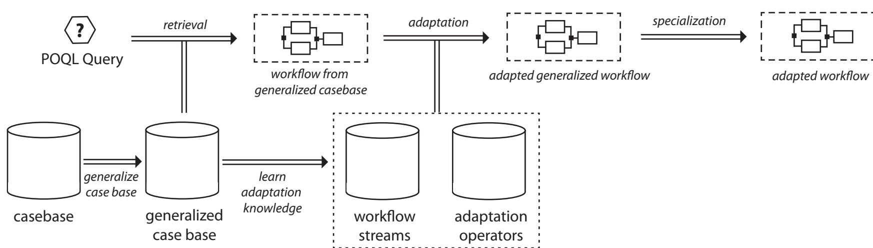

Fig. 1. Overall workflow adaptation process

These adaptation steps are performed by different adaptation approaches, which are integrated in a single process such that they can be executed in alliance in order to improve adaptation capabilities [16]. More precisely, compositional adaptation [15] primarily replaces meaningful subcomponents of a workflow, called *workflow streams*, by more appropriate subcomponents of other workflows. Subsequently, adaptation operators [18], which are learned automatically from the case base, enable to remove, insert, or replace smaller workflow fragments. This adaptation process is further enhanced by generalization of workflows and adaptation knowledge [17]. Both consist of generalized workflow elements that are placeholders representing a set of possible elements. The adapted workflow containing such elements, is finally specialized according to the given query, i.e., suitable workflow elements are chosen.

Consequently, adaptation is executed based on the best maching workflow from the repository. However, Smyth and Keane [23] already stated, that it is important to reflect the adaptability during retrieval. Otherwise, retrieval may provide a workflow that cannot be at best adapted according to the query. Thus, the optimal workflow solution w.r.t. the query cannot always be ensured. Hence, there is a demand for methods enabling the assessment of adaptability of workflows, for example, by executing various example adaptations [6]. The main assumption is that workflows that are very adaptable in many scenarios are also highly adaptable in other scenarios. The computed adaptability value of the workflow can then be considered during retrieval. Another threat for retrieval and adaptation of workflows are insufficiently defined workflow models in the repository. Such a lack of information can result in inappropriate workflows selected during retrieval or incompletely generated adaptation knowledge. Both hamper the presented workflow modelling assistance. To prevent this, workflow completion [20] aims at deriving the missing information automatically prior to retrieval and adaptation.

The modelling assistance has been implemented and evaluated using the CAKE (Collaborative Agent-based Knowledge Engine) framework [1] developed at the University of Trier [4]. The CookingCAKE[2] prototype [16] demonstrates the presented approach in the cooking domain, where workflows represent cooking instructions consisting of preparation steps and involved ingredients.

2 Future Work

Future work comprises approaches for supporting the manual adaptation of workflows by means of the developed POCBR adaptation methods. A drawback of applying adaptation methods automatically, is that the adaptation goal must mostly be known previously. Consequently, this can lead to a non-optimal or undesired solution. Hence, user interaction [1] is a promising approach to overcome this drawback. Interactive adaptation could support the search of a suitable query and hence the desired solutions. The idea for supporting workflow adaptation is that the user is involved directly during adaptation by manipulating the workflow manually. Based on the users' workflow manipulations, the query can be refined automatically. Subsequently, suggestions are made about a possible automatic workflow adaptation. This suggested adaptation can be accepted or rejected by the user. This process, helps to refine the query stepwise and overcomes the drawback of an extensive search for the desired solution.

Finally, the developed methods will be analysed by an extensive summative evaluation. While the adaptation approaches have already been assessed seperately, an overall evaluation is planned to enable a comparison between the presented approaches. Main factors affecting the utility of workflow adaptations are the increased fulfilment of the workflow after adaptation w.r.t. the query as well as the quality of the adapted workflow. Thereto, quality metrics will be based on various quality frameworks [11,21,10].

[1] `cakeflow.wi2.uni-trier.de`
[2] `http://cookingcake.wi2.uni-trier.de`

An analytical evaluation will provide information about several computable quality metrics such as the complexity of the workflow, the throughput time of the workflow as well as the fulfillment of the query. Further, an experimental evaluation will be used to capture a more user-oriented view on the workflow quality and further aims at investigating the utility of adapted workflows. The basic approach is, that the workflow quality will be assessed by a blind experiment ignoring the query in which the users rate the adapted workflow and the retrieved workflow, not knowing which of these workflows have been adapted. Then, they rate several items on a likert scale to acquire users perceptions on the workflow models quality. Thus, the quality of the retrieved and adapted workflows can be compared and conclusions on the impact of the workflow adaptation methods on the workflow quality can be drawn. Moreover, the utility of workflow adaptation methods is investigated. Since utility depends on the current goals [21], workflow utility can only be assessed knowing the query. Then, users rate whether they prefer the adapted or the retrieved workflow.

All workflow adaptation methods will be investigated in a joint as well as in separate applications. Thus, a comparison of the different adaptation methods can be achieved and conclusions on the overall adaptation process can be made.

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