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Towards Intelligent Support of Workflows

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Abstract

In order to support business processes in a dynamically changing environment, workflow management systems are required to flexibly react to changes in the organization of work. We propose the notion of intelligent support for workflows by enhancing an existing workflow management system with three different concepts. First, agents are empowered to adapt the pre-planned workflows to their case-specific situation. Second, a recommender system presents to the agents the operations favorable in their current work situation. Finally, process histories are analyzed in order to make the implicit process knowledge explicitly available for further reuse.

Introduction

The idea of capturing and controlling business processes by means of computer technology is relatively old, the first systems dating back to the 70ies (Zismann, 1977). However, mainly due to immature technology, it took more than 15 years, until business process automation spread beyond research communities and conquered the market as *workflow management systems* (*WfMS*). By making business processes explicit, WfMS promise to increase their efficiency and, consequently, to raise productivity and the competitive edge of an organization.

Customer care systems are an emergent application area for WfMS. One particular project in this area we are currently involved in is the integration of WfMS facilities into a telephone network management and information system with integrated help desk. A WfMS could efficiently automate especially various back-office processes like moving equipment, installing cables, or billing, since they can be easily standardized. However, it has been encountered during our project that there are also many processes like handling of incoming user requests from the help desk, which often lead to unanticipated situations, thus requiring ad-hoc reactions. Such business processes which exhibit properties of both standardized business procedures and ad-hoc workflows not modeled in advance are common in many application areas. What is therefore needed is the homogeneous integration of both, pre-modeled and potentially automated workflows as well as situated actions, with a special emphasis on supporting adaptive and ad-hoc workflows.

Commercial WfMS often do not entirely fulfill these requirements of flexibly reacting to changes in the organizational environment (Sheth, 1997; Ouksel and Watson, 1998). However, there are already various attempts to enhance flexibility of WfMS. Approaches range from the adoption of *more robust process models* based on constraints (Glance et al., 1996; Hull et al., 1999), to allowing *controlled adaption and evolution of process models* (Casati et al., 1996; Reichert and Dadam, 1998), to *exception support*, which requires deviations from otherwise unchanged process models (Klein and Dellarocas, 1998; Chiu et al., 1999). These approaches emphasize predefined models and system control, which has to be surpassed in unanticipated situations. Other approaches, in contrast, put more emphasize on the knowledge and creativity of *agents* (i.e., the ones responsible for performing a workflow) by empowering them to construct personal process models, or to perform entirely ad-hoc workflows (Carlsen and Jorgensen, 1999; Han et al., 1998; Swenson et al., 1994). *Groupware* systems take the concept of empowerment even further, in that agents mutualy coordinate themselves based on shared workspaces and awareness mechanisms (Rolfsen et al., 1999).

However, there is more to adaptive/ad-hoc workflow support than just allowing it. It is especially in unanticipated situations when agents would benefit from WfMS features like the provision of relevant process knowledge, the identification of model patterns useful or even required for an agent's goal, and guidance in composing patterns. While first steps towards such *intelligent workflow support* have been made by research in artificial intelligence, organizational learning, and process knowledge management (Abecker et al., 2000; Berry and Myers, 1998; Carlsen and Jorgensen, 1999; Malone et al., 1997; Mueller and Rahm, 1999), yet a comprehensive solution has not been found.

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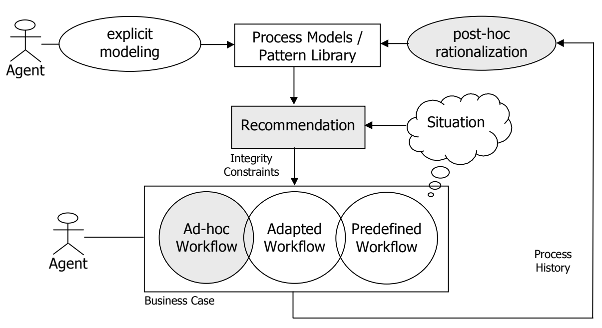
The *Co-flow* Approach

"The trick is to bring plans and particular circumstances into productive interaction" – Lucy Suchman (Suchman, 1987).

Our approach to *intelligent workflow support* builds on the WFMS TriGS*flow* (Kappel et al., 1997; Kappel and Retschitzegger, 1998; Kappel et al., 2000). The emphasize of TriGS*flow* is on balancing between reusability and adaptability. To reach this goal, TriGS*flow* integrates three basic techniques. First, an *object-oriented database system* is used to build a generic workflow model by means of predefined abstract and concrete object classes, including classes for activities, agents, and workflows. This workflow model is generic in the sense that specific business domain objects are modeled by simply inheriting and customizing the corresponding predefined classes. Second, to cope with changes in the personnel, a *role model* has been integrated into the object-oriented environment in order to decouple activities from particular persons. An agent and its roles are represented as instances of several distinct object classes; whereas roles may be specialized by inheritance, an agent may acquire new roles by composition. Third, *event/condition/action (ECA) rules* are used to allow for a flexible coordination of activities as well as for resources needed to perform these activities. Thus they can be seen as the glue between the basic building blocks of the generic object-oriented workflow model.

Co-flow extends this basic system by three main components (cf. the grey boxes in Figure 1), which together constitute our notion of *intelligence*.

Figure 1. Overview of Co-flow Components



First, users are empowered to *adapt and extend the pre-planned process models* of TriGS*flow* to their business case-specific situation, by means of ad-hoc activities and case-specific process models. Second, adaption of process models as well as employment of ad-hoc activities is not only enabled by the system and can be initiated by agents. Rather, these possibilities are actively supported by means of a *recommender system*, which presents to the agents the operations favorable in their current work context. Finally, Co-flow makes use of agents' adaptions of and ad-hoc contributions to the process model by means of analyzing the process history and making this process knowledge explicitly available for further reuse via *post-hoc rationalization.* As will be seen in the forthcoming sections, the integration of intelligent components into TriGS*flow* can be seamlessly done by reusing the basic mechanisms of TriGS*flow* as far as possible.

Plan Construction, Plan Adaption, and Ad-hoc Activities

Co-flow allows for the adaption and extension of process models thus customizing them to the specific situation of each different business case. This is facilitated by the fact that the responsibility for process enactment is not exclusively given to the workflow engine. Rather, each case has an associated *case manager* who is *empowered to adapt* and extend the predefined process model on a case-by-case basis, according to predefined constraints. Furthermore, agents may implicitly extend the plan by means of ad-hoc activities which are performed in the context of the case. Both, model adaptions and ad-hoc activities are allowed any time while a case is active, without having to suspend and restart the case. Thus a homogeneous integration of *both pre-planned and ad-hoc* activities can be achieved. At the same time, the degree of *automation* can range from fully automated processes as needed for production workflows to fully user-controlled workflows as required for ad-hoc workflows.

In dynamically changing environments a suitable workflow depends on many factors of the actual situation, thus making it impossible to model the complete process in advance. Nevertheless it is still possible to identify and predefine stable and thus reuseable aspects of changing processes. Such aspects include, e.g., activity descriptions, goals, pre- and post-conditions, available applications and data objects, agents and resources available. These rather atomic aspects can be further composed into higher-level *collaboration patterns*. All the aspects and patterns form a *library of organizational and process knowledge*. The library of collaboration patterns is organized according to the organizational structure, i.e., patterns may be specific to individual agents or groups, and are managed and used by agents themselves.

The facilities for ad-hoc workflows and model adaption can be easily integrated with TriGS*flow*. The use of the object-oriented paradigm together with roles and ECA rules provide the pre-requisites for adaption of process models. To provide ad-hoc collaboration, TriGS*flow* has to be extended with a communication facility, which has to support both the freedom to express ad-hoc user goals as well as a formal integration with the WfMS in order to keep track of the workflow. We adopt a speech-act based technique, since speech acts provide for a structured communication, and the concept of *conversation for action* suits well into the workflow domain (cf. Medina-Mora et al., 1992).

Recommendation of Activities

In the scenario outlined above, the workflow evolves together with its process plan. It is thus not feasible to know in advance which activities are required or recommended during a particular case. This can be decided only ad-hoc in the context of the evolving situation. We see two severe problems in such ad-hoc decisions. First, it is not ensured that required activities are performed and business rules are not violated. Second, there is a big chance that users do not take advantage of the knowledge of best practices available in terms of process patterns, simply because it requires extra effort to search for suitable patterns.

Co-flow addresses these problems by providing a *recommender system* (Resnick and Varian, 1997), which actively provides the user with workflow patterns that are required or otherwise recommended in the current work context. Such recommendations can range from suggesting agents for performing a given activity (e.g. experts, experienced users, currently available users) to activities appropriate or required in the current context (e.g. invoke a certain tool, delegate the activity) to patterns suitable for extending the current plan. In general, every operation which is available to an agent is subject to recommendation, including plan adaptions (e.g. remove or cancel an already planned or activated activity).

Recommendation is based on the system's guess of the current work situation, and on it's knowledge of both explicitly predefined and implicitly learned process models. The current situation is recognized by first collecting contextual information relevant for the work situation using ECA rules, and second by classifying the contextual information w.r.t. the process knowledge. Based on this classification, process knowledge related to the current situation can be derived and suggested. Contextual information which we consider relevant for classification of a work situation includes:

- The agent and her role.
- The description, i.e., the goal of the current activity. Goal descriptions can range from simple text to structured representations, including completion dates, required documents, and post-conditions.
- The current state of the process, i.e., already initiated and completed sub-activities, planned activities, etc.
- The importance of the case, depending on the priority assigned, deadlines, and related contracts.
- The information associated with a case. Since such information is mostly domain-specific, classification might be improved by qualification-rules like "customers with a total order above 10,000 are considered important", enabling the system to distinguish situations more accurate and thus to provide more appropriate recommendations.
- Notifications of related events from outside of the process, e.g. further problem reports from the same customer.

Learning from Agents

The more freedom each user has in the course of a workflow, the more process knowledge she contributes to the process. Situated plan adaptions and ad-hoc activities like tool invocations, delegation of sub-activities to other agents, forwarding of not yet complete cases, etc., are all expressions of implicit process knowledge. This knowledge arises out of the actual situation and is therefore difficult to be captured by analysis and modeling. Nevertheless, it is an important asset and should be made explicitly available to other users.

Co-flow learns from users by synthesizing process knowledge (i.e. patterns) out of the history of traced user activities (cf. Herbst and Karagiannis, 1999; Agrawal et al., 1998). The occurred situations are classified (see above), and interrelations among such classes as well as relations to existing process models are derived. Process knowledge learned in that way supplements the explicitly modeled knowledge and is immediately made available to agents via the recommender system. In particular, the learned knowledge can provide answers to questions such as:

- What did I/others do in such a situation? (What should I do now?)
- Who else was in such a situation? (Who knows how?)
- How long did it take to ...? (How long will it take?)
- What precedent or similar cases exist?

In addition, learned process knowledge can be utilized to create or adapt / optimize predefined process models.

Ongoing Work

A Co-flow prototype is currently being developed. In particular, the ad-hoc workflow component is already running and is going to be evaluated based on concrete customer care scenarios, such as handling a fault report, or processing a change order.

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