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A Socially-Aware Desktop for e-Science: Supporting Learning in Networked Scientific Processes

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Abstract. *Research is likely to be the most knowledge-intensive environment, and it seems to be quite surprising that so far knowledge management (KM) techniques from business environments have not been transferred to e-Science initiatives in order to improve the efficiency of scientific work on a larger scale. An empirical analysis accomplished in the research area of rapid prototyping has unveiled that due to the high variability and unpredictability of scientific work processes, state-of-the-art business process-oriented KM approaches are not applicable and that scientific work processes need a different paradigm understanding knowledge processes as informal learning processes with a high level of social interaction. For this purpose, we present the model of a "knowledge-added process" as a foundation and a socially-aware desktop as an appropriate tool paradigm.*

1. Introduction

Applied research like in the rapid prototyping environment (our demonstration domain) brings together different researchers with diverse expert knowledge from various application domains like plastics, ceramics, and mechanical engineering. This results in a high degree of multidisciplinarity, where the individual expertise of single researchers is indispensable. On the other hand, getting an overview on already existing perceptions beyond one's own nose is nearly impossible on these terms. In addition, it is very time-consuming to find experts of complementary research fields, thus to identify suitable and at the same time available competencies or skills within and outside of research communities. These problems resemble typical challenges addressed by KM in the business sector; especially state-of-the-art business process-oriented KM methods (BPOKM, [AHM02]). So far, knowledge or competence management has not been transferred to scientific work for efficiency improvement. Thus, the mission of the underlying research project *Im Wissensnetz*[1] ("*In the Knowledge Web"*) is to analyze scientific work processes whether and how KM techniques can be applied to an e-Science scenario, exemplified by a rapid prototyping research alliance. In the first phase of the project, we analyzed concrete scientific work processes (cf. section 2). Because of high variability and unpredictability in these processes distinct from business processes, we have elaborated a new paradigm of process-oriented support which builds on the idea of understanding work processes in research as informal and often collaborative learning processes. This is summarized in the model of the Knowledge-Added Process (section 3). In section 4, we present our methodological and technical approach for building a socially-aware desktop for applied scientific work. Related work is discussed in section 5. Finally, we conclude with an outlook on further steps (section 6).

2. Analysis of the Problem Domain

Committing to an agile and iterative development methodology, design and development activities were accompanied by a formative evaluation with designated end users, in which they have tested and commented on ideas, application design and tool prototypes. The initial phase for requirements elicitation and scenario definition consisted of semi-structured field surveys and user interviews within five different research institutes. In this context high importance has been given to capturing and analyzing scientific work and cooperation processes. This phase was followed by a user workshop comprising four user tests; each accomplished by three users. In a second workshop, we introduced four participants in existing technical solutions of the tool providers in order to try one's hand at them afterwards. Finally, we discussed user experiences and additional requirements to develop new conceptual ideas based on them.

2.1 Results of the Analysis

Our analysis has revealed the weak structuring and insufficient repetitiveness of existing processes. Occurring communication and interaction patterns are highly complex, and the scientists handle their tasks very individually. Moreover, unlike BPOKM's basic assumption, users' knowledge needs hardly depend on the concrete task and definitely not on the process activity. So it is of no account to assign contents to such process activities. In fact, our analysis has shown that generic information seeking

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[1] cf. http://www.im-wissensnetz.de

processes (and process models), holistically interpreted as informal learning processes, characterize scientific work to a much larger extent. These process models do not assume that they can predict knowledge needs (or even an activity sequence), but the different process activities (or rather phases) provide clues on appropriate methods in a specific phase. Besides, researchers, their individual knowledge and the interactions among each other form the center of these processes, since the researchers' individual expert knowledge is solely the basis of the very individual activities in scientific work. However, this know-how is not available in an explicit form, but has to be constructed within extensive learning processes. This results in indirect and informal knowledge transfer through the cooperation and communication between single persons. Thus, for supporting and increasing the efficiency of scientific work it is not useful to provide specific contents but specific methods and tools especially supporting the social characteristics. Indeed, it is not possible to model business processes for scientific work with a reasonable cost-benefit-ratio, but the identified generic knowledge construction processes, where information seeking, learning, collaboration and communication are the key elements—abstractive on a phase model, where such supporting methods and tools can be provided. The so-called **Knowledge-Added Process** (analogous to the concept of the "value-added process" in economical view). In the following, we present this model in detail.

3. Knowledge-Added Process Model

For the development of the Knowledge-Added Process (KAP) Model, we reverted to existing research results about the information behavior in the field of information science. Following [ODa93] or [Bat02], information seeking and knowledge construction go beyond simple information search. It is an individual learning process where new knowledge is constructed by connecting and (re-)combining single small information units—a view reinforced by the connectivist learning theory ([Sie05]).

Because of the insufficient approach of simple information retrieval, Kuhlthau's information seeking process model [Kuh04] provided the basis for our KAP Model in a further step. Kuhlthau assumes a constructivist perspective and considers the information seeking as an integrated process, disposed by uncertainty and divisible into six phases: (1) task initiation, (2) topic selection, (3) pre-focus exploration, (4) focus formulation, (5) information collection and (6) search closure. The progression of the phases can be cyclic and the uncertainty decreases from phase to phase. With this approach of constructivist learning theory for the information seeking

Kuhlthau provides the basis for considering information seeking as a specific learning process. By applying Kuhlthau's information seeking process model on scientific work with focus on its highly social characteristic, we defined the KAP Model as following (see Figure 1):

Figure 1: The Knowledge-Added Process Model

- **Phase I: Request.** The KAP's initiation results from a concrete request, e.g. a costumer request or a project task.
- **Phase II: Selection.** For handling the incoming request, it is necessary to get an overview at first. Therefore the own know-how is the most important basis. First appropriate contact persons are selected, who can further analyze the problem or to whom the request eventually can be delegated.
- **Phase III: Orientation.** Searching, analyzing and discussing characterize this phase. The given problem is analyzed and information for orientation is searched, e.g. to acquire missing but necessary knowledge or to attain first possible solution ideas. As before, the own know-how is very important here, but also the cooperation with other people, e.g. in discussions. Therefore, it is necessary to identify adequate contact persons inside and outside the own organization.
- **Phase IV: Assumption/Solution Idea.** With the knowledge obtained from the orienting investigations first assumptions about the supposed problem and possible solution ideas are generated.
- **Phase V: Consolidation.** The proposed assumptions and solution ideas are evaluated on different levels and consolidated by focused search, analyzing the results and experimentation.
- **Phase VI: Knowledge Exploitation.** The newly learned knowledge, gained during the whole KAP, is exploited as project results in (in-)formal reports and provides a new resource for following researches in other KAP or is outset for a new process.

The phases within the KAP determine the requirements for the behavior and adaptation of methods and tools, which shall efficiently support scientists in their collaboration and knowledge creation. First approaches for such process-aware methods and tools are presented in the following.

4 Methodological and Technological Approach

4.1 A Process- and Socially-Aware Desktop

Personal Knowledge Management (PKM) approaches like [Sau05] follow the desktop metaphor by integrating different tools for knowledge work (“Semantic Desktop”). We have augmented this idea in the respect that this desktop (and the tools it groups together) needs to be aware of (a) the process phase the user is in and (b) of the individual’s social environment. For example, in the process beginning a user’s uncertainty will keep her from contacting unknown persons. Instead there is a reference to ask friends or colleagues. In contrast, the impact of social aspects decreases together with the uncertainty in later process phases. Then, users would also accept to contact unknown persons when they can ask directed questions. This shows that methods and tools can be the same for each process phase, but each phase implies different requirements and thus different system behavior or functionality. However, such a process-awareness and corresponding adaptation rules cannot be defined in general but must be realized for the specific use cases. Following, we present four use cases, grouped into two clusters, for a process- and socially-aware desktop.

4.2 Use Cases for a Process- and Socially-Aware Desktop

Social People Finder and Socially-Aware Mediation of Communication

As aforementioned, one of the major problems in scientific work is directly identifying appropriate key persons as contact persons (particularly for establishing ad hoc networks). Here, KM solutions usually provide support by the use of an “expert finder” component. Recently, social business networking platforms like openBC[2] enjoy great popularity, too. But do we always want to contact experts? And doesn’t it matter if we know this expert and get along well with her? What is missed so far is a qualitative assessment of these contacts in order to balance the “expert status” with the quality of the social relationship towards the potential “expert” and thus to provide *relevant* results. As a result, a colleague and good friend next door, being somewhat competent in the area, could be a much better result than the ultimate expert viewed as a rival. Just as well, it is necessary to regard the real communication approach in a further step. If the request is urgent and the user immediately needs help, recommending someone not being

[2] cf. https://www.openbc.com/

available is useless. Vice versa the experts get annoyed if they get overloaded and distracted from their own work. Often it is not only objective overload and bad timing, but also missing consideration of how the relationship is viewed. For instance, there are always colleagues to whom you will answer even though you are in a hurry, while there are others you will never allow for disturbing you. Therefore, we propose an egocentric network perspective in combination with the approach of social networking platforms similar to existing business networking platforms. In this perspective, individual users and personal relationships come to the fore by having the quality of the relationships determining the ranking of the search result set besides the thematic correlation and by mediating the following communication, taking into account the context of both sides.

Socially-Aware Opinion Sharing and Tracking Advances of Others

As the individual know-how has to be acquired in time- and cost-consuming learning processes, support for the knowledge transfer and synergetic cooperation is needed. As their success shows, social bookmarking services like Del.icio.us[3] or BibSonomy[4] enable collaborative development of subject areas by tagging weblinks and publications. Users are willing to rely on explicit opinions of other users, as these opinions represent a form of guidance. Especially when you are new in a certain subject area, it is extremely helpful to get links to “good” resources instead of just receiving resources matching your query. But how do you know if you want to have yourself guided by another user’s opinion or assessment? And beyond: how do you know if you want to guide others, especially if they are potential competitors? Our analysis revealed that such systems would be used if there was better control with whom to share your findings; e.g., the users do not want to share their literature study results with competing institutes as such, but possibly with individuals within those institutes to whom they have a relationship of trust. Thus, a combination of collaborative services with social networking platforms is useful; directly linking your contacts and the users in social bookmarking systems. By subscribing their bookmark collection, e.g. as RSS feed, it is possible to gain an insight in their work and interests. This further supports tracking activities and advances of others. Moreover, directly tagging people and organizations will be useful especially for tracking people not participating in social networking platforms (cf. [FL06] as a first approach); further enhanced with a proactive provision of information about other people’s advances, e.g. by fading in

[3] cf. http://del.icio.us
[4] cf. http://www.bibsonomy.org

potential contact persons during information seeking or by notifying the user if changes in the profiles of personal (selected) contacts occur.

5 Related Work

Supporting scientific work is usually restricted to improving information seeking and analysis. Recently, PKM support e.g. comprises a loosely integrated environment for annotating information artifacts and retrieving them in a "more semantic" way later on. Haystack[5], Gnowsis[6] and Fenfire[7] provide such approaches, but they currently do not make any assumption about a user's current context (e.g. the current process phase or social environment). As an extension to such activities, a similar approach to ours is provided by [DF04]. The envisioned "Social Semantic Desktop", a P2P-based group collaboration infrastructure, provides querying for information in a network of community members based on trust relationships. The ContactMap system of [WJN04] provides a social desktop for the support of social reminding (reminding people about important contacts to keep in touch with them) and social data mining (analyzing exchanged data and information with a particular contact). The tool prototype TellMeAbout [FD04] captures temporal information about users to provide information about the first or recent time a user was contacted by another user or information about time periods with close involvement. Closely connected users can be identified as well. All approaches have in common that they are an important step into our proposed direction, but they distinguish different qualities of social relationships only in a limited way.

6 Conclusion and Outlook

In this paper, we have described our work on analyzing scientific work processes in the rapid prototyping domain in order to find out if they can be directly supported by traditional methods and tools of BPOKM. As a first result, we found out that traditional approaches cannot efficiently support the identified knowledge creation processes due to their high degree of variability and unpredictability. Based on that awareness, we have drawn up a new paradigm of process-oriented support for scientific work processes, which resulted in the development of the KAP model. In this regard, we have derived the process- and socially-aware desktop as a methodological

[5] cf. http://haystack.lcs.mit.edu/
[6] cf. http://www.gnowsis.org/
[7] cf. http://fenfire.org

and technical approach enhancing existing KM methods and tools. For the future, we plan to synergistically combine state-of-the-art approaches with new developed methods and technologies in order to efficiently support collaborative scientific work processes. The next step will be the first validation of already developed prototypes by productively applying them in the rapid prototyping research alliance. Experiences and user feedback will directly flow into the further development to finally achieve a flexible and adaptive toolset, as well as a process model for enabling collaborative research work adaptable to any other research area.

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