Collaboration in Context-Aware Mobile Phone Applications

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Abstract

Context-aware applications are expected to become a remarkable application area within future mobile computing. As mobile phones form a natural tool for interaction between people, the influence of the current context on collaboration is desirable to take into account to enhance the efficiency and quality of the interaction. This paper presents role of context information in improving the collaboration of mobile communication by supplying relevant information to the cooperating parties, one being a mobile terminal user and the other either another person, group of people, or a mobile service provider.

1. Introduction

Mobile computing has become familiar for large user groups especially in the form of mobile phones. In addition to the conventional communication functions of mobile phones, i.e. call and messaging, they involve other functions, such as calendar and to-do notes, which are relevant for computer supported collaborative work (CSCW) and can be linked to concern the field of mobile computing in general. Mobile phones, which are inevitably used for distant communication, offer a potential platform for developing also other applications, which can assist in distant collaborative work.

As mobile handheld devices are used in dynamically varying situations, the context of the usage may change rapidly. This affects on the selection of active applications, preferred features and performance requirements of the device. Writing a quick calendar note in a busy meeting, answering to the phone while riding a bicycle in traffic, or writing a text message in cold winter weather may have different contextual attributes related to environmental factors, user's activity and user's goals. As mobile phones are used in altering places and on the move, integration of positioning technology also contributes new possibilities.

User's actions taken with his/her mobile device commonly involve directly or indirectly more than the device holder, thus resulting the usage context to have impact on more than just one person. With a mobile phone call, for instance, the knowledge of location and environment has often an influence on the interacting parties. When a father calls to his daughter who is taking a bus home from the school, the daughter's current context has an effect to both: the daughter may have difficulties in hearing and having a conversation in loud traffic, whereas the father can estimate the time for arrival from her location. The context of use situation is having an impact on the collaboration.

Due a enormous popularity of mobile communication technology and its throughout integration to everyday life during the last decade, the collaboration between mobile phone users and communication cultures has been investigated in several studies, see for instance [2], [19] and [3]. In this paper, we examine collaboration in relation to context-aware mobile terminals and discuss possibilities on enhancing the collaboration and improving usability of mobile applications if these two technologies are combined. As the subject is very broad, several aspects can be touched only briefly within this paper. However, we seek to introduce CSCW issues related to this multidimensional topic and build a comprehensive overview to the field.

The paper is organized as follows. First, context-awareness of mobile devices is enlightened and related research is introduced. Secondly, different forms of collaboration in this context are considered. After this, employing context-awareness to enhance collaboration in mobile communication is discussed by considering particular subtasks and some other aspects. Finally, discussion and conclusions are presented.

2. Context-Awareness and Mobile Devices

Dey and Abowd describe context-awareness to be "*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*" [6]. Different sources of contextual information for mobile handheld devices are presented in figure 1. The information sources include sensors, (such as illumination or noise level), device applications, user's goals and information gained via connecting infrastructure. This is one approach for categorizing context. Several other approaches have also been presented for instance by Schilit et al. [31], Dix et al. [8] and Pascoe [25].

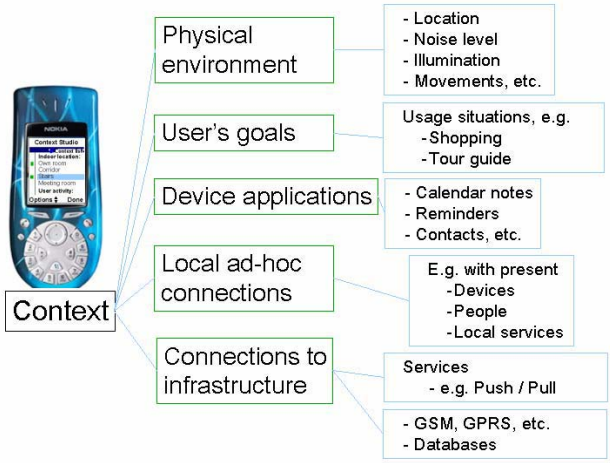

Figure 1. Contextual information sources for mobile devices.

Context-aware mobile devices have so far been investigated mainly from the technological point of view, examining context-recognition and sensor technologies (e.g. [10], [30]), inferring logic, system architectures or infrastructure (e.g. [15], [18]). During recent years, research related to human-computer interaction and privacy issues with context-aware mobile devices has also grown (see for instance [1] and [12]).

Most of the research has concentrated on adapting the functionality of applications in a manner where no collaboration aspect has been involved. Adapting display layout according to the current usage situation [20], or layout orientation [16] are examples of cases how contextual information can be applied. The device can observe the user's behaviour and learn to adapt to the manner that is perceived to be useful at a certain location as was done with the comMotion system [22].

There have also been examples where contextual information has been used to facilitate co-operation between mobile users. User's personal information, such as reminders, phonebook contacts or calendar notes, can be used as an information source which is used when creating location-sensitive messages, as done with CybreMinder [5]. Schmidt et al. [32] introduced a context-aware phonebook, which indicates the availability of a contact the user wants to call to.

Location is probably the most commonly used context attribute, and it has been used to develop numerous location-aware mobile systems, such as GUIDE tour guide in Lancaster [4] or visitor's guide at Tate Gallery, London [28].

2. CSCW with Mobile Phones

Ellis et. al divide different scenarios of groupware in according to the simultaneousness and location in time and space: computer supported collaboration can happen either in the same time and same place, same time and different place, different time and same place, or different time and different space [9]. Due the nature of mobile communication, the scenarios where collaboration takes place in different place are supported. Same place and same time happening collaboration is typically mediated by mobile phone calls, where as communication for collaborative tasks happening both different time and different place can be supported by messaging, either written, e.g. shortmessage service (SMS) or multimedia messaging service (MMS) or with voice mail messages.

Wiberg and Ljungberg [33] propose a framework where the relation of time and place are examined in respect to task's dependency of them. The commonly used phrase 'anytime, anywhere' refers to tasks, which can be done independent of time and place. The strictest conditions are set by tasks requiring the combination of particular time and particular space. Mobile communication offers flexibility especially on the spatially orientated conditions, as the place of communication is usually restricted mainly by network coverage. Independency of time is not so straightforward. Indirect influence can be achieved with easier scheduling and accessibility, which mobile phones can offer.

In [27], mobility is divided into three different forms: locational, operational and interactional mobilities. Locational mobility implies to geographical movement, whereas operational mobility refers to flexible coordination of operations and interactional mobility to intense interaction with people and data through device. Mobile phones can be seen to relate to all these aspects.

The possibilities and benefits the mobile collaboration tools provide for their users have been investigated in numerous studies. The needs and behavior of mobile workers have been investigated for instance by Perry et. al [26], who report on mobile technologies to support data access, flexibility, possibility to ad-hoc type peer communication. In addition to these professionally related functions, mobile communication is also used for social

interaction, as it is reported to maintain the sense of community. In addition to calling with mobile phones, text messages (SMS) are a popular media for collaboration. Teenagers are reported to use messaging not only to chatting, but also to coordinate media and times to interact, revise and adjust arrangements [11]. Children's mobile technologies were used for collaboration in story telling, adventure games and on a field trip [3].

Mobile collaboration concentrating on other than mobile phone platforms has been examined e.g. in [29]. Roth et al. introduce a QuickStep platform for Personal Digital Assistant (PDA) enabling collaborative applications such as calendar. Recent mobile collaboration studies include e.g. UbiCollab project, which aims for supporting mobile user with shared workspace applications [7].

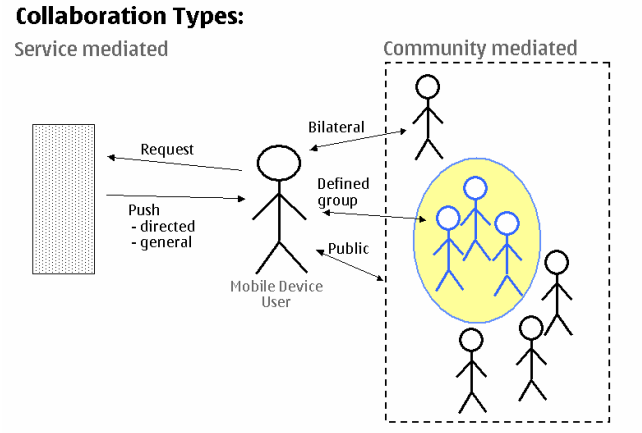

Figure 2. Different types of collaboration.

We define the computer supported collaborative work for the mobile phones to include two or more parties, at least one being a mobile terminal user, who interact with each other(s) in order to complete a certain task The collaboration types can be distinguished according to the co-operating parties, illustrated in figure 2. The interaction can happen in between one or more mobile terminal user, or between a terminal user(s) and a non-person entity, such as service provider or application. Thus, we divide collaboration into two categories, service mediated or community mediated. With service mediated collaboration, there are two basic categories: request-based or push service, the party taking initiative being the mobile user or the service, accordingly. Here, one can also refer to pull and push type services, as done in [23]. In table 1, different collaboration types are illustrated with examples.

Table 1. Examples of different collaboration types.

Collaboration type	Example
Community mediated	
Bilateral collaboration	John calls his girlfriend Ann
Defined group	John sends a party invitation by writing an SMS and selecting multiple friends as receivers.
Public	John sends an electronic business card via bluetooth to all in range of his bluetooth phone.
Service mediated	
Request based	John buys a tram ticket by sending an SMS to the ticket service, which send an electronic ticket within the returning SMS.
Push	John automatically receives an SMS advertisement from a teleoperator when entering to a foreign country.

Currently, mobile telephony is quite strongly bound to bilateral collaboration, where two mobile phone users communicate with each other either by calling or messaging. Another example of bilateral collaboration is two player mobile phone games, where players are connected over infrared.

During recent years, the increasing amount of mobile phone services and applications is introduced, for instance ringing tone downloads, WAP and SMS based information services. When the categories of table 1 are observed, supporting the collaboration between user and either a defined or undefined group of people has not yet been strongly presented among mobile communication. Some exceptions exist, e.g. so called conference calls among several people or SMS sending to several people simultaneously. However, the possibilities for this kind of collaboration modes are expected to grow in the future, as they would form an intuitive continuum for current development trends. Mobile, location-aware tour guides (e.g. [4], [28]) represent collaborative systems, where the other interacting party is not a person but a location sensitive service.

3. Context-awareness and collaboration

Each collaboration types presented in figure 2 can have contextual attributes related to the different parts of the collaboration process.

3.1. Subtasks in Collaboration process

To examine how context-awareness can be implemented to mobile collaboration, we first divide the collaboration task to subtasks, figure 3.

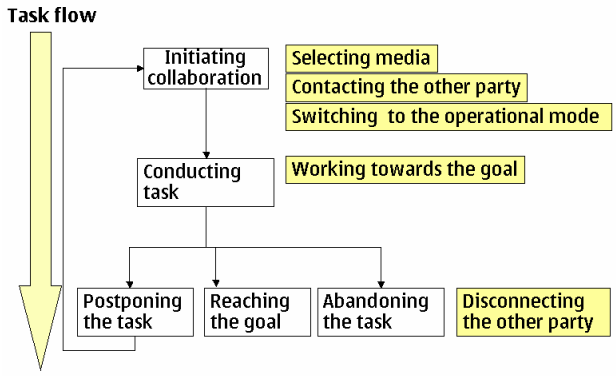

Figure 3. Taskflow and actions taking place in a collaborative task in a communication centric taskflow.

We now consider different aspects of context-awareness that can be applied to distinct phases of the collaboration. The contextual information sources presented in figure 1 and their role in each phase are also examined.

Initiating collaboration. When collaboration is initiated, a contact between the co-operating parties needs to be established. First, the user needs to consider the media (s)he selects for the communication. The selection is very much driven by the goal the user has and restrictions given by application design or infrastructure. The degrees of freedom are usually quite limited: overall communication with a mobile phone is carried out by calling or messaging, and specific actions are performed by opening a certain application (for instance shared calendar of chat).

When the user is contacting the other party, presence information or activity or availability status is useful [32]. If the user can request the availability status of the correspondent, the contextual information can be used for decision making for instance to postpone or reformulate the aimed collaborative task.

Task can also be initiated when certain contextual triggers are met. In scenarios used in [21], user defined contextual settings were introduced to establish a call or SMS sending when pre-defined conditions were fulfilled.

Selecting the other party for collaboration can be done on the basis of certain contextual attributes. This concerns especially cases, where the communication is not directed to a specific person, but any relevant person can be considered. Relevancy here depends on the user's context. For instance, we can consider a location-sensitive messaging system, which supports positioning of mobile users and location-anchored messages [14]. With the application, the user can write and view online messages either defining the position or the audience. Let us assume the user wants to send out messages with the following content: 1) 'if some of my friend is close, please join me for a beer', and 2) 'has anybody recommended the restaurant I'm in'. In the first case, the application first maps the location and passes the message to a target group (friends). In latter case, location is used as parameter to search for existing messages anchored to the location the user currently is.

When collaboration is established, the priorities of the user(s) should be considered: is the collaboration request an interruption? This should be considered especially with service mediated collaboration. A push type of service may easily cross the line between helping and disturbing if the information it provides does not match to the mobile users personal interests or if the context is unsuitable. Unsuitable information is easily perceived disturbing, and experienced as 'spamming' [12]. For these kinds of cases, context based personalized profiles or filtering may provide solution [14].

Switching to the operational mode can include for instance opening an application or communication channel. Here, adjustments towards better usability according to the situation can be done. Measured environmental factors can provide information to adapt device features such as backlight, volume and user interface font size [20].

Conducting the collaborative task. While performing the task, dynamic UI adjustments described above can be executed according to the changes in environment. This is especially relevant with mobile devices, as they can be used while moving and often in dynamically changing situations.

While executing the collaboration task, the contextual questions related to infrastructure become important. Sufficient and stabile network connection is crucial especially in time consuming tasks. Changes in price or security settings are factors, which may be in the interest of the user. Also, network traffic or coverage may have an effect on communication and delays may occur. A context-aware system can try to prevent unwanted situations by switching appropriate setting or warning the user of critical fluctuations.

In some cases, dynamic adaptation of the system is necessary for optimal interaction. For instance, updating information of the surroundings with a location-aware system is relevant while the user is walking long distances while using the device. Accelerometer information indicating that user starts running may cause enlargement in UI layout. There may be situations which even demand the change of communication modality: for instance from text input to voice commands when user is required to use his/her hands to something else.

The ability to access information quickly is one of the key features of mobile information. Some collaborative tasks may require sharing of certain information. With contextual settings, the access rights to the data can vary according to who is asking for what information and when [13].

Ending the task. Ending the task may happen via three different final states: the goal of collaboration task is either reached, abandoned, or the task is postponed. These all may require different functionalities. System developer has to consider also what happens if the collaboration task is interrupted. Keeping logs or records and automatically saving system state can be implemented in necessary situations. Also, unanimous agreeing on the result when completing the task is important, especially if collaboration is done between a mobile user and a commercial service provider. Device memory and connections have a significant role in these actions.

In some cases it may be necessary to think which event is important enough to interrupt the ongoing task. Manual muting of ringing tones what a user did when entering to the movies should not be overwritten with loud tones when a loud shooting scene appears in the film and environment noise level rises. Also, employing personalized filtering matching to user's profile and taking into account user's current goals may prevent from unnecessary interruptions.

3.2. Effectiveness of Collaboration

Mobile phones currently support both synchronous and asynchronous communication, and collaboration can happen analogously. Context-awareness enables message delivering at specific time or place, and can be used e.g. for personal reminders which go off when user passes a certain shop, or message delivering to a first family member home after workday in order to tell her to heat up the sauna. Thus, context-awareness can enhance collaboration by making it more efficient and diminishing the amount of unnecessary messaging at irrelevant time.

The two often-asked questions in mobile conversations are 'Where' and 'When', which both refer to dynamic measures. The usage of mobile phones enables updating schedules and informing of changes in plans and increases the flexibility of the communication. Collaboration done with mobile phones is often ad-hoc type [26]. Knowing person's a current availability status, location and activity information can assist for instance in planning a meeting.

Current mobile phones already support calendar applications, reminders and to-do notes, and employing context-awareness can make them more efficient. Combining the information of user's goals, location and information stored to device memory, the device can provide proactive actions and more efficient task scheduling since for instance travel routes can be optimized.

Mobile phones are not optimized for tasks requiring high quality input and output functionalities or lots of processing power. Consequently, tasks such as document editing are not in the scope of collaborative actions. However, social interaction and sharing are functions, which are well supported. Increasingly popular camera phones and multimedia messaging have provided additional forms for collaboration [17]. By including context-information to the pictures and other messages, the maintaining, storing and searching of the documents can be done more easily. Personalized, context-aware peer-to-peer communication and document sharing offer new possibilities also for mobile services.

In addition to so called fun functions, security features may be addressed with context-aware devices. By knowing the current contextual status of children or elderly people from a request might in some cases be a usable security tool. Another option is to design a system which automatically informs of an unusual phenomenon: For instance, the daughter is sent an SMS if her 70 year old father has not touched his phone for 24 hours.

5. Discussion

As mobile phones are used for mobile communication, their natural function is to support collaboration between the users. We enhance the collaboration from the traditional, bilateral usage between two mobile phone users to include also communication between several, either defined or undefined group of people, and to include not only collaboration between people but also mobile services and applications. Currently, point-to-point communication between two phone users is strongly dominating form of co-operation, and current solutions are not optimized for group collaboration. However, there is certainly market potential within this area, and the trend is expected to get stronger in the future.

Critical questions with context-aware mobile collaborative systems include the privacy issues. User has to maintain in the control of the device and to be able to block others from retrieving his/her information. Privacy questions are relevant also with security applications: how detailed information of your location or current activities is shared. Also, an important social phenomenon is the individual's right to lie. Individual privacy can be violated also if (s)he is interrupted with unnecessary advertisement. The possibility of spamming must be considered when designing context-aware applications. Filtering and personalization are suggested for situations where collaboration involves interacting with a mobile service or non-defined group of people.

System and application design for mobile devices has to take into account their restrictions: small power

consumption, network connections, small memory and reduced computation power. These set limitations also to the forms of collaborative use of mobile applications. With successful employment of context-awareness the device actions can be optimised according to each situation resulting a longer lasting battery life.

Context information has potential to enhance the usage of mobile communication devices and the collaboration between users. However, to take true advantage from the context information and to develop valuable applications for end-users, we need knowledge of users' expectations and acceptance on the issue. To avoid crucial mistakes in application design, the concerns and criticism as well as positive feedback from mobile phone end-users need to be studied.

6. Conclusions

Mobile phones are personal devices, which typically are always with the user and always on. They are used in various different kinds of situations, which make them a suitable platform for context-awareness. Mobile phones are primarily used for communication, between two people, but they also provide an intuitive tool for other types of collaboration.

In this paper, collaboration is defined to have at least to parties, where one is the mobile terminal user. The other party can be a person, group of people or an entity such as mobile service. Accordingly, we have categorized collaboration types into community mediated and service mediated collaboration. This paper has introduced how context-awareness can be employed to different phases of a collaborative task, i.e. initializing the collaboration, performing the task, and ending the collaboration, in order to improve the interaction and enhance the usability of the application.

The most relevant contextual attributes can vary when different phases of collaboration are considered. First, while initiating the collaboration, information about the presence or availability status of the other party is valuable. When the other party of the collaboration is a non-specified one, matching to the user's profile or a need defined by the situation is required.

When the collaborative task is in process, the infrastructure becomes to play a bigger role, and the system can help the user by being aware and able to respond to crucial changes in network connection, data traffic or prices. Also, maintaining the best possible usability can be done by adjusting the UI features according to the surrounding conditions. This can be done for instance by automatically adapting the lights or volume of the application.

When the task is finished, one has to consider agreeing on the result and sharing and storing the outcome. One needs also concern with possible interruptions, and if they are relevant enough to postpone the collaborative task.

Since mobile phones are typically carried with the user, they provide quite reliable information source for user's current context. For the same reasons, they are easily accessed and thus form a good media for context-aware collaboration. Collaboration with mobile phones is usually ad-hoc type communication, information sharing, situational, and done in a dynamically varying use environment. Adjusting device and application input and output after the usage situation, filtering and personalizing services according to the user's profile, providing reminders and information at the right place and right time, enabling location-sensitive group communication, supporting efficient time scheduling and proactive actions to meet user's goals are examples of how context-awareness can enhance the mobile collaboration.

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