Discovering Boundaries for Mobile Awareness: An analysis of relevant design factors

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ABSTRACT

Mobile awareness applications connect you with the activities of friends, colleagues, and communication partners. The development of awareness applications for mobile devices is a top priority for HCI researchers. In discovering boundaries for mobile awareness systems, it is important to consider how these devices will be used. Factors relevant to design include boundaries drawn by technical, functional, privacy and complexity issues. This paper presents a literature review and introduces a Mobile Awareness Conceptual Framework that defines relevant boundaries for mobile awareness applications. The Framework includes information awareness, people-centered awareness, and context awareness. The paper concludes with an application of the Framework to inform the design of mobile awareness systems.

Keywords (Required)

Awareness, HCI, mobile computing, design

INTRODUCTION

Is the mobile phone the computing platform of the future? This is the subject of a fierce debate over the $100 laptop initiative (Whenham, 2006). This debate will not be settled for some time, but it is clear that the widespread use of mobile phones opens up possibilities for networked applications connecting widely distributed actors.

Mobile computing is a recent addition to an HCI research effort spanning more than 20 years to develop awareness systems that connect widely distributed actors (Mantei, Baecker, Sellen, Buxton, Milligan and Wellman, 1991; Dourish and Bly, 1992; Tang, 2001). Dourish defines awareness as "an understanding of the activities of others, which provides a context for your activities" (Dourish and Bellotti, 1992). Noting that cooperation and collaboration are key components to team work, the focus of this research is to deliver awareness among team mates.

How can mobile devices contribute to awareness? From a design perspective, it largely depends on how the device is to be used. Using the "push- pull" metaphor of Web design, information awareness or notification systems "push" information to the mobile device. These deliver real time information on items such as weather, flight cancellations, and stock trades. The next section of this paper will discuss the design boundaries for mobile information awareness systems.

Awareness applications can also "pull" or collect user identification from the mobile device, then use that identifying material to customize the delivery of content, as well as provide location information to trusted collaborators. The section on People Centered Awareness will discuss the design boundaries of location and context aware systems for mobile devices.

The paper introduces a Mobile Awareness Conceptual Framework that describes the boundaries or constraints related to each component that must be addressed by designers of mobile awareness systems. Preliminary results of semi-structured interviews related to the privacy control aspects of mobile location aware services are briefly summarized. The paper concludes with an analysis of the implications of this framework and a discussion of future research directions.

INFORMATION AWARENESS

Information awareness can be provided by status information or a signal of an event. The use of a mobile device for notifications is a natural fit. For example, applications have been developed to transmit sports scores (Holtzblatt, 2005) and weather alerts (www.weather.com).

The speedy delivery of relevant information to interested parties has been a commercially successful component of many industries, including the financial industry (Nylander, Bylund and Boman, 2004). A useful design for notification systems takes advantage of peripheral awareness, which uses software located in the user's peripheral attention (Cadiz, Venolia, Jancke and Gupta, 2002). A potential problem with information awareness is information overload, where the user is overwhelmed by information and does whatever they can to restrict in-flow, even to the point of discarding useful information (Hiltz and Turoff, 1985). Peripheral awareness can diminish distractions, so that the user is not diverted by sounds, blinking or motion, but can as needed keep up with new information.

An example of an information awareness interface that uses a peripheral display is Sideshow (Cadiz et al., 2002). Sideshow takes advantage of peripheral awareness by running as a sidebar that cannot be covered by other applications on the user's primary display. Sideshow consists of a collection of customizable items, called "tickets," that display a small snippet of information. For example, users can have a ticket monitoring local traffic conditions, and the ticket will show a small static image from the camera. Another ticket may point to the user's calendar, and display how many minutes until the next meeting as well as the meeting title.

The goal of Sideshow is to display a high level summary in a small space. Users who need to "drill down" can hover over the ticket and a "tool tip" will appear with more information. Besides displaying information, the tool tip can be interactive. For example, the tool tip for your email inbox can be used to answer or delete mail. Or, by double clicking on the ticket, the user can launch an application related to the ticket, such as Outlook for your Calendar ticket. Sideshow exploits peripheral awareness, allowing low effort monitoring of multiple information sources. "I like the quick glance to see the amount of mail, bug status, traffic and other info without having to open 10 applications to get the same info," reported a software developer (Cadiz et al., 2002).

Technical boundaries

If something is so important that you need to be notified about it immediately, then ironically the mobile device is not the best platform. This is because people do not constantly monitor their mobile device, making it impractical for peripheral awareness applications. It is close at hand, but not continually within someone's line of sight (Myers, 2003). Audio or haptic alerts overcome this by ringing or buzzing or vibrating, but these signals or the act of talking on a cell phone are not always appropriate to the recipient's location.

For designers of information awareness services, the reliability of the delivery network needs to be a primary concern. Cell and network coverage is still quite spotty, even in very large urban areas. Service can be unavailable within buildings, making the notification difficult to deliver. This does suggest that multimedia notifications should be kept to a minimum. Notification systems that depend on text based SMS messaging can overcome network weak links, since they can be transmitted with a weaker signal than is required for an audio channel. The reliability of SMS messaging was poignantly demonstrated in February 2006 when teachers and students trapped in a Philippino school by a mudslide sent several text messages requesting rescue (Conde, 2006).

Another technical boundary to consider is the plethora of hardware platforms and input interfaces. Mobile devices are designed for long battery life, small size, and light weight. This results in low CPU power, tiny screens, and limited memory for client based applications. Interaction with input devices is also a challenge as the number of buttons, direction arrows, and display fonts are not consistent among different models and types of equipment (Holtzblatt, 2005). This requires designers to anticipate multi-device access and automated facilities for adaptation to interfaces (Nylander et al., 2004).

PEOPLE CENTERED AWARENESS

When you call someone on your cell phone, how often do you ask: "where are you?" Walk through any urban setting, and a significant portion of individuals is using their mobile device. The rest are carrying them, placed in special pockets or easily reached compartments. The use of cell phones and other mobile devices is increasing on a steep curve (Gaudin, 2001). The frequent desire for location information and the widespread use of mobile devices presents a clear opportunity for mobile applications that provide awareness.

People focused awareness

People focused awareness systems are designed to recognize the location of individuals within a physical and social context (Jones, 2005). One promising application is a location awareness system using PDAs implemented for a hospital environment (Munoz, 2003). This system delivers messages by context – to the next nurse in the room or the next doctor. This is a very valuable functionality for this kind of system.

This system was developed in partnership with the IMSS General Hospital in Ensenada, México. This public health institution is the core provider of health care services, covering the needs of approximately 82 percent of the population. The developers recognized that capturing the requirements for this system would require an intensive study of processes and interactions within the hospital. They used qualitative methods, such as interviews and participant observation, to "deeply understand how workers perform routine and non-routine tasks each day" (p. 39).

By closely studying the hospital setting, the developers realized that information had to flow to a location, such as a patient's bed, or a role, such as the next nurse on duty. They extended the instant messaging paradigm to recognize not just individuals, but roles and devices. An individual can send a message to a role or a device. In addition, the system could trigger messages. For example, when lab results are available, a message can notify a doctor and even direct them to the nearest public display (i.e. a computer work station) where they could view the results (Munoz, 2003).

Context awareness

The México hospital system described above is a valuable case study in how to capture context in an awareness application. Awareness is a widely noted aspect of collaborative practice (Fisher and Dourish, 2004). Much research in awareness has focused on understanding the dynamics of closely collaborative settings, such as the control room for the London Underground (Heath and Luff, 1992). Collaboration in a control room involves closely choreographed interactions. Close coordination is also found in orchestras, sports teams, and dance groups. The understanding of how co-workers can work together in close collaboration may offer insight into common coordination and collaboration problems with distributed co-workers (Cramton, 2001). With the addition of mobile devices, the question is how can systems be designed to support this kind of coordination?

The ability to communicate context is not an easily defined functionality. There is great cognitive complexity in capturing what components are needed to achieve awareness at a distance. Attempts to generate awareness using media spaces encounter difficulties. For instance, (Mantei et al., 1991) reported that video-conferencing between groups ended up with co-located colleagues talking to each other and ignoring participants on the television screen.

In order to deliver awareness, technology must provide immediacy and collect and organize information needed for cooperation and collaboration, a difficult challenge. One surprising example of the challenges in supporting context awareness is Reno, a location-enhanced, mobile coordination, and person finder application, under development by Intel researchers. Intel wanted to create a system to enable social and family coordination. In experiments with families, Reno was used to assist parents managing car-pooling and transporting their children to activities. While Reno could manage one on one coordination, it could not support the complexity of this multi-person problem (Iachello, Smith, Consolvo, Chen and Abowd, 2005).

(Carroll, Neale, Isenhour, Rosson and McCrickard, 2003) introduced the idea of activity awareness, or awareness of context factors such as planning and coordination. Despite the specific intent of the system, Virtual School, to support awareness, problems common to other CSCW research surfaced. Even though there was initial agreement about goals and plans, coordination tended to deteriorate over time. Carroll et.al. recommend the integration of notifications into the display and control of work objects, or the documents and files collaborators work on. This is because notifications about the availability of a collaborator or versioning of a document section were sometimes not noticed. Supporting activity awareness is more than providing additional notifications. What is needed is to become aware of "the state of someone else's mind" (p. 627). This is indeed a difficult task.

Awareness and Big Brother

Many cell phones and PDAs can be easily configured for location awareness applications, often with the installation of a simple patch (see http://www.accutracking.com). The pieces seem to be all in place, and yet mobile awareness initiatives such as E911 have triggered resistance and obstacles (Eng, 2005).

A recent Google search with the keywords "cell phone" and "big brother" generated 856,000 hits, with titles like "Will Big Brother Track You By Cell Phone?" and "Privacy Advocates Attack Cell Phone Surveillance." The tension between awareness and privacy has been noted in (Hudson and Smith, 1996; Consolvo, Smith, Matthews, LaMarca, Tabert and Powledge, 2005; Smith, 2005).

While surveys indicate privacy is a substantial public concern, the "big brother" reaction to location systems has not been taken seriously by the research community (Iachello et al., 2005). For both the privacy and security of its users, location aware systems must protect the integrity of personal information.

The security of location and proximity aware systems is critical in the wake of incidents where information from one electronic context has easily migrated to another. For example, the Electronic Privacy Information Center (EPIC) has identified more than 40 web sites that offer to sell cell phone calling records without the knowledge of the person making the calls (http://www.epic.org). This ability has been used by private detectives on behalf of suspicious spouses. It also presents a danger to law enforcement and undercover agents. As a test, The FBI used a service named Locatecell.com to retrieve the records of one of its agents. It took only three hours to obtain them (Main, 2006).

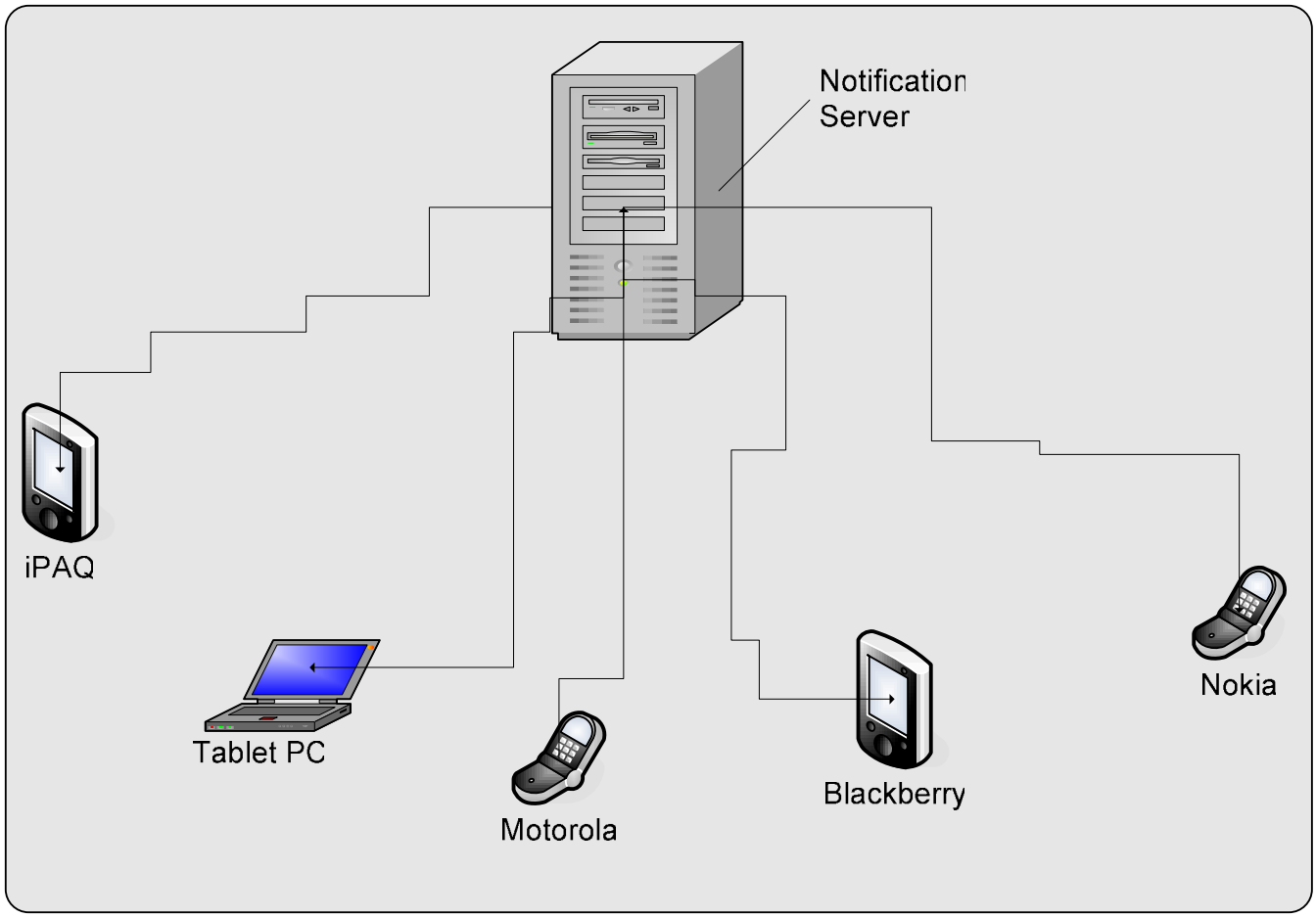

Figure 1: Notifications applications must be able to interact with various hardware platforms

However harmless location aware systems may seem to be, they must include rigorous control against mis-use and allow for individual privacy management (Smith, 2005). This has some serious implications for the design of location aware systems with respect to the use of central servers to calculate and save location information. A more secure and anonymous method is to use triangulation by the device itself with nearby cell towers or wireless hubs to calculate location (Schilit, LaMarca, Borriello, Griswold, McDonald, Lazowska, Balachandran, Hong and Iverson, 2003).

Some systems require that the request for location information be acknowledged before information is sent (Smith, 2005). This is consistent with research that demonstrated people were more willing to disclose location information when they had knowledge of the requestor and the likely reason location information was being requested (Consolvo et al., 2005).

MOBILE AWARENESS CONCEPTUAL FRAMEWORK

Understanding the design boundaries of mobile awareness requires an understanding of how mobile systems can deliver awareness, and how technical and social constraints can be addressed in the system structure. Awareness as defined by (Dourish and Bly, 1992) is a very general concept. It is frequently explained by comparisons with co-located workers, meeting by chance at the water cooler or stopping by if they see a colleague's door is open (Erickson and Kellogg, 2000).

Awareness as a functional requirement is the ability to transmit relevant information to distributed collaborators. Using the Theory of Media Synchronicity (Dennis, 1999), awareness functions essentially as a synchronous communication mechanism, enhancing the immediacy of feedback. Since distributed collaborators often suffer from coordination problems and time lags (Cramton, 2001), awareness is intended to support group cohesion and collaboration of distributed partners.

The Mobile Awareness Design Framework (see Figure 2) captures the main components of mobile awareness, moderated by the boundaries that designers must consider in building their systems. These components are people centered awareness, context awareness, and information awareness, supported by mobile network and hardware platforms. Each component is moderated by boundaries that designers must consider.

People focused awareness systems must include boundaries that take into account privacy, security, and control issues. Notification and alerts are a natural fit with mobile devices, but one that must recognize that a critical message can be held up by network transmission issues, and recognize whether the recipient is in a context where they can be interrupted by a buzzing or vibrating message.

Information awareness systems must enable information filtering and adjustable interruption thresholds. When the information is provided by a collaborative network of users (e.g., a Wiki), it requires a means by which the user can assess its validity (e.g., editor or moderator roles, ratings). Interruption thresholds are now set by the person using the mobile device. Notification systems could benefit from mechanisms to allow messages to override the current phone settings. These thresholds should be set by the user, but it would be very useful for a user to be able to flag any family emergency messages with a threshold that overrode a "mute"setting on the device.

Awareness designers must view technical constraints with a clear eye. Low bandwidth, weak signal, poor coverage, and myriad hardware platforms are serious obstacles to be reckoned with. The interest in developing context aware systems must acknowledge the complexity inherent in coordination tasks. Unless context can be expressed as a computational model, it can not be automatically supported by an awareness system.

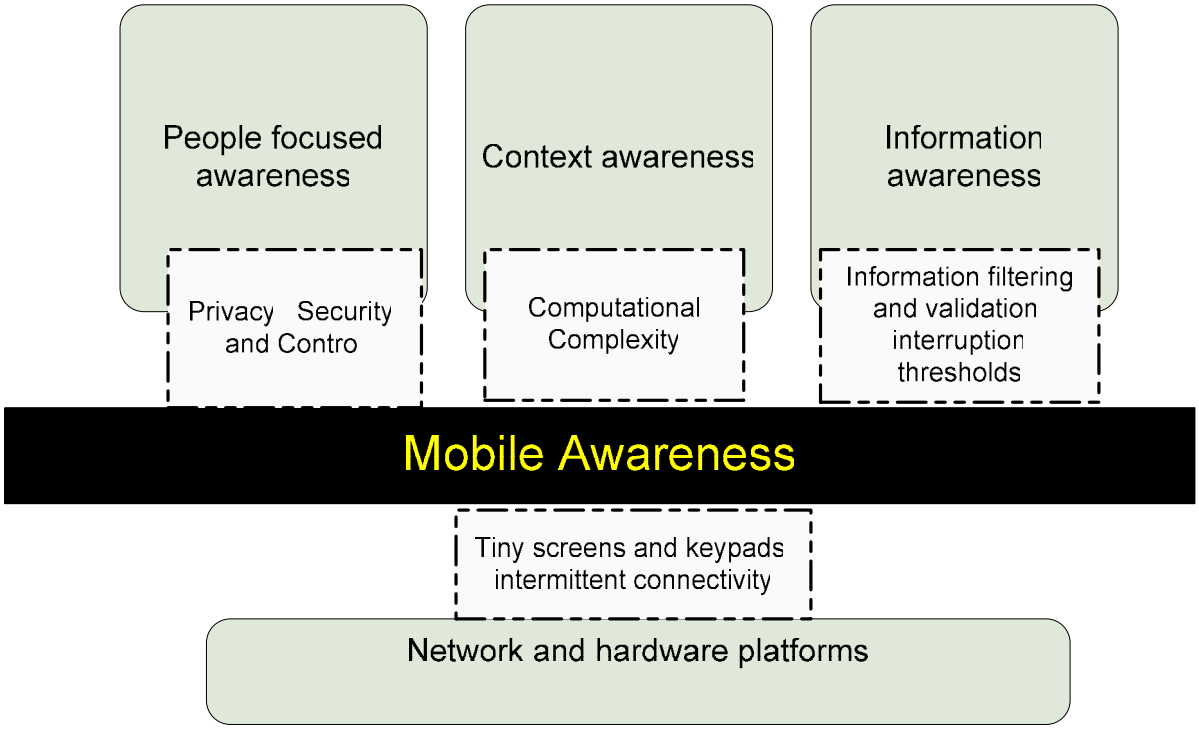

Figure 2: Mobile Awareness Conceptual Framework

PRIVACY CONCERNS: EXPLORATORY RESEARCH

Some preliminary results of research that begins to employ this framework focuses on creating a better understanding of the privacy expectations for location aware systems. Following the model of grounded theory as presented by (Orlikowski, 1993), 65 semi-structured interviews were conducted to understand reactions to plans for a campus wide location aware system. Participants were a cross section of students, faculty, and staff. Privacy concerns were by far the most frequently voiced reservation about use of such a system. The results of those interviews informed the Mobile Awareness Conceptual Framework.

From a student:

> Like your privacy, you don't want anyone to find you. There are times when you just want to be alone. If you can't control the privacy issues, and everyone can see you all the time, then I don't think it is a good idea.

From a student:

> My initial reaction, the first thing I thought about was RFID there. And I heard about some privacy concerns. So the first thing I thought about was hoping there was some way to disable that device, say if you go off campus, because you don't want everyone with an RFID reader viewing that information. Privacy is important, I would like to see some kind of way of implementing, some kind of authorization between the two people, like almost kind of like a buddy list.

From a faculty member:

> I don't think a lot of people would want to put their trust into a computer program. Unless they saw specifically things that were being blocked was something you could control.
>
> My concern would be to what extent this technology, if I sign up for it, will track my use and then tell others that I am not using it to the extent that I should. Now, that may be far fetched, but it may not be. You can see the powers that be saying "Hey look, we want to put everyone …" [so that their location can be tracked] like me saying baloney I want to turn it … on when I want access to people and turn it off when I don't. And I don't want to be held accountable for the fact that I turn it off too often.

While privacy as an individual right has a long history, its definition in the context of information technology is not so clearly defined. For one thing, privacy has no clear boundaries. Type your home phone number into Google, and if your number is listed, a satellite map appears showing the exact address and location of your home. So while yes, your phone number is public information, a satellite image seems like surveillance.

IMPLICATIONS FOR DESIGN

Discovering boundaries is an important part of the design process. While some boundaries, especially technical constraints, can be adapted and extended, others are complex or social in nature and must be respected to obtain user acceptance. Although the widespread adoption of mobile devices holds great promise, there have been to date few awareness mechanisms that have been accepted by a large number of users (Ljungstrand, 2001).

The awareness introduced by mobile devices is continuous, so therefore might be distracting. When people speak via mobile phone, they already communicate context to each other (Ljungstrand, 2001). Introducing context aware applications would be extending an existing application rather than introducing a new one. Mobile awareness is not going to make awareness easier to achieve or more critical – mobility has to matter (Jarvenpaa, 2003).

Even when successful applications are developed, as in the case of the hospital context aware system, boundaries still must be considered. While the doctors who tried the system had no concern about location information being available to their medical colleagues, they explicitly did not want to reveal their location to patients or family members (Bardram and Hansen, 2004).

The Mobile Awareness Conceptual Framework needs to be applied in the design and development of concrete applications in order to be validated. In ongoing research, we are exploring research questions raised by the model as part of the design and implementation of SmartCampus, a location aware community system in development at the New Jersey Institute of Technology.

CONCLUSIONS

The major contribution of this paper is the introduction of a Mobile Awareness Conceptual Framework that explicitly integrates and extends several dimensions of awareness that previously have often been considered separately: people-centered awareness, context awareness, and information awareness. The paper describes promising examples of awareness, and discusses the challenges and constraints developers must address in future applications. This framework makes a contribution to design of mobile social awareness systems by presenting a clear model that integrates both functional requirements and boundaries or constraints (i.e. non-functional requirements) that encompass the major design challenges for mobile social computing.

Challenges and constraints must be acknowledged because creating a system that decides what is or is not important for people moving through changing locations is quite difficult to design and implement successfully. Given the complexity involved in representing context and protecting privacy, it makes sense to build in controls and templates that people can adapt to set the desired levels of awareness, rather than creating a computation model that may or may not be flexible enough to do the job. How people will adapt technology to their situation is often unexpected. For example, office workers dock their PDAs to serve as secondary awareness displays while at their desks (Cadiz et al., 2002). People have made great use of simple robust tools, such as SMS and instant messaging, to coordinate their activities. The final boundary of mobile awareness is the degree to which the user is in charge of what is "pushed" to or "pulled" from their device. It is essential to take into account that mobile awareness applications should offer great flexibility in order to support the variations in privacy constraints required by different users in different contexts.

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