A Collaborative Approach to Maturing Process-related Knowledge

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Abstract. We introduce a new approach supporting knowledge workers in sharing process-related knowledge. It is based on the insight that – while offering valuable context information – traditional business process modelling approaches are too rigid and inflexible to capture the actual way processes are executed. Therefore, business process models are made agile and open for changes during execution. To achieve this, the strict distinction between build time modelling and run time execution are softened and process activities are represented to the users in a way that allows for individual adaptations. That can be done by attaching resources, commenting on an issue or adding problems and solutions to an activity or process. In addition activities can be delegated or new (sub-)activities can be added. Thus, the model can adapt to the reality of actual process executions and valuable resources and experiences are proactively presented to users in the right context. A double-staged approach is chosen to apply the model in the real application scenario of an university.

Keywords: Task Management, Process learning, Adaptive and context-aware processes, Knowledge-intensive processes.

1. Introduction

Agility has emerged as an important common characteristic of successful businesses. Organisations of any size benefit from quick response to volatile markets and rapid changing user requirements. Conventional business process modelling and execution approaches have found themselves overstretched in such situations due to the lack of flexibility and the amount of overhead required for predefined process models.

In this work, we are particularly concerned with process-related knowledge that is both knowledge about processes (called process knowledge) and knowledge needed in processes (called functional knowledge). It is very knowledge that we want to leverage in order to increase the agility of organizations. These need to make sure that employees share both kinds of knowledge to keep experience in the organisation and optimise its performance in the face of employee fluctuation.

Business Process Management Systems address that need making process structures and resources explicit but lack of automation. Workflow Management Systems support automated process execution but in general they are not rich enough regarding their modelling functionality. Moreover, the strict separation of design time and run time functionality leads to problems regarding knowledge intensive processes [1].

In addition knowledge sharing (for all kinds of knowledge) often takes place informally, e.g., via email and telephone or by imitation (apprenticeship). Although this is flexible and can be very efficient at times, it usually restricts the benefits to the persons that are directly taking part in the exchange (i.e., the information is completely lost for all others). Even if employees have documented their experience and made this publicly available (e.g. in a company Wiki or on a file share) this does not mean that others are aware of the existence of such knowledge. Needless to say there is much less chance that they will be able to find it or that they will even look for it in a given work situation where it is needed. With respect to process knowledge the situation is even worse. Usually, process models are created by experts who attempt to collect all relevant knowledge about a certain process. Even if a process model truly represents the way how business is done under certain generalised circumstances, the model often differs from the reality of process execution. In general variations in execution are critical for applying process knowledge to new situations, but seldom readily documented. Even with business process reengineering, the problem remains: business process reengineering is carried out in a structured and systematic way and cannot keep pace with quick business or market changes.

The intrinsic inadequacy of formal and informal knowledge sharing/transfer inspired us to take an eclectic approach. As business process models are based on static process knowledge, providing functional knowledge and supporting knowledge workers during execution of their tasks based on a 'snapshot', we find that in practice workarounds are exercised, by-passing the formal procedures of the workflow engine and using informal knowledge sources, that are not generally available.

It is the aim of this paper to bridge exactly this gap: to learn process models by doing and to enable adding and sharing individual knowledge and experience. This approach already starts with agile process modelling [2] but enhances the functional knowledge provided through process execution, with additional knowledge used in a specific process instance and the possibility of its informal exchange. This requires the participation of users who are to be engaged in knowledge and resource sharing activities. This participation employs a succession of phases that have been called seeding, evolutionary growth and re-seeding in the SER model by Fischer [10] (originally applied in the area of managing complex design environments).

The SER model [10] describes an approach "between the two extremes of 'put-all-the-knowledge-in-at-the-beginning' and 'just-provide-an-empty-framework'". It combines the strengths and avoid the weaknesses of both top-down and bottom-up approaches, respectively. The SER model assumes that once a seed is taken up by a community, there is a phase in which the knowledge artefacts grow in a rather uncontrolled way. According to Fischer, it is necessary not to force users to invest much effort into formalising their contributions since this would interrupt their normal work process (something most people are not prepared to accept). Contribution should be kept simple and will eventually lead to structures that are too redundant and

unwieldy to be understood and managed. They are thus pruned and restructured in the reseeding phase, which is done by a knowledge engineer, removes inconsistencies and creates generalisations (i.e. removing pieces of information that are too context-specific) and formalisations of the knowledge. This is exactly what we want to achieve with the task pattern approach that we introduce in this paper as mediator between process modelling and individual task execution.

Projected onto the SER model, reseeding in our work is understood as a chance to understand and align the most frequent (and hence possibly most important) contributions to task patterns in order to learn about potential improvements of the original seeds. This realises a continuous improvement of process models and the task patterns based on actual work activities. In this paper we explain how this reseeding.

The paper is organised as follows: in section 2 task patterns as the central building block for learning and maturing process-related knowledge is described. This section is followed by a description of our approach to monitor performed tasks in order to semi-automatically support process model adaptations (section 3). In section 3 we give an example of our new approach applied in the application scenario of the University of Applied Sciences Northwestern Switzerland. Next, we describe the architecture and some technical details of the system that we implemented (section 4), then give a brief overview on previous work related to learning, sharing of work experience and agile business process management (section 5) before section 6 concludes.

2. Combining knowledge intensive processes with task patterns

A *business process* is a collection of structured *activities* with a precise goal to be achieved over a period of time. In general, the activities of a process are in a pre-defined order, resources are mapped (e.g. software systems or personnel, via roles) and the process flow is depending on fixed decision rules. The KISS approach [3] aims to bridge the gap of a strict distinction between design-time and run-time. A knowledge intensive process (KIP) can be regarded as a collection of activities building the 'skeleton' of a business process, some activities of which can be knowledge intensive (called 'KIA'). Whereas ordinary activities are always executed (i.e., in every process instances), KIAs are optionally executed depending on information specific for the certain process instance. That can be application data, process data or functional data.

KIAs are modelled during build time but their execution is triggered - or suggested - during run-time based on rules. If, for example, an application has to be checked, several KIAs could be executed such as ‘Refer to an expert’, ‘Ask for additional material’ or ‘Clarify with applicant’. Which one is selected within a specific process instance is to be executed depends on rules operating on run time information: information already provided for the application, decisions taken in previous process instances or data that is available from related information sources, e.g. out of a legacy system maintaining data of former applications.

We will call the concrete instance of an activity (assigned to particular members of an organisation) *task*, regardless whether it is a KIA or not. A *task* is a definition of a

particular item of work that specifies the requirements and the goal of this work (cf. [4]). We introduce *task patterns* as abstractions of tasks that provide all information and experience that is generally relevant for the task execution. By abstraction we mean common features of a family of similar tasks, which aim at the same goals under similar conditions (for details refer to [5],[6]).

In this section, we describe how agile business processes can work together with task patterns to yield a new form of knowledge sharing. Meanwhile, in order to fully understand the way we envisage informal process knowledge to be attached to agile business processes, we explain the notion of task patterns more closely.

2.1. Task patterns

In our approach of maturing process knowledge described below, we will introduce a one-to-one relationship between an activity and a task pattern. That is, for each activity of an agile business process there is exactly one task pattern that serves as the basis for collecting information and experience around the tasks. Tasks concretise task patterns and thus instantiate the corresponding activity.

How does this facilitate the transfer of information and experience work? In general, task patterns provide two means for knowledge sharing (cf. [5], [7]):

- Abstraction services: these provide contextual information about **resources** that can be used in the task – including information objects such as files, but also persons who are to be contacted – or **sub-tasks** that should be started.
- Problem/solution objects: These enable users to share **experience** regarding typical problems that may arise during the execution of a task, together with descriptions of possible solutions.

In addition to this information, a task pattern can contain so-called decision objects that help **filtering** abstraction services w.r.t. a given work context. Let us consider the example of planning a business trip; depending on the means of transportation, the filter mechanism might be applied to available abstraction services so as to recommend to the user only those that are applicable to her particular means of travelling. Users can maintain task patterns in two ways:

- **Consuming** information from task patterns: when working on a task T, a suitable task pattern P can be displayed alongside the task. The user can access P's abstractor services to consume the resources that they offer and attach them to the current task T. The same applies to solutions offered for a problem that happens to occur in T.
- **Contributing** to task patterns: users can also attach resources to their concrete task T while working on it. This enables them to associate such information with abstraction services or problem/solution objects of the task pattern P and publishing that information to a shared repository.

The approach maintains a clear separation between personal knowledge, contained in the individual task, and public experience, contained in the task pattern. This separation prevents an intermixture of private and public data. Therefore, it is obvious for the user what task information can be exposed and shared with others and what should handled with caution [8].

2.2. Sharing work experience

Regarding knowledge sharing, each activity of the process model is the basic unit to which information and experience gets attached. This happens via a one-to-one relationship between task patterns and activities (which are instantiated by tasks): for each activity, the corresponding task pattern collects the information and experience that users attach to it while they work on tasks.

In the following, we will describe how agile business processes and task patterns play together. We differentiate such interplay into one that happens at design time and one that occurs during run time. At design time, for each activity, a draft of a corresponding task pattern is created with the help of a group of experts who define an initial set of abstraction services and known problems together with their solutions (cf. section 2.2 below). The initial pattern should be thought of as a *seed* that triggers the process of attaching experience to a work context. Subject to further refinement, the initial task patterns do not have to be (and will never be) complete in the beginning. These initial patterns are meant to grow larger while their users learn more about the activities and mature over time adapting to the actual way in which they are executed in practice.

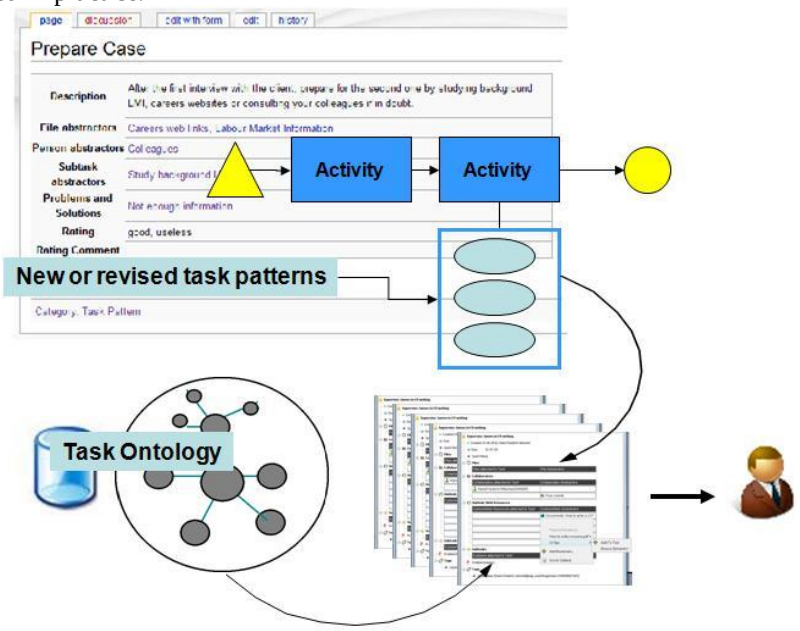

Fig. 1. Using task patterns in activity execution of knowledge intensive activities (KIA).

Figure 1 depicts the task handling in the two phases of process management: the upper part shows the process model with two simple activities (blue rectangles) and 3 KIAs (light ellipses). All process information is stored in an ontology based data store. Specifically, this store contains all information on task instances, encapsulated

in so-called *task description objects* (TDOs). The lower part shows the relation between the activities (here the KIAs) and the task patterns provided to the user.

Fig. 1 also depicts the run time part: when the process is actually executed, the existing task pattern (e.g. *P*) for an activity will be retrieved. A task pattern management system will first consult the task ontology to retrieve the abstraction services of *P*. It then helps users to instantiate *P* by recommending candidate fillers or each abstraction service. More specifically, one proceeds as follows:

- The workflow engine identifies which task T with corresponding task pattern P should be performed next.
- A task T is instantiated and a set of organisational members is selected as potential executors of T. The selected persons are notified. They can accept or reject the request to execute T.
- Since T is the instantiation of an activity A and since for each activity A, there is exactly one task pattern P assigned to it, the workflow engine will next retrieve that task pattern P. It then determines the context of T and uses it to retrieve relevant resources that should be added to abstractor services of the task pattern P. These resources will be added to the TDO corresponding to T.
- Once the first person has accepted the task, the corresponding TDO is fetched, together with the task pattern P. P is enriched with the information in TDO and both the task details and the task pattern are displayed to the user in a task management application.
- The user can then start working on the task, making use of the information provided in the task pattern P. Resources, but also problem/solution objects can be easily copied from the task pattern into the task, becoming *attachments* to it.
- On the other hand, the user can also attach her own resources (that she considers useful in the context of T) to T.
- Enhancements of a task pattern are stored locally. They will thus be available if the same user performs another task T' that corresponds to the same activity A (i.e. when the task pattern is loaded next time). However, if the user chooses to *publish* the enhancements, she can do so by a simple click, thus making them available to all other users who have to perform a task of type A.
- When the user has finished working on the task, she sets the status to "completed" of which the workflow engine is notified.

2.3. Learning from work experience

As mentioned in the introduction task patterns should be thought of as seeds to aggregate information contributed by end-users. This participation becomes particularly relevant since we do not believe in fully automatic improvements of process models. Instead we envisage a tool that is able to detect deviations and analyse the collected data in order to make suggestions for process changes. Based on those blueprints the knowledge engineer will be able to decide on the suggested changes. For process improvement the following aspects will be analysed [5],[6]:

- ***Subtasks*** that are frequently added to a task (or as subtask abstractor to the corresponding task pattern): if many users add the same (kind of) subtask to a

given task, this indicates that potentially the process model can be improved by including that subtask as a new activity.

- ***Delegation*** of tasks could indicate that either the work balance is not correctly considered or the skills of the assigned persons are not appropriately evaluated. Rules for resource allocation should be adapted accordingly.
- ***Problem/solution*** objects added to a task pattern can be included by other users in their tasks. If many users do so, it means that the problem occurs frequently and that it should be considered for process or task pattern improvements..
- ***Resources*** such as documents or persons can be attached to abstractor services of task patterns, indicating the contexts in which they are useful (namely the process, and activity, task, respectively they are being used in). An analysis of these contexts is generally of interest as it may help to categorise the resources according to their domains of application. Similarly, analysis of patterns in the set of all task pattern document attachments can lead to a categorisation of documents based on the type of situation(s) in which they are useful.
- ***Decision*** objects help users to filter resources offered in task patterns. Every decision objects offers alternatives from which users can choose the most appropriate option. Depending on this choice, selected resources are offered by corresponding abstractor services (see section 2.1). An analysis of such (user-defined) decision objects and the chosen alternatives may lead to a more fine-grained process model in which these decisions are incorporated directly

In all these cases, an initial step in the analysis is *aligning* the corresponding items with each other, e.g. to find out that two problem descriptions refer to the same (type of) problem in reality.

3. An application scenario

This section presents the results of a formative evaluation study that was performed within the University of Applied Sciences Northwestern Switzerland (FHNW) in the context of the EU-funded project MATURE[1] to elicit application scenarios and requirements for the ICT system that is being built to realise the process-related knowledge maturing concepts presented in this paper.

The model for business process for matriculation is shown in **Fig. 2**. We can see that the student, the administration office and the dean are involved in the process; tasks can be assigned to the administration office or to the dean as they directly interact with the system. Knowledge intensive activities are highlighted in red.

[1] http://mature-ip.eu

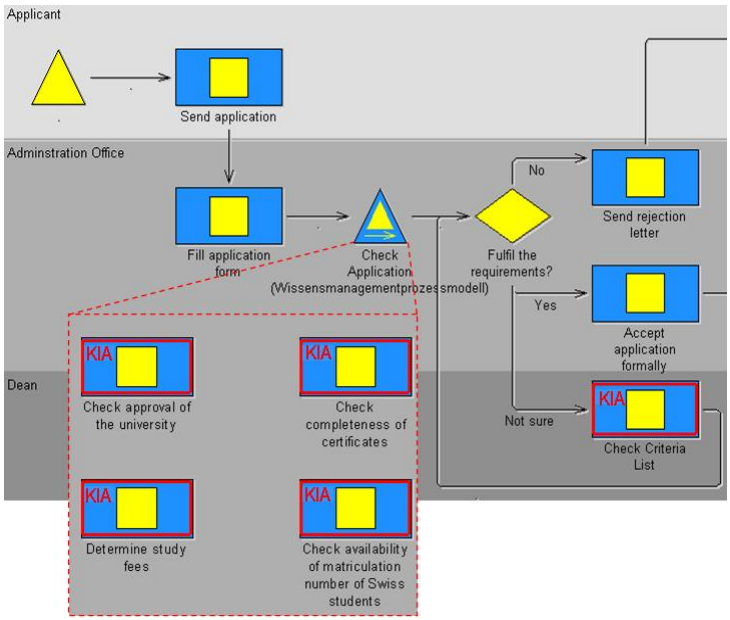

Fig. 2. First part of the matriculation process model and the KIP sub-process "Check application".

The matriculation process starts with a student's application request. After the receipt of the request, several checks of the application have to be executed in a KIP.

As it is shown, the KIAs will not be executed in a pre-defined order. The reason is the following: Depending on where the applicant origins from (but also further criteria), different activities have to be performed. E.g. the availability of a matriculation number has only to be checked when the applicant is from Switzerland. Therefore, a **variable process identification and selection service** automatically chooses the needed activities and assigns them to the possible executor of the activity. The determination of study fees is based on given regulations and can be supported using **constraint checking service** for decision making. Further on, a **resource allocation service** assigns artefacts based on given criteria. E.g. when checking the approval of a university, appropriate websites or experts from a respective nation are attached to the activity.

After these checks, the process goes on and it is decided whether the needed requirements are fulfilled or not. The **branching and decision making service** can be invoked in order to decide, whether it is already clear at this stage that the requirements cannot be fulfilled by the applicant and a rejection letter is being sent. Otherwise the applicant is invited to an interview. Afterwards an interview will be hold, the application dossier will be updated and a commission meeting will be hold to decide about the acceptance or rejection of the applicant. The process continues with some mainly administrative activities till it reaches the end.

3.1. Example of task pattern application

Now, we illustrate the application of task patterns by giving an example from the matriculation scenario described above. Let us consider the task of checking the completeness of an applicant's certificates (part of the knowledge intensive sub-process "Check Application" displayed in Fig. 2).

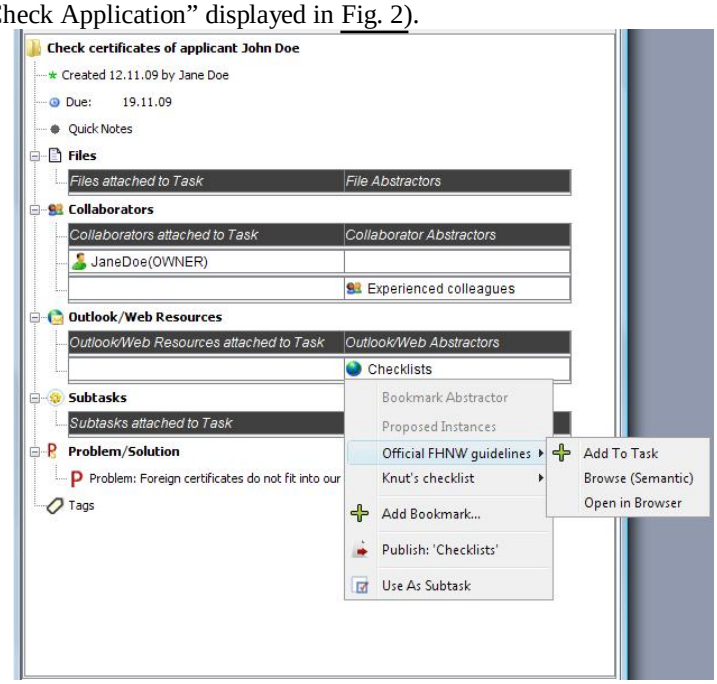

Fig. 3. An example of a task pattern and how to consume information from it.

Fig. 3 shows a task pattern that corresponds to this activity. More precisely, the details of the current task – namely "Check certificates of applicant John Doe" – are displayed (e.g. due date and owner of the task). The task pattern with its abstractor services (called "abstractors" in the UI) is displayed on the right-hand side. We can see two abstractor services:

– Experienced colleagues: colleagues who have handled many applications
– Checklists: lists that provide guidance as to what should be checked and how

The figure also shows a context menu that appears when right-clicking on the latter abstractor service. It contains the resources that are offered by the abstractor service, together with a sub-menu that can be used to consume these resources, where clicking on "Add to Task" results in a resource being displayed on the left-hand-side, vertically aligned with the corresponding abstractor service. A similar context menu exists for resources on the left-hand side, allowing these to be associated with abstractor services.

Thus end users can easily consume information offered in task patterns and contribute to them, simply using these context menus.

In order to verify the automated process knowledge maturing, comprehensive use of the approach is necessary. That will be the case within the evaluation phase 2 planned for 2010. Therefore no statements can be made with respect to that, yet.

4. Implementation

4.1. Process modelling and execution

The modelling of an adaptive business process can be performed in a semantic modelling environment like ATHENE [13] or WSMO-Studio [29]. ATHENE provides the creation of several models (process model, organizational model, etc.) based on ontologies. The activities of the processes will be linked with the related task patterns and resources (files, roles, etc.) which are stored in semantic repositories (1) (see **Fig. 4**). Further on, the process model can be enhanced with adaptivity services (2). After modelling the process in ATHENE it can be transferred to the execution framework and stored in a semantic repository (3). The model represented in a knowledge representation language like RDF/S (http://www.w3.org/TR/rdf-schema/) or OWL(http://www.w3.org/TR/owl-features/) will be transformed via a transformation service in process execution language like BPEL (http://docs.oasis-open.org/wsbpel/2.0/OS/wsbpel-v2.0-OS.html) or XPDL (http://www.wfmc.org/xpdl.html).

The transformed process can be executed in the execution framework (e.g. BPEL workflow engine) (4). The process can access the linked resources which are stored in the semantic repositories. During runtime the process can invoke the defined adaptivity services. The “task management service”, which is part of the process framework, invokes the task GUI (graphical user interface) (5). The instance management service stores and holds the instances.

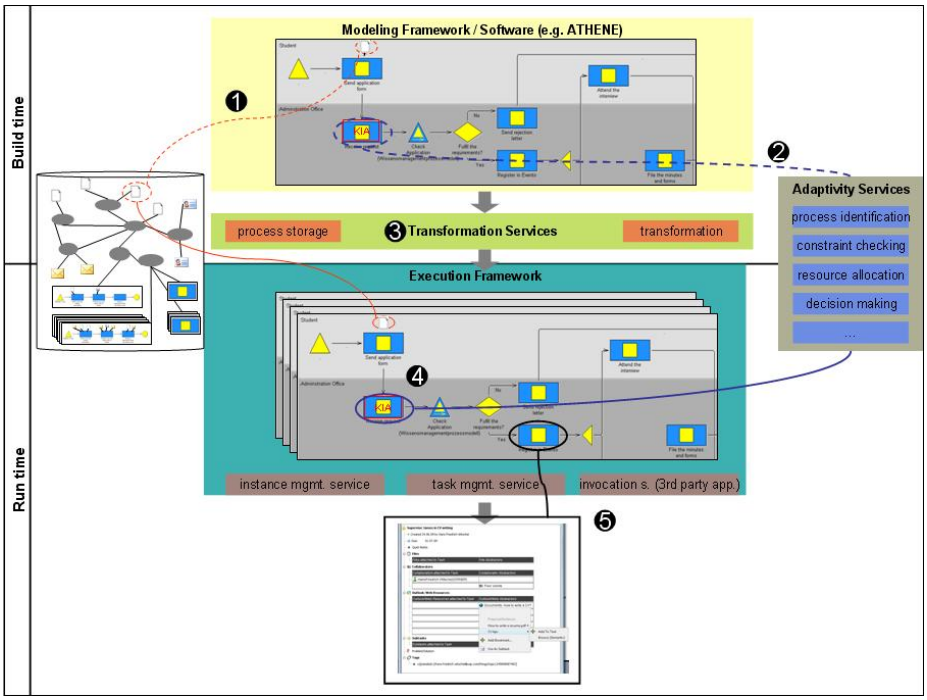

Fig. 4. System Architecture

4.2. Task pattern and task management

Tasks and task patterns are delivered to the user through a Personal Task Management infrastructure. That infrastructure is part of the NEPOMUK Social Semantic Desktop [14].

It consists of a semantic task management framework (STMF, [15]) which offers task-related (web) services over the entire desktop and handles the manipulation, storage and retrieval of all task and task pattern-related information; information is stored locally in the RDF repository of the Social Semantic Desktop in a way that ensures seamless semantic integration of information objects and task representations.

As a user interface the KASIMIR sidebar [16] has been developed, which builds on the STMF task services and makes them available to end users. Kasimir allows users to assign basic task properties and to attach involved persons, information objects and subtasks. It also allows users to view task patterns attached to a task, consume its resources and contribute

In addition to the local storage of personal task (pattern) information, there is a server component that stores public task patterns. It is based on Semantic MediaWiki (SMW, http://semantic-mediawiki.org/), which allows the initial modeling and later adaptation of public task patterns over the Wiki's user interface. Entities related to task patterns are modeled as SMW semantic templates.

5. Related Work

Making business processes agile to meet the requirements of knowledge intensive work and faster changing business environments is a topic that has already been addresses for some time. It is guided by the insight that in knowledge intensive processes the particular sequence of tasks is often variable and depends on the information at hand. Traditionally Workflow Management Systems (WfMS) distinguish between design-time and run-time [17] and it is the dependency of the process on input information that makes this distinction to become blurry. An overview of approaches to tackle this problem can be found in [18].

Usually a process model containing all activities and resources is created during design-time. Flexibility is provided through modelling choices and merge constructs. This can lead to highly complex models which are hard to maintain and change [9]. In addition, especially in the tertiary sector the processes are knowledge-intensive and cannot be foreseen for all exceptional situations and circumstances. During run-time exceptional situations, unforeseeable events and unpredictable situations have to be dealt with. Therefore van der Aalst et al. introduced case handling 'as a new paradigm for supporting flexible business processes' [19] in order to avoid predefined process execution.

However, supporting flexible process execution does not cover all of the dimensions of change in business processes (dynamism, adaptability, flexibility) as introduced by Sadiq et al. [9]. For this, tracking and mining of the actual process/task variations users perform are necessary.

To support agility, semantic technologies have been used in several approaches, amongst others by [20] for process implementation and querying by [21] to build their 'agent based business process management system' or by [18] to facilitate task patterns. Especially the pattern approach is tightly built on semantic technologies and an approach for combining it with Service-Oriented Architecture has been proposed [22]. Another semantic approach to process management based on Unified Activity Management has been suggested by Moran et al. [23]. A general overview is given by [24]. Recently, Feldkamp, Hinkelmann et al. introduced the 'KISS approach' combining semantically enriched process models with business rules ([3], [25]). Although this approach reaches the flexibility to execute agile processes, two aspects are not yet covered: a) how to share the knowledge gained through task handling without cumbersome publishing and b) how to automatically detect execution variances. In this paper we have shown how deviations between the actual process execution and the process model can be identified and how adaptations can be recommended automatically. Question a) is addressed in section 2.2, whereas question b) is detailed in section 2.3.

As far as the world of business process modelling is concerned, approaches to collect and mature process knowledge collaboratively are scarce. [26] has proposed an architecture that integrates knowledge management and business process management. However, this happens in a traditional expert-driven way. Approaches in the field of process mining (e.g. [19]) – which try to extract process knowledge from implicit information contained in system event logs – exploit user interaction, but do not actually encourage explicit user contributions to an evolving process knowledge repository. With respect to knowledge work this is a complicated task

since the nature of individual tasks and the associated experience cannot be identified properly enough to enable successful knowledge proliferation.

Sharing process knowledge in a task management environment has been explored e.g. in [27], suggesting to copy information from previous related tasks. Task patterns, as a more elaborate way of mediating experience transfer have been proposed in [18] and elaborated further, cf. e.g. [6], [8], [5]. In [28], a more process-oriented view of task patterns has been introduced where users can exchange and collaboratively develop lightweight process models.

6. Conclusion and Future Work

In this article, we have outlined a new paradigm of knowledge and experience sharing that enhances agile business processes. This is done through connecting activities in formal process models with loosely regulated task patterns emerged from our everyday work. The former gives guidance to the business target while the latter allows us to proceed in a way that best suits the end users' needs. Task patterns capture how people carry out a task (process knowledge) and how people leverage resources in supporting their solutions (functional knowledge). They thus help to avoid the problem of rigidity inherent in traditional process modelling approaches since it involves the end users in shaping the support that the model offers and since it eventually adapts to the reality of end users' process execution.

The results of our evaluation of the prototype with the University of Applied Sciences Northwestern Switzerland are promising: both the conceptual framework and the prototype were well accepted even though some non-technical barriers were identified.

In our approach we have followed the idea of knowledge maturing as a process that understands "learning activities as embedded into, interwoven with, and even indistinguishable from everyday work processes" [11]. According to the knowledge maturing concept learning is seen as a social and collaborative activity, in which individual and organisational learning processes are dynamically interlinked among each other [12]. This approach has been applied to knowledge intensive processes where the continuous collaborative enhancement appears as particularly important due to continuously changing work targets and situations.

We envisaged the following improvement to our approach. For the future, it is planned to implement and deploy the agile business process (together with appropriate task patterns) at the project application partners and to observe if and how the intended process knowledge maturing takes place. Compared to other types of knowledge, the evolution of process knowledge is less transparent and thus more difficult to analyse. The interplay between task patterns and process model provides valuable insights. Indeed, after having the process productive over a certain period, a reasonable amount of real-life usage data of tasks and task patterns can be accumulated. Such data provide the ground for automatic or customised business process model updates.

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