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Building and evaluating context-aware collaborative working environments

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ABSTRACT

The integration of context-reasoning in Collaborative Working Environment (CWE) may bring important benefits to collaborators, obtaining systems which adapt their behavior to the needs of collaboration and team members. The most common way for building context-aware systems integrates the use of Semantic Web ontologies providing a formal vocabulary which allows to easily express and share the knowledge of the environment. Generally, these ontologies are included in rules allowing to express the desirable behavior according to business rules or users' preferences. Among the advantages obtained from the inclusion of these context rules we underscore the automatic selection between different collaborative services to perform some tasks according to the users' preferences and their current state. More precisely, in this paper we describe the building of a context-aware application integrated in a CWE architecture as well as we compare this new augmented application versus existing ones using Collaboration Usability Analysis (CUA), showing the advantages of the use of context-reasoning.

1. Introduction

The Web has facilitated new ways of communication among people geographically dispersed, providing virtual places where people can share information, ideas or opinions. Regarding communication and cooperation between people, CSCW (Computer Supported Cooperative Work) field emerged with the objective of studying the creation and impact of collaborative applications. In this line, the project "e-Professional Collaboration Space", better known as *Ecospace*, emerged with the aim of studying and obtaining the underpinnings for the creation of Collaborative Working Environments (CWEs) [29]. According to the report [23], a CWE should include, among others, these functionalities:

- A service-oriented approach to support interoperability and the capacity of composing services, giving as a result new composite services.
- An activity-oriented approach to support the automation of tasks that co-workers have to perform in order to fulfill certain activities in their work.
- Context-based collaboration and personalized and adapted interfaces, which enable co-workers to determine how the system should react, thus providing self-organization, self-adaptation and self-deployment.

In particular, the interoperable architecture of the CWE created within the Ecospace project is built based on Service-Oriented Architectures (SOAs) and the use of Web services specifications [29]. The provision of activities is another need

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for CWEs, which amounts to execute a sequence of tasks to fulfill such activities. Another desirable feature of a CWE is the ability to react according to the context in which applications are executed. Particularly, this paper is focused on the capturing and employment of users' contexts to model the reactions of a CWE. To represent users' context we consider relevant information such as the users' status (Online, Away, Disconnected), their roles in the organization, the CWE applications they are using, and any other useful information related to the activities performed in the CWE. The management of this information together with rules modeling the users' preferences or business policies are the grounds to obtain some kind of intelligence in the execution of applications.

The use of context information implies the adoption of some type of knowledge representation. One appealing alternative to represent context information in CWEs resides in the usage of Semantic Web ontologies [4]. They allow defining a vocabulary to describe CWE entities (i.e., co-workers, services, applications, etc.) along with their relationships and associated context. From this vocabulary it is possible to build a formal model which contains the knowledge managed in a CWE, including context rules. As a consequence of the formal features of such a model, several inference processes can be performed over it.

This paper describes the design, implementation and evaluation of a complete context-reasoning system which has been integrated into the Ecospace CWE architecture. To obtain this system we have collected some events from the CWE and they have been converted to contextual information. Moreover, we have described some preferences and business policies in the form of rules to obtain the desirable reactions in the CWE according to them. In order to represent all this knowledge with a common infrastructure we have used a CWE ontology which describes this particular domain. As a proof of concept we have implemented a tool for uploading documents and notifying users providing context-awareness features. Additionally, we have evaluated it using the Collaboration Usability Analysis (CUA) [30].

The rest of this paper is structured as follows. Section 2 presents the related work of context awareness in CWE. Next, the generic CWE architecture developed in the Ecospace project is described, indicating as well the main aspects about context reasoning that should be included in it. Section 4 describes the whole implementation of a context reasoning application. The evaluation of our application is depicted in Section 5 which describes a CUA-based evaluation of this application versus an existing CWE. Finally, Section 6 summarizes the contribution of this paper and points out the future work.

2. Related work

The majority of the current CWEs do not integrate interoperability features. In fact, few standards and specifications have been created for enabling interoperation between collaborative systems. Likewise, little work has been done regarding the use of context-aware for obtaining adaptive CWEs. The most relevant CWEs along with the main initiatives to develop specifications and ontologies in this area are reviewed in Section 2.1, whereas the integration of context-aware in CWEs is discussed in Section 2.2.

2.1. A review of CWEs and interoperability issues

Nowadays there exist several Collaborative Work Environments, such as Shared Work Spaces (SWSs), which integrate a set of collaborative tools aimed to allow a group of people to share information, and ideas. Examples of this kind of environments are BSCW [21], Alfresco [32] and EMC Documentum [22].

Almost all the aforementioned SWS support document uploading, group management, forums, polls, etc. More precisely, the collaborative work in those systems is based on the use of "folders" or "spaces" in which team members collaborate adding documents, forums and other artifacts. These environments constitute a good base for exchanging information among co-workers. On the negative side, BSCW and Alfresco do not maintain any representation of activity, and therefore the flow of information from one application to other is part of the users' responsibility. Contrarily to the rest of systems, EMC Documentum allows the creation of workflow and business processes. Nevertheless, these processes are not based on open standards, which may restrict the interoperability with other processes and the portability to other systems. All the analyzed environments do not offer any method to introduce different behaviors according to the users' preferences or other contexts. Considering the integration of external tools, BSCW provides an XML-RPC API and WSDL services, Alfresco and EMC Documentum also provide WSDL files to interoperate with it which follow the Content Management Interoperability Services (CMIS) standard [27].

With regard to the interoperability among CWEs, one of the main lines that has recently emerged is focused on the interoperability of SWSs. The mission of this line is the provision of services or specifications to describe this sort of systems. The CMIS specification is a result of this line. Apart from it, there is another important effort to develop a common representation for SWSs known as Integrated Collaboration Object Model for Interoperable Collaboration Services (ICOM).[1] More precisely, the main purpose of ICOM is to define a standard for integrated and interoperable enterprise collaboration. However, at the moment it is in draft version.

Another recent line centered on semantic interoperability is the emergence of the Friend of a Friend (FOAF) [15], Semantically Interlinked Online Communities (SIOC) [8] and Online Presence Ontology (OPO)[33] ontologies. More concretely, FOAF is an RDF ontology aimed to facilitate the information sharing about people and their activities by allowing to transfer

[1] Available at http://www.oasis-open.org/committees/icom/charter.php. OASIS.