Representing Context for an Adaptative Awareness Mechanism

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Abstract. The application of mobile computing technologies to Groupware Systems has enforced the necessity of adapting the content of information by considering the user's physical and organizational contexts. In general, context-aware computing is based on the handling of features such as location and device characteristics. We propose to describe also the user's organizational context for awareness purposes. Our objective is to permit Groupware Systems to better select the information and then to provide mobile users with some adapted awareness information. This paper presents a representation of this notion of context to be used by awareness mechanisms embedded in Groupware Systems. Then, we show how this representation is exploited for filtering the content of information inside the awareness mechanism.
Keywords. adaptability, awareness, mobile computing, cooperative work.

1 Introduction

In recent years, Groupware Systems have been using the Web to propose a world wide access to their users. With the massive introduction of web-enable mobile devices, such as laptops, PDAs and cellular phones, these users can access the system virtually everywhere. In fact, nowadays, workers may interact with their colleagues and accomplish some tasks (such as to compose messages or to exchange meeting notes), even when they are not at their office, and through a large variety of devices.

However, the use of this kind of mobile device introduces several technical challenges on system design and development, mainly due to the heterogeneity and the physical constraints (limited display size, power and memory capacity…) of these devices. These challenges make adaptation a necessary technique when building mobile systems [9]. In fact, a mobile user, whilst moving or alternating between different devices, often changes the context in which she/he accesses the system. Therefore, the ability of detecting the context of use seems to be particularly relevant for mobile computing systems, which may be used in different locations, by different users (who may access them from different devices), and/or for different purposes [3]. This detection of the context characterizes what is called context-aware systems. In fact, one of the core premises of context-aware computing is that the computing device should be aware of the user's circumstances and should be able to interpret any interaction in a manner appropriate to these circumstances [16].

Considering the notion of context, it is worth noting that there is no unique definition for this concept (see [2] as an illustration). For instance, according to Kirsh [11], "context is a highly structured amalgam of informational, physical, and conceptual resources that go beyond the simple facts of who or what is where and when to include the state of digital resources, people's concepts and mental state, task state, social relations, and the local work culture, to name a few ingredients". This notion of context can be related to the notion of awareness on Groupware Systems, which refers to the knowledge a user has and her/his understanding about the group itself and her/his colleagues' activities, providing a shared context for individual activities in the group (see, for example, [6] and [14]).

Nevertheless, when considering context-aware systems, we notice that the notion of context usually adopted by those systems is limited to some physical aspects, such as the user's location or device (see [3] as an illustration). There are only a few systems that associate the notion of awareness on Groupware Systems to this idea of context-aware computing (for instance [8]). However, this association appears evident to us, once a mobile user is also involved in some cooperative process. And, as any other user in a cooperative environment, a mobile user needs to be aware of what is going on inside the group in order to build a sense of community [18]. This means that Groupware Systems, in order to cater for these mobile users, should provide them with an awareness support adapted to their situation. Consequently, we should consider the activities and the status of the group as parts of the notion of context handled by the system.

In this paper, we explore the hypothesis assuming that the awareness mechanism should exploit the notion of context in order to adapt the information delivered to the user. We propose a context based awareness mechanism which filters the information delivered to the user according a context description. This context description takes into account the concepts related to the notion of awareness (group and role definition, activities and work process, etc.). We use an object-oriented knowledge representation, where these concepts are represented as classes and associations. This paper represents the first part of a work in progress. Such work considers, when defining this context representation, an awareness mechanism embedded on Web-based Groupware Systems, which is accessed through mobile devices. We focus on Groupware Systems that support asynchronous work, such as systems managing group calendar, messages and shared repository (a shared workspace). We assume those systems as composed by many components (such as components for access control policy, for communication facilities, etc.) which are connected and communicate with each other (and eventually with other instances on remote sites). Hence, we assume awareness mechanism as one of such components, and we propose a filtering process that uses the context representation mentioned above to better select the awareness information delivered to mobile users.

This paper is organized as following: first, we present some works related to adaptation for mobile devices (Section 2). Second, we discuss the notion of awareness, our main focus area (Section 3). Then, we present the context description used to represent the extended notion of context (Section 4), and the filtering mechanism based on this description (Section 5), before we conclude (Section 6).

2 Adaptation and Context

The development of software applications for mobile environments involves several technical challenges, which makes adaptation a necessity for the usability of such systems. Many researches consider this need of adaptation. In their majority, these works deal with the adaptation of multimedia and web-based information content. They usually take into account the technical capabilities of the client device, and try to adapt the content by transforming the original content in such a way that it can be handled by the device (see, for example, [20] and [13]).

Additionally, some works adapt the content by selecting or filtering the content delivered to the user, according to the physical context of the client device. In the latter, the adopted notion of context includes some aspects such as location, time and, of course, the device itself. Some examples of this approach include [3], [16], or [15].

We adopt this approach of selecting the content delivered to the user considering the context where this user finds herself/himself. Moreover, we consider that the organizational context, as well as the physical context, should be taken into account to evaluate what is relevant to a user, and thus, to select the available information for her/him. In fact, according Dourish [5], "context – the organizational and the cultural context, as much as the physical context, plays a critical role in shaping action, and also in providing people with the means to interpret and understand action".

Indeed, this organizational context is important to determine what information is relevant to users. These users are engaged in a cooperative process. Because of this process, such users are particularly interested in information related to their belonging group. More precisely, users, in most circumstances, are interested only in events related to their work context, i.e. events that can lead them to better decisions and/or increase their capacity to decide [4]. In our approach, we represent and explore this context in order to better cater for the user the awareness information to be delivered.

3 Awareness and Adaptation

It is worth noting that the term *awareness* represents a large concept, which can be used in very different situations, as shown by Liechti [14] and Schmidt [21]. The term awareness refers to actors' taking heed of the context of their joint effort, to a person being or becoming aware of something [21]. However, this definition is too vast and we adopt a more concise defined by Dourish [6]: "an understanding of the activities of others, which provides a context for your own activity. This context is used to ensure that individual contributions are relevant to the group's activity as a whole and to evaluate individual actions with respect to the group goals and progress".

There is, in the CSCW community, a consensus about the importance of the awareness support for cooperative work [21][7]. Awareness represents the knowledge about the group, its activities, status and evolution. This knowledge refers to the organizational context where the cooperative work takes place. Thanks to the awareness support, users may coordinate and evaluate their own contributions considering the group evolution. Indeed, awareness support can be used as an implicit coordination mechanism, since whether the members of a team are kept aware of their

project status and activities, then they will be able to communicate with each other and coordinate themselves [19].

However, providing an awareness support presents some risks. Espinosa et al. [7], for instance, have obtained encouraging evidences about the benefits of awareness tool use, but they stress the fact that the availability of such tools can turn out to a distraction when not properly used. Awareness tools should fit with the tasks performed by the users.

For users who access Groupware Systems through mobile devices, such as PDAs or cellular phones, the delivered information should also match the constraints of the device as well as the mobile situation of such users. Typically, people using such mobile devices are interested only in information that can help them in their current context. In order to adapt the awareness information to such users, the notion of context should be represented to be exploited for adaptation purposes. In the next section, we present a representation of this.

4 Context Representation

In order to adapt the delivered awareness content to the user's context at a given moment, we have to represent this context in such way that it could be exploited by the awareness mechanism. In order to be useful, we believe that this representation should be limited to relevant aspects of the notion of context. As stated before, we address an awareness mechanism embedded on Groupware System supporting asynchronous work. Thus, the representation of the context described below focus only on concepts relevant to users who access the system through mobile devices.

There are, in the CSCW literature, several propositions of user's context representation. For instance, Leiva-Lobos and Covarrubias [12] propose that the context where cooperating users are situated is tripartite: spatial, temporal and cultural. The spatial context addresses artifacts populating physical or electronic space, while the temporal context refers to the history of performed cooperative processes and to the expected future one. The cultural context gathers users' shared view and practices (i.e., the community practices). Similarly, Allarcón and Fuller [1], define, as principal entities for the work context, the content (tools, shared objects, etc.), the process (activities and their calendar) and the users themselves. In addition, these authors emphasize the importance of the user's electronic location and integrate this concept into the user's context.

Considering these works, we identify five viewpoints containing main entities for a context representation: space, tool, time, community and process. The *space* viewpoint refers to the concept of physical *location*, while the *tool* viewpoint refers to the concepts of physical *device* and *application*. The *time* viewpoint refers to the group *calendar* idea. The *community* viewpoint refers to the composition of the community, including the concepts of *group*, *roles* and *user*. Finally, the *process* viewpoint refers to the *process* (workflow) performed by the group, including the concepts of *activities* (tasks) and *shared objects* (objects handled by the group).

We consider these concepts as the most relevant ones when defining a user's context for a cooperative mobile environment. Using these concepts as a starting point, we define our representation of the notion of context. We represent this notion

through an object-oriented representation, using the UML notation. In this representation, the concepts above (user, group, role, location, etc.) become classes (member, group, role…) and the relationships among them, associations.

This representation of context relies, then, on the concepts identified by the five viewpoints above. We consider these concepts as the basic entities of the context description, which we see as a composition of such entities. Thus, our representation starts by the definition of a *context description* class, which is composed of a set of basic elements and is defined for a user that is currently accessing the Groupware System (see the UML class diagram in Fig. 1).

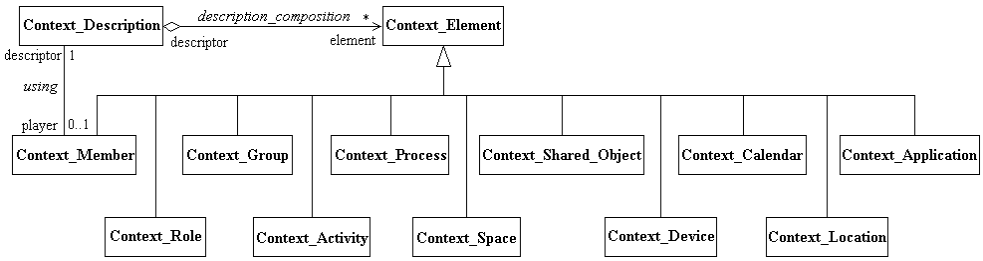

Fig. 1. The context description and the basic elements of the context representation. The prefix "Context" is used in this paper to distinguish the elements of the context representation from those of the awareness mechanism.

These basic elements are related to each other, defining relationships between the corresponding concepts, as represented in the Fig. 2. Thus, we define relationships such as the user (called here 'member') that belongs to the group through the roles she/he plays in this group, represented in the model by the ternary association '*belong'* among the classes '*member'*, '*role*', '*group*' (see Fig. 2). We also consider that each group *defines* a *process*, which should *respect* a given *calendar* and is *composed* by a set of *activities* (or tasks, also composed by subtasks). The *roles allow* the execution of an activity, which is effectively *performed* by a member. Each activity *handles* a set of *shared objects* through a set of applications, which are *designed* for specific devices. This *member* is located, during a certain *time interval*, into a certain *space*. This space is composed by a physical space (the member's physical *location*), by a virtual space, comporting the *application* that the member is accessing, and by an execution space, including the *device* used by the member. The Fig. 2 presents the complete context representation proposed.

These elements, combined through the context description, are able to describe the context of a user that is accessing the Groupware System through a mobile device. These elements, together with the context description, are instances of a knowledge base, which can be exploited by the awareness mechanism. It exploits this context representation through the context description.

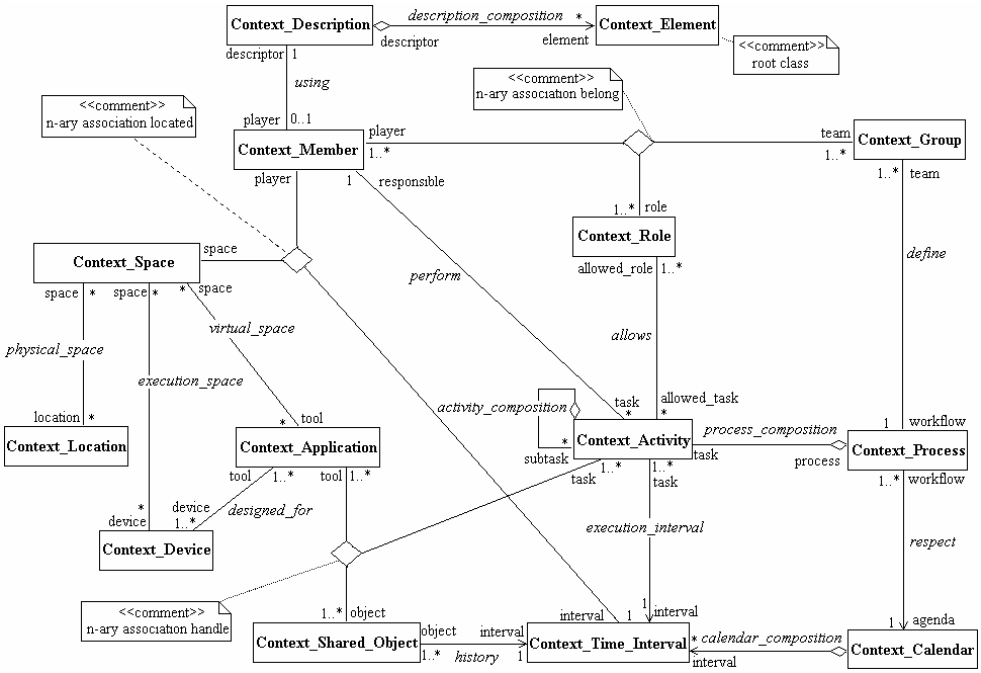

Fig. 2. The context representation with the relationships among all represented concepts.

As an illustration, let's us introduce a simple scenario of a group member (the team coordinator) who is participating to a business meeting in the company central office. During a break, she/he may access the Groupware System, using her/his PDA, in order to consult the last information about a report that her/his group is writing. For this scenario, the context description will contain the following basic objects: a "member" object describing the mobile user (her/his name, email…); a "role" object, describing the coordination role (rights, etc.); an "activity" object describing the report writing (status, components, deadline…); a "location" object pointing out to the central office; a "device" object defining her/his PDA; an "application" object indicating what application she/he is using; and a "process" object describing the group's main process. Finally, all these objects will compose the context description object associated with this mobile user. The Fig. 3 shows the relationships among these basic objects.

In addition, since this description is defined as a composition of basic elements, the mechanism can handle partial representations of the context. For instance, a *context description* object may refer, through this composition relationship, only to objects describing the member, her/his roles and the activities she/he is performing, and omit some information about the application or location, or it may include only objects referring to the notion of space (location, device, and application), and ignore all information about the activities and the group process. This omission means that the system does not have enough knowledge to represent these elements, and then it can assume nothing about them. This feature (the omission of some context elements in the context description) is very interesting for awareness mechanism, since often the

system is not able to determine all elements of this context representation. Back to our scenario, if the system cannot determine the user's location and device, context description will be defined without such objects ("central office" and "pocketPC").

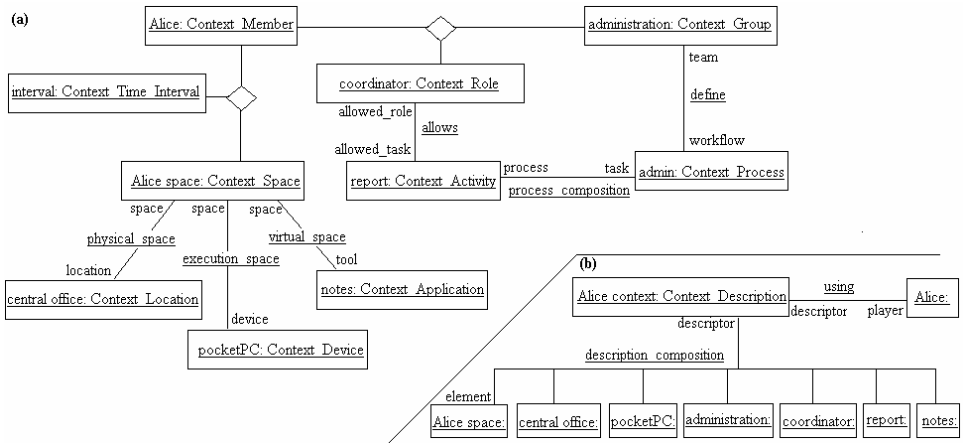

Fig 3. A scenario of context description. In (a), the relationships among the context elements. In (b), the context description object composed by these context elements.

We implemented this representation using the AROM system [17] that is an object-based knowledge representation system, which adopts classes/objects and associations/tuples as main entities. This representation allows queries such as if a user is currently using a given device or stands in a specific location. This corresponds to query whether the objects representing such device or location belong to the current user's context description (for instance, if the object "central office" belongs to our mobile user's context description). We now describe how an awareness mechanism can exploit this context representation.

5 Filtering Awareness Information According Context

As we stated before, we consider the awareness mechanism as a component of a web-based Groupware System. This awareness mechanism should be able to analyze the users' activities, as well as those performed by others components, in order to collect information that could be relevant to the performance of the group members. However, the amount of information collected by this mechanism can be very important. Hence, we consider that the awareness information delivered to a group member should be subject of a carefully selection, in order to avoid problems such as an information overload and to better cater for the user's needs.

In this work, we intent to exploit the context representation presented above to perform this selection. We consider an event-based awareness mechanism and we assume that all information that can be delivered to a group member is carried by events. Events are defined by the Groupware developer and each event selects useful information about a specific subject. In order to select the events that should be

delivered, the awareness mechanism defines the concept of "*general profile*". This concept represents the preferences and the constraints that the system should apply for a given element (group member, role, device…). For group members, this concept is specialized on "*preferences*", describing the preferences of the user concerning the awareness information delivery, and for devices, it is specialized on "*characteristics*", describing the capabilities of the referred device. These profiles may define what types of events and information should be delivered, as well as its quantity (maximum number of events or Kbytes supported). For devices, the "characteristics" profiles can take the form of a CC/PP description, whereas the "preferences" profiles may indicate a priority order for the events, the time interval that is suitable for the user, and other conditions related to the context description (for instance, if the current device accepts a given media type, or if a given activity has been concluded).

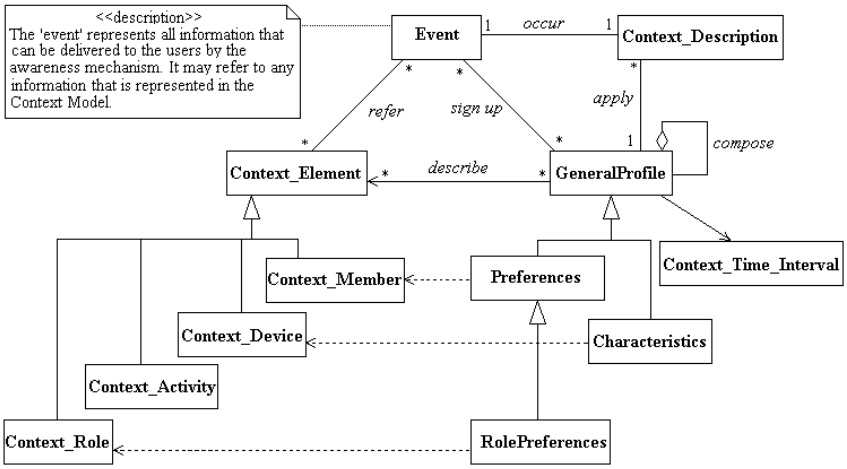

Fig. 4. The application of the context representation on the awareness mechanism.

In order to perform the context based filtering process, we associate those events and general profiles with context description objects (see Fig. 4). In fact, these events should be produced in a certain context, which can be represented by a *context description* object. Further, once a user accesses the system, she/he is doing so through a specific context, which is identified by the Groupware System and represented by a context description. We also associate with the profiles, at least, one context description object describing the circumstances where it can be applied. The Fig. 4 presents the associations among events, profiles and the classes defined by the context representation (Section 4).

Then, the proposed filtering process uses these context description objects associated with the group member and with the general profiles to perform the selection of the suitable events for the current context. This filtering process is performed in two steps. First, the awareness mechanism selects the profiles (preferences or characteristics) that are applicable to current user's context description. In fact, we consider that each group member can define for herself/himself a set of profiles and the circumstances, through a context description

object, in which each profile can be applied. The selection is performed by comparing the content of the context description objects of both, user and profile: if the context description object of the profile has the same content or is a subset of the current user's context description object, then this profile can be applied. For example; a preference profile for which the context description object is composed by the objects "coordinator" (for the *role*) and "report" (for *activity*) will be selected in the previous scenario (cf. Section 4). In addition, individual elements of the user's context may have its own profiles (e.g. a device which has its own "*characteristics*" profile).

Once all applicable profiles are selected, awareness mechanism can apply them over the available set of events, performing the filtering process. We suggest a gradual application, first applying the selected preferences of the user and then applying the other selected profiles. This can be made respecting a selection order (one profile at a time) or performing first a merge of the content of each selected profiles. This latter is especially interesting for "preferences" objects, which union can form a complete set of the group member's preferences. It is worth noting that, in this case, the awareness mechanism should be able to handle eventual incompatibilities among the selected profiles

The result of such filtering process should be a limited set of events that will be delivered by the Groupware System. However, our approach presents some limitations. The first one relies on the profiles definition that may be a hard and boring task. In addition, the definition of profiles with strict sets of application circumstances (profiles with context description composed by many context objects) may lead to the selection of no profile at all. If the context description object associated with the profile is larger than the one related to the user, it will never be a subset of the latter and such profile will never be applied. This will block the filtering process, leading to the presentation of all the available events.

Other limitation of our approach concerns, similarly to other context-aware systems, the context detection as all filtering process depends on the user's context description object. Hence, the definition of this object by the system (the context detection process) is very critical.

6 Conclusion

This paper presents a proposition of context base filtering process for awareness mechanisms, using a context representation that uses an object-based knowledge model. This context representation represents the main contribution of this paper. It was successfully implemented on a knowledge base, using the AROM system, and we are now implementing the filtering process, using a framework for awareness support called BW [10]. We expect to perform practical tests using a test application, a cooperative game, specially designed for this purpose. In this game, small teams will use PDAs and laptops to look for (and describe) targets (sights and objects) geographically distributed. Users will then use the system mainly to communicate and build the descriptions of the targets, and the awareness mechanism to coordinate their actions. Through these tests, we expect to evaluate the effective impact of our proposition in a context based awareness mechanism, and the user's acceptation, specially concerning the limitations related to the profiles (cf. Section 5).

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