Utilizing Context-Awareness in Office-Type Working Life

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ABSTRACT

This paper presents a context-aware mobile application for office-type working purposes. Via the user tests we have evaluated if this kind of application can support worker's daily life. In the experiments we had real users in real working environment. Our investigation illustrates that workers could utilize context-aware features to ease up their working routines such as keeping presentations. The results of this paper can help designers and developers to envision and implement future ubiquitous devices and environments.

Categories and Subject Descriptors

J.0 [**Computer Applications**]: General

General Terms

Experimentation

Keywords

Context-aware, mobile application, user experience

1. INTRODUCTION

Weiser [13] has introduced his grand vision of ubiquitous computing over ten years ago. Still we can argue that it is just a vision. Several developers and researchers have tried to envision such a system or environment. So did we. We developed an application which is ubiquitous for a user. It brings services near to user. It brings documents near to user. It decreases disruptions when user is not available. However, is ubiquitous device useful, can it support users' daily working activities? That is what we have investigated.

There are several studies of context-aware applications for guidance purposes mainly. So, Weiser's vision has been evaluated before, for instance, Bellotti et al. [3] have researched what impacts ubiquitous computing systems have to real visitors in actual environment, museums. They have investigated can pervasive computing support a museum-like experience. Likewise, Fleck et al. [6] have introduced an electronic guidebook for an interactive museum, called the Exploratorium.

Aittola et al. [1] have developed the SmartLibrary system for the University of Oulu. It is a WLAN-based location-aware (Wireless Local Area Network) mobile library service, and it offers a map-based guidance to find books and collections on a PDA (Personal Digital Assistant) device and mobile phone. The purpose of the service is to support both students of the University and the personnel of the library.

Already many researchers in the field of ubiquitous and context-aware computing have created various demonstrations of applicability of context-awareness to support people's daily lives. Part of this work closely resembles the work that we have done. For example, the CybreMinder by Dey and Abowd as described in [4] or the ComMotion by Marmasse and Schmandt in [8] share some of the concepts with and are closely related to the context-aware prototype we have created for supporting business users in their daily work. However, we are not aware of any work with equally wide set of application components utilizing context-awareness in co-operation in one single prototype, which is tested with real test users.

This paper describes how office-type working life can be supported via context-aware application. By office-type work we mean sort of work were a person has meetings, he uses services like printers and data projectors and he keeps presentations etc.

The paper is organized as follows. The first section introduces reader to research and development area. In the section 2 we describe the application prototype from user perspective not from technical approach. In the section 3 and 4 we want to give the reader a good picture of the conducted experiments by describing them in detail and walking the user through the test phases. The section 5 presents the results of the evaluation. The section 6 summarizes the results and outlines some future work. Finally, the paper is concluded.

2. PROTOTYPE APPLICATION

The prototype is realized as context-aware personal assistant application, which consists of several context-aware services. The components that were implemented and tested with real test users were personal assistant, service browser, context-aware file browser, calendar, context-aware profile manager, and projector service. The prototype has been built over CAPNET architecture which is an architecture developed for distributed context-aware and pervasive ap-

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plications. The architecture has been under development now for more than two years and the further development work is still being carried out in CAPNET-project (http://www.mediateam.oulu.fi/projects/capnet/?lang=en).

The most important application views used in the testing are shown in Figure 1. Calendar, context-aware file browser and service browser are complex application components containing internally multiple views to provide the functionality, whereas the personal assistant and profile manager contain only a single view. The screenshots, presented in figure 1, are captured from the screen of the PDA running the prototype software.

The personal assistant presents to the user static list of the most important services offered by the application and acts as a shell for accessing different service components in the system. In the user tests personal assistant was configured to present to the user the services which were mentioned above apart from the projector service, which is accessed dynamically through the service browser.

With **the service browser** the user can find service components in a dynamic fashion. The user can either search services by parameters such as location, name and service description out of the set of all services registered within the system, or he can set the service browser to dynamic discovery mode, which means that he is presented with constantly updated list of services which are in his vicinity. If user enters a place recognized by the system, say for example 'meeting room TS335', he is presented a list with the services which have been registered in the specified place. From the service list user may choose and launch a service which he wants to access. Once the selected service gets the request it builds its own user interface on to the user's device by using the facilities provided by the underlying CAPNET architecture, and thereafter the user can interact with the service directly from his device.

The context-aware file browser offers the user a possibility to organize and query his data based on contextual data recognized by the system. User can store data also in the conventional way without context-aware indexing. Indexing takes place when the user is storing the data with the context-aware file browser by the current context perceived by the system or through the calendar in which case the content can be indexed for future contexts. When retrieving data the user may choose to use context-awareness or traditional query. If he chooses to use the context-aware features, he is presented with the list of content related to current context as perceived by the system at the same excluding the content which is not related to current context.

Calendar acts in the prototype as an event organizer which provides also contextual information for the system. Calendar events in the application have three types of information associated with them - the type, time, and place of the event. The type of the event describes types of events, such as 'meeting'. The meaning of time is the period of time when the event occurs and the place of the event is the symbolic name of the place where the event should occur, such as 'cafeteria Datania'.

Context-aware profile manager adapts the profile of the device based on the user's context. For example, when the user enters a meeting, his device may automatically change the profile of his device to meeting mode, if the user has accepted that the profile manager should automate the changing of profile based on the user's context. In an earlier prototyping round the system was also able to automatically detect recurring patterns in the user's behavior regarding the device profile. The earlier prototype capable of learning user's routines and routine learning algorithm used in recognition are described in [10] and [11]. However, this functionality was not yet integrated into the second prototype during the time when the user tests were carried out on the system and the rules were pre-specified for the system in the prototype which was tested now.

Projector service was implemented as an example of a dynamic service which can be accessed through the service discovery mechanism of the architecture and the service browser. Through the projector service the user can send presentations to and control them on whichever of the projectors which have been registered in the system.

An overview on how the applications concretely behaved during the real user test scenarios will be illustrated in more detail in the chapter 4.

The technical environment for the prototype consisted of a 3870 Compaq iPaq PDA with a WLAN card and IBM's J9 virtual machine, which were used to host the personal assistant application, a server running on Red Hat Linux 9 in the university premises hosting a MySQL database and some of the services required by the underlying architecture, and a WLAN-enabled laptop with Windows XP were used to host the projector service. Prototype was mainly implemented according to PersonalJava 1.2a specification with few native extensions, which were utilized through the Java Native Interface. The network in the test environment was the university-wide WLAN network in Oulu also known as panOULU (public access network OULU) (http://www.panoulu.net/index.shtml.en). Test environment was equipped also with Ekahau positioning engine (http://www.ekahau.com/products/positioningengine/) to provide accurate positioning of the devices based on WLAN signal strengths.

3. TEST SETUP

In order to make user test it would be beneficial to have fully operational and reliable tool not a prototype. However, preliminary tests in early phase of product development are necessary to perform in order to achieve information about end user's preferences and needs [3]. Therefore we made user tests and the goal was to find out would this kind of ubiquitous application really supports users in their daily work. Moreover, user experience issues were acquired as well as new ideas how this kind of application could be exploited in users' daily life. According to Preece et al. [12] user experience includes the following issues: satisfying, enjoyable, fun, entertaining, helpful, motivating, aesthetically pleasing, supportive of creativity, rewarding and emotionally fulfilling. Instead, usability concerns aspects like efficient to use, effective to use, safe to use, have good, utility, easy to learn, easy to remember how to use [12].

According to Nielsen [9] different user test methods supplement each others. Moreover, Arhippainen and Tähti [2] presents that especially when studying user experience issues, several methods are required in order to get better understanding of users' experiences and emotions. Therefore, we used five different techniques in this evaluation; interview, observation, walkthrough, capturing screen events and emotion collection method.

The main methods were interviews and observation. Test

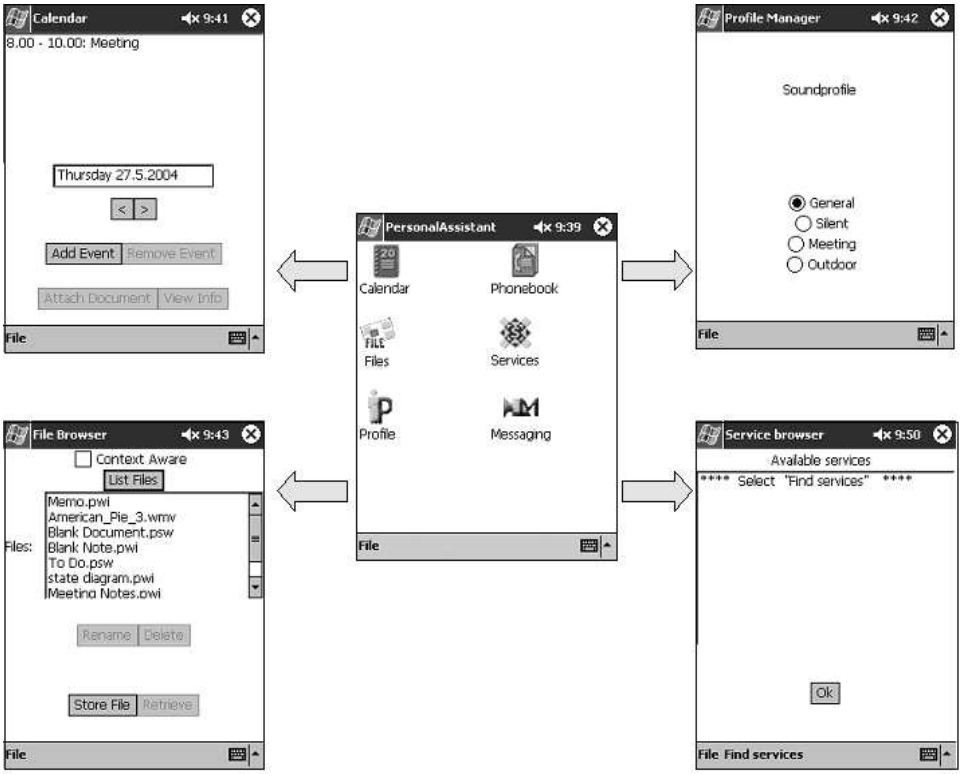

Figure 1: The basic application views. Calendar (upper left), personal assistant (center), profile manager (upper right), context-aware file browser (down left) and service browser (down right).

users were interviewed before and after the use of the application. The questions of the interview considered of user's background, what users think about this kind of application and would it support users in their daily life. The participants were asked to think aloud and observed while using the prototype application. Interviews and observations were recorded by video recorder. Moreover, the PDA screen events were captured on video, to see every action made by the user. In addition, we used SAM (Self Assessment Manikin) method for emotion collection [7]. We used walkthrough in order to follow user's actions and maybe advice if necessary. However, we wanted participant to use prototype independently so we offered the user written instructions of the prototype.

The experiment was performed so that one researcher was as a moderator and interviewer, and another was recording the test to the video. One subject performed the experiment at the time and each experiment took approximately 40 minutes.

According to Dumas Redish [5] and Nielsen [9] three to five participants is comfortable in order to notice all problems. Our experiment consisted of one pilot test and five actual test. During the pilot test the experiment settings as well as interview questions were evaluated. After the pilot test there was no need for changes in settings or questions so it was taken into account when analyzing the results.

All test users were male, their age was 33-53 years and they all have university degree. The test users were selected to cover the average users that could need this kind of application. Thus, all test users worked in a position where they have many meetings and that way they could need this kind of application in their work. Participants have different amount of prior experience with PDA devices. Three of the test users have own PDA device and they use it daily. Two of users had some experiences with such device; they have used it a couple of times but did not have a device of their own. One of the users had not used PDA before but he was very interested in using it.

4. WALKTHROUGH OF THE SCENARIO

This chapter walks the reader through the test scenario which the test users performed during the user tests. The user tests were conducted in an office-type environment (3rd floor of Tietotalo of the University of Oulu).

Figure 2 shows the path in the university premises through which the test users traversed. In the path you can see numbered key points where the application behavior is explained in detail. You can see also the services which were registered to the system in the figure marked with dots with a letter connected to them. They are referred to with the letters during the walk through.

The scenario started in the user's office, which is marked to the figure as key point 1. In the office user added the meeting into the calendar application by defining the time, place and type of the event. He also attached a presentation he had prepared for the meeting by using the file browser application. User enabled also the dynamic service discovery in the service browser.

When meeting was about to start, application notified the user about oncoming meeting. The user then left his office and at key point 2 service discovery dynamically offers

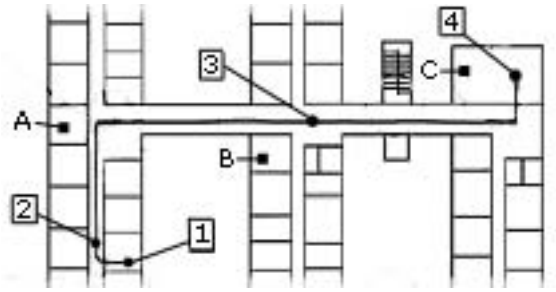

Figure 2: The physical path traversed in the test scenario.

Figure 3: The user is walking to the meeting room and checking the nearest services at the key point 3(.eps format).

services to the user in ordered by distance - that is, first A, then B, and finally C.

As user continued walking towards the meeting room, he arrived at key point 3 (Figure 3), where service discovery offered services to the user in the order B, C, and A, again ordered by distance.

Finally, when the user arrived in the designated meeting room at key point 4 the system recognized that user has entered a place which the system knows by symbolic name, and the service discovery offers only service C (data projector) to the user as it is the only service which is present in the meeting room.

When the user entered the room and the time was appropriate for the meeting, system also recognized that user has entered the meeting context and the profile of his device was changed to meeting mode without any need for interaction.

Then in the meeting the user selected the projector service from the service browser and started it. The user interface of the projector service appeared on the screen of the PDA and then user chose to send a presentation to the projector, which caused the context-aware file browser to be invoked on the device. Now user could choose the context-aware file browsing option and was presented only the files, which were relevant to the user's current context - the meeting context in this case, which meant that user was presented only with the presentation he had attached to this context back at his office, thus filtering out all the other irrelevant files. Then user chose the presentation he had prepared back in his office and it was transferred to the projector service running on a laptop and finally it appeared on the presentation screen in the meeting room and the user could keep the presentation.

5. USER TEST RESULTS

In this chapter we present the results of the conducted user tests. The point of view is how well this prototype can support users' daily work in office-type environment. In addition, SAM results are presented in order to confirm user experience gathered by interviews and observation. The results of SAM will give some ideas about the emotions elicited by the prototype. Moreover, some new ideas for improving and using the application, presented by the test users, are described.

5.1 Supporting work

All of the test users liked the idea of the prototype. For almost all users the application would be very useful and supportive during normal working hours. Test users mentioned that this kind of application would make working life easier, and reduce stress because they would not need to carry so many devises, disks etc., and worry whether they have all documents along with them.

5.2 New ideas

One of the most positive results from user testing of prototype was that the test users gave lots of new ideas and proposals for improvement. Most of these proposals came during the interview, but some during test period, when users made suggestions what would make the prototype serve them better. Subjects told what application might be useful in meetings and, for example, in school environment.

Additional and useful features for meetings could be: one shared and synchronized calendar, where one would see all available times for keeping a meeting. The slides could be seen on the PDA screen and there could be possibility to draw something on the slides and everybody in the meeting could see the changes. It would also be useful to use PDA for transmitting files to colleague's computer and printer. Also accessibility to documents from anywhere (even abroad) anytime was seen as a useful feature.

This kind of application would make extempore ideas possible, without worrying whether one would have that and that slideshow or not. This kind of application could really profit the school system, too. It could make the teachers work easier, for example, by offering mobile and direct access to class room reservation information and material in the warehouse. Thus, there would be no need to go and pick up some papers and make class room reservations or materials, like slides, from the warehouse. This kind of application will not only make the teachers' work easier but also save time for other activities like teaching or preparing lectures.

5.3 SAM results

SAM method was used to collect emotions elicited during the use of the prototype. The results collected by SAM are presented in Table 1. In the Table 1 the scale of plea-

Table 1: SAM results and users' prior experience with PDA

User	PDA experience	Pleasure	Arousal	Dominance
1	active user	7	5	6
2	active user	6	4	4
3	active user	6	5	7
4	some experience	6	7	8
5	some experience	7	6	8
6	not used	9	8	3
mean		6,8	5,8	6

sure, arousal and dominance are as follows: **Pleasure:** 1-9 (unhappy- happy), **Arousal:** 1-9 (sleepy - aroused) and **Dominance:** 1-9 (low- high).

From the Table 1 we can see that the application elicited quite positive emotions and that all users find the application quite pleasurable. The mean value of every emotional dimension was over the average value (5). Even though there were some test users that rated the arousal and dominance below the average value.

The SAM results seem quite positive, but we must remember that the test users were filling the SAM questionnaire in front of the testing personnel and this may affected to the final results. We can assume that the results are slightly too positive, than what they would be without the presence of testing personnel.

The SAM results support the results that were collected via interviews and observations. For example, those test users that were confident and independent while using the application selected high values for dominance and those having some troubles selected lower values.

6. SUMMARY AND FUTURE WORK

In this chapter we summarize user experience results and also present some future features for context-aware services. The Table 2 presents how users regarded that application can support their work. Also user's worries, needs and wishes are described. We identified usability and user experience issues from users' comments. Those issues are presented in the Table 2. according to Preece et al. definition [12]. In addition, some comments did not clearly fit the definition, but are very important from user point of view.

The Table 2 depicts that users find a lot of different situations where they would need context-aware mobile application. Some of the needs are related to technical requirements of office-type working life e.g. "I can draw something on the slides in PDA and all in the meeting could see the changes in the slides".

Moreover, some of the comments illustrate that the user' work is stressful and he need some support for that: "Do not have to worry about all documents".

During this study we found several improvements ideas for such context-aware mobile application. Some ideas related to components of application, for example, for calendar we identified such improvements: Share the calendar with colleagues, synchronized the calendar automatically, search and propose group meeting times, search an available room automatically.

Automatically changing profile (the profile manager) would be efficient to extend to cover more wide area e.g. meeting room, lunch room, own office, lecture room.

Figure 4: The user had to stop when checking the nearest services.

The context-aware file browser could be more aware of context. This means that it could transmit the file automatically to the right service (e.g. from the PDA to the data projector). Moreover, the component could remind the user the documents that he had to update or create based on context and calendar information. Also, the document can be shared automatically with all people in the meeting.

The service browser could use different graphical interface, for example, it could show the services on the map or other graphical view but not as a list. Sometimes it was difficult for the user follow the available service when walking at the same time (Figure 4). In addition, the component could provide some guidance to the user how to find the service. Guidance could be implemented by voice, text, graphic or vibration (Figure 4). In addition, service browser could include more services but they can be shown on the screen according to user profiles or needs.

The prototyping work will be carried on and in the upcoming versions of the prototype our purpose is to provide the applications with more versatile context information. In addition to the position, time, and user-generated events, which were context types utilized in this version of prototype, we have planned to include acceleration sensors on the device, temperature and other weather sensors available in the local scale in the Oulu region. This is enabled by CAPNET architecture which allows us to easily introduce new types of sensors in the system.

Also we are looking for introducing more services for common routines which are accessed in the dynamic way by the user as presented earlier in the article. In addition the interpersonal communication, collaboration and sharing in the system will be improved drastically and also context-aware features related to the communication will be introduced.

And finally we are planning to port the system on Symbian environment and utilize the context information and inference provided by the system in widely used 3rd party applications, such as MS Word or OpenOffice, to bring the features closer to the real-life of the users.

Table 2: The summary of the user test results (S=Support, W=Worries, N=Needs and wishes)

Comments	usability issues	user experience issues	misc issues
S: It would be useful in work life	utility		
S: It would easier work life	utility		
S: It would reduce stress		helpful, supportive	
S: Context-aware profile changing is good		helpful	
W: Can I use the application everywhere			availability
W: Does it works always as it should	effectiveness		
N: A quick connection to the data projector	utility		
N: An easy connection to the data projector	efficiency		
N: Shared and synchronized calendar	efficiency	supportive	
N: Prefer a mobile phone than PDA	easy to learn		
N: Do not have to worry about all documents		supportive	
N: I can see slides on the PDA screen	efficiency, easy to use		
N: Can I draw something on the slides in PDA	efficiency	supportive	
N: All in the meeting could see the changes in the slides	efficiency		
N: To use PDA for transmitting files to colleagues	efficiency		
N: Accessibility to documents from anywhere	efficiency	supportive	availability

7. CONCLUSION

In this paper we have presented the context-aware mobile application for supporting work life in the office-type environment. In addition, we have described user experience results that we have obtained via experiments. Six office-type employees used the context-aware mobile application in real environment which includes workrooms, meeting rooms, corridors and services e.g. printers.

Based on our findings we can argue that office-type work can be supported via context-aware mobile application. Especially supportive characteristics are very welcome to user's daily working life. The context-aware application could easier user's daily routines by taking care of user's presentation slides and other documents. It would decrease stress if a person does not need to worry about all necessary documents and devices e.g. laptop. However, context-aware adaptive devices have to enable to the user a dynamic working environment. This means the user has to have availability make changes in to documents whenever and wherever he wants. This requirement is close to Weiser's vision of the availability of technology.

In the future, it would be interesting to increase context-awareness. Application could adapt according to user's place, moment, activity, mood, needs, and pre-defined profile, etc. Moreover, context-aware application could take into account context-switching which means that the user moves one context into other smoothly. Therefore, the adaptive device should be able to behave the same way.

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