ENABLING END USERS TO PROACTIVELY TAILOR UNDERSPECIFIED, HUMAN-CENTRIC BUSINESS PROCESSES

"Programming by Example" of Weakly-Structured Process Models

Todor Stoitsev, Stefan Scheidl
SAP Research, SAP AG, Bleichstr. 8, Darmstadt, Germany
todor.stoitsev@sap.com, stefan.scheidl@sap.com

Felix Flentge, Max Mühlhäuser
Telecooperation Group, Darmstadt University of Technology, Darmstadt, Germany
felix@tk.informatik.tu-darmstadt.de, max@informatik.tu-darmstadt.de

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Abstract: Enterprises face the challenge of managing underspecified, human-centric business processes, which are executed in distributed teams in a rather informal, ad-hoc manner. This gave hibernating CSCW and ad-hoc workflow research a new push recently. However, there is still the need to clearly perceive end users as the actual drivers of business processes and to enable them to proactively tailor these processes according to their actual expertise and problem solving strategies. This paper presents the design and evaluation of a prototype for end-user development of weakly-structured process models through email-integrated task management. The presented CTM (Collaborative Task Manager) prototype uses "programming by example" to leverage user experience with standard email and task management applications and to extend user skills towards the definition of reusable process structures. By closely correlating to the actual user work practices and software environment, the tool provides a "gentle slope of complexity" for end users engaging in process tailoring activities.

1 INTRODUCTION

Up until recently, workflow systems were too formal and restrictive to be useful for knowledge-intensive and rather informal processes (Schwarz et al., 2001). The importance of such processes and the increase of distributed team work led to further research on enterprise efficiency, which clearly presents how "individual actions lead to overall enterprise performance" (Wiig, 2004). It becomes apparent that the traditional enterprise process modelling perspective is being replaced by tailoring of business processes according to the individual point of view and connecting them towards the achievement of common enterprise goals. This novel view on business processes emerges in analyst reports as the "Process of Me" (Gartner, 2006) and is recognized as one of the major challenges for the next generation Business Process Management (BPM). It states the fundamental need to provide end users with adequate techniques to proactively express process knowledge and to participate in business process management and design.

End User Development (EUD) is defined as "a set of methods, techniques, and tools that allow users of software systems, who are acting as non-professional software developers, at some point to create, modify, or extend a software artefact" (Lieberman et al., 2006). Within the presented paper a process model is considered as a software artefact, which can be adapted and enacted to support underspecified, human-centric processes. The presented study is motivated through the possibility to "render" appropriation of process models to end users and to "exploit the potential of opportunity-based and emergent changes" from the introduction of groupware in enterprises (Wulf & Jarke, 2004).

Riss et al. (2005) discuss the challenges for the next generation BPM by suggesting the recognition and reuse of "task patterns" and "process patterns" as alternative to static workflows. However, concrete examples for engaging business users in task pattern definition and modelling towards

generic enterprise process models are still missing as well as techniques for achieving that. This issue is in the focus of the presented paper. The described approach ensures a "gentle slope of complexity" (MacLean et al., 1990) for process tailoring activities by leveraging user experience with standard tools for collaboration (email) and task management (to-do lists) and extending user skills towards definition of weakly-structured process models through "programming by example" (Lieberman, 2001). This EUD technique enables unobtrusive support by embedding the process definition in the existing end user working environment and inferring process models from the captured executed activities. The described approach presents a valuable extension to "evolutionary" workflows (Hermann, 2000) and "interactive process models" (Jorgensen, 2004) by allowing "seeding, evolutionary growth, and reseeding" (Fisher et al., 2004) of weakly structured process models in shared enterprise repositories and task instance-based evolution tracking. The iterative, evolutionary transitions from execution to design (and vice versa) of adaptable, weakly-structured process models exceed the capabilities of known email-based workflows (Agostini et al., 1997).

In section 2 we present basic problems regarding current practices in ad-hoc processes, which are used to introduce process tailoring by end users. Section 3 presents a prototype for end user driven process definition. Section 4 describes results from prototype evaluation at a partner company. In section 5 we give conclusions and future research directions.

2 ADRESSED PROBLEM AREAS

The presented study builds up on state of the art research in the areas of task management, flexible workflows, CSCW and EUD. It is based on intra-organizational knowledge sources accumulating customer requirements as well as on dedicated site visits and interviews at three companies from various industries: textile (120 employees), software (ca. 500 employees), automotive (ca. 150 employees). Based on the preliminary studies we identified five generic problem areas concerning user work practices in ad-hoc processes that can be used to introduce user-driven process composition:

Lacking Transparency. Email is the main tool for exchange of tasks and task-related information in informal processes (Bellotti et al., 2005). Users further organize tasks in to-do lists (Bellotti et al., 2004). These tools do not provide end-to-end overview of running collaborative activities.

No Structured Storage and Retrieval of Process Knowledge. Users spent considerable effort to search for task-related data in email folders (Bellotti et al., 2004). While having individual strategies for storing data in email and file folders, users are not able to predict how their "sorting" practice will scale over time. Increasing data amount increases search effort and user efficiency degrades.

Lacking Exchange of Process Knowledge. As process knowledge often remains implicit, stuck in personal email and file folders, people "know" what to do but cannot share it efficiently with their colleagues. This leads to problems when domain experts are not available and cannot provide support on time critical activities.

Disjunction between Best-practices and Running Processes. A common way to store process guidelines is in text documents (e.g. Microsoft Word). Text representations do not provide the possibility to follow evolving user tasks with respect to the provided guidelines and to observe to what extent the described (best) practice is being followed, or why deviations have occurred.

Inability to Trace Evolving Best-practices. Best-practices for informal processes may often change due to the changing business conditions. Having previous process information in email and file folders and guidelines in text-based documents does not allow structured comparison and reasonable evaluation to what extent best-practices need to be adapted or if different variations have to be managed for different application contexts.

3 COLLABORATIVE TASK MANAGER (CTM)

The Collaborative Task Manager (CTM) is an email-integrated task management tool, with extensive support for definition, adaptation and reuse of weakly-structured process models. All industry partner companies involved in our preliminary studies were using Microsoft Outlook (OL) as a standard email client. To ensure an integrated support within the common working environment, CTM is delivered as an OL Add-In, additionally exploiting the fact that tasks and email are provided in the same office application. The CTM Add-In provides extensions of the OL mail and task items and enables "programming by example" (Lieberman, 2001) by using web services to track user actions, executed on CTM tasks and replicating

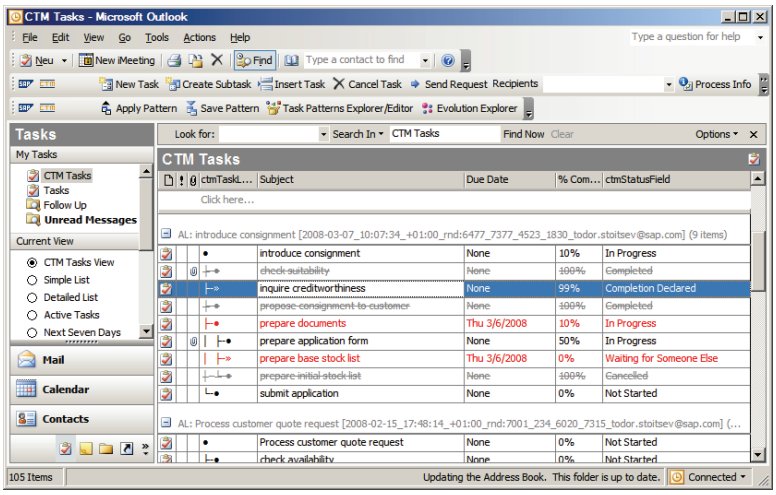

Figure 1: CTM To-Do List (TDL).

data on a central server. The data is held in a Database (DB) that provides a central tracking repository for all CTM users. Tracking of email communication for task delegation integrates the individual task hierarchies of different users to overall enterprise process structures, emerging on the server. The CTM Add-In application provides "Process Info" links on tasks and task-related email messages, which open a web-based client, providing overview and navigation in the generated process structures by retrieving data from the server.

3.1 CTM To-Do List (TDL)

The TDL is shown in Figure 1. CTM extends OL tasks with functionality for displaying a hierarchical tree structure. The Add-In provides additional toolbars for direct access to the main CTM functionalities. CTM enables insertion and removal of tasks and sub tasks in a task hierarchy in a light-weight manner. Task insertion opens a new OL task dialog where the user works with the familiar OL task fields. Files can be added to CTM tasks as common OL task attachments. An email can be saved as CTM task, whereby the mail subject, body and attachments are accordingly applied to the task.

3.2 Transfer of Tasks and Deliverables

A CTM task is delegated through a preformatted "Request" message. Recipients can "Accept", "Decline" or "Negotiate" the request. While request/accept/decline are standard actions known also from the exchange of meeting requests in OL, iterative negotiations allow additional clarifications

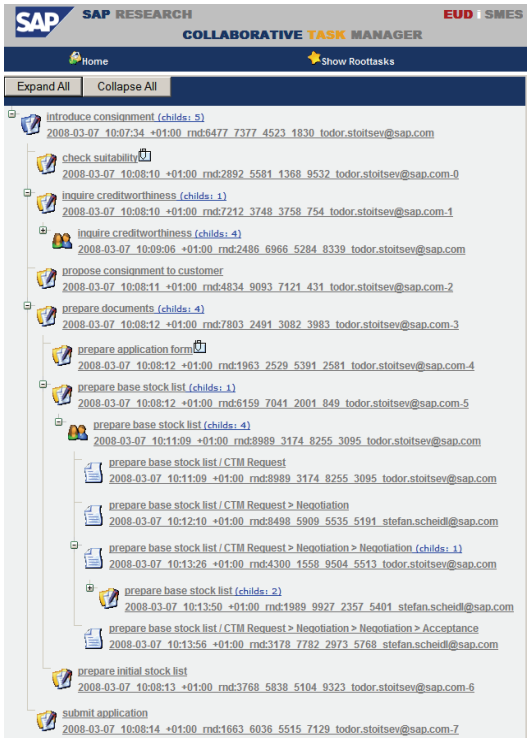

Figure 2: Detailed task dialog overview.

on tasks. The actual discourse takes place in the email text, which is independent from the given message type. This allows open-ended collaboration on tasks and prevents from submitting user behaviour to strict speech-act rules, which is a known limitation in speech-acts adoption (Button, 1994). When a request is accepted, and later on completed by a recipient, the latter issues a "Declare Complete" message. Hereupon the requester can respond with "Approve Completion" or "Decline

Completion" message. These additional actions allow negotiation of deliverables, before the final completion of a delegated task. To avoid flooding of the OL inbox with task-related messages, a "Move CTMs" button is provided which moves all task related emails to a special CTM mail folder.

All email exchange related to a task is associated to a task dialog and stored on the server. Dialogs can be inspected through a hierarchical process tree-view, where the nodes provide links, opening the exact task and email descriptions, including text and attachments (Figure 2).

The collaborative functionality in CTM is further supported through a notifications framework, which issues notifications throughout the task delegation hierarchies to inform participants in collaborative processes if a related task of another process participant is changed. Stakeholders can accordingly adapt "in-situ" to the occurred changes.

3.3 Process Overview & Navigation

In CTM, process models emerge as examples for the actual process execution and comprise the individual to-do lists of all process participants. These lists are integrated through the tracked task-related email exchange. Thereby overall process models emerge as Task Delegation Graphs (TDG) (Stoitsev et al., 2008), where the personal task trees of different users are shown in different user containers (Figure 3). We suggest that this overview provides a highly intuitive process representation and enables end users to more adequately recognize their position and role in overall enterprise processes at a glance, to identify potential bottlenecks and to evaluate work distribution. Currently, due date, status and percent complete indications are provided. The description link within a task node opens a dialog with full task (text) description. Tasks attachments, added in OL tasks, are replicated in a central, DB-based Artefacts Repository (AR) on the CTM server, and are accessible in the task instances. Through the "Show Roottasks" button the user can open a list view with all initial process tasks (root tasks) generated on the server throughout the whole enterprise. Within this view the user can navigate through the root tasks list and open a TDG (process execution example) for a given root task.

3.4 Process Model Adaptation & Reuse

Within the presented paper a Task Pattern (TP) (Riss et al., 2005; Stoitsev et al., 2008) is considered as a reusable task structure, comprising one task with its sub task hierarchy and the complete context information of the contained task instances, like e.g. description, used resources, involved persons etc. CTM enables export of a local task from the personal TDL to a single TP, and export of complete TDG from the server to multiple TPs, which are interlinked through suggestions according to the delegation flow. A TP can be saved in a local or remote Task Pattern Repository (TPR). A local TPR is a XML-based document (Stoitsev et al., 2008), whereas remote TPRs reside in a DB on the CTM server. The exported task structures are managed in the Task Patterns Explorer/ Editor (TPE) which is shown in Figure 4. The TPE provides rich editing and search functionality: cut, copy, paste, insert, remove operations are enabled on task trees and on

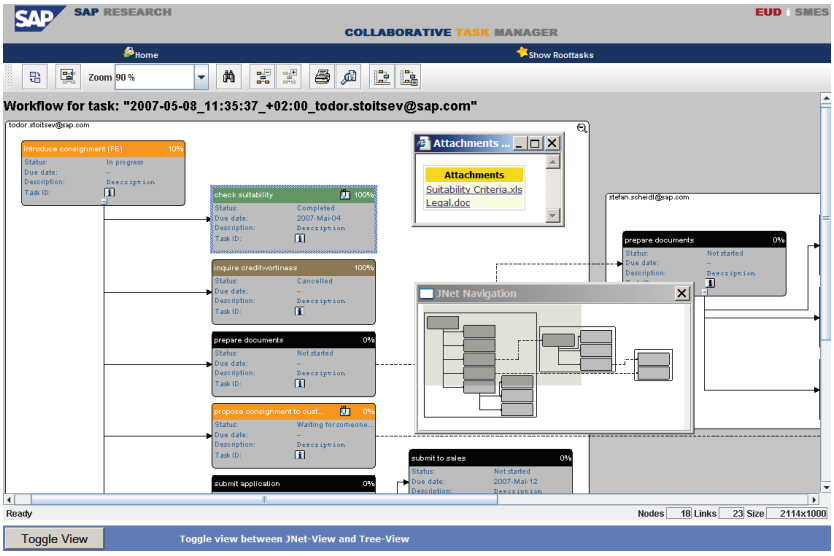

Figure 3: Detailed process overview – Task Delegation Graph (TDG).

data in context fields (on the right hand side). TPE enables also search and extraction of TPs from the tracking repository. When editing the provided process execution examples (interlinked TPs) in the TPE "the user is not required to interact in the interface domain of computational abstraction, but works directly with the data that interests him or her" (Lieberman et al., 2006). In this sense CTM enables programming by direct manipulation of the TP fields. The "Name", "Description" and "Suggested Execution Time" fields hold simple task context information in text format and are self-explanatory. The "Owner" field recommends expertise, i.e. when a TP is extracted from an executed process, the owner is the person in whose TDL a task was residing. The field "Suggested Delegates" contains information about the persons, who have the expertise to execute a given task. When a TP is extracted from a collaborative process, task recipients are set in this field. The "Suggested Pattern" field holds a reference to a TP, which can be used for the further processing of a task. In case of TDG extraction, such references in requester tasks point at recipient tasks, used for the further task processing. The recipient tasks are themselves extracted as separate TPs. Attachments to tasks are represented as "Artefacts". Custom adding of artefacts to a task replicates these to the AR.

Studies on ad-hoc processes report that "Employees often do not accept a strict sequencing of those tasks which they have to execute themselves, because this causes a limitation of their flexibility" (Hermann, 2000). Our preliminary studies confirm that statement and the necessity to minimize sequencing of activities where possible. Therefore we avoid the declaration of explicit temporal relationships known from formal task modelling approaches (Paterno et al., 1996; Veer et al., 1996; John & Kieras, 1996) and formal workflow modelling notations (OMG, 2006). TPs provide structured process execution examples, where the default assumption is to execute tasks along the provided task hierarchy in a top-down manner. Actual temporal relationships between tasks can be observed only through the task statuses, e.g. "Waiting for someone else", "In Progress" provided in the TDG in the web client during the concrete process execution (see Figure 3). Automated detection and export of temporal relationships to design-time (TPE) is not provided currently, although this may be useful for optimization of rigidly recurring processes.

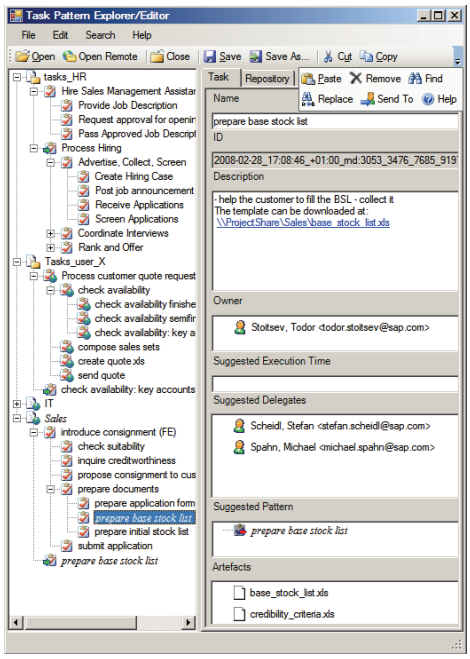

Figure 4: Task Pattern Explorer/Editor (TPE).

TPs can be reused through an "Apply Pattern" operation, available on tasks in the TDL. It opens the TPE, where the user can browse through different TPRs and search for tasks on the server, based on different criteria (owner, subject, description etc.). Tasks from remote TPRs can be opened in the TPE, whereas tasks from TDGs can be additionally viewed in the web client so that users can estimate the task applicability to their current situation. No advanced proactive information delivery on tasks (Holz et al., 2006) is currently provided. We have considered that many users approach their colleagues for help prior to looking for solution in the available software infrastructure (see also Ribak et al., 2002). Therefore TPs can be exchanged through a "Send To" function in the TPE and as attachments in task requests.

The application of a TP reactivates the process example by generating the complete task hierarchy and filling all pre-modelled structure and content information in the TDL. If during execution a user initiates a delegation, available delegates are automatically suggested. A user can change the anticipated (example) flow by entering different recipients. Suggested TP references are also available on tasks. A suggestion, stored as a reference to a recipient task in the original process execution, may be used by the person, activating the TP, to accomplish the task themselves without further delegations. If on the other hand a delegation is issued, the recipient task contains the reference

and the recipient(s) can still refer to the suggested TP to possibly adapt and reuse it. To allow this, application of a TP from a local TPR enables iterative replication of all referenced TPs from the local TPR to a default remote, user-specific repository, where these are accessible by all users.

3.5 Task Pattern Evolution

Best-practice deviations may occur due to changing business conditions and different problem solving strategies of end users. CTM provides functionality to trace such deviations through task instance-based ancestor/descendant relationships (Stoitsev et al., 2008). Such are set e.g. on copy/paste of (sub) task hierarchy in the TPE - iteratively each task in the resulting hierarchy receives an ancestor reference to the corresponding task in the original hierarchy. When a TP is exported from an executed process and saved to a remote TPR, all resulting tasks receive ancestor references to the corresponding original tasks in the tracking repository. If a remote TP is applied, the resulting tracked tasks receive ancestor references to the corresponding tasks of the remote TP. If a TP is exported from an executed process to a local TPR, the resulting tasks preserve the information (id's) of the tracked tasks. When a local TP is applied, the resulting tasks receive ancestor references to the originating tasks in the tracking repository. Evolutions can be viewed in the Task Pattern Evolution Explorer (TPEE) shown on Figure 5. The "introduce consignment" task of user Y (selected node) originates from a tracked ancestor task with the same name, which was executed by user X (root node). The latter task has also another descendant, resulting from its reuse by user W (task in the bottom). User Y has saved a global TP from his execution to a remote TPR (expanded node with black descendant icon under selected node), which

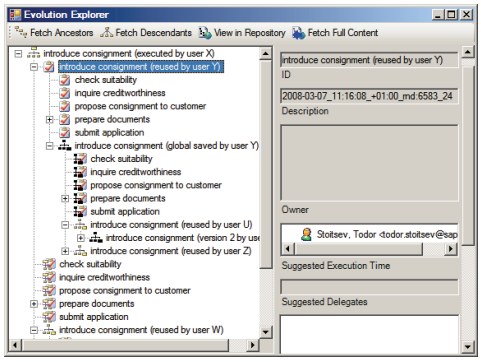

Figure 5: Task Evolution Explorer (TEE).

was reused in two further executions, the one of which resulted in a second global TP version. The TDG and dialogs of tracked ancestor/descendant tasks can be shown through the "View in Repository" button for case analysis.

4 CTM EVALUATION

The CTM evaluation was conducted at the textile production company (cf. 2) and involved 6 users, selected for having related, collaborative tasks:

Chief Officer Assistant (COA). serves as a single point of contact to the chief officer (forwards accept/reject) of contract proposals; coordinates all departments (sales, IT etc.);

Chief Sales Officer (CSO). coordinates activities in sales department, responsible e.g. for: internal processing of special customer sales applications (consignment, credits), credits approval, budget planning;

Sales Employees (SL1 & SL2). process sales orders, make credibility checks, participate in price definition processes, assist CSO;

IT Department Lead (ITL). coordinates activities of IT department, decides about acquisition of new software and hardware; manages adaptations and extensions to existing systems;

IT Employee (ITE). installs soft-and hardware; executes business process-related transactions in internal systems; maintains documentation about executed transactions; provides guidelines for transactions execution.

4.1 Setting & Extent of Use

The evaluation was initiated with a workshop in which we gave a 1 hour presentation on CTM, followed by 30 minutes individual training of each user in the basic functionalities. Detailed CTM user guides were provided to all participants. After several days we visited the users individually to check how they are working with the tool and to provide further instructions. The evaluation concluded with a short video recording and transcription of the tool use, followed by a structured debriefing interview, in which we asked each participant to assess the basic features and to rate to what extent CTM improved their ability to manage tasks in ad-hoc processes using Likert scales and freeform explanations.

The CTM trial was planned initially for 4 weeks. However, the installation of the tool required network adaptations as well as OL configuration changes. Therefore only a 2 weeks trial was possible. Problems with character encoding schemes

suspended the CTM usage by the COA for a further week.

4.2 Findings

Despite the initial technical difficulties and usability issues, mentioned in the following, end users found the concepts behind CTM compelling and clearly identified the high potential to structure and optimize their activities with the tool - the average overall approval rating for CTM was 4.29 (on a Likert scale of 1: Hate it, to 5: Love it). A summary of the observations follows:

Missing Initial Process Context. Some users suggested that root tasks should be created by senior employees, who actually trigger processes.

ITE: "I do not initiate processes, I actually execute on them. […] I always expected to get a task request from somebody [COA, CSO] who would create a root task and distribute the sub tasks. I then would receive a task, break it down and distribute the resulting tasks to the others [Sales]."

Due to the encoding problems in the TDL of the COA, the latter did not send requests for a week after ITE had started using CTM. This affected also the amount of tasks ITE acted on. Similarly, SL1 had created a root task for a task description, which was sent by CSO per email some time ago but was not acted upon before the CTM installation. No root tasks were created for ongoing activities in which users were engaged before CTM installation. This reveals that process modelling can be triggered along the organizational hierarchy, where senior employees can drive a top-down implementation of the "Process of Me" (Gartner, 2006).

Transparency. The ability to represent artefacts in process steps was considered crucial. We encountered that different artefact versions were attached to consequent tasks in a process flow, which revealed how artefacts are elaborated within a process. For example an empty, preformatted MS Excel table was attached in a request issued from CSO to SL2, and a filled MS Excel table was available in the resulting SL2 recipient task, which was elaborated to 75%. Further, users highly approved status information and notifications on task changes as they saw in them the potential to reduce overload for calling colleagues and writing emails with task status enquires.

SL1: "Such processes [price definition] draw like a red thread through the whole company. I certainly want to know how far things have gone. […] It is annoying when you do not get feedback on requested actions. This [CTM process overview] will save me the effort to constantly call people or write mails to ask about the status of things."

Generally, employees with managerial functions had greater interest in the overview functionality than others. SL2 for example surprisingly stated that seeing what others do might not be of interest to him as it might concern activities outside of his expertise scope. COA, CSO, SL1 (who had more senior functions) and ITL clearly wanted an overview.

As CTM was used only by a small group of people, privacy issues were not raised during the trial. However ITL stated that authorization has to be considered for extended CTM use in the enterprise by providing the possibility to hide certain process fragments in black-box containers in the web process overview. SL1 further demanded extensions in the notifications handling and suggested e.g. having notifications on each change in a delegated task and its sub tasks – structural or context change. Notifications for overdue of delegated tasks were also requested. As a further extension, users suggested summing up percent complete of sub tasks and increasing the percentage of a parent task.

Structured Storage and Retrieval of Process Knowledge. Users generally reported that creating a task in the TDL does not impede their current work practice compared e.g. to dealing with email.

SL2: "A task is a task - I clearly know that I should act on it. […] Putting it in the CTM task list does not bother me. I need to think how it should be handled anyway. If I can explicitly write that down, this only helps me to clearly structure my thoughts before executing and reduces the chance to miss something."

ITE further reported, that sometimes CSO asks him to execute transactions, which he is normally not allowed to. Before the CTM installation, ITL would preserve the emails, requesting those transactions, for responsibility tracking. Receiving a CTM task for such transactions reflected this "opportunistic" behaviour in the generated process example (TDG) on the server and hence in the emerging process model. Despite the clear benefits from CTM usage for visibility on time-critical activities, users stated that email cannot be replaced fully by CTM tasks. Informal enquiries outside of a concrete process would still be done over email.

Although only several TP were extracted – 2 in IT department (1 in a remote TPR and 1 in a local TPR) and 3 in sales (1 in a remote TPR and 2 in local TPR), the benefit from structuring process knowledge in a way that it could be reused was stated as a clear benefit. However, we clearly perceived that users were uncertain about the reuse potential of TP and the way these should be

distributed to others. The overall attitude was that global TP should be delivered by a (senior) domain expert, who can handle also the responsibility for providing them. CSO e.g. experimented and developed a TP on a remote TPR instead of writing a text-based guideline. SL2 on the other hand refrained from submitting a TP on a remote TPR while stating that he could send the local TP to a colleague personally upon request and furthermore, that he "silently agrees" for other colleagues to take and adapt his implicitly generated task example from the tracking repository on their own responsibility.

Some of the users proposed that the collaborative flow on tasks should be structured better to facilitate the handling of CTM emails for task delegation. The "Move CTM's" functionality (cf. 3.2) was not accepted well - users preferred to get CTM request messages in a dedicated "CTM Mail/Requests" email folder and responses in a "Responses" folder.

Exchange of Process Knowledge. Having an example of how a problem should be approached was appreciated by all users.

SL2: "Basically I have to achieve certain output for the tasks I receive [from CSO]. I really appreciate to know how she would break down the task and what the different facets in the task are. This helps me to stay on the right track and to know what is expected of me."

However, we actually observed that CSO would send a single task with generic description e.g. "prepare contracts for customers C1, C2, and C3" and SL2 would then break it down, creating a task for each customer. Therewith tasks disperse and refine by falling through the organizational hierarchy. This reveals that "seeding, evolutionary growth, and reseeding (SER)" (Fisher et al., 2004) towards complementing abstract process descriptions can happen during task execution and iterative reuse of process examples in organizations.

Domain experts, e.g. ITL, on the other hand did not think that they would benefit much from external knowledge. ITL however appreciated being able to distribute knowledge himself i.e. as TP on a remote TPR, to avoid repeated inquiries from other employees on same topics.

Connecting Best-practices and Running Processes. The users considered that comparison of TP and running tasks, resulting from their application, might not scale for large processes. Best-practices were generally desired as higher-level process descriptions, while running processes could produce multiple fine-grained tasks.

CSO: "As far as I am concerned a TP will contain only top-level tasks as my employees always do things differently. This doesn't bother me if the results are delivered on time. […] It is good to have a guideline, even if you do not care how the described tasks are accomplished concretely."

The overview provided in the TEE was not considered intuitive. Differences in task structures could be identified through additional effort, which would bring benefit only to managerial employees.

Users suggested enabling task comparison in "swimming lane" overview, where the corresponding top-level tasks can be put against each other. This would enable users to better see the corresponding and missing process facets, by possibly discarding the low level tasks. For the latter, filtering techniques based on different criteria like e.g. "Task Level" and "Owner" were suggested.

Tracing of Evolving Best-practices. Despite of the deficiencies in the TEE usability, the functionality it provided was considered necessary by senior employees due to the frequent changes in informal process recommendations. Tracing of such changes could help to at least undo wrong strategies.

SL1: "We often change processes to check if we can achieve better results. We check e.g. for the processing of these contracts we needed that much time, while we have planned that much. […] If we see that a change does not deliver better results, we switch back to our previous practice. […] An overview and comparison of the tasks for both practices in CTM is nice to have."

With this respect the provided structural overview was still insufficient as users cared also about certain performance indicators.

Users proposed that the comparison of task hierarchies in TEE should be enabled based on specific criteria like e.g. execution time, persons involved. It was further suggested that in addition to the ancestor/descendant relationships also versioning of TP should be supported.

5 CONCLUSIONS & FUTURE WORK

The presented paper describes an integrated approach for leveraging user experience with email and to-do lists and ensuring a "gentle slope of complexity" for process tailoring by end users. It delivers a valuable extension to known evolutionary workflow approaches by enabling "programming by example" of decentralized-emerging, weakly-structured process models by both: users - executing processes, and domain experts - explicitly adapting captured process examples. Thereby SER of weakly-structured process models is enabled through the top-down implementation of the "Process of Me",

where: (i) generic tasks refine during execution; (ii) users can adapt reusable process fragments (TPs) through direct manipulation of the execution data (delegations, artefacts, suggested TPs). Thereby opportunistic and emergent changes are supported during runtime and design time. CTM captures conversational (email) and control (task) flows. Unlike known email-based workflows, CTM provides the ability to decouple process fragments (interlinked TP) with different granularity from process runtime representations and to make them available for SER by managing task instance-based ancestor/descendant relationships, allowing navigation to the original or to similar execution contexts and inspection of task-related dialog flows.

The CTM evaluation delivered user-proposed extensions which will be addressed in further prototype implementations. Long term evaluation in the partner companies is under negotiation and will allow the generation of larger tracking and TP repositories and their quantitative evaluation as well as scalability assessments. Further research will aim at the translation of user-defined process fragments to known formal process modelling notations towards automation of rigidly recurring processes.

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