Journal of Universal Knowledge Management, vol. 0, no. 2 (2005), 101-127
submitted: 2005-10-14, accepted: 2005-11-14, appeared: 2005-11-28

From Lightweight, Proactive Information Delivery to Business Process-Oriented Knowledge Management

Harald Holz, Heiko Maus, Ansgar Bernardi, Oleg Rostanin
(DFKI GmbH – German Research Center for AI, Germany
`<firstname>.<lastname>@dfki.de`)

Abstract: Knowledge work processes consist of interleaved agile, weakly-structured processes and strictly-structured processes. Knowledge management approaches for weakly-structured, ad-hoc knowledge work processes need to be lightweight, i.e., they cannot rely on high upfront modeling effort. However, approaches for business process-oriented knowledge management require intensive modeling activities. In this paper, we introduce a bottom-up strategy for proactive information delivery to cover the complete spectrum of knowledge work processes in different phases, and present a series of prototypes realizing selected phases of this strategy. Among these is a novel prototype for supporting weakly-structured processes by integrating a standard to-do list application with a state-of-the-art document classification system. The resulting system allows for a task-oriented view on an office worker's personal knowledge space in order to realize a proactive and context-sensitive information support during her daily, knowledge-intensive tasks.
Key Words: Weakly-structured workflows, agile workflows, proactive information delivery, personal knowledge space
Category: H.3.3, I.2.0

1 Motivation

The recent emergence and popularity of several new desktop search engines such as Google Desktop Search[1], x-friend[2], MSN Desktop Search[3], etc. has clearly shown the need for tools that help users in managing their personal knowledge space (PKS). Typically, the documents needed by a knowledge worker for the task at hand are spread over various places such as e-mail folders, file system folders, or paper stacks on the desk. While the concept of a desktop-wide search certainly relieves the user from the burden of querying several different information sources (e-mail, local and network drives, etc.), current desktop search engines still follow the standard, passive query/retrieve model: the user has to explicitly 'pull' for information that might be relevant for a task he is currently trying to accomplish. Besides being inefficient, empirical studies have shown that such pull approaches typically lead to suboptimal reuse rates of available documents [Mahe and Rieu, 1997].

[1] http://desktop.google.com/
[2] http://www.x-friend.de/
[3] http://toolbar.msn.com/

In order to address this issue, several business process-oriented knowledge management approaches have been developed for proactively providing process participants with information that is relevant with regard to their current tasks [Abecker et al., 2002]. However, as most of these approaches rely on static workflow/process specifications, they typically are inadequate for weakly-structured processes such as knowledge-intensive office work processes. Currently, state-of-the-art workflow and document management systems offer valuable support only for routine activities in office work. In spite of such support, it has been claimed that knowledge-intensive office work has not reached satisfying increases in productivity in recent years (cf. [Schütt, 2003]). The reason for this perceived lack of productivity increase in such office work is seen in the insufficient understanding of the nature of knowledge-intensive work and the lack of adequate integration of information support and work activities.

From our experience, knowledge work consists of both agile and strictly-structured processes that often are highly interleaved. Whereas recent project support systems aim at uniformly supporting users in both kind of processes [Riss et al., 2005], an integrated approach for information support in the form of proactive information delivery seems to be still missing. Moreover, in order for such an approach to be accepted by both knowledge workers and their employing organizations, it is highly important that investments into upfront modeling efforts can be kept at a minimum. Much of the current desktop search engines' popularity seem to stem from the fact that information becomes immediately available without requiring any modeling action from the user's side.

In this article, we present a bottom-up strategy for introducing proactive information delivery support into an organization, as well as a series of prototypical systems we have developed over the last years in order to support selected phases of this strategy. [Section 2] introduces a spectrum spanned by the dimensions of process support and information delivery approaches, and identifies the need for an integrated, encompassing approach. In [Section 3], we outline the phases of our strategy for introducing proactive information delivery support into everyday knowledge work processes. [Section 4] presents and reviews examples of prototypes covering different phases of this strategy. In particular, a novel prototype for lightweight information support within knowledge-intensive processes and work environments by realizing proactive knowledge delivery in agile knowledge workflows is introduced. Related work is reviewed in [Section 5], followed by a conclusion in [Section 6].

2 Process and Information Delivery Spectrum

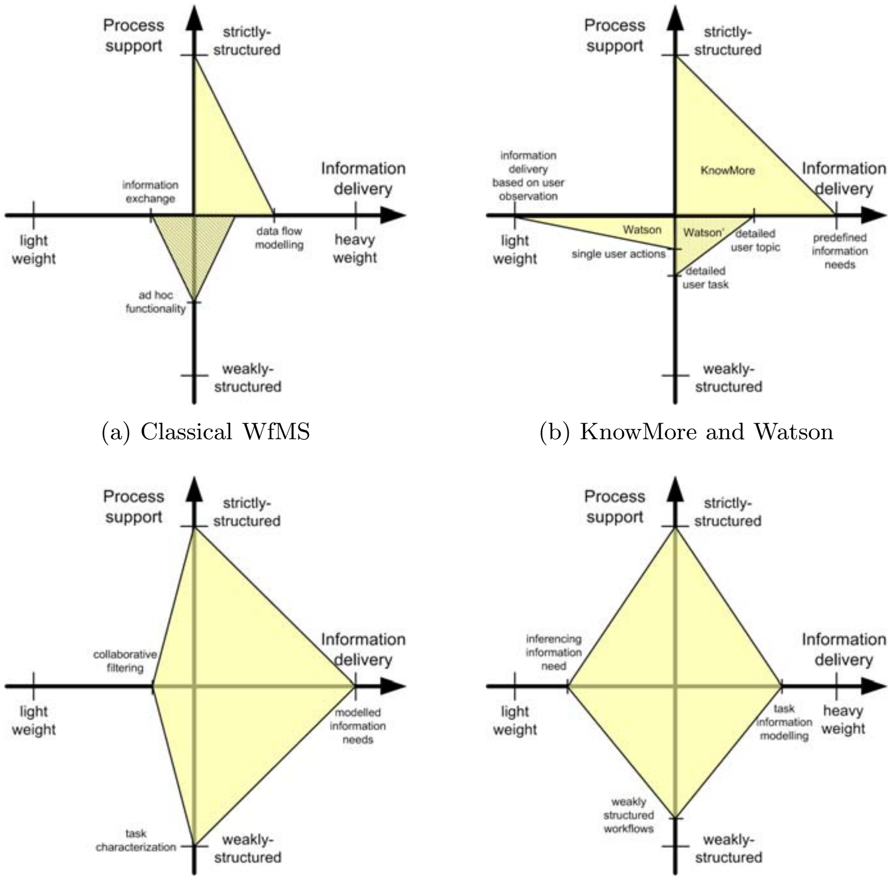
The importance of integrating knowledge management activities into business processes modeling and enactment is being increasingly accepted, and several different approaches have already been proposed and successfully realized [Abecker et al., 2002]. Among the prominent examples of such systems are EULE [Reimer et al., 1998], Freeflow [Dourish et al., 1999], KontextNavigator [Goesmann, 2001], POKER [Fenstermacher, 2002], KnowledgeScope [Kwan and Balasubramanian, 2003], PreBIS [Delp et al., 2004], KnowMore [Abecker et al., 2000], and OntoBroker [Staab and Schnurr, 2000]). One of the primary goals of these business process-oriented knowledge management initiatives is to establish, run and maintain an organizational environment that provides process participants with the information needed to successfully perform their tasks/activities as defined in process models. Consequently, most of the approaches rely on the existence of generic process models or workflow specifications, around which the knowledge capturing and provision strategies are organized. However, a considerable amount of knowledge work processes that occur daily in the context of office work are highly dynamic, ad-hoc, and weakly-structured by their nature, and cannot be modeled in advance at a sufficient level of detail.

For such agile, weakly-structured processes, knowledge workers often fall back to working in a document-triggered way; at best, they make use of task list applications, e.g., as provided by MS Outlook. What we claim is still lacking is an integrated proactive information delivery approach that supports knowledge workers in both agile and strictly-structured processes. In the following, we will illustrate this claim in more detail.

Whereas process support can range from weakly-structured, agile processes to strictly-structured processes, information delivery can range from lightweight to heavyweight approaches. Here, 'lightweight' refers to the upfront modeling effort needed by an organization that wants to deploy the approach. For example, we would consider collaborative filtering to be a lightweight approach, whereas approaches requiring a priori modeling of relevant information in the form of explicit information needs as realized in KnowMore would be considered heavyweight. Considering both dimensions for supporting knowledge work yields a spectrum spanned by process support and information delivery [see Figure 1(a)].

Most of the prominent approaches focus on one end of the spectrum while neglecting the others. For instance, [Figure 1(a)] shows the area covered by classical workflow systems with their ability to support strictly structured processes and to model a dataflow resp. input and output of workflow activities. In cases where the workflow system provides ad hoc capabilities such as InConcert or SAP NetWeaver Business Process Management (cf. [Riss et al., 2005]) also weakly-structured parts are covered (hatched area). However, due to the ad hoc nature, usage of a priori modeled dataflow is very limited; yet, it can be used to easily exchange or request information items, thus supporting collaborative scenarios.

As mentioned above, there are various approaches using processes or workflows for information support in order to assist the knowledge workers involved in



(a) Classical WfMS
(b) KnowMore and Watson
(c) PRIME
(d) FRODO TaskMan

Figure 1: Examples in the process support and information delivery spectrum

the processes. As an representative of these approaches, [Figure 1(b)] shows the KnowMore approach that extends the coverage of classical WfMS to heavyweight information delivery by modeled information needs. KnowMore allows to model a priori information needs for knowledge-intensive tasks in workflows; these information needs are then evaluated during workflow execution for providing relevant information. KnowMore fits well for classical workflow approaches, i.e., automating strictly-structured processes, but fails to support weakly-structured processes of knowledge workers with their a priori unknown process steps, ad hoc changes in content as well as in the working plan.

Approaching the problem from the other side of the information delivery spectrum, Watson (lower left corner in [Figure 1(b)]) is a representative for lightweight approaches supporting users in their knowledge work without requiring processes or modeling information needs. Watson is based on user observation, and uses a very generic model of possible user actions during document editing; similar approaches are, e.g., Lumière [Horvitz et al., 1998] and WordSieve [Bauer and Leake, 2001]).

However, in an evaluation of the system [Budzik et al., 2000] it was observed that many offered information items were rated by the users as not relevant for their current situation. The reason for this is that Watson searches for documents similar to the one in use by the user using an adapted similarity measure from information retrieval. As a result, relevance is measured in terms of similarity between the user's current document and the documents already indexed by Watson. But relevance also depends on the user's task and context; and thus, depending on the situation, provided documents were not the ones the user needed. Therefore, Watson was adapted and tailored to exactly one user task, namely to provide counterpoints for the current topic the user addresses (see punctated area in [Figure 1(b)]). As a consequence, the offered information objects now were more relevant for the task at hand. Although an immense modeling effort was necessary, it shows that, for an adequate support of users, it is essential to know their current task or goal which they follow.

Considering this from an information assistance point of view, systems need to be more aware of what knowledge workers are actually doing and what kind of information is required. Approaching this from the heavyweight end of the information delivery spectrum, the PRIME approach [Holz, 2003] shown in [Figure 1(c)] therefore allows to model in detail the circumstances under which an information object is considered to be relevant by modeling collections of recurring information needs. With this approach, the applicability of PRIME ranges from standard processes (where workflow activities can be referenced in an information need) up to weakly-structured processes (where characterizations of situations help to identify during which tasks an information item should be provided). It should be noted that PRIME does not support process enactment by itself; rather, it is intended to be part of a workflow system, as realized with the integration in MILOS [Holz and Maurer, 2002]. Applying PRIME involves a considerable modeling effort which is expensive, and hence, subject to a trade-off consideration between modeling effort and expected benefits. Therefore, PRIME also provides collaborative filtering functionality [Holz and Schäfer, 2003] which extends its applicability to the lightweight spectrum of information delivery.

Confronted with such problems of upfront modelling efforts in knowledge work support, various approaches try to provide more flexible tools where knowledge workers are able to accomplish their work and finally exploit the working experience, e.g., as best practices (e.g., Decor [Abecker et al., 2001]), workflow evolution by applying flexible workflow approaches (e.g., WorkBrain [Wargitsch et al., 1998], GroupProcess [Huth et al., 2001], or team collaboration in shared workspaces (e.g., Caramba [Dustdar, 2004]).

[Figure 1(d)] depicts the spectrum for FRODO TaskMan[4] [Elst et al., 2003, Elst et al., 2004] as a representative for this kind of systems. FRODO TaskMan supports knowledge workers involved in weakly-structured processes by using an adapted workflow paradigm named *weakly-structured workflows*; for details of the provided functionalities [see Section 4.2].

FRODO TaskMan combines light- and heavyweight techniques from both the process support and information delivery dimension. Therefore, we extend in [Figure 1(d)] the area covered by classical workflow systems in the direction towards more modeling effort for information delivery (but not as much as in PRIME), as well as in the direction of lightweight methods for information organization (e.g., attaching information objects to tasks, protocolling working results) and information delivery by information agents trying to interpret the available workflow context. Although FRODO TaskMan supports weakly-structured processes, we do not claim the whole spectrum here because still – although fairly low – modeling effort by the knowledge worker is required to reflect his tasks in the system.

Facing the problems of knowledge work with the two dimensions of process support and information delivery, our long-term goal is to realize an approach that covers the whole spectrum. In order to accomplish this, we have to combine presented paradigms, methods, and techniques as well as to consider their specific reasons why they were applied. That means, in order to be accepted by knowledge workers, the envisioned approach must not require high modelling efforts for realizing information delivery, i.e., lightweight information delivery approaches need to be exploited. On the other side, the approach must allow to spend more modelling effort for the information delivery if this is reasonable for the organization such as during a knowledge management initiative. Here, business process-oriented knowledge management has its strength if processes are already available or will be introduced, or when workflow systems are already deployed (for details see [Abecker et al., 2002]).

Regarding the support of knowledge work, also the process dimension needs to be tackled. The envisioned approach should support the whole spectrum of process support because knowledge workers are involved both in standard processes as well as in agile processes reflecting their knowledge work. This might be achieved by approaching the process spectrum from the weakly-structured side to the strictly-structured one: starting from supporting knowledge workers' everyday work practices and trying to evolve the work experience towards reusable knowledge as well as process know-how. In this article, we will focus on the information delivery perspective; the process perspective is addressed in

[4] `http://www.dfki.de/frodo/taskman`

detail in [Riss et al., 2005] in this issue.

3 A Strategy for Introducing Process-Oriented Knowledge Management

While there is evidence for the usefulness of business process-oriented knowledge management for strictly-structured processes [Reimer et al., 1998], this kind of evidence still has to be provided for agile, knowledge-intensive work processes. So far, our experience has shown that, in most cases, no specific support is provided for such work processes, and appropriate process descriptions rarely exist. Moreover, organizations are not willing to spend resources into upfront modeling efforts with an unclear return of investment. What is needed is a strategy and an incremental approach that can start directly from the knowledge workers' desktops, similar to the current desktop search engines. Only when a sufficient level of acceptance has been reached with the strategies current phase, and a need for further improvement has been identified, the next phase should be tackled. During this process, it is important to keep changes to a minimum, allowing the knowledge workers to continue using the infrastructure and tools they are already familiar with, in order to keep the tool-mastery burden as low as possible.

Therefore, we argue for a holistic approach that covers the whole spectrum of proactive information delivery, ranging from document-oriented work with its implicit tasks over simple to-do lists and weakly-structured workflows to business process models and strict workflow specifications. In addition to a technology that allows for such a bottom-up approach, a strategy must be provided that guides organizations in adopting it. The strategy we propose consists of the following phases:

1. Document-based, lightweight proactive information delivery
2. Systematic proactive information delivery by tagging
3. Tag-Specific Collaborative Filtering
4. Task-Specific proactive information delivery
5. Conditional proactive information delivery
6. Process model-based, a-priori modeled information delivery
7. Process-embedded E-Learning

In the following, we will describe the phases in more detail.

3.1 Document-based, Lightweight Proactive Information Delivery

The simplest form of proactive information delivery that required no upfront modeling effort starts from the knowledge worker's individual desktops, i.e., his/her personal knowledge space. The documents stored on local or shared drives, emails, bookmarks, browser history, wikis etc. make up the initial set of information items. In order to make use of them, each knowledge worker needs to install an application that realizes three main functionalities: (i) user observation, (ii) proactive information delivery, and (iii) user feedback. User observation is needed to make a smart guess about the user's current context (see, e.g., [Schwarz, 2005]), usually defined by a set of relevant terms extracted from the document in the currently focused application window. Proactive information delivery makes use of the user's context representation by automatically forming queries, posting these to search engines that index the personal information space, and present retrieval result sets to the user. This presentation needs to be realized in an unobtrusive way, e.g., integrated into the title bar of active desktop windows (e.g., as in blinkx[5]), or by a configurable sidebar (e.g., as in Watson[6]).

User feedback is required because the heuristics deployed for query formulation tend to be suboptimal, i.e., they might not capture the user's actual information needs adequately, resulting in irrelevant documents being offered to the user. In order to allow for an interactive query refinement, users need to be provided with appropriate dialogue components, e.g., simple relevance feedback controls, or functionalities for direct manipulation of the query terms extracted from the user's context.

3.2 Systematic Proactive Information Delivery By Tagging

Since the retrieval methods used in the first phase usually rely on standard keyword-based full-text search, two disadvantages arise: first, whether a relevant document is found depends on whether it actually contains a keyword extracted from the user's context. Second, the user context typically consists of several keywords that all influence the ranking of a relevant document, depending on how many of these keywords it contains.

In order to allow for a more systematic proactive provision of relevant documents, we introduce the possibility of tagging documents in this phase (see, e.g., [Shirky, 2005]). Users can assign arbitrary tags to indexed documents that are then considered during proactive information delivery: if one of a document's tags is included in the user context, the document will be suggested. Especially in combination with a collaborative tagging approach, an effective way of both

[5] http://www.blinkx.com
[6] http://www.intellext.com/

sharing documents (see e.g. [Hammond et al., 2005]) between knowledge workers, extending the set of automatically relevant terms, and building a shared vocabulary can be achieved. Also, it should be noted that one of the main ideas of process-oriented knowledge management, namely that of structuring relevant information around process descriptions, can already be simulated in this phase by introducing a tag for each process description.

3.3 Tag-Specific Collaborative Filtering

Once users are sharing a sufficiently large document set (e.g., by making their personal information spaces available to colleagues) that is categorized with a shared tag vocabulary, collaborative filtering [Resnick et al., 1994] can be applied for proactive document recommendation. The existence of such a categorization is a prerequisite because, in general, a match in the document preferences on a given topic (here denoted by a tag) can only be used for recommending documents from the same topic, but not for document recommendations on some other topic. We argue that by making use of collaborative filtering techniques, the likelihood that potentially relevant documents are proactively suggested can be increased.

3.4 Task-Specific Proactive Information Delivery

So far, we have only focused on a document-oriented context definition. A problem with this approach is that it does not take into account the fact that a knowledge worker is usually trying to reach a certain goal, or to complete a current task. However, this usually will have an influence on which documents are considered to be relevant by the knowledge worker; e.g., depending on whether he is currently writing a given document or reviewing it, different documents will be useful to him.

In order to address this issue, we advocate usage of task list applications (e.g., as provided by MS Outlook) in order to let each knowledge worker maintain a list of current tasks. Moreover, we encourage them to attach (i.e., link) documents to a tasks whenever they need to frequently access these document during enactment of that task. That way, a user's context can be defined by selecting the task the user is currently working on, so that the context can now encompass all attached documents (instead of only one as in Phase 1), as well as the textual task or goal descriptions. Furthermore, the explicit representation of tasks together with their attached documents supports knowledge workers in performing context switches that they might frequently experience, e.g., customer calls, or colleagues requesting information.

In addition, the tasks themselves now become first-order citizens within the proactive information delivery: for a given task, the knowledge worker should be provided with information on former, similar tasks, e.g., in order to access lessons learned or attachments associated with those tasks.

3.5 Conditional Proactive Information Delivery

So far, the only modeling effort has been directly connected with the organization of documents (i.e., tagging and attaching documents to tasks) or work processes (i.e., task lists). Thus, modeling happened implicitly as a by-product of activities knowledge workers are already familiar with, without additional effort.

In particular, the tags used for organizing documents also served as conditional triggers that decide whether a document is suggested (see phase 2). In this phase, more complex conditions can be specified for documents to be suggested, e.g., conjunction or disjunctions of tags. While such kind of modeling requires additional effort from behalf of the user, we argue that it lies still in scope for an experienced user. The motivation for him to invest this effort will be the advantage of being systematically, proactively provided with certain documents under defined, reoccurring contexts, e.g., different code review checklists depending whether the tags `review` and `java`, or `review` and `c++` are contained in the context description.

3.6 Process Model-Based Proactive Information Delivery

In this phase, it is assumed that the organization is willing to invest resources in business process modeling activities, into which knowledge engineering activities required for proactive information delivery can then be integrated [Abecker et al., 2002]. It is important to note that this assumes the existence of a separate organizational unit for process modeling, as it can hardly be assumed that process modeling is part of the daily activities of the average knowledge worker. Consequently, this phase is only useful for strictly-structured, knowledge-intensive processes that are often repeated, and during which the same information needs frequently occur for the process enactors. Existing approaches for realizing this phase vary mainly in the expressive power of the modeling languages, and their capabilities to cope with newly arising information needs (see, e.g., [Holz, 2003], Chapter 6).

3.7 Process-Embedded E-Learning

In the last phase, the organization's initiatives for process-oriented knowledge management and e-learning are combined [Rostanin and Holz, 2005]. Here, the modeling effort encompasses not only processes models and recurring information needs, but also the preparation of learning elements, required skills, user qualifications, course schemata, etc. The advantage lies in an organizational environment where learning is directly integrated into the every-day work processes of knowledge workers, and only happens on demand.

In the next section, we will present several building blocks for implementing this strategy within an organization.

4 Tool Support for Implementing the Strategy

The strategy introduced in the previous section presented a bottom-up approach for introducing business process-oriented knowledge management, starting on the lightweight end of the information delivery spectrum, and moving progressively towards the heavyweight end. The investment into more modeling effort should gradually result in a more systematic (i.e., repeatable) reuse of available information, improved recall/precision, as well as a personalized information delivery.

In the following, we present tools from our research for realizing the aforementioned strategy. These are presented in three building blocks, first from the project EPOS (Evolving Personal to Organizational Knowledge Spaces) which uses the state-of-the-art document classification system BrainFiler to create Personal Knowledge Spaces (PKS), second, an integration of BrainFiler with FRODO TaskMan, and finally, the PRIME approach.

4.1 Evolving Personal Knowledge Spaces

Supporting knowledge work should start by focussing on the knowledge worker himself because knowledge workers tend to avoid additional efforts for knowledge management activities without an immediate benefit. Contrary to that, knowledge workers put a lot of efforts in their personal knowledge management, e.g., they tend to structure their information space by introducing folders to organize their emails, creating project-specific folders to store project documents, or by creating electronic document 'piles' as places for reminders, tasks, or topics. This observation motivated the EPOS-project[7] to have a closer look at structures and documents on the computer desktop because they represent the user's subjective view on the world and especially on his knowledge work.

Therefore, EPOS investigates how a personal information model (PIM) can be constructed starting from the native structures of a knowledge worker. Such structures can be found, e.g., in file directories, bookmarks, or e-mail folders dealing with topics, projects, contacts, tasks, etc. The structures, their respective content, and the user's interaction with these structures and contained information give valuable hints on the user's subjective view as well as on how to evolve

[7] `http://www.dfki.de/epos`

the PIM. Thus, as depicted in the main circle in [Figure 2], EPOS investigates the knowledge worker's electronic footprints on his desktop to build a personal information model representing the user's subjective view. Such a model can be utilized for supporting knowledge workers by user adaptive services. The services are now able to take the knowledge worker's subjective view into consideration. This realizes a user's personal knowledge space. Furthermore, EPOS investigates methods on how the combination of personal information models within an organization can be evolved to come up with a shared understanding for building organizational models and ontologies [van Elst and Kiesel, 2004], thus realizing the smaller circle in [Figure 2].

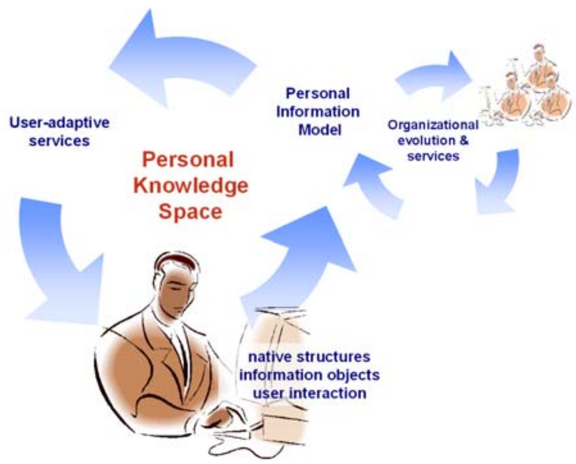


Figure 2: EPOS Personal Knowledge Space cycles

4.1.1 Building Personal Knowledge Spaces

While most of the information that is relevant to the knowledge workers during their daily tasks is available from their desktop, the current popularity of desktop search engines indicates that a considerable amount of time (and hence: money) is spent searching for that information [Delphi Group, 2002]. Two main reasons seem to be responsible for this:

1. Documents are stored in several different systems (e.g., e-mail, various local and network drives, etc.)
2. Most folder hierarchies only allow to place a document in at most one folder, i.e., a document cannot be indexed under more than one topic/concept (without creating redundant copies).

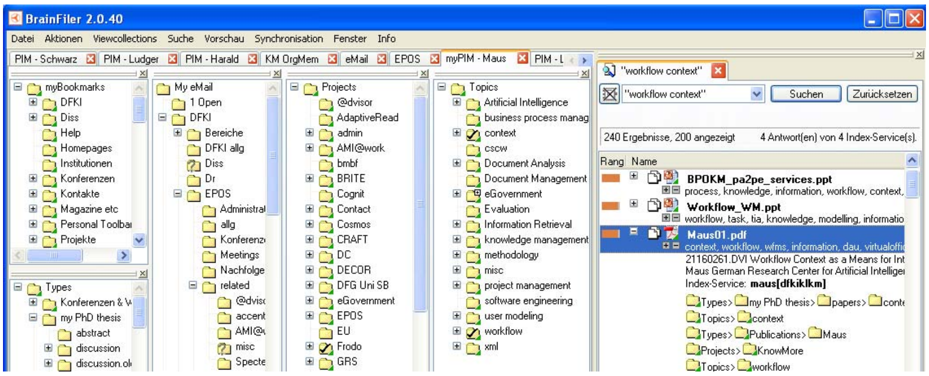


Figure 3: Multi-criterial indexing of documents with BrainFiler

While current desktop search engines address the first issue, they do not provide a solution to the second issue. In the ideal case, what would be required in order to reduce the necessity of search is a *task-specific organization* of documents, i.e., a (logical) folder or view on the document space containing all available documents relevant to a current task.

In order to exploit the user's native structures from the desktop, we developed together with brainbot technologies[8] the BrainFiler™ which realizes a personalized document management environment allowing multi-criterial classification of documents, search functionality such as boolean search and document similarity evaluation, as well as incorporation of remote (peer-to-peer) BrainFiler instances. BrainFiler enables a user to build a personal information model by allowing to import (and synchronize) native structures such as e-mail folders, bookmarks, and file directories together with contained e-mails resp. documents [see Figure 3]. The imported structures are shown as trees (usually interpreted as *is-a* hierarchies) and can be arranged in different views. The nodes (interpreted as concepts) get their meaning by a document term-similarity vector determined statistically from the assigned documents.

A user is now able to elaborate the personal information model by creating new or rearranging existing structures, making relations between concepts (a concept can have multiple parents), and assigning documents to several concepts (i.e., annotating reso. tagging a document with concepts). These structures then can be used for a conceptual search (e.g., all documents annotated with the concepts X and Y) as well as a combination with the keyword-based search (e.g., all documents annotated with the concept X and containing the term T).

[8] `http://www.brainbot.com`

Moreover, the BrainFiler also allows to publish own structures and documents, introduce remote classifications from colleagues (in a Peer-to-Peer-manner) or from the organization (as an organizational peer) as complete views or as single concepts which are added to personal views. This enhances the personal knowledge space with views and information items from other sources and reflects the organizational aspect of the knowledge worker (e.g., a query is also issued to all available peers).

With the BrainFiler, the knowledge worker has a personal desktop search spanning nearly all information sources, allowing multicriterial classification and different views on his personal document collections as well as those from his workgroups, thus, it is a first user-adapted service for a knowledge worker in the EPOS scenario.

4.1.2 Towards Lightweight Assistance in the Personal Knowledge Space

In order to provide a lightweight information delivery support in EPOS, we are developing an information assistant based on user observation, the personal information model, a desktop search engine (i.e., BrainFiler), and context elicitation (for details see [Schwarz, 2005]). The current prototype is part of the gnowsis Miniquire – a sidebar front-end for the gnowsis[9] Semantic Desktop (see [Sauermann, 2005, Sauermann et al., 2005]). [Figure 4] shows a screenshot of the Miniquire prototype with the following areas from top to bottom:

- the field ‘global search’ allows to search the Semantic Desktop with the help of the BrainFiler,
- the tab ‘concepts’ provides access to the user’s personal information model,
- the assistance area: the tab ‘Recent’ contains recently touched objects such as folders, documents, emails, and websites; the tab ’Relevant’ shows currently relevant resources which we will detail in the following.

The tab ’Relevant’ offers documents from the personal desktop and concepts from the personal information model based on the user’s desktop activities. In the screenshot, user Maus browsed from the project homepage of EPOS to its flyer (currently shown). Therefore, the user context consists of elements related to EPOS (and gnowsis as part of EPOS). The tab offers now several documents which are related to this user context (e.g., the EPOS project proposal[10] and several slides about EPOS and gnowsis). In the next section, concepts from the PIM are presented which are relevant in the current context, e.g., the e-mail

[9] available as Open Source at `http://www.gnowsis.org`
[10] The proposal has been found in two different version on the user’s desktop.

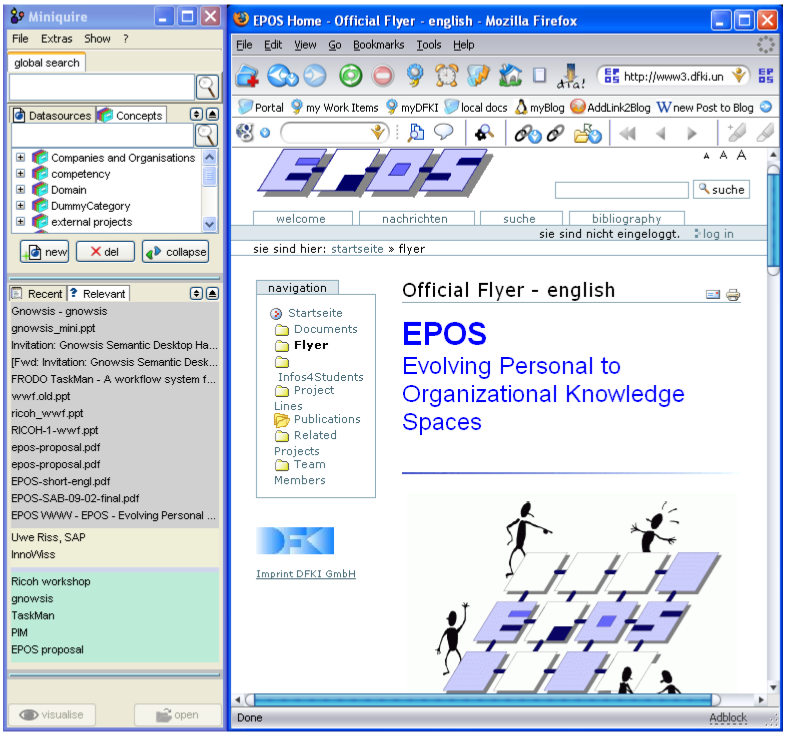


Figure 4: EPOS assistance as part of the gnowsis Miniquire

folder ‘Uwe Riss, SAP’ where a cooperation between the user and Uwe Riss was discussed (resulting in the publication [Riss et al., 2005]). The last one presents projects the user is involved in (i.e., where EPOS leveraged that the related folders have project character, based on work presented in [van Elst and Kiesel, 2004]) such as gnowsis and TaskMan.

As already mentioned, the assistance based on the Personal Knowledge Space is currently under development. Future extensions of the GUI also provide documents and structures from peers, thus also showing the workgroup environment of the knowledge worker.

This lightweight assistance is an exemplary tool which can be used to realize the first phase of the strategy presented in [Section 3]. Furthermore, by using the the BrainFiler functionality of annotating resp. tagging of documents with the folders they are contained, the second phase is also realized. However, a task-oriented view on the PKS is still lacking. For this, we make use of the knowledge worker’s tasks maintained using a to-do list application which is detailed in the next section.

4.2 Realizing Task-Orientation in Personal Knowledge Spaces

In [Section 2], we classified FRODO TaskMan as an approach extending classical workflow systems towards lightweight process support and information delivery. In detail, the system allows to:

- instantiate workflow models or start a workflow from scratch, evolve it during runtime (define, modify, refine, and delete tasks) and instantiate task templates,
- intertwine modelling and execution and use lazy/late modelling of tasks,
- refine tasks by hierarchical modelling (including control flow),
- organize information items according to workflow tasks (thus, getting a process-oriented information organization) such as relevant, information (documents, websites, ...), memos, keywords and concepts from domain ontologies, queries as simple information needs,
- collaboratively work on tasks by describing potential or actual executors using user, roles, organizational units, skills, and experience (i.e., process roles for each workflow activity),
- identify similar tasks by the concept of generic tasks contained in a task concept ontology [Schwarz, 2003],
- be supported by proactive information delivery providing relevant information based on the current workflow context [Maus, 2001], and
- reuse the process know-how contained in the workflow instances.

Although most of the functionalities require at least some modelling effort, much emphasis was laid on the lightweight character of a task: the FRODO TaskMan requires just a name to create a new task. However, the more details are given, the more support is enabled by the system. These minimal requirements let the TaskMan also function as a simplistic to-do-list application. In general, to-do list applications allow users to manage their current tasks, e.g., such as in MS Outlook, Mozilla Calendar, or standard workflow systems. Typically, the representation of a task covers a short task name and a due date, together with an (optional) longer task description that describes the task's goal and objective in more detail, or – depending on the application – is used as a scratchpad to jot down things to remember with regard to the task.

To realize the fourth phase of the strategy, namely a lightweight task-specific proactive information delivery, we made use of the to-do list functionality provided by the FRODO TaskMan and coupled it with BrainFiler ([see Figure 5]):

for every task added to the to-do list, a corresponding folder node is automatically created within the PKS.

While a knowledge worker is working on one of his tasks, usually he needs access to certain documents (e-mails, PDF documents, etc.) in order to successfully perform the task. Typically, these documents are distributed over several different e-mail or file folders, depending on individual preferences with regard to file organization. For knowledge workers who experience frequent task context switches during their work, or for tasks that take longer than one day, this means that the knowledge worker has to repeatedly either browse manually through his file structures, or repeatedly perform a desktop search in order to find the required documents/folders. Although, the Miniquire sidebar presented in the previous section provides such folders and documents and allows easy access, they depend on the user context based on activities, not yet on the user's tasks. Thus, task switches of the user currently result in some delay until relevant information for the new task context is shown.

Therefore, we extended the FRODO TaskMan to-do list application by allowing knowledge workers to associate bookmarks (i.e.: links) to relevant file folders and documents with their tasks. Technically, for every task-specific bookmark, a corresponding subnode is automatically created under the task node within BrainFiler. This extends the knowledge worker's PKS with a task-oriented view and yields the benefit of providing him with immediate access to the heterogeneous set of relevant documents in the context of a given task. Within the Miniquire sidebar, this results in an additional tab 'tasks' where tasks can be easily accessed by the user without using the FRODO TaskMan GUI. Furthermore, the current research in EPOS presented in [Schwarz, 2005] aims at eliciting the (workflow) tasks based on the observed user actions and information handling. The resulting task-specific organization of documents also provides the basis for a proactive delivery of other documents which we will present in the following section.

4.3 Task-Specific Document Delivery

So far, we have assumed that knowledge workers manually associate relevant folders and documents from their PKS with their tasks. In order to realize phase four of the strategy presented in [Section 3], it would be desirable here that the concept of an automated assistant that "looks over the task enactor's shoulder" and (pro)actively provides him with available documents that are relevant for the task currently being enacted. In order to achieve this, we make use of BrainFiler's document classification functionality: for a given document, BrainFiler can suggest those of the user's concepts which fit the best, based on the statistically induced term relevance information.

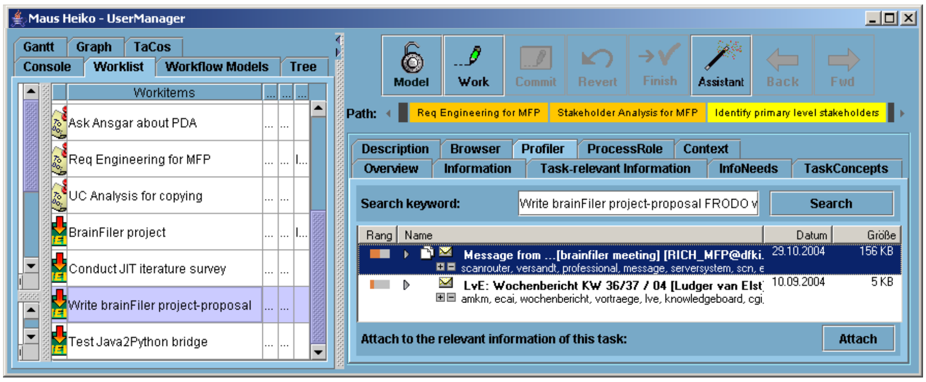


Figure 5: Task-specific, proactive document provision from the personal knowledge space within FRODO TaskMan

In order to proactively provide knowledge workers with access to documents stored within their PKS that might be relevant in the context of their current task, we extended the TaskMan to-do list application by a component that displays the results of BrainFiler's classifications of documents with regard to the current task. [Figure 5] shows a screenshot from the FRODO TaskMan to-do list application: the left-hand pane shows the user's to-do list, with the task "Write brainFiler project-proposal" currently being selected. In the right-hand pane, two emails being provided to the user by the component in the context of the currently selected task; a double-click on one of these emails will open the email with the user's default email application. The two emails have been automatically retrieved by using the relevant terms displayed in the text field labeled "Search keywords", that have been extracted from the task name and already associated documents. That way, relevant e-mails are no longer easily overlooked, e.g., because important e-mails with regard to a given task can now be automatically identified among the unorganized flood of continuously incoming e-mails, and displayed to the knowledge worker in their proper workflow resp. task context.

Technically, this functionality has been realized by automatically creating a file with the task name and description, that is being placed within the task's node folder in BrainFiler, in addition to the folders and documents (including e-mails) that the knowledge worker manually associated with the task.

All other documents within the user's personal document space, as well as any newly "incoming" documents, are automatically analyzed by the component and tentatively associated with those of the worker's current tasks that the documents seems to be related to, by making use of the BrainFiler's classification suggestions with regard to a task's folder node.

Currently, our prototype can cope with three different ways in which a document can be "incoming": the document can be sent by e-mail, scanned and delivered via a multi-functional product (combining scanner, copier, printer, and fax in one device) – creating an intelligent office appliance, see [Maus et al., 2005]) – or saved into a file directory that is being synchronized with BrainFiler's concept hierarchies.

4.4 PRIME

PRIME (*PRocess-oriented Information resource Management Environment*) is a system to proactively provide software developers with access to relevant information specific to their current tasks and preferences. PRIME provides a technical infrastructure for a continuous, task-specific capture and dissemination of information needs that typically arise for developers, and of information resources considered to be useful for successful task completion. In the following, we will illustrate PRIME's functionalities with an example usage scenario.

[Figure 6] shows a snapshot sequence from an example PRIME usage scenario: from her to-do list [Fig. 6(a)], developer Barbara launches a PRIME Information Assistant [Fig. 6(b)] for the selected task "Implement ECA rule editor". The Information Assistant presents her with three lists of information resources, labeled "Private InfoNeeds", "Peer InfoNeeds", and "Global InfoNeeds".

These lists consist of typical information needs (e.g. *"Where can I find a tutorial on EJB?"*) assumed to arise for Barbara during her task, together with available information resources likely to satisfy those information needs (e.g. Sun's Java Developer Domain). On issuing the "Show" command on a selected recommended information resource, a browser opens [Fig. 6(c)] with a list of links that have been transparently retrieved from the Developer Domain on the topic "EJB Tutorial/Instructions" via predefined query templates. Barbara can now refer to the hyperlinks to access those information items.

Moreover, while browsing the web for documents that help her in performing her task, Barbara adds bookmarks to documents that she considers as useful for her task (e.g. the EJB specification) to her task-specific list of "Private InfoNeeds". Whenever she is unable to find the information she is looking for, she posts a question or information request to a task-specific message forum (see the example below). This forum is used by all team members as a means to support each other by posting answers to a colleague's questions. The Information Assistant posts the user's requests to a corresponding forum, and creates a new task-specific, private bookmark to the corresponding question/answer thread (rendered with a question mark [see Fig. 6(b)]), providing Barbara with immediate access to her question threads.

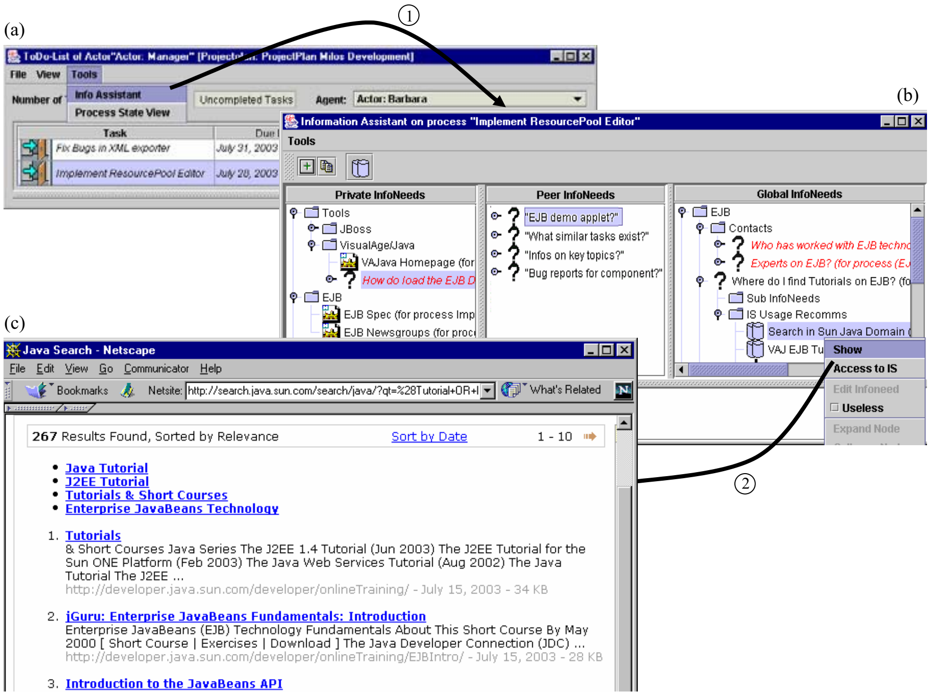


Figure 6: PRIME usage scenario snapshots

Based on the assumption that people who shared information needs in the past are likely to have the same information needs in similar, future situations, Barbara's Information Assistant recommends certain "private" information resources in the list labeled "Peer InfoNeeds" that were added by her colleagues. For example, the information need "EJB demo applet?" that was posted recently by a colleague [see Fig. 7] is now offered to Barbara [see Fig. 6(b)]. This information need is among the recommended resources because the similarity between Barbara's selected task and the colleague's former task is sufficiently high (e.g. both are dealing with EJB technology), and their (implicit) ratings on information resources correlate sufficiently (e.g. both Barbara and the colleague accessed the EJB specification and the tutorial under the category "EJB").

Certain information resources are likely to be useful whenever a particular type of task is being performed, or whenever a certain tool, technology, language or software component is used. For example, Barbara might prefer to have access to the EJB specification whenever she is working on a task whose characterization references EJB technology. For this reason, PRIME allows users to define a shared, organization-specific domain ontology (here: a class hierarchy, together

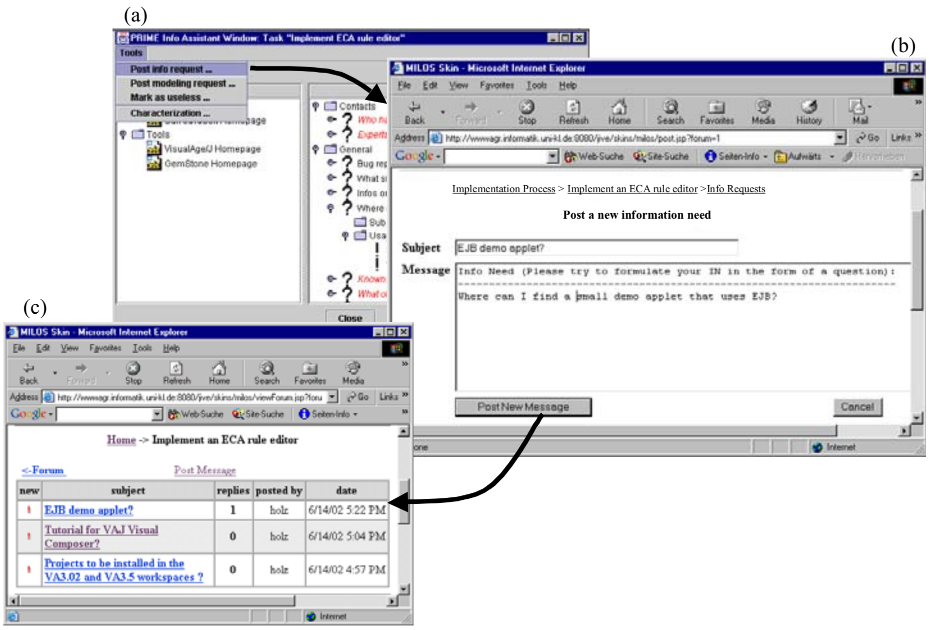


Figure 7: The Information Assistant (a) allows its user to post a request (b) transparently to a forum (c)

with instances of these classes), and to associate already captured information resources with these types and instances. [Fig. 8] shows a snapshot from the PRIME Information Need Manager window: from the tree in the pane labeled "Objects", Barbara has selected the instance "EJB" of class "Distribution" from the domain ontology. The tree in the pane labeled "Attached Information Needs" displays the information needs associated with entity "EJB", grouped under user-specified categories (e.g. "VisualAge for Java", "EJB", "EJB¿Contacts", etc.). For example, Barbara has associated the EJB specification with entity "EJB".

The classes and instances defined in the ontology can also be used for task and product characterization. For a selected task, the Information Assistant will list in the pane labeled "Global InfoNeeds" [Fig. 6(b)] all resources associated with a type whenever an instance of this type (or subtype) is referenced by the task characterization; resources associated with an instance are retrieved and offered whenever this particular instance is referenced by the task characterization. Accordingly, Barbara's Information Assistant will list her bookmark to the

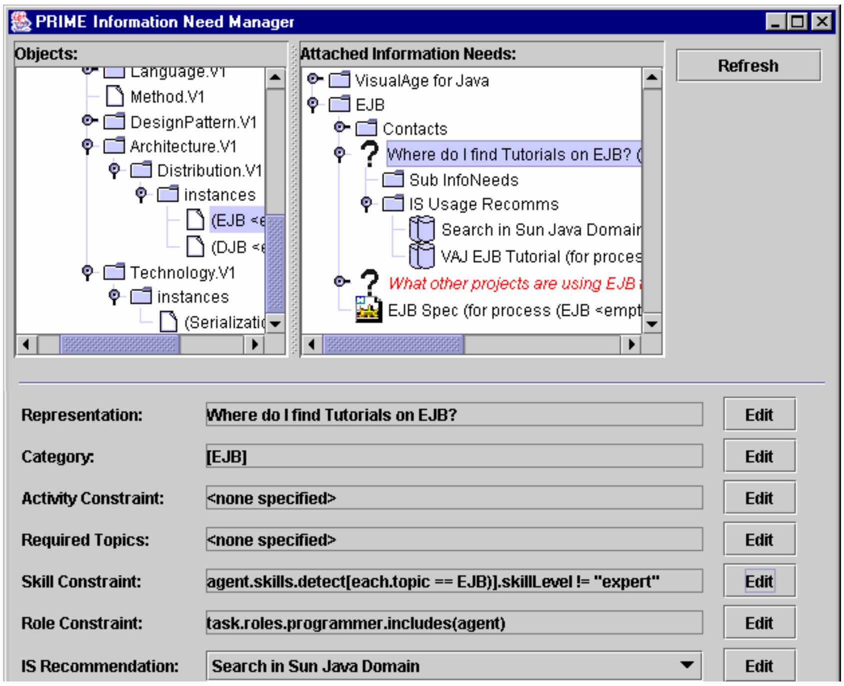


Figure 8: Information Need Manager

EJB specification for all future tasks whose characterization references "EJB".

Only when the situations in which an information resource should be offered need to be even further refined (e.g. because several factors need to be considered), or when access to the information source requires explicit query commands, a more formal specification might become necessary. To this end, PRIME provides the means to formally specify information needs, encompassing the specification of (i) *what* information might be useful (typically expressed as a question), (ii) *where* and *how* this information can be found, (iii) *when* it might be useful, and (iv) to *whom* it might be useful. In the Information Need Manager [Fig. 8], the corresponding attribute values of the information need *"Where can I find Tutorial on EJB?"* are shown in the lower window pane. For example, the skill constraint specifies that the selected information need should only be offered to developers who (like Barbara) have not characterized themselves as an EJB expert.

In summary, PRIME addresses the phases 3-6, with its main focus on phase 6. In fact, PRIME's support for collaborative filtering (phase 3) was added afterwards, when it became transparent that modeling information needs was too much of a burden for the average user.

5 Related Work

The issues addressed by the approach presented here stem mainly from the areas of process-oriented knowledge management and desktop search engines. In the following, we briefly compare existing work with the approach described in this paper. Most work on integrating knowledge management and process support has been done in the field of business processes (see [Abecker et al., 2002] for a recent overview of Business Process-Oriented Knowledge Management). Prominent approaches such as EULE [Reimer et al., 1998], OntoBroker [Staab and Schnurr, 2000], WorkBrain [Wargitsch et al., 1998], PreBIS [Delp et al., 2004], or DECOR [Abecker et al., 2001] focus mainly on fairly static (in contrast to weakly-structured) processes with regard to proactive information delivery; hence, they rely on structured task representation and ontologies. Caramba [Dustdar, 2004] realizes an activity-based knowledge management approach for ad-hoc processes by enabling knowledge workers to link knowledge artifacts to tasks. However, only artifacts that have already been linked to a task are made accessible for the task's enactors; a proactive distribution of potentially relevant artifacts based on the content of artifacts already linked to the task is not provided.

The CALVIN project [Leake et al., 2000] investigates lessons learned systems supporting the process of finding information relevant to a particular research task. CALVIN learns about information sources by automatically recording cases that represent the consulted information sources. As the user browses for information, the system maintains the user's current research context (e.g., a set of keywords describing the main topics) and compares it with former contexts. If the similarity between the current and a former context exceeds a certain threshold, the resources associated with the former context are presented to the user as relevant in his current context.

Other approaches to provide light-weight, proactive information delivery are based on collaborative filtering (CF) technology, e.g., GroupLens [Resnick et al., 1994] or Entree [Burke, 1999].

Current desktop search engines (e.g., Google Desktop Search, x-friend, MSN Desktop Search) do not yet have a notion of a user's task or some other retrieval context. An exception is blinkx[11], that provides on-the-fly recommendation links to available documents that are relevant to the user's active window (e.g., an open document or e-mail editor).

[11] http://www.blinkx.com

6 Conclusion

In this article, we presented a bottom-up strategy for introducing proactive information delivery support into an organization. The strategy facilitates an incremental adoption of process-oriented knowledge management technologies, allowing an organization to decide whether to invest into further modeling effort. Such an approach is especially important when no process descriptions are available, e.g., for weakly-structured, knowledge-intensive processes.

Moreover, we presented ongoing work and several prototypes that represent building blocks for realizing the strategy. EPOS illustrates the concept of a tool that proactively provides knowledge workers with relevant information while editing their usual documents. While no upfront modeling is required on behalf of the user, the lack of a an explicit representation of a user's goal or task might lead to irrelevant documents being suggested. This issue is addressed in FRODO TaskMan by requiring users to maintain personal task lists. Although we used a workflow system as a basis for the prototype, the presented approach is also applicable to standard to-do list applications as found in personal information management tools (e.g., PDAs) of today's office workers. In combination with BrainFiler, FRODO TaskMan realizes a lightweight approach to task-specific, proactive document delivery. The term vector similarity-based approach used here is intended to complement our earlier work on more heavyweight approaches based on process models and ontologies [Elst et al., 2003], which require considerably more modeling effort on behalf of the user. Likewise, the heavyweight approach realized in PRIME has been complemented by collaborative filtering techniques. However, because of the associated ramp-up problem, experience has shown that additional lightweight approaches are still needed, e.g., similar to the BrainFiler integration for FRODO TaskMan.

While the tools presented here have different user interfaces for historical reasons, they share the same concepts and, in fact, most of the data structures. In a next step, we aim at developing an integrated system that can be extended stepwise to supporting phases 1-6. The prototype combining the FRODO TaskMan and the BrainFiler is currently under development and will be evaluated as part of a distributed software development case study that is scheduled for this year. Based on the positive evaluation results for our process-embedded information support [Elst et al., 2003], we believe that an efficiency gain can also be achieved in an everyday office setting with the approach presented here, by making documents more easily available during the office worker's tasks, and helping to prevent that relevant documents might be overlooked.

Acknowledgements
Work funded in part by "Stiftung Rheinland-Pfalz für Innovation" (InnoWiss) and BMBF (EPOS, contract number ITW 01 IWC 01).

References

[Abecker et al., 2000] Abecker, A., Bernardi, A., Maus, H., Sintek, M., and Wenzel, C. (2000). Information supply for business processes – coupling workflow with document analysis and information retrieval. *Knowledge-Based Systems, Special Issue on AI in Knowledge Management*, 13(5):271–284.

[Abecker et al., 2001] Abecker, A., Bernardi, A., Ntioudis, S., Mentzas, G., Herterich, R., Houy, C., Müller, S., and Legal, M. (2001). The decor toolbox for workflow-embedded organizational memory access. In *ICEIS 2001, 3rd International Conference on Enterprise Information Systems, Setbal, Portugal*.

[Abecker et al., 2002] Abecker, A., Hinkelmann, K., Maus, H., and Müller, H.-J., editors (2002). *Geschäftsprozessorientiertes Wissensmanagement*. xpert.press Springer.

[Akman et al., 2001] Akman et al., editors (2001). *Modeling and Using Context. 3rd International and Interdisciplinary Conference, CONTEXT'01*, volume 2116 of *LNAI*. Springer.

[Bauer and Leake, 2001] Bauer, T. and Leake, D. B. (2001). Wordsieve: A method for real-time context extraction. In [Akman et al., 2001], pages 30–44.

[Budzik et al., 2000] Budzik, J., Hammond, K., Birnbaum, L., and Krema, M. (2000). Beyond similarity. In *Working notes of the AAAI Workshop on AI for Web Search (Austin, Texas, USA)*. AAAI Press.

[Burke, 1999] Burke, R. (1999). Integrating knowledge-based and collaborative-filtering recommender systems. In *Proc. Workshop on AI and Electronic Commerce*.

[Delp et al., 2004] Delp, M., Bhm, K., and Engelbach, W. (2004). Pre-built information space: Some observations on the challenges of process-oriented knowledge management. In *Proceedings of IKNOW'04, Graz, Austria*.

[Delphi Group, 2002] Delphi Group (2002). Taxonomy & content classification. Market milestone report.

[Dourish et al., 1999] Dourish, P., Bentley, R., Jones, R., and MacLean, A. (1999). Getting some perspective: Using process descriptions to index document history. In *ACM Conference on Supporting Group Work GROUP'99, Phoenix, Arizona, USA*. ACM.

[Dustdar, 2004] Dustdar, S. (2004). Reconciling knowledge management and workflow management systems: The activity-based knowledge management approach. In *Proceedings of IKNOW'04, Graz, Austria*.

[Elst et al., 2004] Elst, L. v., Abecker, A., Bernardi, A., Lauer, A., Maus, H., and Schwarz, S. (2004). An agent-based framework for distributed organizational memories. In Bichler, M., Holtmann, C., Kirn, S., Mller, J. P., and Weinhardt, C., editors, *Coordination and Agent Technology in Value Networks, Multikonferenz Wirtschaftsinformatik (MKWI-2004), 9.-11.3.2004, Essen*, pages 181–196. GITO-Verlag, Berlin.

[Elst et al., 2003] Elst, L. v., Aschoff, F.-R., Bernardi, A., Maus, H., and Schwarz, S. (2003). Weakly-structured workflows for knowledge-intensive tasks: An experimental evaluation. In *IEEE WETICE Workshop on Knowledge Management for Distributed Agile Processes (KMDAP03)*. IEEE Computer Press.

[Fenstermacher, 2002] Fenstermacher, K. D. (2002). Process-aware knowledge retrieval. In *35th Hawaii International Conference on System Sciences – HICCS*, Hawaii, USA.

[Goesmann, 2001] Goesmann, T. (2001). Kontextnavigator - a workflow integrated organizational memory information system to support knowlege-intensive processes. In *Second Workshop on Supporting Organizational Learning (SOL 2001), Tokyo*.

[Hammond et al., 2005] Hammond, T., Hannay, T., Lund, B., and Scott, J. (2005). Social bookmarking tools a general review. *D-Lib Magazine*, April. http://www.dlib.org/dlib/april05/hammond/04hammond.html.

[Holz, 2003] Holz, H. (2003). *Process-Based Knowledge Management Support for Software Engineering*. dissertation.de Verlag.

[Holz and Maurer, 2002] Holz, H. and Maurer, F. (2002). Knowledge management support for distributed agile software processes. In *Advances in Learning Software Organizations, 4th International Workshop, LSO 2002, Chicago, IL, USA, August 6, 2002, Revised Papers.*, volume 2640. Springer.

[Holz and Schäfer, 2003] Holz, H. and Schäfer, J. (2003). Task-specific information delivery for agile processes. In *Proc. of the 12th IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises (WET ICE '03)*, pages 320–325. IEEE Computer Society Press.

[Horvitz et al., 1998] Horvitz, E., Breese, J., Heckerman, D., Hovel, D., and Rommelse, K. (1998). The lumiere project: Bayesian user modeling for inferring the goals and needs of software users. In *Proceedings of the Fourteenth Conference on Uncertainty in Artificial Intelligence, Madison, USA*, pages 256–265.

[Huth et al., 2001] Huth, C., Erdmann, I., and Nastansky, L. (2001). Groupprocess: Using process knowledge from the practical operation of ad hoc processes for the participative design of structured workflows. In Sprague, R. H., editor, *Proceedings of the 34th Hawaii International Conference on System Sciences, January 3-6, Maui, Hawaii.*

[Kwan and Balasubramanian, 2003] Kwan, M. M. and Balasubramanian, P. (2003). KnowledgeScope: managing knowledge in context. *Decision Support Systems*, 35(4):467–496.

[Leake et al., 2000] Leake, D., Bauer, T., Maguitman, A., and Wilson, D. (2000). Capture, storage and reuse of lessons about information resources: Supporting task-based information search. In *AAAI-2000 Workshop on Intelligent Lessons Learned Systems.*

[Mahe and Rieu, 1997] Mahe, S. and Rieu, C. (1997). Towards a pull-approach of km for improving enterprise flexibility responsiveness: A necessary first step for introducing knowledge management in small and medium enterprises. In *Proc. Int. Symposium on Management of Industrial and Corporate Knowledge (ISMICK 97).*

[Maus, 2001] Maus, H. (2001). Workflow context as a means for intelligent information support. In [Akman et al., 2001], pages 261–274.

[Maus et al., 2005] Maus, H., Holz, H., Bernardi, A., and Rostanin, O. (2005). Leveraging passive paper piles to active objects in personal knowledge spaces. In Althoff, K.-D., Dengel, A., Bergmann, R., Nick, M., and Roth-Berghofer, T., editors, *3rd Conference Professional Knowledge Management – Experiences and Visions. WM 2005. Proceedings*, LNAI. Springer.

[Reimer et al., 1998] Reimer, U., Margelisch, A., Novotny, B., and Vetterli, T. (1998). Eule2: A knowledge-based system for supporting office work. *ACM SIGGROUP Bulletin*, 19(1):56–61.

[Resnick et al., 1994] Resnick, P., Iacovou, N., Suchak, M., Bergstorm, P., and Riedl, J. (1994). Grouplens: An open architecture for collaborative filtering of netnews. In *Proc. ACM 1994 Conference on Computer Supported Cooperative Work.*

[Riss et al., 2005] Riss, U., Rickayzen, A., Maus, H., and van der Aalst, W. (2005). Challenges for business process and task management. *Journal of Universal Knowledge Management. Springer*, this issue.

[Rostanin and Holz, 2005] Rostanin, O. and Holz, H. (2005). Task-embedded e-learning. In *Proc. I-KNOW '05.*

[Sauermann, 2005] Sauermann, L. (2005). The semantic desktop - a basis for personal knowledge management. In Maurer, H., Calude, C., Salomaa, A., and Tochtermann, K., editors, *Proceedings of the I-KNOW 05. 5th International Conference on Knowledge Management*, pages 294–301.

[Sauermann et al., 2005] Sauermann, L., Bernardi, A., and Dengel, A. (2005). Overview and outlook on the semantic desktop. In Decker, S., Park, J., Quan, D., and Sauermann, L., editors, *Proceedings of the First Semantic Desktop Workshop at the ISWC Conference 2005.*

[Schütt, 2003] Schütt, P. (2003). The post-Nonaka Knowledge Management. *Journal of Universal Computer Science*, 9(6):451–462.

[Schwarz, 2003] Schwarz, S. (2003). Task-Konzept-Ontologie: Strukturierung und Semantische Annotation von Workflows. In Abecker, A., Studer, R., and Sure, Y., editors, *2. Konferenz Professionelles Wissensmanagement. Luzern, Schweiz*, number 28 in LNC. GI, Bonner Kollen-Verlag.

[Schwarz, 2005] Schwarz, S. (2005). A context model for personal knowledge management. In *Post Proceedings of the IJCAII'05 Workshop on Modeling and Retrieval of Context*, LNAI. Springer. to appear.

[Shirky, 2005] Shirky, C. (2005). Ontology is overrated: Categories, links, and tags. shirky.com, http://www.shirky.com/writings/ontology_overrated.html.

[Staab and Schnurr, 2000] Staab, S. and Schnurr, H.-P. (2000). Smart task support through proactive access to organizational memory. *Knowledge-Based Systems*.

[van Elst and Kiesel, 2004] van Elst, L. and Kiesel, M. (2004). Generating and integrating evidence for ontology mappings. In *Engineering Knowledge in the Age of the Semantic Web: Proceedings of the 14th International Conference, EKAW 2004*, volume 3257 of *LNAI*, pages 15–29, Heidelberg. Springer.

[Wargitsch et al., 1998] Wargitsch, C., Wewers, T., and Theisinger, F. (1998). An organizational memory-based approach for an evolutionary workflow management system - concepts and implementation. In *31st Hawaiian Int. Conf. on System Sciences, HICSS*.