Location Awareness and Local Mobility

Exploring Proximity Awareness

Jens Bergqvist, Per Dahlberg, Henrik Fagrell and Johan Redström
http://www.viktoria.org/
Viktoria Institute
Box 620
405 30 Göteborg

Abstract

This paper investigates how location awareness can support local mobility. Location awareness, i.e. systems that are aware of where they are located, is an emerging trend in mobile computing. The paper starts with a brief overview of different types of location awareness, which are summarized and categorized. Further, two studies of local mobility is presented. Local mobility is a term used to describe people that are mobile within a certain area, such as in an office. The studies show that proximity of other people seems to be important for work. However, the overview of location awareness shows that not much has been done to use proximity of other users as a resource for mobile computing. We have also implemented a prototype of such an application that filters information based on the users physical location in relation to other users. It is built using a personal digital assistant (PDA) fitted with a radio transceiver. The prototype is currently being developed. The conclusion is that even though there is a lack of proximity aware systems, they seem to be useful, at least in locally mobile situations.

Keywords

AB, AI0108, BD0201, GC05

Introduction

The development in information technology has been used to bridge the (physical) distance between people. The telegraph, that was put to use more than 150 years ago, was the first way to send messages over longer distances. In the beginning of the 20th century the telephone made voice communication possible with other persons all over the world. Later, computers connected to public networks, enabled a wide range of communication and messaging means. More recently, mobile phones where developed that give us a number that can be seen as tied to a person, rather than to a specific location. The portable computers let us read mail and have access to information networks at almost any location.

However, when looking at people's habits physical meetings are still very important. Even though technology has made it possible to smoothly communicate with other people all over the world, we still want to meet in real life. The result of global communication means is not that we travel less, but the other way around. The number of persons that flies all over the world has never been so many as today, and it just keeps increasing.

Further more depending on where a person is located, only some of all the information in the world is relevant. If I want to go to a restaurant today, it is very unlikely that I am interested in a restaurant in another country.

People moving around, i.e. being mobile, is a focus of interest in the CSCW field (e.g Luff and Heath 1998, Belotti and Bly 1996, Bergqvist et al 1999). A type of mobility is denoted local mobility (Belotti and Bly 1996), which is mobility in a limited physical space, such as in an office. Local mobility seems to be very common, even at work sites normally categorized as containing none-mobile work (cf. Bergqvist et al. 1999).

A method for dealing with all the information available is using the context of an application to adapt the information presented. For instance, only information about local stores is presented when looking for a shopping mall. However, the context of an application can be anything. The temperature, the mental state of the user, if there is a war going on at the place of use just to mention a few examples of the context of an application. The most used context of mobile systems is the location of the system. First, the location is easy to determine, as oppose to more abstract contexts, such as the mental state of a user. Further more, it is often meaningful to use the location to adapt the behavior of a mobile application.

However, not much work has been done in merging local mobility and location aware computing. Since local mobility seems to be very common and location awareness has been proven useful in other situations it might be interesting to explore how location awareness can support local mobility.

The paper starts off with a brief literature overview of the concept of context-awareness with a focus on location-awareness for mobile computing. We then report from two studies that were conducted last fall that reports of different locally mobile situations. They help us to understand if location might be relevant when being locally mobile. After presenting a design suggestion (the NewsPilot prototype) we finish the paper with a discussion.

Location Aware Mobile Computing

The term context awareness has been discussed in a wide range of concepts and applications for different types of IT artifacts. The help functions in our office applications claim to be context aware when they try to figure out what we are having problems with when turning to the help function. The plug-and-play features in some operating systems can be said to be context aware when detecting and helping us to install new hardware on our computers. The navigation help in cars that knows where the car is located is called context aware. Obviously context can be used to describe a wide area of characteristics, ranging from defining the context as knowing what a user is doing, what

other applications in the same computer is doing or knowing where a user is located.

As described by Schmidt, Beigl and Gellersen (1998) the context of an application or artifact can be divided into physical environment and human factors. The human factors include the state of the user, what task he is performing as well as his social environment. For instance, if an application knows that its user is attending a meeting, is a physical aspect of context awareness.

Further more, the physical environment is at a lower abstraction level. Here, we find all physical variables, e.g. location, temperature as well as the infrastructure and other physical conditions.

As strongly pointed out by Schmidt et al (1998) the location awareness is only a portion of context-awareness. In our project, however, we are only interested in location awareness and not other forms of contexts. In the following section we will present a number of existing location aware systems, followed by a simple classification of those systems.

Location Aware Systems

A wide range of location aware systems has been developed the past decade. In this section we give a brief overview of some of those systems. By location aware systems we mean systems that, in some manner, are aware of their position.

Cyberguide

The Cyberguide (Abowd et al, 1997, Long et al, 1996), developed at the GVU[1] at Georgia Institute of Technology, is a family of prototypes developed to explore the usage of location for guiding people in different settings.

The first prototype was developed for indoor usage during open houses GVU. The Apple Messagepad (Newton) based prototype is used to guide visitors around the houses of GVU, displaying different kinds of information depending of the location of the visitor.

Among the services developed there are a map module, a communication module and a position module. The map module shows the user's location on a map of GVU, including where different demonstration stations are located. Information is presented at each station. The communication module is based on a wired connection to a TCP/IP network for retrieving new web pages and sending e-mail. The position module uses an Infrared (IR) transceiver on the MessagePad and a network of IR transmitters attached to different location of GVU. Each transmitter has a unique location code that is periodically sent out. The IR transmitters are actually ordinary remote controls for TV-sets that where reconfigured to periodically send out a code. When the MessagePad receives a code from a remote control it knows where it is located.

On a later prototype a module based on the Global Positioning System (GPS) technology replaced the initial positioning module. The GPS system does not work in indoor settings, so the whole system was reconfigured to be a guide to the Georgia Tech

[1] Graphics, Visualization and Usability Center, College of Computing, Georgia Institute of Technology

campus. This prototype still uses IR transceivers. However, not for positioning purposes, but to access a network

Thinking Tags

The Thinking tag, developed under the Things That Think project at MIT Media Labs, is a small badge used to initiate communication among co-located people (Borovoy et al, 1996).

The badge consists of five LED signs and an IR-transceiver. The IR-transceiver is constantly looking for other badges to communicate with. If a communication link is established it indicates that the user is standing face-to-face to another person that also wears a Thinking Tag. By sending out the personal preferences of the user wearing the badge the other badge is able to indicate if the two persons have anything in common, by lighting one or several LED signs, and there by (eventually) initiate a conversation. The tags are designed to be used during conferences or other events, spanning a couple of days of time. The preferences of the user is programmed initially and consist of answering yes or no to a number of questions related to the event, e.g. “Are you interested in the Y2K problem?”

The Active Badge System

The aim of the Active Badge System (Harter et al, 1994, Want et al, 1993), developed at the Olivetti Research Center in Cambridge, was to develop a small badge to handle location of personnel as well as equipment. The system consists of personal badges wore by persons, which looks similar to name badges. The badges send and receive data from “base transmitters” installed in walls in rooms and computers at the site of use.

Using the badges and base transmitters it is possible to retrieve information on where the user is, what computer and what telephone extension he is located at. The information is distributed to a central server that allows remote users to check where a personnel is located. The systems are integrated with other systems. For instance, a printer might not start printing until the user is located in the same room as the printer. While a user is away from his office the workstation is locked and will be automatically unlocked when the user enters.

PARCTabs

The PARCTabs (Want et al, 1995) is part of the famous Ubiquitous Computing (Weiser, 1990) experiments at Xerox PARC. The PARCTab is a specifically designed piece of hardware that operates together with hubs and transceivers using IR technology. The PARCTab is a platform that has been used to develop a wide range of different applications. Want et al. (1995) classifies the applications that has been developed into Information access, Communication, Computer Supported Collaboration, Remote Control and Local Data Applications. In the information access category we find applications that present different information depending on where the PARCTab is located, e.g. museum guides. In the communication category we find locator applications, similar to the locator application used in ActiveBadges, discussed above.

The PARCTabs where also used as an integrated part of other systems in the

ubiquitous computing experiments, such as the LiveBoard. The PARCTabs senses when it is in the same room as a LiveBoard and can adjust its behavior to that situation.

The Humming Birds

The Hummingbirds (Holmquist et al, 1998) were developed to "give members of a group continuous aural and visual indications of which other group members are in the vicinity." As opposed to the Active Badge system, the Hummingbirds do not rely on an infrastructure built into the building where they are going to be used. The Humming Birds also have a user interface, allowing the user view what other members are co-present.

Types of location aware systems

There are two types of techniques to gain location awareness, namely *relative* or *absolute positioning*. The absolute location-based awareness is awareness of the actual location, either the co-ordinates, or in what place (e.g. country, city, building, or room). There are a number of different technologies for absolute positioning, e.g. GPS or Global System for Mobile communication (GSM) cell information together with the Mobile Positioning System (MPS). For instance, the Cyberguide and the Active Badge systems use absolute positioning. They all know their exact position. The positions can, however, be absolute in a building only, without knowing where in the world the building is located. The term absolute positioning is used to describe that the systems are aware of their own spatial position.

The absolute position of the user (or rather: the device tied to a specific person) can either be used by the user herself or be transferred and used by other users in a larger system. The Active Badge system, for instance, allows persons to view where Active Badge-users were last "seen" in the system on a web page. However, since the use of the system included putting transmitters on computers and printers – thereby enabling user's awareness of the proximity of equipment – it does in a way use relative location awareness. Not awareness user-to-user, but user-to-artifact.

Relative location awareness systems are, in contrast to absolute location awareness, aware of what other objects that are in their proximity. The objects can be moved around and when using relative location awareness a system should recognize other objects without pending on where the device is located. For instance a device could be aware of which printer that is available locally and use that information to automatically adjust the system behavior to print on the local printer. For those types of devices, IR communication links have been the dominant technique. The Hummingbirds and the Thinking Tags are examples of relative location awareness systems.

If a system uses absolute positioning and is able to communicate with a network (e.g. using IR or GSM) it is possible to simulate relative location awareness, which is the case of the Active Badge system. However, the Active Badges do not include any user interface that allows a user to gain awareness of other users.

To summarize, a location aware systems can use absolute or relative location. It might be possible to simulate a relative location awareness by using absolute location awareness and communication to a network with information of other devices location. The relative location can either be user-to-user, e.g. the Hummingbirds, or user-to-

artifact, e.g. ActiveBadges. The systems and their location awareness techniques are listed in table 1 below.

Name	Absolute Location Awareness	Relative Location Awareness
Cyberguide	Yes	No
Thinking Tags	No	Yes, user-to-user
Hummingbirds	No	Yes, user-to-user
PARCTabs	Yes	Yes, user-to-artifact
Active Badges	Yes	Yes, user-to-artifact

Table 1: Classification of the location aware systems

Empirical Examples and implications of local mobility

The NewsPilot project finds inspiration from two field studies, i.e., a study of journalists at a Swedish local radio station (RS) (see Fagrell et al 1999) and the IT staff at a Swedish municipality (see Bergqvist et al 1999). The studies were conducted during the autumn of 1998. Revisiting this the field from the studies we have elicited implications for location aware IT support. The working conditions in the two cases differ we will focus on the generic implications. The following sections will summarize of findings for the cases.

The Radio Station Case

On the editorial staff at RS people continuously engage in informal discussions about how news stories may be reported and who might contribute. When a journalist gets a story to investigate it is a necessity to find background information. From a journalistic point of view this is very important, because the story has to have originality, i.e. if the story has been under coverage before it needs to be approached from a new angle and if the story is new it needs to be put in an appropriate context. Another important issue is that the journalist does not always know if other RS journalists or news channels (e.g. the local newspaper) have worked on the story or related stories before.

A typical working day for a journalist could be described as a bit chaotic. Each minute the journalist has to perceive new information and re-prioritize what to do next. The constant shift of focus is mainly based on which persons that are present at each situation, on what news ideas that are coming up. The office landscape is open-plan and most co-workers work at different desks depending on which task they are doing.

Summing up, we found the following features of the work of the journalists to be of importance to get the job done, i.e., produce newsworthy material:

- **Collective**: A large part of the work is collective, involving discussions and joint explorations among staff.
- **Exploring questions**: The work is very much about exploring how to frame the events taking place. In a sense, it is not about finding answers to questions, but rather to frame the problem and give the correct background.
- **Time-dependent**. The work is very time dependent, e.g., the time for a program

cannot be postponed.
- **Unrepeatable**. Many activities cannot be done more than once, e.g., a live interview.

The design implications for location aware computing in this setting would be:
- Facilitate contacts between journalist that could contribute to each other's task when they are geographically close to each other.

The IT Department Case

In "Moving out of the Meeting Room, Exploring Mobile Meetings" Bergqvist et al (1999), report the results from a field study conducted at an IT Department in a local government in Sweden. The department supplies the local government with IT-support and software based on Lotus Notes and can be described as a mix between an in-house development company and a consulting company. Much time is spent out of office giving support but the major share is spent on the premises. About 25 persons work at the department. The study describes how local mobility is an important factor in getting the in-house work done. Often away from their desktops where the principal IT support is located the personnel moves around in the office searching for people they need to communicate with. There is no IT-support at all for this facet of their work.

Bergqvist et al describe this as "Mobile Meetings", which are short informal, yet work related meetings, which depend on physical proximity. These meetings take place in an office environment and are instigated either by a persons need to find a person and solve a problem or a chance meeting which reminds the participants that there is something they must talk about. Another reason for interaction is the need to brief other persons on current events.

As mentioned the physical proximity is very important for establishing meetings, which are needed to solve emerging problems. Either a person must search for a needed participant for a meeting to occur or a chance meeting spawns a mobile meeting. In both cases the relative location of potential participants is of utmost importance.

In those few cases where IT is indeed used for mobile work it is only because it is absolutely necessary in order to perform the task at hand. Usually the involvement of stationary IT (e.g. gather around a desktop PC) is detrimental to the nature of the flexible and mobile work making conversation, action and interaction difficult.

Design implications for location aware computing in this setting would include:
- supporting the search for people in the immediate vicinity using relative position aware hand-helds
- using location aware hand-held computers for reminding the users of topics to discuss depending on who is nearby
- making such IT-support mobile and flexible enough to not hinder the interaction between persons

Merging Local Mobility and Location Awareness

The common descriptor for the two cases is the importance of other people's proximity in order to be able to perform their tasks well.

The type of location awareness needed to implement our implications is user-to-user relative location awareness, which we call proximity awareness. A system is proximity aware if it knows what other systems that are located within its proximity. The proximity can, depending on the application, be “in the same room”, “10 meters or closer to the system” or some other relative measurement. The only systems we found that supports user proximity are the Hummingbirds (Holmquist et al, 1998) and the Thinking Tags. The Hummingbirds do not enable users to broadcast anything but a user id, while a Thinking Tag can only be aware of one other Thinking Tag at a time. Further more, the Thinking Tag only sends out short static data to other Thinking Tags. Our implications on the other hand need support for broadcasting small messages embedded with the user information to all other devices in the proximity. Hence, there was a need for developing a new system – the NewsPilot.

Our suggestion: The NewsPilot

Based on the implications from the empirical studies and on the review of other systems, the NewsPilot (see figure 1 below) is being designed.

Figure 1: A NewsPilot

The NewsPilot is based on the 3Com Palm III. The PDAs were fitted with radio transceivers in order to be able to communicate with each other and with transmitters in the surroundings. The client periodically sends out an ID-tag that other clients can pick-up. Hence, NewsPilots may be aware of the presence of other NewsPilots. This functionality is the base platform of the NewsPilot. On top of the platform different applications can be designed.

The first application was designed specifically for the journalist case. With this application, each user is able to enter a string that is being distributed to the other NewsPilots in its vicinity. When a NewsPilot detects another client, it receives and presents the message to the user of the receiving NewsPilot. When the connection between the NewsPilots is lost the messages disappear from the screen.

The second application was designed for the IT department case. The application is similar to the journalist application, but instead of broadcasting information on what topics a person is working on, this application uses the proximity of other NewsPilots as a filter mechanism for to-do items. Each to-do item in the to-do list of the Palm III can be

associated with one or several person. When one of those persons is nearby, the to-do item is shown and a small beep is emitted. This application is mainly aimed towards supporting Mobile Meetings, but we hope that it will be more generally applicable for people that are locally mobile.

Discussion

In this paper we provide an literature overview of the area of context-aware mobile computing and show, informed by the result of an empirical study of journalists and one of IT support personnel, that there is an opening for different kinds of location aware applications. The main implication of the studies is that proximity is important when being locally mobile. People meet, discuss various topics, make decisions and brief each other of what is going on. However, when the overview of location awareness was presented it showed that previous work on proximity is not enough to support our implications.

Our practical contribution is the description of a prototype of such an application – the NewsPilot. We are aware that an evaluation in the field is required in order to conclude whether the NewsPilot is useful to the group of co-workers. Such a study would also make it possible to investigate the relation between information tied to persons and information tied to places. Using NewsPilot to find out more about what information to route where and when in a dynamic environment, will give new insights in how we should create useful location aware computing applications. Moreover, an evaluation could explore other aspects of location aware computing, e.g., integrity, which are difficult to say something about from only a theoretical point of view.

Acknowledgements

The authors would like to thank Joakim Wigström, who made the radio transceivers, and the Mobile Informatics and PLAY research groups at the Viktoria Institute for idea generation and valuable comments and finally the participants in the MobiLinq and MobiNews projects for sharing the results from their field studies.

References

Abowd, G. D., Atkeson, C. G., Hong, J., Kooper, R., Long, S., and Pinkerton, M. (1997) Cyberguide. A mobile context-aware tour guide. In ACM Wireless Networks, 1997, Vol. 3, No. 5 (Oct. 1997), pp. 421-433.

Belotti, V. and S. Bly. (1996) Walking away from the desktop computer: Distributed collaboration and mobility in a product design team. In *Proceedings of ACM 1996 Conference on Computer Supported Cooperative Work*, edited by K. Ehrlich and C. Schmandt, ACM Press, pp. 209-218

Bergqvist, J., Dahlberg, P., Kristoffersen, S., and Ljungberg, F (1999) Moving Out of the Meeting Room: Exploring support for mobile meetings To be presented at the European

Conference on Computer Supported Cooperative Work, September 1999, Copenhagen, Denmark

Borovoy, R., McDonald, M., Martin, F., and Resnick, M. (1996) Things that blink: Computationally augmented name tags in IBM Systems Journal, Vol. 35, No. 3&4, 1996 - MIT Media Lab, pp. 488–495.

Fagrell, H., S. Kristofferssen and F. Ljungberg (1999) How Journalists decide which Questions to Ask: Implications for Mobile Knowledge Management. Submitted for publication. Available at http://www.viktoria.informatik.gu.se/groups/mi3/results/papers/groupsr.pdf

Fano, A. E. (1998) Shopper's eye: using location-based filtering for a shopping agent in the physical world. In Proceedings of the second international conference on Autonomous agents, 1998, Minneapolis/St. Paul, MN, USA, pp. 416-421.

Harter, A and Hopper, A. (1994) A Distributed Location System for the Active Office, IEEE Network, Vol. 8, No. 1, January 1994

Holmquist, L.-E., a. Joakim Wigström and J. Falk (1998) The Hummingbird: Mobile Support for Group Awareness, Demonstration at ACM 1998 Conference on Computer Supported Cooperative Work.

Long, S., Kooper, R., Abowd, G.D., and Atkeson, C.G. (1996) Rapid Prototyping of Mobile Context-Aware Applications: The Cyberguide Case Study. In the Proceedings of the 2nd ACM International Conference on Mobile Computing and Networking (MobiCom'96), November 1996.

Luff, P. and C. Heath. (1998) Mobility in Collaboration. In *Proceedings of ACM 1998 Conference on Computer Supported Cooperative Work*, edited by S. Poltrock and J. Grudin, ACM Press, pp. 305-314.

Schmidt A, Beigl M and Gellersen H. W. (1998) There is more to context than location in International workshop of Interactive Applications of Mobile Computing, Rostock, 1998.

Want, R, Hopper, A, Falcao, V and Gibbons, J The Active Badge Location System, ACM Transactions on Information Systems, Vol. 10, No. 1, January 1992, pp 91-102.

Want, R, Schilit, B. N., Adams, N. I., Gold, R., Petersen, K., Goldberg, D., Ellis, J. R. and Weiser, M. (1995) The PARCTAB Ubiquitous Computing Experiment, Technical Report CSL-95-1, Xerox Palo Alto Research Center, March 1995.

Weiser, M. (1991) Ubiquitous Computing, Scientific American. pp. 94-10, September 1991