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Web-based Support Systems

Springer

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Preface

Web-based Support Systems (WSS) are an emerging multidisciplinary research area in which one studies the support of human activities with the Web as the common platform, medium and interface. The Internet affects every aspect of our modern life. Moving support systems to online is an increasing trend in many research domains. One of the goals of WSS research is to extend the human physical limitation of information processing in the information age.

Research on WSS is motivated by the challenges and opportunities arising from the Internet. The availability, accessibility and flexibility of information as well as the tools to access this information lead to a vast amount of opportunities. However, there are also many challenges we face. For instance, we have to deal with more complex tasks, as there are increasing demands for quality and productivity. WSS research is a natural evolution of the studies on various computerized support systems such as Decision Support Systems (DSS), Computer Aided Design (CAD), and Computer Aided Software Engineering (CASE). The recent advancement of computer and Web technologies make the implementation of more feasible WSS. Nowadays, it is rare to see a system without some type of Web interaction.

The research of WSS is classified into four groups.

- WSS for specific domains.
  - WSS for specific domains:
  - Web-based DSS
  - Enterprise-wide DSS
  - Web-based group DSS
  - Web-based executive support systems
  - Web-based business support systems
  - Web-based negotiation support systems
  - Web-based medical support systems
  - Web-based research support systems
  - Web-based information retrieval support systems
  - Web-based education support systems
  - Web-based learning support systems
  - Web-based teaching support systems

- Web-based applications and WSS Techniques
  - Web-based knowledge management systems
  - Web-based groupware systems
  - Web-based financial and economic systems
  - Web-based multimedia systems
  - Web information fusion
  - Internet banking systems
  - XML and data management on the Web
  - Web information management
  - Web information retrieval
  - Web data mining and farming
  - Web search engines
  - Information fusion
  - Web services
  - Grid computing
- Design and development of WSS
  - Design and development of WSS
  - Web-based systems development
  - CASE tools and software for developing Web-based applications
  - Systems analysis and design methods for Web-based applications
  - User-interface design issues for Web-based applications
  - Visualizations of Web-based systems
  - Security issues related to Web-based applications
  - Web engineering

This book can be viewed as an extended culmination to three international workshops on WSS. The First International Workshop On WSS was held on October 13, 2003 in Halifax, Canada. The Second International WSS was held on September 20, 2004 in Beijing, China. The proceedings were published by Saint Mary's University in Canada. There are 26 and 24 papers in each set of the proceedings respectively. The Third International Workshop On WSS was held on December 18, 2006 in Hong Kong, China. There are 14 papers presented in a volume of IEEE published proceedings.

In order to keep track of the research on WSS, a Web site devoted to the research of WSS has been set up at http://www.cs.uregina.ca/∼wss/. There are articles on the Bibliography page of the Web site. If you want your publications to be listed on the page or identify yourself as a researcher in the area of WSS, please send information to wss@cs.uregina.ca. Proceedings for the first two workshops are also online at http://www.cs.uregina.ca/∼wss/wss03/wss03.pdf and http://www.cs.uregina.ca/∼wss/wss04/wss04.pdf.

This book is intended to present research related to fundamental issues of WSS, frameworks for WSS, and current research on WSS. A key issue of WSS research is to identify both domain independent and dependent activities before selecting

suitable computer and Web technologies to support them. We will also examine how applications and adaptations of existing methodologies on the Web platform benefit our decision-making and other various activities.

The selection of this book was started with call-for-chapter proposals. We received 33 chapter proposals. Authors of 26 proposals were chosen to submit full chapters. After receiving the full chapters, each chapter was reviewed by three reviewers. Including the authors, some domain experts were asked to review chapters. After a couple of rounds of revisions, we present 19 chapters in this book.

There are three parts of this book: WSS for specific domains, Web-based applications and WSS techniques, and Design and development of WSS.

The first part consists of seven chapters. Chapter 1 entitled "Context-Aware Adaptation in Web-based Groupware Systems" presents research on applying context-based filtering technology for a Web-based group decision support system and its mobile users. Chapter 2 entitled "Framework for Supporting Web-based Collaborative Applications" proposes a framework to support automated service management, in particular for a Web-based medical support system. Chapter 3 entitled "Helplets: A Common Sense Based Collaborative Help Collection and Retrieval Architecture for Web-Enabled Systems" presents an online intelligent query support system for replacing a traditional help desk. Chapter 4 entitled "Web-based Virtual Research Environments" presents a Web-based research support system for research collaborations. Chapter 5 entitled "Web-based Learning Support System" proposes an adaptive learning support environment that effectively accommodates a wide variety of students with different skills, background, and cognitive learning styles. Chapter 6 entitled "A Cybernetic Design Methodology for 'Intelligent' Online Learning Support" describes a Web-based learning support system that aims to evolve Web-based teaching environments into intelligent learning systems modelled on cybernetic, systems theory principles. Chapter 7 entitled "A Web-based Learning Support System for Inquiry-based Learning" employs a treasure hunt model for teaching and learning support.

Part two includes six chapters. Chapter 8 entitled "Combinatorial fusion analysis for meta search information retrieval" describes a combinatorial fusion methodology including a theoretical framework and illustrations of various applications of the framework using examples from the information retrieval domain. Chapter 9 entitled "Automating Information Discovery within the Invisible Web" discusses issues related to the deep Web information retrieval. Chapter 10 entitled "Supporting Web Search with Visualization" introduces information visualization as a means for supporting users for their search and retrieval tasks on the Web. Chapter 11 entitled "XML Based Markup Languages for Specific Domains" describes the need for domain-specific Markup Languages within the context of XML, provides a detailed outline of the steps involved in markup language development, and gives the desired properties of Markup Languages for WSS in incorporating human factors from a domain based angle. Chapter 12 entitled "Evaluation, Analysis and Adaptation of Web Prefetching Techniques in Current Web" presents a study on Web prefetching to reduce the user-perceived latency in three steps: evaluating Web prefetching

techniques from the user's point of view, analyzing how prefetching algorithms can be improved, and exploring the performance limits of Web prefetching to know the potential benefits of this technique depending on the architecture in which it is implemented. Chapter 13 entitled "Knowledge Management System Based on Web 2.0 Technologies" demonstrates that Web 2.0 technologies could be used to design user interaction in a knowledge management system to improve online interaction with WSS in other application domains.

Part three consists six chapters. Chapter 14 entitled "A Web-based System for Managing Software Architectural Knowledge" presents and discusses the design, implementation, and deployment details of a Web-based architectural knowledge management system, called PAKME, to support the software architecture process. Chapter 15 entitled "CoP Sensing Framework on Web-based Environment" presents a Web-based social learning support system based on the concept of Community of Practice and theories of social constructivism. Chapter 16 entitled "Designing a Successful Bidding Strategy using Fuzzy Sets and Agent Attitudes" presents the implementation of an online biding system armed with intelligent agents using fuzzy strategy. Chapter 17 entitled "Design Scenarios for Web-Based Management of Online Information" discusses a scenario-based design process, and results thereof, used to examine how online communication management might be supported by a Web-based system. Chapter 18 entitled "Data Mining for Web-based Support Systems: A Case Study in e-Custom Systems" provides an example of a Web-based support system used to stream-line trade procedures, prevent potential security threats and reduce tax-related fraud in cross-border trade. Chapter 19 entitled "Service Oriented Architecture (SOA) as a technical framework for Web-based Support Systems (WSS)" discusses issues on applying service oriented technique to WSS.

Last but not least, I would like to thank all authors who contributed a chapter in this book as well as the reviewers who helped to improve the quality of chapters. I would like to thank Series Editors Drs. Lakhmi Jain and Xindong Wu and Springer editors Catherine Brett and Rebecca Mowat, for their assistance and help editing this book. Dong Won Kim, a graduate student of the University of Regina under my supervision, helped final compiling with LaTeX. He also spent a lot of his time on converting some chapters prepared in Microsoft Word. I thank him for his time and patience. Without everyone's effort, it is impossible to see the completion of this book.

Regina, Saskatchewan *JingTao Yao*
Canada, June 2009

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Part I
Web-Based Support Systems for Specific Domains

Chapter 1
Context-Aware Adaptation in Web-Based Groupware Systems

Manuele Kirsch Pinheiro, Angela Carrillo-Ramos, Marlène Villanova-Oliver, Jérôme Gensel, and Yolande Berbers

Abstract In this chapter, we propose a context-aware filtering process for adapting content delivered to mobile users by *Web-based Groupware Systems*. This process is based on context-aware profiles, expressing mobile users preferences for particular situations they encounter when using these systems. These profiles, which are shared between members of a given community, are exploited by the adaptation process in order to select and organize the delivered information into several levels of detail, based on a progressive access model. By defining these profiles, we propose a filtering process that considers both the user's current context and the user's preferences for this context. The context notion of context is represented by an object-oriented model we propose and which takes into account consideration both the user's physical and collaborative context, including elements related to collaborative activities performed inside the groupware system. The filtering process selects, in a first step, the context-aware profiles that match the user's current context, and then it filters the available content according to the selected profiles and uses the progressive access model to organize the selected information.

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1.1 Introduction

1.1.1 The Web and the Collaboration Issue in Mobile Environment

Nowadays, the Web is omnipresent in both our personal and professional lives. The recent development of Web 2.0 technologies makes it simpler for users to share information and collaborate with each other. The underlying notions of *social networks* and *communities* are a main concern for Web 2.0 [1] and systems based on the Web 2.0 principles, such as Wiki systems like XWiki[1] and MediaWiki,[2] can be considered as a new generation of Web-based groupware systems.

For this new generation of Web-based groupware systems, as well as for traditional ones, one expects from collaboration gains not only in terms of productivity (in the case of workers for instance), but also in terms of facility and efficiency in retrieving and accessing some information that matches the needs of each member of a collaborative group. Such gains depend on the capability of exploiting the social dimension not only of large communities of users, but also of smaller groups (for instance in some collaborative work). *Folksonomies*[3] built in social bookmarking approaches or the *Friend Of A Friend (FOAF)* initiative [5] are examples of this recent trend.

The social dimension of these communities can be exploited by making the users aware of the communities they belong to, of the goals of these communities, and of the activities performed inside them. The notion of *group awareness* [13, 30] refers to the knowledge a user has about her or his colleagues and their actions related to the group's work. By taking into consideration this knowledge, a Web-based groupware system can supply the community members with some content better related to their own activities inside this community.

At the same time, mobile technologies, such as Wi-Fi networks, PDA, and 3G cellular phones, make it now possible for users to access any Web-based system from various kinds of devices, *anytime* and *anywhere*. This is the underlying idea of the *Ubiquitous Computing* [32, 33], defined by the W3C [16] as the paradigm of "Personal Computing," which is characterized by the use of small wireless devices.

Combining mobile technologies together with some of the Web 2.0 principles has given a rise to a new generation of Web-based systems that allow *mobile users* to share data and contextualized information (e.g., location-aware annotations or photos exchanged by Flyckr[4] users) and to collaborate with other users (through wikis or blogs, for example). However, we are only at the beginning of this new mode of accessing and sharing information, and still many problems have to be overcome.

[1] http://www.xwiki.org/

[2] http://www.mediawiki.org/

[3] http://www.vanderwal.net/folksonomy.html

[4] http://flickr.com/

1.1.2 Adaptation to Web-Based Groupware Systems Mobile Users

In this chapter, we focus on the specificities of the adaptation that can be expected by mobile users who have to cope with the intrinsic limitations of mobile devices (MD) (such as battery lifetime, screen size, intermittent network connections, etc.) and with the characteristics of their nomadic situation (noisy or uncomfortable environment) when accessing Web-based collaborative systems. These users generally use MD in brief time intervals in order to perform urgent tasks or to consult a small, but relevant, set of information. They usually consult, through these devices, information that is needed regarding the current situation (e.g., when away from her or his office, a user may use her or his 3G cellphone to consult only high priority messages related to her or his group work). All these aspects have to be considered when searching for and displaying information. More than traditional users, mobile users need informational content that suits their current situation.

In order to provide any member of a community with some appropriate and relevant information when she or he uses an MD some adaptation mechanisms are required. Adaptation, as a general issue, has to be tackled from different perspectives: What has to be adapted (i.e., data, service, etc.)? To whom or to what is adaptation required? Which are the guidelines or strategies for the adaptation? How can adaptation be performed? Which are the subjacent technologies? In this chapter, we do not intend to address every aspect of adaptation. Rather, we limit our study of content adaptation to the case of Web-based groupware systems that are accessed through MD.

Adaptation mechanism can be guided by different criteria such as user's personal characteristics, background, culture, and preferences. Often, the user's interests and preferences differ according to the situation in which this user is interacting with the Web-based groupware system: While some information may be valuable when the user works at her or his office, it may well be completely useless when the same user travels even for professional reasons. The situation in which the user is accessing the system, including the device she or he is using, her or his location, the activities she or he is performing, and many other aspects, can be seen as the user's context.[5] The actions and expectations of the user directly depend on the context in which she or he interacts with the system [14]. Thus, in order to improve the adaptation process, both the user's current context and her or his preferences (in terms of services, data, presentation, etc.) for this, context should be considered by the adaptation process. For example, let us consider a student preparing with her friends a dissertation. She is organizing a meeting in order to manage their work (group *activity*). For this, she invokes the service "consult colleagues agenda." In this case, she is only interested in a content referring to her friends availability for the period during which they have to prepare the dissertation. In another situation, for example in a holiday period, this student may plan a picnic (a different group activity), the same service

[5] Context refers here to "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves." [12]

can be used but only selecting friends who are in the same city during the holiday period. This example shows how a same service (here, "consult colleagues agenda") can be carried out differently for the same user according to the context in which it is invocated.

Moreover, since the user interacts with other users through the collaboration process she or he is involved in, this interaction must be taken into account when considering some contextual information [15] and integrated in decisions made during the adaptation process. Indeed, the goals and activities of a group usually highly influence the actions of each member. Consequently, information related to this collaboration process, such as the concepts of *group*, *role*, and *collaborative activity* must be considered as part of each user's context. We call this set of information the *user's collaborative context*. This notion of the user's collaborative context is related to the *group awareness* concept [13, 30], since both refer to the same knowledge: the knowledge about the group and the collaborative process. In our previous example, the group awareness refers to the fact that the people whose agendas are consulted are not the same since in the two situations the groups are different from the point of view of the user's collaborative context.

1.1.3 A Context- and Preference-Based Adaptation for Web-Based Groupware Systems

An idea, more and more widely accepted, is that by considering the characteristics of the group a user is a member of (i.e., considering the group's common goal to be reached, the group's expertise and knowledge, etc.) helps in better selecting information she or he individually needs. Thus, we propose a context-based filtering process which combines an object-oriented context model [18], representing the user's physical and collaborative context, with shared profiles definition, describing the user's preferences for a given context. The underlying principle of this filtering process is to improve the group productivity by helping individual users who compose the group in their own tasks. The main idea is to allow Web-based groupware systems to provide an adapted content to each user in order to improve the group activities as whole. For example, when a geographically distributed group of specialist doctors is using a Web-based groupware system in order to make a diagnosis for a patient, they can access to it through different kind of access devices and use the system to exchange information about the patient. By supplying content adapted to any doctor's preferences and current context, the system helps this doctor to make her or his own diagnosis activities, which directly contributes to the diagnosis of the patient as a whole.

The proposed filtering mechanism, based on [21], is guided by context-aware profiles, which define filtering rules that apply in a specific context. We believe that the collaborative and social dimensions of the group can be exploited by offering users the opportunity to share their profiles and preferences so that they benefit from the experiences of each other. We achieve this by allowing the users to share,

with their colleagues, the profiles they have defined for some specific situations they usually encounter when using a given Web-based groupware system. These shared profiles are associated to particular context situations to which the preferences in the profile refer to. Moreover, these profiles use the Progressive Access Model (PAM) [31] in order to organize the delivered information according to the user's preferences.

The proposed filtering mechanism is therefore performed in two steps: first, it analyzes the user's current context and selects, among the available predefined profiles, those that match the user's current context. Second, it filters and organizes available information according to the selected profiles. Besides, we implement this filtering mechanism in a framework, named BW-$\mathcal{M}$, which has been used to build up a Web service. By using this technology and a context model explicitly referring to collaborative context, we believe that the proposed filtering process better suits the new generation of Web applications that focus on communities user-generated content sharing.

1.1.4 Chapter Organization

This chapter is organized as follows: In Section 1.2, we discuss related work in order to identify open issues and drawbacks from the state of the art on context-aware adaptation mechanisms for Web-based systems. In Section 1.3, we introduce an object-oriented context model particularly designed for context representation in Web-based groupware systems. Section 1.4 presents the content model we propose in order to represent the informational content that is filtered following the adaptation mechanism. Section 1.5 proposes a context-aware profile model for representing the user's preferences in a Web-based groupware system. Section 1.6 introduces the filtering process we propose in order to adapt available informational content based on a set of context-aware profiles. Section 1.7 presents our implementation of the filtering process and discusses some experimental results. Finally, Section 1.8 gives our conclusions and future work.

1.2 Related Work

Content adaptation, which aims at providing user with a customized content, is not a new topic for Web-based support systems (WSS) [6, 9, 31]. In this chapter, we are particularly interested in how context-aware adaptation mechanisms are used for content adaptation in these systems. Context-awareness [8, 12, 24] can be defined as the capacity of the system to perceive and analyze the user's context and to adapt itself (i.e., its behavior, services, interface, etc.) accordingly. The concept of user's context refers to a very large notion, for which there is no single definition [4, 8, 12, 14, 24]. In one of the pioneer works, Schilit et al. [29] define context as "the location of use, the collection of nearby people and objects, as well as the

changes to those objects over time." Another view is given by Moran and Dourish [24], "context refers to the physical and social situation in which computational devices are embedded." Dey [12] defines context as "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and the applications themselves." In this work, we adopt this largely accepted definition since it also applies particularly for designing context-aware systems.

In order to exploit this notion of user's context inside Web-based support systems (WSS), we have to represent somehow this notion. The literature proposes different models for representing context information [2, 18, 26, 29]. In their majority, these models cover concepts related to the user's location and to the characteristics of the mobile devices. Even if some propositions, such as [26], include the user as part of the contextual model, most of these models consider the user as an isolated individual and do not consider the activities performed by her or him. However, when considering the users of Web-based groupware systems, the social aspects related to the collaborative process that takes place in these systems should be considered, since the goals and the activities of a group influence the actions of each individual in the community. In this chapter, we consider users as members of a social network, of a given community of users, or simply people using a wiki system. As member of a community, a user generally shares, with her or his colleagues, activities, goals, interests, etc. Thus, Web-based groupware systems, which support a community of users, need a context model that takes into consideration the social aspects related to the collaborative activities. We propose an object-oriented context model that represents the user's collaborative context in addition to the user's physical context, traditionally used in context models.

In the same way that context model does, context-aware adaptation mechanisms usually focus on the user as individual, considering for instance her or his location and device for adaptation purposes [17,23,27,28,34]. When considering Web-based systems, these mechanisms often propose the transformation of an original content into another version that suits the capabilities of the access device (for instance, transforming a content from an unsupported format, dimension, or resolution to a supported one), or the selection of the most appropriate versions of a content (e.g., to choose a BMP version of an image instead of a JPEG version) [23, 29]. Besides the capabilities of the access device, other elements of the user's context can also be considered for adaptation purposes. For instance, Yang and Shao [34] use concepts such as network bandwidth, user accessibility (e.g., if the user is blind), and situation (if the user is driving, or in her or his office, or in a meeting, etc.) for proposing a rule-based content adaptation mechanism in which content presentation is adapted based on a dynamically selected set of rules.

As one may observe, works such as [23,29,34] are mainly concerned with adapting content presentation according to the user's current context. However, the context in which the users interact with a Web-based support system can affect the relevance of a given content. A content that is relevant in a particular situation can be completely irrelevant (even useless) in another situation. Some works in the

literature, such as [17, 27, 28], propose to supply users with a content particularly adapted to their current location. However, the user's current activity or her or his possible interactions with the communities she or he belongs to are not considered by these mechanisms.

Finally, it is worth noting that traditional content adaptation mechanisms for WSS are guided by user's preferences represented in user *profiles*, which can also refer to user's interests, history, or information needs [11]. Several works propose user profiles regarding different aspects (e.g., the user's knowledge or goals) [6, 11, 22] for adaptation purposes. However, these works often do not consider contextual aspects important for mobile users, such as location and device constraints [6, 22]. Others works, such as [11], do not relate these profiles to particular situations. However, mobile users interests and preferences may vary according to the context in which these users access a Web-based system. By proposing a fixed set of preferences that applies in every situation, these profiles might not correspond to the user's expectations.

In order to overcome some of the drawbacks presented by the works above, we propose a content-adaptation mechanism based on a filtering process. This process is guided by a set of context-aware profiles that can be shared among a community of users, and which also allow users to represent their preferences for a given context.

1.3 Context Representation

Inspired by the context definition given by Dey [12], we adopt the object-oriented representation of context originally proposed in [20], which focuses on a mobile use of collaborative systems. Based mainly on a set of UML diagrams, this model represents both the user's physical context (including the concepts of location, device, and application) and the user's collaborative context (which includes the concepts of group, role, member, calendar, activity, shared object, and process). We claim that collaborative context should be taken into consideration since users are also involved in some collaborative activities. Web-based support systems that claim to belong to Web 2.0 often propose applications (or services) whose main goal is to allow collaboration among users. Systems that propose wiki applications are a good example of this tendency. Thus, since we consider users belonging to communities, some information related to the group, such as its composition, its activities, etc., can be considered as relevant for such users, and consequently have to be included into the user's context. Moreover, since these systems are now accessible through different kinds of mobile devices (*MD*), it is also important to take into consideration information related to these devices and to the physical environment that surrounds the user interaction with these systems.

In this model (see Figure 1.1), the concept of context is represented by a class *Context Description*, which is a composition of both physical (location, device, space and service) and collaborative elements (group, role, activity, shared object, etc.). These elements are represented by classes that are specializations of a common

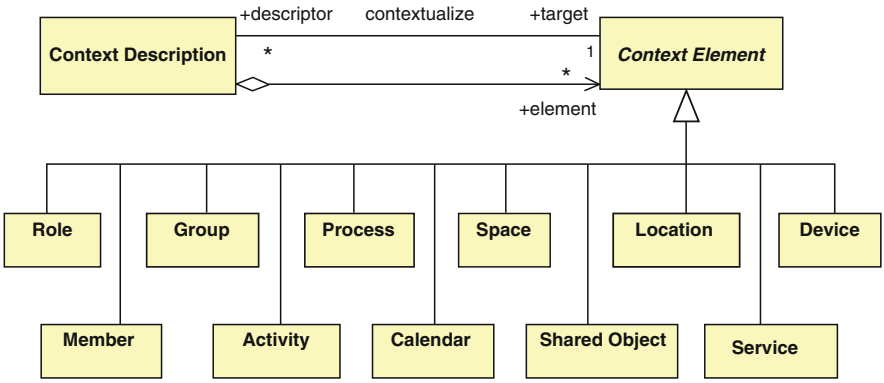

Fig. 1.1 A context description is seen as a composition of context elements

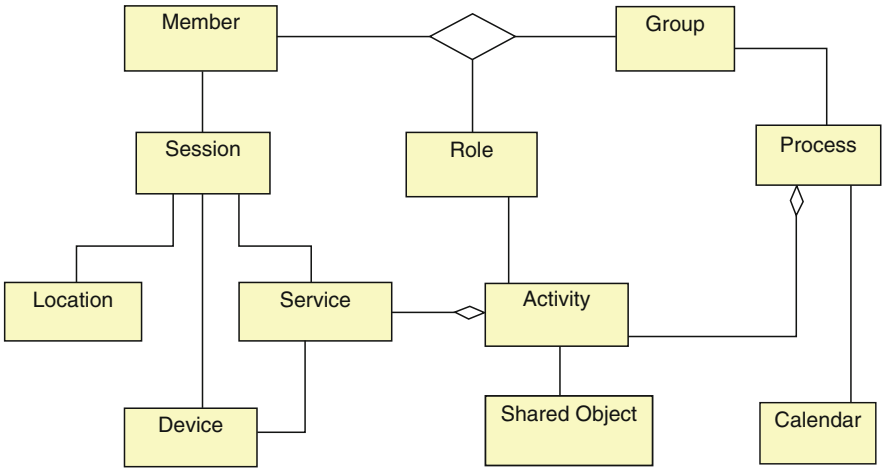

Fig. 1.2 Associations relating context elements in the context model

superclass, called *Context Element*. Furthermore, these context elements are related to each other, defining associations between the corresponding concepts. Each element of context is not isolated information, but does belong to a more complex representation of the user's situation. For instance, we consider that a user is the member of a group through the roles she or he plays in this group, and that a user handles a shared object through some application service that allows it, and so on. It is worth noting that this application service concept refers to system functionalities (e.g., weather previsions, agenda management, wiki edition, etc.), which often corresponds, in the case of new Web-based groupware systems, to Web services supplying particular functionalities. Moreover, from the system point of view, an activity can be considered as a set of services, which are executed in order to achieve this activity. Figure 1.2 presents a more complete description of these associations based on [20].

The context of a user (member of a group or community) is then represented in this model by an instance of the class *Context Description*, which is linked by composition to instances of the class *Context Element* and its subclasses (see Figure 1.1). Figure 1.3 illustrates an application of this context model. We consider a user ('Alice'), who is the coordinator ('coordinator' role) of a team ('administration' group) that uses a wiki service. Let us suppose that Alice is accessing this system through her PDA in order to consult the latest changes on the document that her team is writing. When Alice requests these changes, her current context can be represented by the context description object represented in Figure 1.3(b). This object is composed by the context elements representing Alice's location ("office D322" object of the location class) and device ("PocketPC" object of the device class), her team ("administration" object), her role in this team ("coordinator" object), and so on. These objects are related through a set of associations: Alice belongs to the administration group through the role coordinator; this role allows Alice to perform the

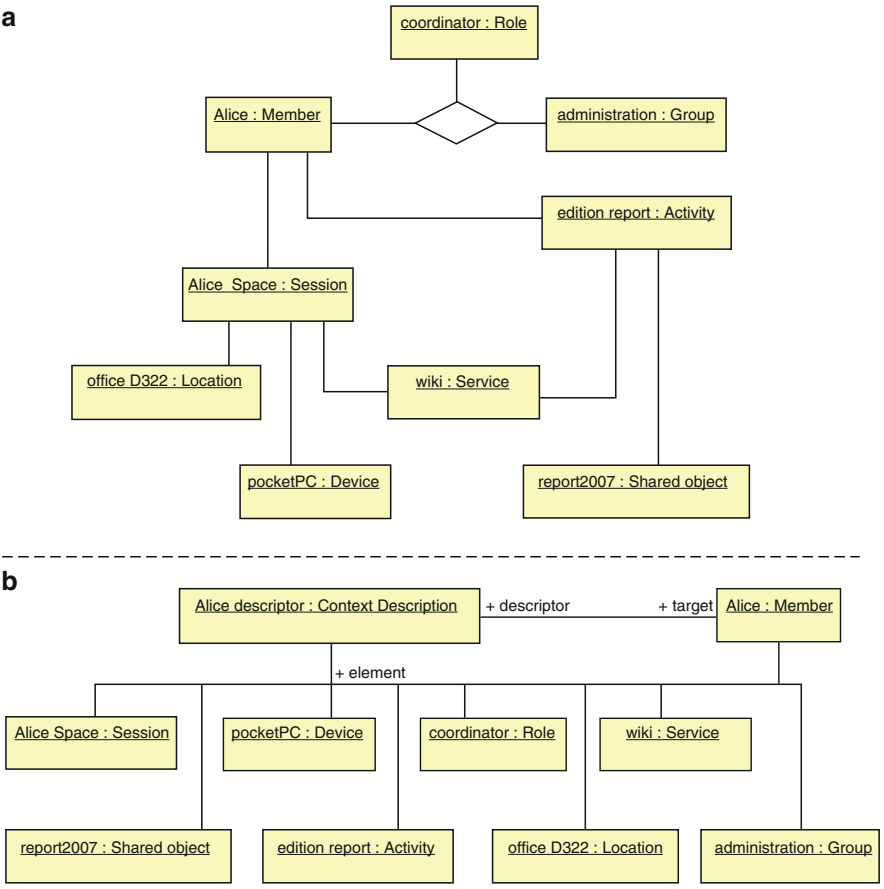

Fig. 1.3 Example of a context description for a given user (Alice). Global view on (**b**), association view on (**a**)