Awareness and Privacy in Mobile Wearable Computers. IPADS: Interpersonal Awareness Devices

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Abstract

An Inter-Personal Awareness Device, or IPAD, is a handheld or wearable device designed to support awareness and collaboration between people who are in physical vicinity of each other. This paper describes three IPAD systems, comparing their characteristics and approaches to the problem of opportunistic meeting. The characteristics are identified according to the Steinfield et al. [SJP99] awareness classification. Some of these mechanisms are discussed and some improvements and ideas are proposed in order to improve the systems.

Key Words*: CSCW, Wearable Computers, Awareness, IPAD, Mobility.*

1. Introduction

Many studies about collaborative systems are concerned about the use of the desktop workstations and network technologies to provide support for distributed collaborative work and awareness. These systems however, are available on devices that are static and tied to the desk [LH98]. Recently, the development of mobile devices as wearable computers, cellular phones and PDAs (Personal Digital Assistants), and the improvement of the wireless network infrastructure [Bluetooth], are bringing the power of the workstations to handheld computers. The computer now is a ubiquitous device, and the working time is now more flexible.

In this context, the CSCW are not restricted to desktop computers in the user's office or home anymore. The concept of work as an activity restricted to the meeting rooms and the offices are changing, becoming more flexible. Much time can be spent working at other places than the office. For example, work and informal meetings can be performed in many ways and in many different places as in the coffee shop, at home, or during a business trip. In this context, much time is spent looking for people in order to initiate a meeting (a face to face interaction) [BDKL99], even though these environments increase the opportunity to start an opportunistic interaction is improved. Technology to support these (opportunistic) meeting are necessary.

In this paper, some IPADs (Inter Personal Awareness Devices) [HFW99] are evaluated. These systems are mobile portable devices which aim is to improve the opportunities to face-to-face interaction in a group of people.

These are some questions that will be addressed:

What type of awareness the system provides? How successful are the systems in providing this kind of awareness? How can the system be improved? What other functionality could be added to increase the awareness effectiveness? What are the main limitations of these systems?

The systems presented here do not represent an exhaustive list of all projects in this area. The objective is to provide a glance of some research topics and evaluate them according to the spectrum of the different kinds of awareness and requirements of these kinds of systems.

Another discussion topic is the privacy concerns of the system. In this paper, it is analyzed the degree of privacy provided by the system, how it is accomplished and how it can be improved.

Paper Description

Section 2 presents the basic awareness and privacy aspects used in this paper. In Section 3, the main awareness aspects of three IPAD systems are presented and identified. In section 4 some related work is discussed and in Section 5 some conclusions are posted.

2. Basic Concepts

In this session we introduce the basic concepts that will support the discussion in this paper.

2.1 Awareness Definition

In the context of group work, awareness usually refers to the information about the activities of other group members. This information is crucial in facilitating the collaborative work.

Steinfield et al. [SJP99] consider awareness as "occurring when group members poses knowledge about the content status and actions of the various components (including people) in a collaborative system".

2.2 Awareness Classification

Steinfield et al. provides a comprehensive classification of different types of awareness. This classification considers the types of information the awareness mechanism must gather, and the alternative ways in which this information might be delivered to the group members. This classification is presented below. According to the types of awareness data, it can be classified in activity, availability, process, perspective and environmental.

- **Activity awareness**: provides information about the actions that other members of a group are performing at any given time.

- **Availability awareness**: allows the identification of the physical presence of user in the system and its willingness to participate in the group activities. For example, if the user is on-line, busy or available for talk in the ICQ system [ICQ].

- **Process awareness**: is a kind of awareness usually provided by workflow systems. This information allows the user to identify the current state of a process (a sequence of tasks), which tasks was performed and where his work fits in the whole system.

- **Perspective awareness**: gives information about the other group member's backgrounds, beliefs and knowledge, allowing members of the group to better understand the contributions and decisions of the other members.

- **Environmental awareness**: provides information about events that occur outside the immediate of a workspace, that may have implications for the group activity.

In the context of Activity Awareness, another classification introduced by Dourish and Belloti [DBelotti92] defines the concepts of **Activity Content Awareness** and **Activity Character Awareness**. In the first one, low-level information about what the other members of the group are doing is presented, for example, which menu the user selected at a moment. In the second case, it is provided a higher level information, about the nature of work a user is performing, for example, if the user is editing a text or a spreadsheet for a specific propose.

According to the way awareness information is delivered in the system, it can be passive or active; differentiated or undifferentiated, customized or fixed, focal or peripheral, within an application or across application. These kinds of awareness are described as follow:

- **Passive Delivery**: in this approach, the collaborative system monitors the information and delivers it without requiring any specific action of the users. This approach can lead to information overload and intrusiveness described by Hudson and Smith [HS96]. This approach however, increases the chance to get some important information delivered to the user before its context goes away.

- **Active Delivery**: requires users to take specific actions to request the awareness information. They are less intrusive. On the other hand, this may lead to under utilization of the awareness data.

A balance between active and passive delivery must be provided in order to achieve a high level of awareness without the overload of information [HS96]. This can be accomplished by the use of a hybrid police, in which the user can **customize** the awareness data, registering for the receipt of certain kinds of events. The system can also use group role information to filter and route the awareness data to a particular group member, providing only "relevant" information to this user (**differentiated** police). On the other hand, this customization process must demand excessive expertise from the user, not being easy to accomplish and configure. The Elvin system [FMKAPS99] is an example of a configurable notification server that implements some of this functionality, allowing the users to register for certain kinds of events.

Two approaches can be identified according to the way the awareness data drives the user attention form his present work, in a more or less intrusive way, i.e. if the awareness information disturbs the attention of the user [BBFMR95]:

- **Focal Awareness Information**: Requires immediate attention of the user, driving its current working focus to this data. The excessive use of this kind of awareness can be obtrusive to the user.

- **Peripheral Awareness Information**: This approach conveys awareness data without requiring a group member to take his or her attention away. The idea is to reduce the cognitive effort of the user. An example is the exploration of the user peripheral vision, sound signals, visual cues and other non-intrusive HCI design techniques.

Additionally, users can access awareness information through a **single application** or the system can be able to provide this information through a **set of applications**. An example of the last case is a system that collects information through a web page and delivers data to the users using e-mail. One example of such systems is the AREA [BKS99] that provides awareness by the generation of notifications about activities performed by users in anyof the client applications.

According to the way the awareness information is collected by a collaborative tool, it can be **explicit provided** or **automatically provided**. In the first case, the user has to directly input the awareness information into the system. Although this is a more obtrusive method, it allows the user to provide more accurate and complex information about their activities, in a way the system would not automatically generate. In the second case, the system must automatically collect the awareness data based on the user activity.

This classification is very broad and addresses many different aspects of awareness. For each kind of application one of these aspects is more important.

2.3 Awareness and mobility

The mobility systems introduce new kinds of awareness, the most prominent ones are location and presence awareness.

- **Location awareness**: provides information about where a (mobile) system is located. Dahlberg et al. [DLS99] also defines the concept of location awareness as a simple instance of **context awareness**. "A context aware system collects data about its environment and adapts its behavior accordingly. While location aware systems only collect data about absolute or relative location, context aware systems may collect data about the history of user operations, the weather, the location, etc.".

- **Presence awareness**: provides information about the presence (or absence) of another person. This is the most important kind of awareness present in the mobile systems described in this paper.

Awareness information can also be accessed "**anywhere**", as the example of a mobile device, as opposition to a **particular place**, as a example of a desktop system, in which the user must provide login identification to access the application.

2.4 Privacy

One important aspect that is usually considered when awareness information is provided, is the privacy concerns. Sensitive information as people location, addresses, shopping habits, routine and other kinds of personal information should not be provided in an indiscriminate way. Polices, rules and security providences must be adopted in order to protect the misuse of this data.

To ensure privacy the systems usually apply two techniques: Access Control Lists (ACLs), providing a list of users that must be authenticated in order to access some information, and cryptography, used to protect the data being transmitted.

3. Systems Description

In this session, three different systems whose main goal is foster the user's face to face interaction are discussed. These characteristics are described in terms of the classification and concepts introduced in the previous section.

3.1 Hummingbird

The Hummingbird is an IPAD that aims to support continuos awareness of the physical presence (or absence) of collocated group members [Holmquist 98, WH99]. Differently from a contact mediator, as the example of a cellular phone, the idea behind the Hummingbird is to be a contact facilitator, not an intercommunication device.

3.1.1 System Description

The main goal is to provide continuous **presence awareness** of other people in the vicinity of a user. A Hummingbird extends the range of our ordinary senses,

allowing the user to know that a colleague is nearby even though he or she is not close enough to be directly seen.

An important basis for IPAD concept comes for the observation that informal communication may occur whenever people are in the same place, but that it does not necessary matter which place they happen to be in. In this sense, the Hummingbird seeks to maintain general awareness in mobile groups to support spontaneous interactions.

A Hummingbird is a wearable computer, in the size of a cellular phone, integrated with a radio transceiver and a LCD display. It scans its surroundings (approximately 100 meters range) for other Hummingbirds. It provides **peripheral awareness**: generates a sound ("hums") and displays the name on the screen when another device has been detected. No additional information about the user is displayed.

Privacy: In field tests using the system, described in [WH99], some users reported concerns related to privacy. The system could be used to surveillance purposed and could harm the personal integrity. The information provided by the device, however, is very generic: (presence/absence) and its range (100m) allows some location privacy.

3.1.2 Suggestions and Extensions:

Some extensions could be implemented in the system. It could provide availability awareness information as if the user is available to talk (or not). Location awareness, including distance and direction information could also be implemented. However, this information could render the system in a people locator machine, which would introduce some privacy concerns.

The system could be extended to provide direction and distance information about the other users. The vicinity range could also be configurable, and the capacity to become invisible (or visible) to a certain group of people could be included.

3.2 Proxy Lady

The proxy lady [DLS99] is a mobile system developed by Dahlberg et al., which objective is to foster the informal, *opportunistic* face-to-face communication. The system runs on a Windows CE PDA equipped with a radio transceiver.

3.2.1 System Description

Dahlberg et al. [DLS99] assumes the following definitions for informal communication and opportunistic meetings.

- **Opportunistic meeting**: It is used the Kraut's et al. [KFRC90] definition, in which the opportunistic meeting is an event anticipated by one party (user), but that only occurs when the parties happen to meet each other.

- **Informal communication**: is a synchronous fate-to-face interaction, which is brief, unplanned and frequent. It can be strongly related to work but it can also be purely social. In these types of meetings the interactions have an unsettled agenda, no preestablished topics are discussed; and the interaction can have a random number of participants.

In this context, the proxy lady system was designed to be used by people that meet frequently (co-workers for example) and needs to share information as soon as an opportunity occur, in special, during their locomotion around work places, in corridors and coffee rooms for example. This situation characterizes what Bergqvist et al. calls mobile meetings [BD99], in the context of what Belotti and Bly [BB96] defines as local mobility.

The idea behind Proxy Lady is to support these informal meetings providing location awareness, along with some discussion material (*information items*). The information items are stored in the PDA during desktop synchronization operations. The current version supports items like e-mail messages and some files.

Proxy Lady assumes that *information items* like e-mails and tasks can be used as the basis for informal interaction. For example, one reason why Bob wants to approach Joe (in an opportunistic meeting) is that he wants to discuss an e-mail he received from him previously. This assumption implies that the system supports the meeting of acquainted and known people, typically, people in the same workgroup. Hence, the system supports work-related informal communication.

Proxy Lady lets the user associate information items (e-mails and tasks) with other people, called *candidates for interaction*. When this candidate is in the proximity of the proxy lady's users, this device notifies its owner (**presence awareness**), which can initiate a face to face conversation with this person and (possibly) start a brief meeting. In this meeting, the information items can be used to support the conversation.

Location Awareness: This kind of awareness is used in this system to notify a given user of the presence of other users in his vicinity (*area of proximity*). The system is based on relative location, i.e. detects the users in its vicinity using its own radio transmitter resources. The vicinity is inside a range from 20 meters from the PDA device.

Based on the vicinity information, a user can decide whether to interact or not with another user in the vicinity range. In special, the system filters the users, showing only those in the "candidates for interaction" list, i.e. those people having "information items" associated with. That is an example of passive customized delivery of awareness data.

Peripheral Awareness: the system notifies the presence of the users using a flashing light or a sound signal in a non-intrusive way.

The notification and the user list can be turned off.

Privacy: The Proxy Lady system provides an invisible mode. If a user is in the invisible mode, the other users are unable to detect his presence. The use of relative location, in which the geographic location of a device is not used, also copes with the privacy of the users. The invisible approach can be improved using filters in which the user can select to whom become visible or not.

Availability Awareness: Information about the availability of the users is outside of the scope of the system. This can be accomplished by face to face conversations, for example, asking if the other person is available for chat.

Some usability tests were preformed with a group of users. After the tests, some suggestions were proposed as follows:

- Addition of new information item types as homepages;
- Addition of notification of artifacts, not only people. In this case, one can be notified about a new version of software when passing near a workstation.

Some suggestions about the proximity range of the device were also proposed: a configured range could be useful to adjust the device for different situations. In an office, where people are very close, the proximity range could be reduced; on the other hand, in an open area, it could be increased.

3.2.2 The Proximity Problem

The Proxy Lady uses the notion of space proximity, in contrast with place [HD96]. Hence, for instance, a *candidate for interaction* that is on the second floor of a building can appear in the vicinity of another person's PDA that is on the first floor, which, according to the user place, is relatively more distant than. Dahlberg et al. proposes a solution to this problem by the use of tags (annotations) of places. These annotations can provide a more accurate location awareness information. In this approach, the system can provide information like: John is in his office, or Mary is in the corridor. The implementation of this mechanism, however, is not described in detail.

This technology, however, is a double edge sword, in the sense that it can introduce privacy problems, for example, people can monitor how often their colleagues goes to the restroom or whether they are outside smoking.

3.2.3 Suggestions and Extensions

In order to foster the informal face to face communication among people, the system cold inform a user when another partner have information items associated with him. This bi-directional awareness could facilitate the interaction and the encounter among the users. In order to avoid the excess of information, this awareness could be only activated when one user gets inside the vicinity of the other.

3.3 Proem

The Proem system [KST99] introduces the notion of *profile-based cooperation* as a way to support awareness and informal communication among mobile users during *chance encounters* (encounters evolving people that do not know each other). It is implemented as a wearable computer for profile-based cooperation allowing users to publish and exchange profile information during physical encounters.

This system is different from the Hummingbird and the Proxy Lady, for supporting encounters of people that have never met before. It was designed to investigate how the concept of user profiles and online identities can be used to support cooperation during physical encounters of individuals in situations evolving large crowd places such as indoor/outdoor meeting conferences, and trade-show events.

3.3.1 Profile-Based Collaboration:

This subsection describes the basic concepts used by the Proem System, in special the profile-based cooperation concepts.

User Profile: is a collection of personal data stored on a mobile device that describes the user. For example: personal tastes, interests, expertise, opinions and all other information that the user may like to share. Profiles are flexible: attributes categories can be added and removed as needed. A profile may contain information as: personal and work addresses, company affiliation; calendar information, emergency telephones, a list of favorite URLs, a relation of favorite books, research interests and so on.

In order to exchange profile data, two users must agree on the meaning and purpose of the exchanged attributes in their profiles.

Encounter: describes a situation were two or more people meet unexpectedly (chance encounter). An encounter among people using the Proem system occur when:

- individuals are in close proximity to each other;
- the mobile devices of these individuals have discovered each other's presence and;
- the devices are able to communicate.

Encounter Properties:

- Can occur between 2 or more individuals;
- Are asymmetrical: it is possible that user A meets user B, but not vice-versa;
- Encounters are situations with a time duration, not momentary events;
- Encounters are not transitive. If user A meets user B and user B meets user C, a not necessarily meets user C;

Profile Exchange: the transmission of personal data between two or more mobile devices during an encounter.

An encounter between individuals is a **chance** for profile data exchange. The **owner** is the individual who is described by a profile; the **reader** is any individual who accesses another user profile.

The profile exchange process is ruled by the following principles:

- *Owner control*: The access to profile data should be controlled by its owner, who decides about **what** information to include, **with whom** to share and **when** to share.
- *Reader selection*: The dissemination of profile information should be controlled by the reader of this information (other device) and not by the owner device;
- *Reciprocity*: The owners should be able to restrict access to their profile data to individuals which themselves are willing to share their data;

Privacy: The profile should also include privacy restrictions, allowing the users to select and customize their owner control. This is accomplished by the use of *multiple privacy levels:*

- First order friend - a friend of yours;
- Second order friend - a friend of a friend of yours;
- Third order friend - a friend of a friend of a friend of yours;
- All - every other user.

It also support for user authentication (Access Control Lists) and anonymous user accounts.

The user can select which profile information to share with other users according to its list of friends.

3.3.2 System Description

The system implements the characteristics described in the previous sub-section. It also provides the following awareness mechanisms:

- **Presence Awareness**: at any moment, the awareness tool presents the list of user friends that are in the vicinity (3 meters) of the Proem device and the time each user is in this range.

- **Location Awareness**: The system uses relative location awareness, provided by a radio transceiver, which the only function is to detect other devices (users) presence.

- **Perspective Awareness**: During encounters, the friend's visible data (according to access list rules) can be automatically collected by a proem peer device for future reference. For example, all user names and telephones, which were selling a particular product that were in the user vicinity during the day.

The Proem system allows the specification of **rules,** predefined behaviors that are trigged as side effect of a profile exchange. These rules are specified using a rule editor. Some examples of rules, a user could specify is described below:

1. "Alert me when I meet a friend of mine."
2. "Alert me when I meet someone who sell and IBM PC."
3. "Alerts me when I meet someone who went to my junior high school."
4. "Save a record of everyone I meet who is interested in wearable computing."

During encounters, **software agents,** on behalf of the user, scan profiles in the other Proem peers in the vicinity of the system for user-defined patters and perform actions when some kind of data is found.

A profile based cooperation system can be used in many situations evolving people that do not know each other. Some examples of these situations are:

- Scientific conference: "Finding people with related interests";
- A swap meet, where people come together to buy and sell unusual things: "Find a person who sells the item that one is interested in."
- Meeting between a small group of people: visit to a construction site by architects, contractors and owners.

In these scenarios a device supporting profile-based cooperation could serve multiple purposes:

- As an *awareness tool*: sharing names and company affiliation
- As a *reminder*: "When I meet … , remind me to say … to him"
- As a *diary*: "Tell me who I met today"
- As a *matchmaker*: "Find someone who … that I did not met yet"

3.3.3 Trust

The exchange of profile information during chance encounters in the proem system creates some trust concerns. How to trust the information provided by someone? For example, in a buy and sell interaction one user could include its address data for further contact in his anonymous access control list. How can a user trust that someone he does not know will use his personal information in a proper way?

Some trust informations based on community opinions are discussed in [SKJFS00]. In this study, each time two people met, trust information about others are exchanged: "here are my feelings about the people I've traded with and here's what I've been told about them". This information is represented as a number from -2.0 to 2.0, and can be computed as the pondered average of other people opinion. New information is given less weight than old information. If one information is significantly divergent from the others, it is discarded.

Some problems with this approach could arise by the fact that some people can know the other people's opinion about himself. This fact could constrain the grade given by someone since the grades are not anonymous. They are associated with some user ID.

3.3.4 Suggestions and Extensions

One problem that arises in the profile-based interaction is the agreement on the profile attributes. How can a user read the other's attributes without knowing their names? This could be solved by the adoption of an interest protocols, set of rules and attributes to each occasion. For example, a protocol can be specified for buy and sell procedures. It includes attribute names, types and the interaction rule; another protocol could be specified for matches of people from different genders. These information could be used to configure the system as add-ins.

Proem uses a wireless network composed of a local area network and a campus area network to transmit data. This add-ins with application protocols could be downloaded on demand to the system as new interaction opportunities appears.

In the current version, a user collects and stores information about people from who the data was collected. No Information about people who read a user data is provided. For example, a user would like to know the name of all users who read his public profile data and that are not in his friends list.

The vicinity of the system is very short, 3 meters of ray, if compared to the Hummingbird system (100 m) and the Proxy lady (20 m). This is a limiting restriction of the system since users within this vicinity are able to talk and start face to face conversations with each other without the need of the device, and users beyond this vicinity, that could have the awareness of the user, are not detected. Hence, an increase of this ray of action to the one of the Proxy Lady for example, could increase the effectiveness of this system. A better approach, that wold cope with the

user privacy, could be to render this parameter user as configurable.

Context awareness: some of the rules could be sensible to context, in order to be activated/deactivated according to the location and the context of the user. For example, some rules associated to buy and sell attributes could be turned off during scientific conferences, while some rules that track people with the same academic interests would be turned on.

Currently, the Proem allows the activation and deactivation of rules however, this process could be automated by the use of a personnel calendar application in which the user could configure the system to adjust itself according to his personal schedule.

Proem could be also extended to store other kinds of data as files, forms and data folders, improving the potential for collaboration as the same way Proxy Lady does.

Medical applications: An example of application in which the Proem system could be used is hospitals. Doctors are continuously moving from one place to the other, meeting patients and other doctors. In this context, the system could be used, for example, in medical applications in which the doctor IPAD is updated with the patience profile as soon as it gets close to his bed. The patient bed could have a profile transmitter. This information could be used for future reference of the doctors during their work journey. This information could also be transmitted between physicians during the work journey change, as a support for its speaking reports.

4. Systems Comparison

The Table 1 compares the previous three systems according to the awareness information they provide.

	Humming-bird	**Proxy Lady**	**Proem**
Presence Awareness	YES	YES	YES
Location Awareness	NO	YES	YES
Peripheral Awareness	YES	YES	YES
Perspective Awareness	NO	NO	YES

Table 1: Comparison Chart

The most important awareness mechanisms used by these systems were the presence awareness. This data is the central information used to provide the user interaction in these systems.

5. Conclusions

In this paper, three systems providing an implementation of an IPAD prototype are presented. Each system addresses the problem in a slightly different way. The Hummingbird system has a very simple approach, providing presence awareness within a long distance ray. The Proxy Lady extended the Humming bird concept introducing a list of users and a set of files to support opportunistic discussions.

The level of awareness that is provided by these systems increase as new functionalities are introduced. This improvement, however, has some drawbacks. The more information about the user is provided, the more concerns and protection about sensitive data are required.

The systems described in this paper are used to promote informal conversations (face to face interaction) among people. In this context, awareness can be defined as the sense the presence (or absence) of other people in the vicinity of the system. This knowledge can range from the simple presence awareness, in the case of Hummingbird and Proxy Lady, or be more detailed information about unknown people, as the example of the Proem System.

Another important point is the current lack of experiments and usability tests using these kinds of system. This is a new area in which many questions are still open.

Some improvements and suggestions were provided for each of the applications, providing some insights about future extensions and applications of these concepts.

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