Transparency - Activity Theory-Guided Support for Information Work

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ABSTRACT

Information work is characterized by non-routine problem solving and a highly context-dependent execution of work processes. Moreover, frequent switches between work items are typical for this kind of work, making frequent adaptation and reevaluation of the work context necessary.

As the work structure emerges ad-hoc, it is difficult for the information worker to keep track of all ongoing activities. Yet, the non-standardized execution of work processes prevents the use of common workflow management systems. For this very reason, existing tools for information work support often focus on support for the organization of information objects, but neglect the work process perspective.

In this paper, we employ a systems design method based on activity theory to elicit requirements for knowledge work tools, focusing on interruptions and a loss of work overview. We address these requirements with a tool named Transparency that improves information work process awareness. We present two design cycles with real world evaluations.

Author Keywords

Activity Theory; Systems Design; Context; Knowledge Work

ACM Classification Keywords

H.5.2 User Interfaces: Graphical user interfaces (GUI)

INTRODUCTION

Information work, despite its acknowledged relevance for today's economy [7], is a concept that is hard to define precisely. More than often, it is used rather as an abstract label, encompassing a large variety of job roles (e.g. engineers and construction managers, but also accountants and countless other workers in modern enterprises). Yet, it is agreed that information work is characterized by two features [7]: 1) information work does not follow pre-defined processes, 2) information in any form is both the central work resource and the outcome of information work.

While the focus on (often digital) information seems to work well with IT support systems, both the lack of a clear definition and of pre-established work structure make it difficult to build tools that support information workers. As a result, there is a tendency in most current tools (e.g. [6]) to focus on the management of information resources only, effectively providing little to no support for structuring work or improving work process awareness for self-optimization.

We argue that this lack of support stems at least partly from the lack of adequate theoretical underpinning, and that it can be addressed using activity theory, a framework that has recently received increasing attention by the HCI and CSCW communities, to analyze knowledge work. Activity theory has features that make it particularly useful for such an endeavor. In particular, it provides a contextualized understanding of HCI that stresses the interdependencies between humans, the tools they use and the artifacts they use these tools on.

In this paper, we analyze information work with a recently developed activity-theory based system design method [10] which extends the human centered design cycle [4]. Based on a literature review and the results of two previous studies on information workers [8], we derive requirements for an information work support tool via the named method. The tool Transparency tackles interruptions and a loss of work overview by improving information work process awareness. We report on two design cycles with accompanied evaluations. Finally, we conclude with a discussion of the evaluation results and the implications on the employed design method, and identify directions for further research.

DESIGN PROCESS

The following section describes and underpins the application of the activity theory based system design model (AT-SDM) to the domain of information work at the computer workplace. Most existing human-centered design methods (e.g. ISO 9241-210) apply task analysis to identify requirements for a system. Focusing on task analysis is a convenient method for work tasks that have stable workflows and can be standardized well. For information work we see problems, as occurring workflows highly differ and work emerges as two factors interplay: 1) context demand and personal decisions, e.g. an individual works on two projects, recognizes demands to write reports to certain deadlines and then autonomously structures the personal work accordingly. Such an open setting demands the integration of factors like the individual, the autonomy and the work context (e.g. projects) into the design. Additionally it seems to be important to identify the effects of changes to the complex work setting that result from a newly introduced tool. As Schultze put it: when a new system is developed, one needs to identify “what the doing does” [9].

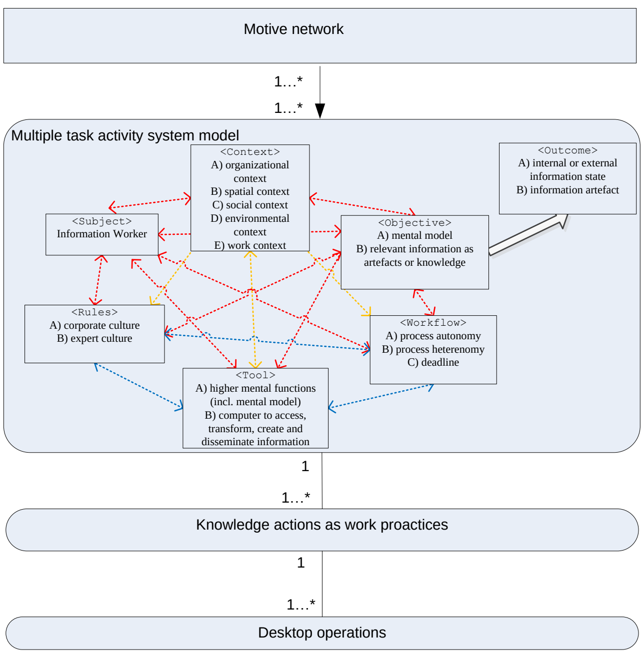

Figure 1: The AT-SDM for knowledge work.

AT-SDM builds upon activity theory which provides a vocabulary to model connected systems and the interplay of the different system elements. For AT-SDM the system consists of subject, instrument, object, context, workflow and rules. AT-SDM covers the first two elements of the human-centred design cycle [4]: the context of use analysis and the requirement engineering. To design a tool using the human-centred design cycle with AT-SDM as method for context of use analysis and requirement engineering follows this process: first an activity system is constructed to model the context of use, second a tension analysis helps to identify required modifications which result in requirements. Third, based on the requirements a system design is proposed which is evaluated. If the evaluation shows deficits the upcoming knowledge enriches the system model and a new cycle starts until the evaluation is successful. As the initial AT-SDM is not product of a design evaluation, one starts with a data grounding that is deduced from literature or initial studies.

TRANSPARENCY

The data grounding for the design process is provided by two sources: a literature review and two field studies. Initially, we reviewed literature about knowledge work execution and organization. We saw a gap with respect to workflows, context and individual awareness of work structure. Therefore, we have conducted studies focusing on the gap, using interaction histories and questionnaires [8].

The resulting structure can be understood as follows. Based on a network of motives, the subject anticipates goals which are objectified by an outcome. To realize the outcome solution techniques, so called knowledge actions are applied which are executed by fine grained interaction with the computer, so called desktop operations (for details, see [8]).

For information work, the outcome generally is an information artifact or a change in the world which is triggered by information. The information artifact is an obvious work result: the externalization and organization of information in encoding systems which are stored or disseminated using a medium. The change triggered by the information is more complex to understand. It is the effect of information in a subject which is closely related to the effects of speech acts on real world activity (referred to as perlocutionary and illocutionary acts) described by Austin [1]. As the information is consumed by subjects it interacts with the cognitive processes which encode it and may change the behavior directly or indirectly.

To realize the outcome anticipations, an activity system is constructed for each task, which shows the relation of the subject to the context of the task, the mediators (rules, tools, workflow) and the object. Each system produces the outcome based on the object. For the information worker the object generally is a mental model of involved domains and the relevant information existing as artifacts of knowledge. All other elements involved in the activity system are visible in figure 1. Information workers use higher mental functions as well as information and communication technology (tool mediator) in work processes which are largely autonomously identified (workflow mediator) following rules like the corporate culture and the expert culture (rule mediator) to realize the outcome based on the object. The context is a complex combination different context factors (including but not limited to organizational, spatial, social, environmental and work context).

We have conducted a conflict analysis on the structure and identified different threads that emerge in a structure of many parallel maintained task activity systems. Here, we only report on two main aspects: prospective and retrospective memory failures and show their relation to interruptions.

Interruptions occur frequently for information workers. Interruptions are "the process of coordinating abrupt changes in people's activities" [5]. This statement already shows that interruptions are required. Information work is challenged by multitasking. Therefore they have to coordinate many coexisting task activity systems which are executed in parallel or in rapid succession. The switches among the different activities (as represented by AT-SDM) are largely caused by interruptions. Even before a goal is completed, an information worker might be interrupted. He decides on the parallel activation of another activity system or on a switch of the activity system. One can distinguish between internal and external interruptions. Internal interruptions are decisions of the subjects while external interruptions are events that interrupt the work process. Studies have shown that interruptions are evenly distributed among internal and external interruptions (Czerwinsky [2] talks about 40 % self-initiated interruptions).

Each interruption triggers the identification and the activation of a new task activity system. The task activity system which is active when the interruption occurs needs to be kept active additionally or needs to be rehearsed.

As a result, the likelihood of prospective and retrospective memory failures is increased. Prospective memory failures stand for forgetting outcomes and the respective systems. Retrospective memory failures stand for problems in the activation of an activity system as its status is not remembered anymore. The large amount of tools and information objects involved in activities and the cognitive work on executing and controlling the system status once work was interrupted threats successful work executions.

Due to deadlines and priorities interruptions are used to organize work executions. Overall, interruptions are necessary to coordinate information work, but they increase the threat of prospective and retrospective memory failures. Support has been proposed: systems that have information about the user activities to 1) block certain information (to restrict external interruption) [3] and 2) manage relevant resources [6]. As these tools require additional manual effort during work execution, the main problem of such tools is that they themselves create interruptions and generate a conflict between subject, process and object. To solve the conflict, we see a demand for tools that improve awareness of personal activities without requiring manual effort during task execution.

First design iteration

For the first design iteration of a tool to support knowledge work, we focused on improving awareness of the personal work process, to support managing work related information and switching between different work items. Thus, decisions for interruptions as well as the task switching process itself can be supported, as the user directly knows what he has done, can recreate the required working environment and keep track of the spent time. We do not follow the idea of avoiding interruptions by hiding information, as most interruptions come from the individual and are not externally triggered [5].

The Transparency tool logs the user-system interaction based on software APIs and hooks, i.e. . The collected data is input to a pipeline that creates activity data as sets of used applications and the accessed information objects. Heuristics classify the activity data sets (e.g. identify authoring or consuming). The system uses a clustering algorithm to identify activities that belong together (based on temporal and semantic relatedness).

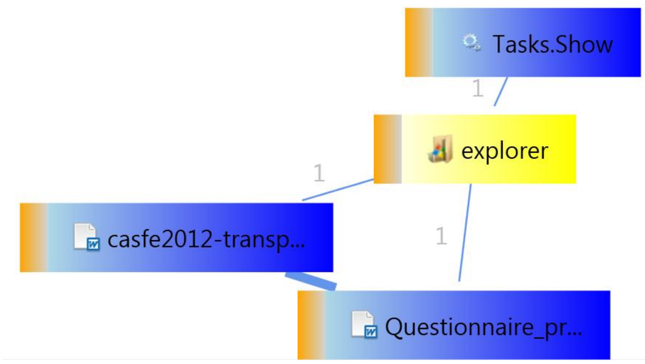

Figure 2: Graph representation of the executed work.

Design: The Transparency 1.0 system offers two visualizations. The situation view and the management view. The situation view shows a graph representation of user activities (see Figure 2). Nodes represent work on an information object with an application (e.g. authoring "casfe.doc" with Microsoft Word). Based on the node, a user is working on, and its neighbors, recommendations are generated.

The management view allows the user to identify relevant related activity data (e.g. all activity data around a travel planning), and to manage it, i.e. to have access to the time spent with the activities, the work sequence and to simplify accessing the elements.

Setup: For the evaluation of Transparency 1.0, eight users were recruited using convenience sampling. 6 were male, 2 female, their age between 26 and 38. Users were either researchers or managers and had significant IT experience. Their work included a high degree of self-organization, involvement in multiple projects and commitment to an expert culture, thus fitting the profile of the information worker very well. None of them had used Transparency before. Users tested Transparency 1.0 for two weeks during their daily work activities (i.e. for 10 work days).

At the beginning of the study, they received a demonstration of Transparency's features and were asked to fill out one questionnaire regarding their personal working style and one regarding their impression of Transparency. They were asked to complete the latter again, after the study was completed. Additionally, an unstructured interview was conducted after the study. We evaluated the interviews using topic coding.

Result: The questionnaire on working styles found that 2 users consider their personal work style as unstructured, 3 as partly structured, and 4 as completely structured. 2 are rarely confronted with external interruptions, 4 are occasionally confronted w. external interruptions, 2 are frequently confronted w. interruptions. Most (6 of 8) state that they sometimes have difficulties to remember all things they worked on. 6 users already used tools to organize work, mostly using sticky notes and Outlook tasks

The initial questionnaire on Transparency showed a general appreciation for the presented features. Most participants expected the graph representation of the work to be useful or very useful (6 of 9). The attached recommendations were rated moderately useful or useful (8 of 9). The participants especially expected an improved insight into their personal work style (moderate impact (2 of 9), relevant impact (1 of 9), strong impact (1 of 9)). Most did not assume that the tool will help them to focus their work (small impact (5 of 9), no impact (1 of 9)). Activity mining and the possibility to save collections of related activities to keep track of the time spent on these activities were considered an interesting feature; yet, most users did not see it as very relevant (no one chose the management view as preferred functionality).

After two weeks of using the tool in a normal work context, different problems became apparent. The appreciation of the graph representation for the work decreased (not useful (2 of 9), partly useful (2 of 9), moderately useful (2 of 9), useful (3 of 9)). 5 users considered reading the graph to be very complex. In the interview, all participants stated that they found the graph view interesting, but did not find a connection to their daily work, as it was time consuming to interact with the visualization, esp. due to its size (after 8 hours of work a graph sometimes contained more than 100 nodes). Few participants saw the possibility to improve insight into personal work – and, as stated in interviews, this was directly connected to the complexity of the graph. Some stated, however, that they started to be more focused in work due to the visualization (5 of 9). Saving performed activities to keep track of the time spent and the improved quick access to information access was an aspect that was mentioned frequently in the interview as an "unfinished feature". The participants saw it close to task management but they missed functionalities like due dates and task classification.

The participants showed a general appreciation of the design ideas and features. The resentment shown by the participants was directly related to the complexity of interacting with transparency; this may, however, be the effect of transparency being perceived as complementary to existing work organization procedures. A complementary tool that requires additional work efforts (especially due to the complex visualization) tends to be rejected due to a conflict in the AT-SDM between subject, workflow and instruments. We integrated this additional knowledge into the AT-SDM, concluding that a tool that aims to support focus in work and an improved insight into personal work not only needs to improve the data collection, but also needs quickly consumable visualizations that seamlessly integrate with the existing efforts of structuring work (6 of 9 persons already did task management).

Second design iteration

The major goal of Transparency 2.0, the second iteration of our design, was to improve the integration into existing activities in users' daily work. Therefore, we focused on one function in particular: activity data enriched task management. The tracking of user interaction and the automated clustering of related activities remained unchanged from Transparency 1.0, but were combined with features and a user interface for task management.

Design: To provide a convenient task management UI, we extended an existing system called tasks.show[1] with capabilities to enrich tasks with activity data, to access information objects, and to get detailed information about the individual work process. The main entry is a task list w. standard features (tasks belong to categories, have due dates and time estimates - see Figure 3.1). Additionally, each task can carry activity data. The activity data is presented in the form of related information objects, statistics on the time spent on activities (see Figure 3.2), and a graph representation of the interactions.

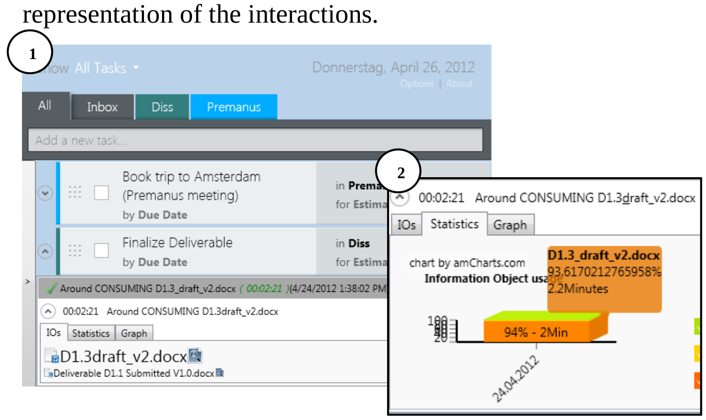

Figure 3: Transparency 2.0: 1) Task List with activity data for one task 2) Statistic about time spent with the resource.

To relate tasks and activity data two paths exist: 1) Users can browse clusters of related activities - extracted from their personal work history - and create new tasks based from activity data. 2) Users can manually add information

[1] http://code.msdn.microsoft.com/windowsdesktop/TasksShow-1bf01c8d

objects to tasks; the system automatically enriches the respective activity data and proposes related information objects based on extracted activity clusters.

Setup: For a first evaluation of Transparency 2.0, 4 users were recruited, again using convenience sampling. 3 were male, 1 female, their age in the between 25 and 40. Users had similar characteristics to the participants of the first study. In fact, 3 of them had already participated in the first study. Users tested Transparency 2.0 for four days during their daily work activities. While there was a demonstration of Transparency's features again, no questionnaire was handed out initially, this time, i.e. there was only post-study questionnaire and interview.

Result: Both interview and questionnaire indicate that most participants consider task management as useful/very useful (3 of 4) or moderately useful (1 of 4). The integration of activity data in task management is considered beneficial by all participants. The features deemed most helpful are access information objects and time information. However, one participant saw it as time consuming, to keep an eye on the completeness of the activity data associated with a task. We will investigate this in more detail in the future.

The interviews revealed that both described methods of using transparency were applied (starting with tasks and attached information objects as well as starting with activity data to identify tasks).

With regard to the results of the first evaluation, the most important outcome of the second study were an (self-reported) improved awareness of the personal work process (3 of 4 useful/very useful, 1 moderately useful) and the perception of being supported in organizing the personal work process (2 moderately useful, 2 useful).

CONCLUSION

The two design cycles have shown that supporting knowledge work is complex, as support solutions need to be integrated into the individual work processes w.o. requiring additional effort. The design of a knowledge work support system needs to reflect this.

In particular, we argue that the application of AT-SDM has shown the strength of activity theory-based approaches for complex domains like information work. The systemic approach to requirements in the AT-SDM supports the reflection of the effects of a newly developed solution, and helps to integrate evaluation results into the design. The presented Transparency tool is the result of two design iteration and two respective evaluations. Drawbacks of the initial design have been addressed in Transparency 2.0 by integrating activity data and task management.

Most participants explained in the interview that they would start working with the tool on a daily basis, given integration with the existing tool landscape was improved (synchronization of tasks with Outlook, support for the detection of more/other accessed information objects as e.g. sites visited in Google Chrome).

Furthermore, in the interviews two participants stated that they miss additional information retrieval functionalities. We plan to address this in a third design iteration.

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