Sharing Contextualized Attention Metadata to Support Personalized Information Retrieval

Martin Memmel, Andreas Dengel
DFKI, Knowledge Management Department &
University of Kaiserslautern,
Computer Science Department
{memmel,dengel}@dfki.de

ABSTRACT

The ability to provide the right resources in a given context is a key factor for the support of knowledge workers. The information provided about the resources is crucial for any information retrieval approach, and it should allow multi-perspective descriptions of the resources. Enhancing these descriptions with information about the attention that users spend on such resources in a specific context will provide valuable additional information. The architecture proposed in this paper will allow to share and distribute contextualized attention metadata gathered with different user observation components to enable the integration of context-aware, personalized information retrieval services in arbitrary contexts and applications.

Categories and Subject Descriptors

H.3 [**Information Storage and Retrieval**]: General, Information Storage, Information Search and Retrieval, Systems and Software, Online Information Services; H.4 [**Information Systems Applications**]: Miscellaneous; H.5 [**Information Interfaces and Presentations**]: General, Multimedia Information Systems, User Interfaces

Keywords

Contextualized Attention Metadata, Information Retrieval, Knowledge Management, Resource Profiles, User Observation

1. INTRODUCTION

In a world where the amount of available information and knowledge is growing with a speed higher than ever before, and where knowledge workers have to learn consistently throughout their lifespan, the role of information retrieval techniques becomes more and more important. They should support users in efficiently accessing digital resources, i.e., to get just the right content in just the right time, ideally without having to leave the current task and workspace context.

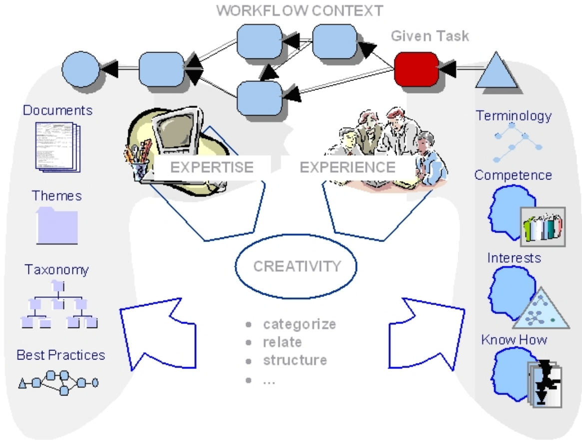

Figure 1: Creativity depends on the quality to combine tacit knowledge with explicit information

At their workspace, knowledge workers are involved in various processes in which they have to solve tasks by employing available expertise or make use of their experience from earlier similar situations. In this considerations, as shown in figure 1, they have access to local or shared repositories capturing best practices and other information objects which may be clustered into categories or even structured into hierarchical schemes helping to make decisions or drive workflows. Furthermore, they have tacit knowledge based on terminological background, on individual competences, know how but also subjective interests all of which can be combined with the accessible sources for being creative as soon as new documents are received or generated.

It is a matter of fact that the quality of solving a given task strongly depends on the operating experience with the available explicit sources (where to find what for which purpose in which form, ...) and how to relate these pieces of information with context of the given task.

By interacting with documents users form mental models based on their experience and the contents with which they are interacting. These mental models provide both predictive and explanatory power for understanding and categorizing the containing messages, questions, commands, notices, or orders. This is because bits of information are never stored in memory as individual units, but integrated into known clusters which correspond to the very individual view of the world of a human being. Although the information object does not change, such clusters may differ over time because the perspective has changed, i.e., because new insights have been gained or the information is applied to another problem.

Mental models evolve naturally through our interaction with particular environments. They play an important role for orientation and problem solving because they are used to simplify understanding and learning by representing and organizing general knowledge. They are formed to explain complex phenomena of our world and to filter our environment making it easier for us to interpret and predict the things which may happen as well as to take action to respond. Because we are part of different cultural and social systems, belong to different peer groups, have different attitudes or beliefs, and play different roles, there are also differences in these models.

If we were able to understand and to capture how people evolve their mental models, we might provide cognitive adequate interaction platforms for communication and collaboration. These interfaces should include attention, memory, perception and learning but however, should also consider the way users perceive, categorize and remember in the context of specific tasks.

The famous statement of the Austrian philosopher Ludwig Wittgenstein (1889 - 1951)

'Die Bedeutung eines Wortes ist
sein Gebrauch in der Sprache'
'The meaning of a word is its use in the language'

can be transferred into the world of (digital) resources:

'The meaning of a resource is its use in the community'

Capturing and sharing information about the attention that users spend on resources in specific contexts will provide valuable information enabling significantly improved, personalized information retrieval services based on the mental models of the users.

In this paper, we will first introduce the concept of multi-perspective personal document management and the implications for the description of resources with metadata. Several existing approaches to realize context-aware support and general requirements concerning the distribution, matching and sharing of Contextualized Attention Metadata (CAM) will provide the basis for our proposed architecture allowing to aggregate, share, and distribute resource descriptions and CAM captured in different scenarios, and to provide context-aware, personalized information retrieval services. An interactive *context cockpit* will allow users to intuitively control the matching processes between contexts and resource descriptions.

2. MULTI-PERSPECTIVE PERSONAL DOCUMENT MANAGEMENT

Establishing contextual information is a difficult task. Manually defined formal ontologies and process models typically address only a high-level fraction of a domain and require continuing maintenance that is cost-intensive. Automatic methods mainly driven by statistical machine learning approaches, in most cases, leave too much ambiguity and disorientation when they are used in shared contexts because users have different roles, tasks and interests, and thus consider the contents subjectively. This becomes obvious if we take a contract document about a technical innovation and ask a group of persons, say a lawyer, a sales person, or a technician how they would file the document into their repository.

It is obvious that each of them would categorize the document in a different way. Apparently it strongly depends on the role of a reader, at what time the document is considered, in which terminology and language it is written, on which tasks he/she is currently working, and what expertise and experience is available. Thus, a document may be seen as valuable information, as bootless or even as an annoyance.

Even a single user may have difficulties because documents usually allow for perspective considerations depending on the given circumstances. The 'who', 'what', 'where', and 'when' aspects inherent to documents usually give a choice of filing a document into different folders. Taking all of these issues into consideration, we have proposed an adaptive personal memory system allowing to import native structures, such as file folder hierarchies, bookmark collections or email repositories. It is built on the following principles:

1. Using statistical machine learning techniques for generating terminological conceptualizations to explain the subjective understanding of the folder names.

2. Provide multi-dimensional views to a document space, e.g., document type, topic, project, event, contact.

3. Install an integrated view that combines the documents of the file system with those in the email system and the bookmarks.

In this way, a user may reorganize his own workspace into a personal memory offering him different organizational views for filing and seeking information. For more details, we like to refer to [1].

Note that all initial categorizations result from the imported structures or from an initial training phase. As soon as some documents are already categorized into the folder providing a representative conceptualization, the system supports the user based on earlier categorization decisions. For example, new emails arriving in the inbox of a user are, after conceptualization, compared to the concepts of folders and the system comes up and proposes folders the email may belong to, such as document type 'A', event 'B' and topic 'C'. This is visualized by question marks. In figure 2, we show some exemplary views from a real personal workspace.

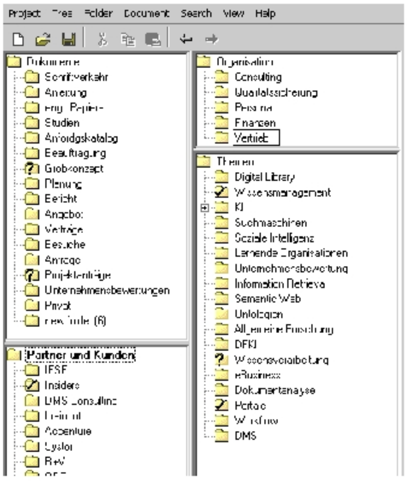

Figure 2: Snapshot from a multi-perspective personal memory providing information views such as document type, partner and customer, department, and topic.

For views 'document type' (German: 'Dokumente'), 'partner and customers' (German: 'Partner und Kunden'), 'departments' (German: 'Organisation'), and 'topics' (German: 'Themen') allow for filing one and the same document into multiple folders at the same time.

Beside the organizational aspects and the support for categorizing new documents, we have implemented a set of retrieval techniques. It includes:

- Classical full text search.
- Contextual search (as a query expansion using those terms which are conceptually close).
- Combining terms queries and folders, i.e., search for 'eLearning' restricted by the folder 'Reports'.
- User feedback by indicating good documents (click on '+') or bad ones (click on '-'), etc.

Moreover, we allow the additional use of metadata, such as author, generation date, document size or type (see also [1]).

3. DESCRIBING RESOURCES

The quality of the information provided about digital resources is crucial for any information retrieval approach. There are different ways and standards (e.g., Dublin Core) to describe digital resources. However, these approaches usually suffer from several problems (see [2]) that can only be partly solved with technology. The main problem is that there is the implicit assumption in the structure of most metadata formats which suggests that there is a one-to-one relationship between a resource and the metadata that describes it [3]. But as we have already argued in section 2, there is no 'single and correct' way to describe a resource. A lot of the information depends on the context in which a resource was created, and by whom it will be used for what

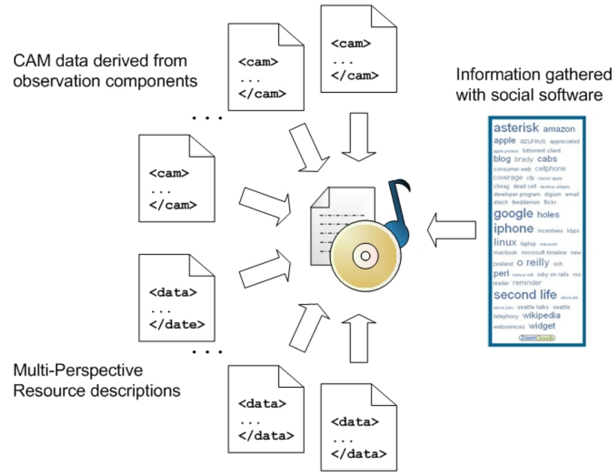

Figure 3: Resources are described with different information captured in various ways

reasons. Wiley et al. therefore distinguish between objective (e.g., the size of a file) and subjective (e.g., the degree of interactivity of a resource) metadata [11].

Despite the existence of methods that allow for the automatic generation of metadata, meaningful data can often only by created by humans, but often 'People lie', 'People are lazy, 'People are stupid, and 'People are lousy observers of their own behaviors' as Doctorow states in [2].

Due to these facts it is clear that centralized approaches are a bad idea if we want to provide resource descriptions according to our needs. Instead, any attempt to describe resources should embrace diversity. Thus, we propose the use of 'resource profiles' instead of single metadata sets [3]. A resource profile is defined as a 'a multi-faceted, wide ranging description of a resource'. It is not conform to a particular XML schema, instead, it is a patchwork of metadata formats (potentially created by different authors) which are assembled as needed in order to form a description that is most appropriate for the given resource.

When designing a system to share digital resources and according CAM, and to realize context-aware, personalized information retrieval, this means we should offer the possibility to annotate various descriptions for each resource (see figure 3). This includes multi-perspective descriptions of documents, context information gathered with various components, and information created in a lightweight approach using social software (e.g., tagging of resources).

Nevertheless, there must of course exist some mandatory metadata to *enable basic functionalities* such as search and display (containing, e.g., the name and location of a resource), about the *technical format of a resource and the technical requirements to use it*, and for *intellectual property rights* with information about the way in which a resource may be used. An example of an according format will be given in section 6.3.2.

```
<file:3860.pdf> <http://www.dfki.de/peek/penannotation#annotationType> "underline"
<file:3860.pdf> <http://www.dfki.de/peek/penannotation#annotationText> "discovery feedback"
<file:3860.pdf> <http://www.dfki.de/peek/penannotation#documentName> <file:3860.pdf>
<file:3860.pdf> <http://www.dfki.de/peek/penannotation#annotationCreatedTime> "2006-11-24T06:43:57"
<file:3860.pdf> <http://www.dfki.de/peek/penannotation#annotationModifiedTime> "2006-11-24T06:43:57"
...

<context:contains>
   <object:HtmlFile rdf:about="http://jena.sourceforge.net/">
      <object:location>http://jena.sourceforge.net/</object:location>
      <object:title>Jena Semantic Web Framework</object:title>
      <object:fileType>text/html</object:fileType>
      <object:lastAccess>2005-04-13T14:45:42</object:lastAccess>
      <context:confidence>1.0</context:confidence>
   </object:HtmlFile>
</context:contains>
```

Figure 4: Excerpt of context information captured within PEEK and EPOS

4. APPROACHES TO REALIZE CONTEXT-AWARE SUPPORT

There are various different approaches allowing to capture CAM in a knowledge worker's environment. In the DFKI Knowledge Management Department, several efforts have been undertaken to realize context-sensitive support:

- In the research project *EPOS*[1] (Evolving Personal to Organizational Knowledge Spaces), a context-sensitive system to support knowledge workers was developed [4, 10]. The objective of EPOS is to leverage a user's efforts for his personal knowledge management for his own benefit as well as to evolve this within the organization.

- The research project *MyMory*[2] (Personal Memories with Attentive Documents for Knowledge Workers) aims at employing technologies for unobtrusive user observation in order to create relations between information items that are meaningful to the user in his specific context, using attention evidence for more precise information delivery, and providing mechanisms of meaning coordination to facilitate reusability of knowledge among different contexts. MyMory results shall be demonstrated within the C3DW (Connected, Context-aware, Creative Document Workspace) application.

- The *TaskNavigator* developed in the competence center 'virtual office of the future'[3] is a novel prototype to support weakly-structured processes by integrating a standard task list application with a state-of-the-art document classification system. The resulting system allows for a task-oriented view on office workers' personal knowledge spaces in order to realize a proactive and context-sensitive information support [5].

- The project *PEEK* (Personal and Episodic Knowledge Retrieval in Desktop Search) aims to enhance Semantic Desktop Applications by capturing relevant information about document with a Digital Pen.

[1] `http://www.dfki.uni-kl.de/epos`
[2] `http://www.dfki.uni-kl.de/mymory`
[3] `http://www.ricoh.rlp-labs.de/`

The methods used in these projects to capture context information will be introduced later in section 6.1.

5. DISTRIBUTING, MATCHING AND SHARING CAM

When we want to use CAM captured by different user observation components, first of all a common format to represent context and according mapping mechanisms are required. The data provided in this format can then be used to realize context-aware information retrieval. But when this technical problems are solved, we only have a basis for context-aware, personalized information retrieval. The main task will be to encourage users to participate in the system, to create and publish context information, and to provide additional information about resources. This especially includes issues such as privacy and security.

5.1 Representing CAM

To avoid ambiguities, and to ensure that a common understanding of terms is guaranteed, we propose to use a flat and rather simple format as the basis for context-aware information retrieval. The matching algorithms used to find similar contexts will use context information provided in this way. A basic context format can, e.g., consist of the following concepts:

People: Persons that are involved in the current context, e.g., contacted via mail or instant messaging.

Resources: Resources used in the current context (e.g., documents modified with a text processor, sent via email or created in a file explorer application)

Topics: Topics that a user dealt with, e.g., extracted by analyzing used resources, highlighted passages, etc.

Tasks: The user's current tasks, e.g., extracted from a workflow or task management system.

Projects: Projects that are related to the current context.

Organizations: Organizations that are related to the current context.

Events: Events that are related to the current context.

Locations: Locations that occurred in the users's context.

Time: The time the context information was captured.

```
(?X rdf:type rdfs:Class),
noValue(?X rdfs:subClassOf ?X)
-> (?X rdfs:subClassOf ?X).

(?X rdf:type ?D),
(?D rdfs:subClassOf ?C)
-> (?X rdf:type ?C).

##################################
#    PIMO                        #
##################################

(?X pimo:hasOtherRepresentation ?Y)
-> (?Y pimo:hasOtherRepresentation ?X).

(?X pimo:hasOtherRepresentation ?Y),
(?Y pimo:hasOtherRepresentation ?Z),
notEqual(?X, ?Z)
-> (?X pimo:hasOtherRepresentation ?Z).
```

Figure 5: Excerpt of mapping rules created with the Jena framework in the EPOS project

5.2 Integrating CAM

The information gathered by the user observation components is often represented in heterogeneous formats. Figure 4 provides an example for information gathered in EPOS and PEEK. This information can be enhanced using entity extraction algorithms (provided, e.g., by tagthe.net[4]), and related concepts can be added using existing classificators or ontologies.

When the captured context data is enriched with information, it has to be mapped to the concepts introduced in section 5.1. Therefore, mapping rules can, e.g., be defined using the Jena semantic web framework (see figure 5 for an example used in EPOS).

5.3 Encouraging users to participate

As already explained in section 5.1, centralistic approaches have a lot of weaknesses. Thus, the aim must be to attract enough stakeholders that can contribute valuable (context) information about resources, at best working as a self-sustained community. Apart from dissemination efforts, it is very important to encourage users to participate:

- The interaction with the system should be as easy and intuitive as possible. Therefore, user interfaces are required that follow the principles of simplicity [8] and joy-of-use [9].
- Reward mechanisms can be used to promote contributors and the quality of contributions.
- Users should be offered the possibility to use functionalities in their usual contexts and applications, so that they can contribute without having the need to use new tools. E.g., widgets and a service oriented architecture can be used to realize such an integration.

Especially in the field of user observation, ensuring privacy, security and transparency are crucial for the success of our approach. It is important that the user is always in control of what happens with the information he provides. This includes the right to delete information at any given time, and to provide a transparent system where every user can see exactly how his information is used [6].

[4] http://www.tagthe.net/

6. OVERALL ARCHITECTURE

The overall architecture of the proposed CAM sharing system is depicted in figure 5.2. It consists of the following components:

- *User observation components* developed in various projects to gather CAM data in different formats,
- *CAM preprocessing components* allowing to enhance gathered CAM data, and to map it to a common format as described in section 5.1,
- a *resource and metadata hub* to store resources and information about them, e.g., provided by the user observation components, and
- *context-aware information retrieval services* based on the information provided by the user and the resource and metadata hub.

6.1 User observation components

As shown in figure 5.2, there are numerous possibilities to capture CAM. In the projects mentioned in section 4, different methods have been developed to capture information about a user's context:

- In EPOS, context information is gathered through the use of installable user observation plugins for standard office software such as email clients (thunderbird), browsers (firefox) and text processors (jedit). These plugins can analyse, e.g., which content was in the user's focus (also taking into account scrolling behavior), and which searches have been carried out. In addition to that, file explorers were used as a source for CAM.
- MyMory enhances the components developed in EPOS by using an Eye Tracker to deliver more precise information about on which part of a document a user spends attention.
- In PEEK a Digital Pen is used that can capture and store handwritten annotations on printed documents (printed on paper with dot pattern to allow the recognition of the document); annotations are stored with the original document as pdf.
- The TaskNavigator prototype captures information about resources used in certain tasks. It is also possible to assign a document to a task when copying or scanning it with a multifunctional product (MFP). In this case, OCR techniques are used to extract information from a document.

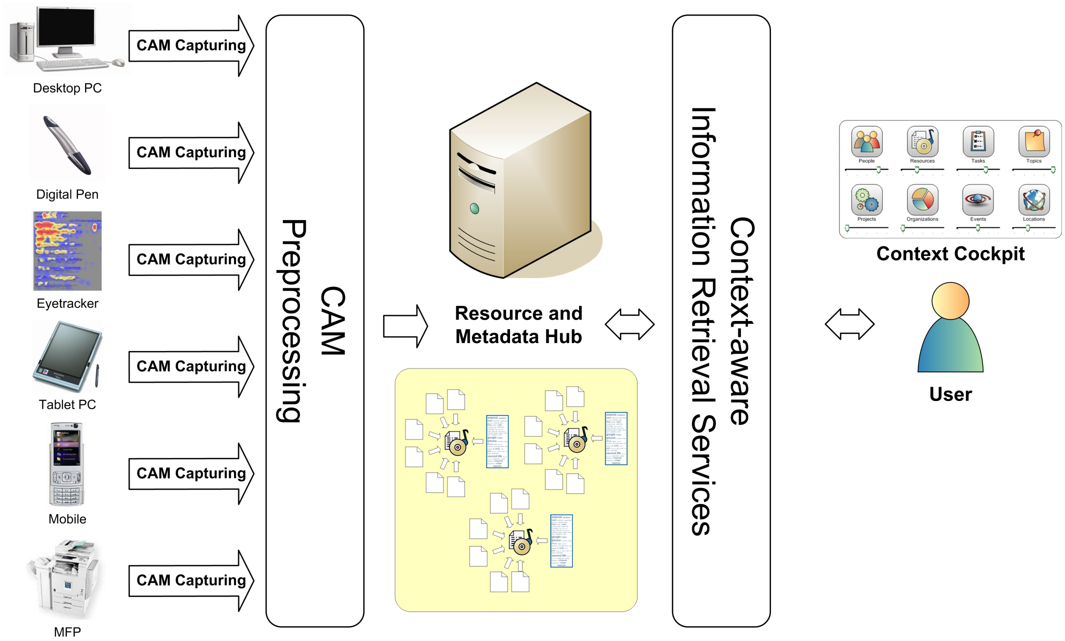

Figure 6: Overall architecture of the proposed CAM sharing system

6.2 CAM Preprocessing

For each user observation components, a method has to be defined to create CAM data according to the format used for context matching components used by the context-aware information retrieval services. As described in section 5.2, such a method can also be used to enhance the captured information. It is also important to notice that existing descriptions of resources used in the given context can be used as a source of information for this task.

6.3 Resource and Metadata Hub

To provide information retrieval based on information about digital resources and shared CAM, a component allowing to share resources and according CAM, and to collect and retrieve this information is required. In the project *CoMet*[5] (Collaborative Sharing of Metadata), such a component is currently being developed in DFKI.

6.3.1 Functionalities

CoMet provides functionalities to insert, search and display resources.

Insert: A resource can be inserted by uploading it as a file into CoMet's WebDAV repository, or by just using a reference to the resource, i.e., its URI.

Search: CoMet provides different search filters, e.g., a user can search for resources which contain certain keywords in their title, description or tags. Further an advanced search is provided that allows to search for keywords in defined metadata terms.

Display: Supported formats are those which can be displayed directly by a browser (e.g., JPEG, MP3, SWF, etc.)

[5] http://www.dfki.uni-kl.de/comet

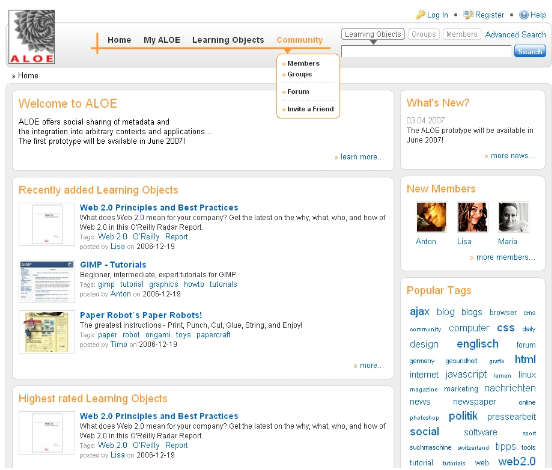

Figure 7: Screenshot of the CoMet user interface

For registered users, CoMet also offers mechanisms to rate, tag and comment on resources, and to manage own tags and lists of friends and favorite resources. The information provided by the users allows to browse content via tags (social browsing), and resources can be ranked according to different criteria, e.g., alphabetically, most viewed, best rated, etc.

Most of the functionalities can be accessed via Web Interface (see figure 7) or Web service API. This allows for an easy integration in different contexts and applications.

6.3.2 Metadata

CoMet stores a derivative of the Dublin Core Metadata Element Set for every resource which is registered in the system.

Mandatory Resource Metadata	
dc:contributor	Person who inserted the resource into CoMet.
dc:creator	Author of the resource.
dc:date	Date of insertion.
dc:description	Description of the resource.
dc:format	Either MIME type or a proprietary format.
dc:identifier	URI which identifies the resource uniquely.
dc:rights	CC license which is associated with the resource.
dc:title	Title of the resource.
Metadata of a User-Defined Metadata Set	
dc:contributor	Person who inserted the metadata set into CoMet.
dc:creator	Author of the metadata set.
dc:date	Date of insertion.
dc:description	Description of the metadata set.
dc:format	Metadata format (e.g., DC)
dc:identifier	Identifier of the metadata set.
dc:relation	URI of the described resource.

Table 1: An excerpt of the metadata used in the CoMet system

Additionally, users can associate resources with metadata sets in arbitrary formats (e.g., about the context in which they used a resource). Together with these metadata sets information about the metadata (i.e., the meta-metadata) has to be provided. An excerpt of the metadata used to store information about resources and user-defined metadata sets in CoMet is presented in table 1. CoMet also allows the definition of different variants of resources. These variants are intended to mediate similar information in different dimensions (e.g., 'language' or 'difficulty'), and they constitute a basis for personalized content provision (see [7]).

6.4 Context-aware, personalized information retrieval services

Based on the information we have captured and preprocessed in the presented way, information retrieval processes can be significantly improved. Instead of just performing a search based on single terms and the classification of a resource, we can now use the following information:

1. multi-perspective descriptions of resources
2. the user's current context
3. descriptions of the contexts in which resources have been used before

Any context-aware information retrieval service must be able to determine the degree of similarity between two different contexts. In case of the context representation introduced in section 5.1, this can be realized by adding up the calculated similarities between each of the concepts (e.g., between topics, between persons, etc.) For this purpose, various existing approaches can simply be reused.

Figure 8: Mockup of a Context Cockpit

To allow users to adapt the information retrieval process to their current needs, we propose an interface following the metaphor of a mixing desk (see figure 6.4). This 'context cockpit' allows users to intuitively control the matching process by assigning different weights to the different concepts. Thus, the results as well as the order in which they are presented can be adapted to the specific needs of the user.

7. SUMMARY AND FUTURE WORK

Capturing and sharing information about the attention that users spend on resources in a specific context provides valuable information about the mental models of users. The possibility to use this information can significantly improve existing information retrieval approaches. To realize an according system, we propose a service oriented architecture that allows to integrate various user observation components, and where arbitrary types of multimedia resources can be integrated and described using resource profiles. Thus, we can provide multi-perspective descriptions about the resources and the contexts in which they were used. To ease context sharing and matching, we propose the use of a simple, common format to represent context information. The data gathered with the different user observation components therefore has to be transformed using preprocessing components to enhance the gathered data, and to map it to the common format. Context-aware information retrieval services can use the information provided in this way to realize advanced and innovative functionalities, among others by using an interactive context cockpit that allows the user to intuitively control the matching process between contexts and resource descriptions. We are currently developing an according system to integrate existing approaches developed in several projects, and we expect the first prototype to be available in autumn 2008.

8. ACKNOWLEDGMENTS

The project *EPOS* has been supported by a grant from the German Federal Ministry of Education, Science, Research, and Technology (FKZ ITW-01 IW C01). *MyMory* is currently funded by the German Federal Ministry of Education and Research (FKZ 01 IW F01). *CoMet* is currently funded by the Stiftung Rheinland-Pfalz für Innovation. *PEEK* is funded by Hitachi Central Research Laboratory, Tokyo. *TaskNavigator* is a joint project of DFKI and Ricoh Co. Ltd.

9. REFERENCES

[1] A. Dengel. Six thousand words about multi-perspective personal document management. In *Proceedings EDM, IEEE Int. Workshop on the Electronic Document Management in an Enterprise Computing Environment, Hong Kong, China*. IEEE Computer Society, 2006. None.

[2] C. Doctorow. Metacrap: Putting the torch to seven straw-men of the meta-utopia, 2001. Electronic document. Date of publication: August 26,2001. Retrieved March 14, 2007, from http://www.well.com/˜doctorow/metacrap.htm.

[3] S. Downes. Resource profiles. *Journal of Interactive Media in Education*, 5, 2004. ISSN:1365-893X.

[4] H. Holz, H. Maus, A. Bernardi, and O. Rostanin. From Lightweight, Proactive Information Delivery to Business Process-Oriented Knowledge Management. *Journal of Universal Knowledge Management. Special Issue on Knowledge Infrastructures for the Support of Knowledge Intensive Business Processes*, 0(2):101–127, 2005.

[5] H. Holz, O. Rostanin, A. Dengel, T. Suzuki, K. Maeda, and K. Kanasaki. Task-based process know-how reuse and proactive information delivery in tasknavigator. In *Proceedings: CIKM '06. ACM Conference on Information and Knowledge Management, November 6-11, 2006, Arlington, USA*, pages 522–531, November 2006.

[6] A. Iskold. The Attention Economy: An Overview, 2007. Read/WriteWeb. Electronic document. Date of publication: March 01, 2007. Retrieved April 05, 2007, from http://www.readwriteweb.com/archives/attention_economy_overview.php.

[7] M. Memmel. Adaptivity with multidimensional learning objects. In G. Richards, editor, *Proceedings of the World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2005, Vancouver*, pages 2221–2230. AACE, 2005.

[8] J. Nielsen. *Designing Web Usability: The Practice of Simplicity*. New Riders Publishing, 2000.

[9] I. E. Reeps. Joy-of-Use: eine neue Qualität für interaktive Produkte. Master's thesis, University of Konstanz, 2004.

[10] S. Schwarz. A context model for personal knowledge management. In *Proceedings of the 2nd International Workshop of Modelling and Retrieval of Context (MRC 2005) in conjunction with IJCAII 2005*, pages 39–50, Edinburgh, jul 2005.

[11] D. A. Wiley, M. Recker, and A. S. Gibbons. Getting axiomatic about learning objects. In D. A. Wiley, editor, *The Instructional Use of Learning Objects: Online Version*. 2000. Retrieved February 01, 2006 from http://reusability.org/axiomatic.pdf.