Situation-based Knowledge Presentation for Mobile Workers

Alessandra Agostini, Roberto Boselli, Flavio De Paoli and Riccardo Dondi

***Abstract*—** The work presented in this paper focus on Knowledge Management services enabling CSCW (Computer Supported Cooperative Work) applications to provide an appropriate adaptation to the user and the situation in which the user is working. In this paper, we explain how a knowledge management system can be designed to support users in different situations exploiting contextual data, users' preferences, and profiles of involved artifacts (e.g., documents, multimedia files, mockups...). The presented work roots in the experience we had in the MILK project and early steps made in the MAIS project.

***Keywords*—**Information Management Systems, Information Retrieval, Knowledge Management, Mobile Communication Systems.

I. Introduction

THE work presented in this paper focus on Knowledge Management (KM) services enabling CSCW (Computer Supported Cooperative Work) applications to provide an appropriate adaptation to the user and the situation in which the user is working. In other terms, the ultimate goal of our services is facilitating the job of applications supporting situated action and learning ([7], [12]) of mobile people involved in their every-day collaborative work activities. This focus on KM and, on the other hand, on cooperative work of mobile knowledge workers shapes the requirements for adaptation and personalization to the user's context.

We believe that context is "any information that can be used to characterize the situation of an entity" [6] and it "includes [...] even the social situation; e.g., whether you are with your manager or with a co-worker"[11].

For our services, the collection, representation, and use itself of contextual data have a twofaced objective. On the one hand, contextual data enable a suitable adaptation of the behavior of CSCW applications. On the other hand, as already recognized in various researches (e.g., [2], [8], [10], [13]), users' awareness—i.e. providing contextual information regarding the cooperative work processes in which users are involved—enables people to act more effectively.

Moreover, we believe that not only the current user situation is relevant but also the complete history of actions and interactions among people, objects, data, and applications creating the unique actual situation of the user. Finally, to allow a finer adaptation and personalization, the activity the user is doing as well as information about the "content" of the activity itself (e.g., messages, documents) contribute to enrich contextual data. Practically, our solution is based on (meta-)data about the context and the user allowing—among other things—to extract the more appropriate knowledge for a specific situation of the user.

In this paper we address these issues by explaining how our knowledge management system has been designed to support users in different situations exploiting contextual data. We focus on users with specific characteristics. In fact, from the beginning of the MILK project [8], two business organizations have been involved as end-users of the system. The users participate to the system design and have been observed to discover their needs and understand their context of work. At the end, they tested the resulting system. A complete description of users' requirements is out of the scope of this paper (for more details see [1]); however, the most characterizing aspect is that they are mobile workers. In other words, employees of both companies are forced to frequently move on their day-by-day activities due to various reasons (e.g., external meeting with clients, different office branches).

The rest of the paper presents our approach and features. Section II briefly illustrates the general interactions among pertinent modules composing the whole system. Section III describes how our system organizes knowledge. In Section IV we describe the adaptation regarding the specific user's situation. Finally, Section V provides the personalization features based on user's characteristics.

II. System Architecture

The KM engine of the MILK system is composed of various cooperating sub-systems and modules (see [1]). The core supporting the adaptation and personalization of end-user applications is the Metadata Management System (MMS). It relies on various further sub-systems sketched in Figure 1.

We exploit the MAIS [4] functionalities for capturing real-time updated information about the user local environment in terms of spatial location, physical, and technological environment (e.g., communication channels, devices, network bandwidth); applications can also obtain relevant information for the Quality of Services.

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Alessandra Agostini is with the Dipartimento di Informatica e Comunicazione, Università degli Studi di Milano, Milano, Italy (phone: +39-02-50316307; fax: +39-02-50316373; e-mail: agostini@dico.unimi.it).

Roberto Boselli, Flavio De Paoli Riccardo Dondi are with Dipartimento di Informatica, Sistemistica e Comunicazione, Università degli Studi di Milano Bicocca, Milano, Italy (e-mail: {lastname}@disco.unimib.it).

The MMS, to provide its services, is aware of the various interactions between the end-user applications and the MAIS middleware. Practically, the MMS is the hub between all data-flows and interactions between users and applications, systems and middleware services, etc. Note that—to ensure the right level of abstraction from any particular technology, device and situation—application modules are separated from presentation module(s) (see next Section for more details).

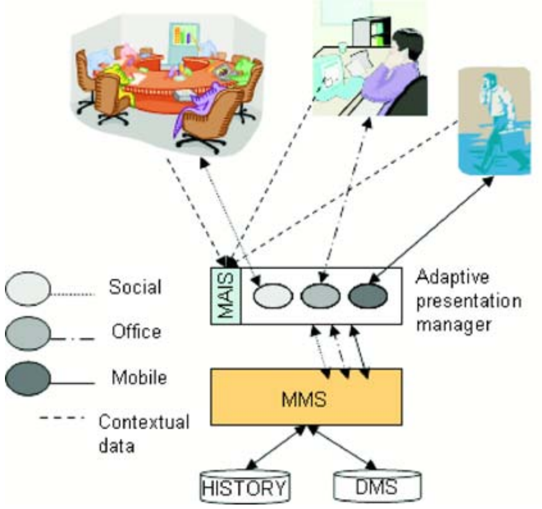

Figure 1 Overview of System Architecture

The MMS is part of the KM system. The KM system includes also a Data Management System (DMS) and a component devoted to track the history of interactions. The various KM components have been designed as web services (see [1], [5]).

III. Knowledge Organization

The KM system we developed captures and integrates various kind of knowledge associated with organizational issues (meeting minutes, work plans...) and ongoing work (working documents, finalized reports...). This knowledge includes information about people and their activities. The organization of this knowledge is centered on a profiling mechanism that associates common knowledge descriptions with objects of different nature. The objective is to be able to integrate knowledge associated with objects –*elements* in our terminology– like documents, people, communities and projects comprehensively. The key factor is the ability of comparing and contrasting elements of any type to compute various kinds of relationships. The MMS component addresses the issues of computing and maintaining profiles and relationships.

Moreover, artifact replaces the traditional concept of document. An artifact is a compound object collecting various files, each of them being a different representation of the same conceptual content –e.g., the full-text and slide presentation for a paper. This allows the system providing people the most appropriate representation in accord with the activities they are performing and with the specific situation. Moreover, a single representation can have different file formats (e.g., HTML, pdf, ppt for a presentation). Finally, since MILK supports versioning to track document evolutions, versions of any representation may also be available. The system supplies users with preferred file formats and newest versions.

Summarizing, we maintain: information about different representations for artifacts; qualifying information describing such artifacts (i.e., a set of metadata); and, information related to them (e.g., discussions, e-mails...).

IV. Service Adaptation Based on Context

The functionalities provided by our system support adaptation and personalization according to the context of use. Even if adaptation and personalization are strictly interleaved and are not separated phases, let us first focus on adaptation. In MILK, three main contexts of use, arisen from users' analysis, have been considered (i.e., office–via PC, social–via large interactive screens, and mobile–via cell phones). In accord, three specific presentation managers have been developed. They have the goal of providing the more appropriate presentation of the knowledge. The more appropriate knowledge to be shown, instead, is selected and ordered by the MMS (see Section V). Therefore, presentation managers can exploit contextual information received from the MAIS middleware and the more appropriate knowledge received from the MMS for adapting the final user interaction.

The above-mentioned concept of representation has been introduced to obtain a finer content adaptation based on the context. In fact, different contexts may require different formats and modes for accessing an artifact. In particular, different representations are selected according to the device used to access information, since some representations may be unsuitable for certain technology. For example, it is not attractive to watch a presentation or read a technical paper on a mobile phone.

The introduction of representations is motivated by the characteristics of the used channel too. For example, if the user is connected to a fast network, s/he has few limitations in accessing any kind of representations. However, if s/he is in an environment with a slow connection, or no network connection is available, then synthetic representations are the only representations available for her/him. The MAIS middleware is in charge of detecting available channels and their characteristics to let an application select the best available representation.

A further reason for supporting multiple representations is to address the issue of presenting the content of documents in different formats. The system adapts to display the right format according to the situation.

To address all possible situations several aspects related to the activity of the user need to be considered. For example, a user working alone in his/her office should be able to access artifacts and related information differently as when s/he is in a social situation such as a meeting. In the former case probably more detailed information is needed and no privacy filtering is applied. In the latter, more synthetic information is suitable and no private or personal information should be displayed. Note that in both cases the user may use the same device, for example a laptop computer.

Different combinations of the aspects considered above define a specific situation. We focused on a limited list of the most relevant situations; they are derived from MILK case studies and have been selected with the collaboration of MILK test-users. Some possible situations have not been considered, since they are not reasonable; for example, a user interacting with a large screen when traveling by train. Each situation corresponds to a specific representation. Of course, each single user can specify all these associations or personalize default system associations.

In Table I we provide some typical situations with a selection of factors describing them.

TABLE I
SOME EXAMPLES OF TYPICAL SITUATIONS

Situation Name	Device	Net Speed	Place	People Involved
Desktop	PC	fast	user's office	user
Internal Meeting	large screen	fast	room meeting	project's members
Customer Meeting	mobile	slow	other	customer
Social Area	mobile & large screen	slow	social area	public

The first column shows different situations in which a user is involved, while the other columns show some elements to be considered for selecting the situation. We do not claim to be general but, on the contrary, we focus in a specific domain: business workers with a high mobility; organizations with multiple sites; and, continuous changes of work places with a simultaneous presence of different devices.

The MAIS middleware is in charge of discovering some aspects of situation. However, it is not able to directly capture all aspects that define a situation, for example the high-level parameter defining the kind of activity the user is doing. In MILK, the end-user organizations preferred to explicitly provide some of these parameters to the system; in fact, they consider that the automatic deduction of these parameters is still too error-prone and in an early phase of development.

To better illustrate those situations let us describe a scenario that we have experimentally implemented. Mike is head of Customer Relations for an international firm. While he was reviewing a set of confidential documents trough his PC, he received a call from a customer for an urgent meeting. Leaving his office in a hurry, he took just his mobile phone. When in the taxi, he wants to continue the interrupted work using his mobile phone. MAIS senses that Mike is using a mobile phone and that he is accessing data through a slow connection channel, the MMS accordingly selects the proper representation of documents. Thus Mike is able to skim the plain text of those documents he was browsing on his PC moments ago. During the meeting with the customer, they started to discuss the feasibility of some technical modifications to the last customer's order. Mike's mobile sensed his new location and the presence of other people's laptops and of a large interactive screen. Thanks to these information, integrated with the MMS and the KB data, the system is able to propose a selected list of possible situations. Mike selects the *Customer Meeting* situation. Specifying some keywords in the query form, Mike finds a set of documents closely related to that customer. Note that, private documents are not extracted due to the presence of external people in the same room. He is able to find at once the document containing the technical specifications he needs to discuss. Finally, he uses the mobile phone for redirecting and displaying the document in the large screen.

It is worth to note that, thanks to the (meta-)data handled by the MMS, further capacities of adaptation to the context are possible. In fact, the knowledge retrieved can be easily shown and organized in different ways; in MILK we developed three main ways. Within the first mode, called the View with Context metaphor [1], [5], an element is presented surrounded by all its related information; that is, related documents, people, communities, projects, and so on.

A different visualization reflects the organizational structure of the data. For example, the tasks of our end-users are projects oriented. Thus, they need to classify their documents according to their belonging to specific projects. In our experiments we designed a hierarchical structure representing the specific organization of the company. However, in general, the structure can be adapted to different needs, simply defining the criteria to organize the data.

A further way –specifically introduced for large interactive screens [3]– is represented by a set of clusters; each cluster represents a thematic area in which all elements related to that area are grouped. A number of layout rules are used for facilitating a quick overview and for representing information about clusters (e.g., the size of clusters depends on the overall amount of activity).

V. USER PROFILING AND SERVICE PERSONALIZATION

A key issue for KM systems is providing tailored information for users based not only on the query they submit, but also depending on their working context and their interests. Both user interests and working context are relevant aspects to consider when retrieving information. As an example, consider a user looking for information on java programming language. If the user is a technical worker, s/he probably needs information about programming in java or however technical information about it. If the user is a commercial worker, s/he is probably looking for commercial analysis of the use of java programming language.

Similarly, the context affects the kind of information needed by the user. If a user is working at her/his desk writing a paper s/he needs other papers on the same topic, if the user is presenting her/his activities in a commercial presentation, s/he needs commercial reports. Thus, to provide useful information for a user is fundamental to take into account in the retrieval process the subject of documents, her/his interests and the environment s/he is working in.

In particular, MILK system provides the user with a personalized view of the information retrieved. It provides two ways to discover information: the traditional query model and the View with Context metaphor. In both cases, the information is first retrieved based on the similarity between elements or between an element and the query, and then it is ranked and filtered according to user interests and context. In what follows we will focus on the View with Context, since the query model can be considered as variations of the View with Context model.

To deal with the issues described above, the information stored in the system has first to be organized. This task is made by the MMS associating each element with a profile that captures relevant aspects for correlating, filtering and ranking. Profiles represent a flexible set of metadata collecting information about different aspects of an element. In particular, semantic information is collected, representing the content and the meaning of a document, the interests and expertise of a person, etc. Moreover, generic attributes associated with elements, like the title of a document or the name of a person, are part of an element profile. Finally, also dynamic properties connected to the history of elements, for example, how many times a document has been read, are collected in the profiles.

Profiles are useful since they organize information, and allow the computation of correlation between elements. Moreover, profiles are useful also to personalize the information showed, as well as the correlation algorithms.

In this direction profiles allow the system to support user activities and change the system behavior according to user interests and user context of use. In fact, the system, through the profile associated with a user, knows her/his interests and thus rank and filter information according to them. In this way each user has a personalized view of the information.

Moreover, since our end-users deal with different environments and with different activities during their day-by-day work, the criteria of filtering and ranking may change. For example, the data can be filtered depending on the place where the user is. In a public environment the system filters the displayed elements in order to show only the public information. Thus if a user is looking at some documents on her/his laptop, when s/he connects her/his laptop in a public room to make a presentation of her/his activities private documents will not be showed.

Our system provides the user the capability to create different personalities starting from her/his own profile and modifying it, in order to represent different points of view associated with different situations of work. The user decides which profile s/he needs in a specific situation and these criteria are used by the system to filter and rank information.

Profiles provide also a way to construct different paths to navigate the knowledge of the system. Suppose a user has found the View with Context of a certain document. Since s/he recognizes that the related information found by the system is not tailored for her/his needs, s/he has the capability to control and modify her/his View with Context, editing the profile of the document, deleting topics s/he is not interested in and adding relevant topics not considered in the document. In this way s/he can refine the retrieval process and through different steps s/he can discover new information relevant to her/his current interests.

VI. Conclusions

The integration of MILK with MAIS is an on-going development. The main goal is to achieve an implicit deduction which automatically captures the user's situation. However, we stress the fact that our approach of collaborating with end-users on the design of the system is successful; therefore, the characterization of the possible meaningful situations and the definition of their enforceability still have to be done with the full collaboration of the end-users. Moreover, to reach a suitable solution, it is necessary allowing users to personalize the system views for achieving a total customization of the system behavior.

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