RSMG Progress Report 3

(Thesis Proposal)

Mobile Location-based Awareness and Connectedness

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Abstract

Researchers in context-aware computing aim to solve real-world problems by adapting systems to context. For many years, the HCI research community have explored the possibilities that context-aware computing has to offer, leading to novel applications in the CSCW (Computer-supported Collaborative Work) domain.

This work is tied in with presence research in sociology and psychology, which aim to learn more about how the value of mediated communications technology is affected by the extent of which you feel "present" with the other person(s) while using the system. We search a domain of a lighter form of presence–one that uses ambient forms of emotional communication to make one feel aware and connected with someone.

Location as a geographical coordinate is a relevant dimension of context that can be transformed to a low level indicator of activity. Knowing ones patterns and history of location is machine-detectable and if transformed correctly can be combined with social knowledge, to help people infer activity. However, the mapping between geographical coordinates of one or multiple people into an efficient visualisation that supports sociability has not been previously explored comprehensively in previous research efforts. Additionally, measuring the amount of awareness and connectedness between those with such information has thus far been inadequate.

This document proposes methods that will attain knowledge to fill this gap in research after explaining in detail the issues involved in this syndication of research areas from social psychology, HCI and computer science.

Contents

Chapter 1

Introduction

We start off this proposal with a usage scenario of the technology concerned. The people you know are not physically accessible at all times, and geographical separation have a large impact on the way you communicate over time. You wish to stay connected to that person, but neither have the time or emotional resources to call them regularly. How can technology help you connect to that person, without the problem of feeling you are interrupting them? What is the best way to indicate your interruptability, balancing factors such as effort of updating your status with privacy concerns? In HCI, how do we evaluate such a system in terms of its affective benefits? What inspiration can we draw upon from the literature in sociology and psychology that can aid us?

1.1 Recent Conferences and Workshops

This proposal has been written after a comprehensive effort of considering the social benefits of location based technology, and has been inspired by two conference and two workshop visits.

Alpine CSCL Rendez-vous Workshop: Beyond Mobile Learning

This workshop was held in Villars-sur-Ollon, Switzerland from January 21th till January 26th, 2007. We explored issues with context related to mobile learning, I contributed to discussions of how mobile phones can use context to aid in learning scenarios. I adapted many of the ideas from this workshop into my current research.

Conference on Human Factors in Computing Systems

CHI 2007 was held in San Jos, CA between April 28th till May 3rd, 2007. My contributions were attending the Shared Encounters workshop and presenting a paper

on a previous research project on visualising emotional qualities of a music collection through colour synaesthesia.

The workshop explored questions of spatiality in an urban environment, and helped me discover the potential in mobile contextual computing to aid in urban life, adapting to the social and information world around us. The paper I presented at this primary conference in HCI helped me gain presentation experience with a project primarily based around visualising music–quite a complex notion–in a simple form creating a unique, affective, interactive experience.

The British HCI Group's Annual Conference: HCI 2007

This is an upcoming conference between September 3rd and 7th 2007, where I will be a student volunteer. The annual conference gathers a large amount of HCI researchers and practitioners, as well as industrial representatives, primarily in the UK.

1.2 Research Background

The proposal relates heavily to contextual computing, location-based systems, theories of awareness and connectedness. They will be touched upon briefly in the aforementioned order, and explained in detail in the proceeding chapters. Firstly, we need to define awareness and connectedness in the context of our work.

1.2.1 Awareness and Connectedness

The aim of awareness systems is often simply to stay in touch, i.e. to be reassured about the well being of others, to let others share your experiences, to let someone know youre thinking of him/her, or to create opportunities for synchronous communication. Dey and Guzman define **awareness** as the following: "state of knowing about the environment in which you exist, the surroundings, and the presence and activity of others" [18]. For this type of communication, the informational content of the message is of secondary importance to the emotional, relational content that is being transmitted [37].

By **connectedness**, we mean the degree that a person feels in touch with somebody. From a media richness point of view (the likeliness to real-life experiences), the class of systems concerned is very poor. From a social presence point of view along the richness dimension, they will score low, but the feeling of being close to a person can be strong and highly appealing [37].

1.3 Research Questions

From this brief overview of the research domain we formulate the research questions. An elaboration will be made in Chapter 7 (Evaluating Success of Proposed Research).

RQ1: What is the favoured visualisation type for location information used for the social utility of being aware and connected?

RQ2: Can we formulate an effective measure and devise a relevant evaluation technique for connectedness and awareness?

RQ3: Can location information designed into a visualisation increase a sense of awareness and connectedness, and increase group identity?

RQ4: How does the representation of location and activity affect the feelings of social presence and awareness/connectedness?

1.4 Importance of Research

HCI research is essentially interdisciplinary, and often involves drawing in, synthesising and building on research from social sciences, psychology and design. Combining knowledge from other fields and applying it to computer science is an integral aspect of HCI research, and advances in a multidisciplinary way can be holistically more significant than each singular advance within one particular field. Conventional research imposes great value on journal publications, but the difference in HCI is that conferences can create a similar impact level. Conferences offer outlets for researchers to reach out to an international and multidisciplinary audience, which offers particular value in this domain of work. This is reflected on by the hands-on, experimental, human-based nature of the this proposal, and is something to bear in mind while assessing the methodologies and research targets laid out.

The contribution to the field is threefold. Firstly, the comparison of social visualisations and the linking to social context is previously unexplored. The results of the work will offer designers guidelines to consider when designing systems that make use of social visualisations in real-world scenarios, and heuristics of how to use location effectively, ensuring scalability of human comprehension whilst alleviating privacy concerns.

Secondly, this research will aim to demonstrate ways of applying theoretical social science and psychology into practical systems, potentially leading to the advent of new branches of practical systems. If the experimental methods are successful, practitioners will be given methods to identify flaws and conceptual difficulties in their location-based systems, leading to designs that can reach more people. An advance

within this domain of low-bandwidth communications systems may significantly impact the role of technology in supporting social communication in the future.

Thirdly, a longitudinal study on effects of location-based mediated communication with large groups should contribute to designers at mobile handset and software companies, who with current designs are having trouble reaching critical mass. Formulating a comprehensive measure of awareness and connectedness with lightweight communications systems will help move towards a better understanding of evaluating experience-focused HCI [42].

1.5 Structure of Proposal

The remainder of this proposal is as follows. Section 2 introduces the theoretical knowledge essential to understanding this domain of work regarding transfer of social meaning over a mediated channel of communication. A discussion is made of the concept of connectedness, comparing two distinct types of supporting systems.

In Section 3 we discuss location-based systems in detail, identifying the characteristics, technologies behind location acquisition, and discuss the inadequacies of commercial systems already deployed. We talk about how location can may be visualised in a way to support intimacy, awareness and connectedness, and the privacy implications inevitably involved. In Section 4, guidelines are drawn from the literature forming the basis of discussion on design.

Section 5 examines popular research methods in the domain, such as Wizard-of-Oz and reversal design. We identify an essential problem in this area of research– the absence of adequate theoretical grounding in the evaluation of social awareness systems. Sections 6, 7 and 8 lay out the statement of proposed research, how we plan to evaluate the success of this research in the context of the research questions and the timetable for the next two years, respectively.

Chapter 2

Social Awareness and Connectedness

2.1 Overview

In this section, we discuss in more detail the theoretical notions of presence in the context of mediated communication, establish an understanding of social presence (the extent of feeling that you are with someone), and give a literature review of emotional awareness systems and techniques of measuring awareness and connectedness.

2.2 Groups

When we talk about technologically aiding social relationships we must appreciate the difference between types of groups. Technology plays its part differently depending on the nature of the relationship. Primary and secondary groups are one key separation; primary groups being close-knit friends, family, etc., and secondary being larger, more formally organised groups such as a student society [36]. It has been shown that people desire more connections within primary groups, especially when its members are geographically separated.

We also identify group attraction–a member's desire to identify with and be an accepted member of a group. The degree of group attraction felt effects how the member contributes to the group's outcomes, and high feelings of group attractions tend to result in wanting to attend gatherings more regularly. Communications technology can play a part in increasing group attraction, and hence increase the growth of groups.

2.3 Mediated Communication

Time, distance and emotional bandwidth are constraints imposed on people stopping them from keeping in close contact with friends. As relationships become separated by distance, the regularity of communication decreases: "out of sight, out of mind" said one participant of a field study to determine communication breakdowns between people moving apart; they were formerly close friends with whom he has now lost touch [59]. The assertion comes forth that the degree of interdependence between two people is a determinant of the closeness of their relationship. Mediated communication offers a way to bridge these physical gaps, but the solution is not just to increase the bandwidth available to increase your feeling of "being there". We later associate this with the notion of copresence, and see how design approaches must be balanced, carefully taking into account factors such as emotional bandwidth, size of groups and nature of the people involved.

Teenagers love to send text messages, and 20% of messages sent are general "chat about nothing" [28]. IM (instant messaging) is an extremely important medium for teenagers; in a a study by Grinter and Palen, findings showed that teenagers felt disconnected with their friends if they did not use instant messaging enough [29] [30]. Focus groups showed that people use IM for awareness, not just for ordinary communication [18]. Media richness theory might predict that people would prefer using a telephone over IM, but this is shown to be untrue for teenagers under peer-pressure and the requirement to feel part of a group. Insights into how teenagers feel may inform us of how communications technologies should be designed for the future. Social networking websites like Facebook enable people to stay hyper-aware [49] of large groups of friends, and the unstoppable trend seems to point in the direction of "more is better". People want to be more aware of their social surroundings; but weather this is more about the self-gratifying feeling of being accepted, noticed and fitting in is an interesting issue for psychologists, and therefore researchers in HCI.

2.3.1 Presence

Overview

Presence is a "psychological state in which virtual objects are experienced as actual objects in either sensory or nonsensory ways" [47]. This term can be extended to telepresence within the context of mediated communication, which was first coined by Marvin Minsky in 1980 [53]. Minsky defined telepresence as follows:

> "[telepresence is] the phenomenon that a human operator develops a sense of being physically present at a remote location through interaction with the systems human interface, i.e. through the users actions and the subsequent perceptual feedback he/she receives via the appropriate teleoperation"

It is commonly believed that the efficiency of telecommunication is increased together with the feeling of telepresence [9], as with face-to-face communication a full array of emotions are visually accessible, making it easy to create a sense of shared context. Hence, in CSCW (computer supported cooperative work), high bandwidth mediated communications systems was commonly believed to be the favoured way to improve communication between groups of workers [9]. With the growth in realism of presence technologies such as video conferencing, there are associated claims of improved social communication, collaboration, social presence and performance, but there is very little evidence to support this. For example, the British Video Conference Association frequently quotes Stendahl, "the quality of life is about the quality of meeting", the quality of mediated meetings have been inadequately measured [8]; there is a distinct lack knowledge of the parameters that we can use to effectively measure social communication. This is one of the problems this thesis proposal attempts to find ways to address.

Social Presence

Social presence is slightly different to telepresence, and focuses on the social aspects of communication. Short *et al.* invented the term, defining it as characterising "how well a subjective experience emulates face-to-face contact... the sensation of being together". From this theory we can draw in inspiration from the measurements they take in the field, and use it as theoretical grounding for measuring social connectness. Huijnen *et al.* note that it is unknown whether the interpersonal needs are satisfied by social presence, and that it is desirable [36]. Most social presence research has involved the assumption that the communication is the primary activity in which users are engaged. Huijnen finds in an experiment where two geographically separated groups watch the same football match, with ambiently projected video of the other group shown on the wall, that subjects feel more part of the group. This result is significant as it means that **social presence can be felt without a direct focus on the communications medium itself**.

Erickson *et al.* based a project called Babble [23] on the recognition of the importance of knowing who is around you. They extended ordinary message boards with indications of usage trails; that is, a visualisation of who has accessed the messages. This was part of a belief that systems should include "translucent social windows" that reveal minimal information; but enough to let users use social knowledge and common sense to make reasonable deductions that help them with their understanding and decision making [22]. Social presence can tie in with social navigation, as it can affect decisions you make on what to direct your attention at.

Media capacity theories such as social presence and media richness theory are based on the premise that different communications medium carry different interpersonal cues. In face-to-face communication, non-verbal cues such as facial expressions carry primarily affective information. When we move towards the less rich mediums such as text, the representations are not so visually affective, but still so depending on the words used. Through hundreds of years of language development, we have shaped

as a culture the affective meaning of the expressive language. Similarly, imitative visuals such as avatars in virtual worlds can convey social presence, even though it is known that the representations can be false, or playful. This opens up the question–**how affective can representations of social activity and locations of people be?** How do we harness this to bring geographically separated people feel more connected and aware of each other?

In the next section, we discuss how researchers have explored this idea in emotional awareness devices for the home.

2.3.2 Emotional Awareness Systems

A class mediated communications systems, often labelled lightweight communications systems, emotional awareness system or connectedness oriented systems [46] aim to make use a combination of network technology (usually the Internet) and fixed (furniture) or unfixed (mobile) visualisations with the aim of making these connections easier to keep. With the widespread availability of broadband communications networks in developed countries; the ability to communicate instantly with people regardless of geographical location is now an expected provision. IM (instant messenger) systems and e-mail are inherently episodic in nature–and instant replies are not expected [30]. This contrasts with high-bandwidth, rich-media systems such as the telephone, VOIP and video conferencing, where full attention is required (and expected).

Twitter[1], Facebook[2] use content aggregation to make others more aware of a user's activities. Similar to the principle behind aggregated RSS feeds, status information is consolidated into list form (usually ordered by date), and mechanisms are available for users to subscribe to such information. The primary filtering method is the social network, meaning that hyper-coordination [49, 24], the constant "being in touch with" a social group is experienced provided users update the system regularly and accurately. Hyper-coordination is a phenomenon within social circles where individuals select certain social bonds to concentrate on and keep in constant touch; hence this is only possible between a very limited few people in a person's social web due to limited emotional bandwidth. Arguments against this method of maintaining awareness of friends include the fact that **users cannot be expected to update their status constantly and in sufficient detail**. Facebook works because its mass adoption and success in harnessing the exponential, recommendation and social pressure-led aspects of the network effect means that people spend a lot of time on the system, relying on it to serve many parts of their social needs [1].

[1]Twitter–Social Story Aggregation: `http://www.twitter.com/`
[2]Facebook Social Utility: `http://www.facebook.com/`

2.3.3 Peripheral Approaches

Many people do not have the time to constantly monitor social networking websites. As such, we can design systems that use low-bandwidth and sometimes mimetic or abstract approaches to communicating status information; that can be monitored in the peripheral. The characteristics of these systems are clearly asymmetric to "instant communication" methods, which are designed for rich communication between a few individuals, whereas emotional awareness systems have the potential to communicate between many.

Ambient virtual co-presence [40] is a term used to describe maintaining a continuous social awareness with others. Some systems use "buddy lists" to convey awareness information between people. Examples of these include Active Badge [69], StudioBRIDGE [72] in addition to most IM programs that have basic status information sharing features (e.g. away or busy statuses). The basic idea is that availability information can easily be updated and shared, providing that the required contacts are known to the system.

Röcker and Etter shows examples of awareness displays [56] that make use of explicit visualisation techniques such as video, text or pictures but are abandoned after the demonstration period [60]. It is argued that although they provide easier communication, they fail due to privacy violations and "recurring interruptions". They sought for a more *expressive* way to communicate presence through the displays that are not tied to an "unintuitive mapping between input and output". Social Radio was designed, consisting of several wirelessly networked, music-playing artefacts and an underlying multi-user infrastructure [60]. When the artefacts are oriented in a certain way, no music is transmitted or received, indicating a "not available" status and reducing the chance for interruption. This sub-symbolic approach to mediating awareness and emotions is similar to Ståhl and Höök's augmentation of text messages with a sub-symbolic colour and pattern encoding of mood, which was found to be effective in transferring emotional information using a low-level representation [65].

Marmasse in his Ph. D. thesis on wearable awareness devices, puts it as follows:

> "The strength of the stimulus is not necessarily a function of the channel bandwidth or the content of the message, but rather what it triggers in the recipient and/or sender"

Work by Joseph Kaye illustrates an example of a mimetic method of communication, where just one bit at a time (red or blue) is transferred–its interpretation is customisable and arbitrary [43]. Kaye found that even one bit information can foster increased feelings of awareness between two people in a long-distance relationship. The Motion Presence application allowed family and close friends to view one of two activity statuses: moving or not moving. This simplification allowed participants to **confirm thoughts about existing locations and activities of others**, and few privacy concerns were expressed [7]. Similarly, work-in-progress by Tsujita *et*

al. demonstrate how everyday pieces of furniture can express a feeling of copresence by synchronising its physical state in two completely separate locations [68].

Abstract representations designed to be viewed in the peripheral include Babble [23] which provides additional message history and awareness of who is interested in the thread, visualising additional contextual cues. Other projects, Buddy Beads [44] and Nokia's SLAM [71] have group members wear a bracelet, allowing them to communicate via symbolic cues such as L.E.D lighting patterns/vibrations. WatchMe [51] is a personal communicator in wristwatch form, and tracks a user's status as a function of location (via GPS), acceleration and speech activity. An iconic representation of a face is the resulting visualisation, and takes its inspiration directly from the popular emoticon concept. Looking towards projects on the web, Me.dium[3] places its importance on people, with the motivation that "people around you changes everything". Using ideas not too dissimilar to Erickson's social translucence concept, this web browser plug-in uses proprietary algorithms to show you people looking at similar pages to you. The core concept is that co-matching trails means similar tasks are being performed by those people. The plug-in includes a sidebar that shows a radar-like visualisation of avatars of people browsing similar pages, and allows chatting to them in a message board created specifically for your browsing trail context. An example of its use is the following—imagine you are searching for a home cinema system, using websites ranging from manufacturer websites to price comparison services. Knowing about other people searching for similar things has the potential to widen your search without having to do any additional work.

2.4 Intimacy

Following a review and analysis of published definitions, Moss [55] proposed a definition of intimacy:

> "intimacy in enduring romantic relationships is determined by the level of commitment and positive affective, cognitive, and physical closeness one experiences with a partner in reciprocol (although not necessarily symmetrical) relationship".

Gift giving is one way that we renew and refine existing relationships, and "reciprocal giving makes possible a shared understanding of the relationship as one that is founded upon mutual regard and cooperation" [13]. Evidence of this can be found during Christmas, where gifts are mutually exchanged for reasons of relationship building, as both parties would be worse off than if they had held onto their monetary resources and used them to satisfy their own wants. Mediated communication also shows this - when we feel the need to send a message back when we receive them, or a message left on our social networking profile prompts us to return the favour.

[3]Me.dium–"being around people means everything": `http://www.me.dium.com/`

This giving and taking is an important part of intimacy, which should be held as an important factor in the design process of systems supporting intimacy.

We can draw upon this definition and see how it relates to our theories of connectedness between people, whether intimate or not. The following constituent parts can be drawn from the formal definition: commitment, affective intimacy, cognitive intimacy, physical intimacy and mutuality.

Projects have been undertaken to explore the concept of intimacy with the design and evaluation of systems that use sub-symbolic representations to communicate intimate gestures [71, 45, 43, 65]. The sub-symbolic nature relies on mutual understanding between users of the system so that **relevant awareness information can be inferred, which is contrasting with high bandwidth mediated communication systems**.

2.5 Evaluation

Table 2.1 summarises the evaluation techniques used in key projects involving mediated affective communication. The evaluation of the emotional affects of these types of systems (experience-focused) differ from the evaluation of the interfaces themselves (task-focused), and has been a challenging problem in HCI [42]. This point is reflected in Isbister and Höök's workshop on innovative methods of measuring affective technologies [39] in April 2005, and is relevant to experience-focused HCI. More recent projects have taken to multiple evaluation techniques to cover the spread of issues at hand–social, cultural, psychological, ergonomical as well as technical. By far the most common method, and in some ways the easiest for experience-focused HCI is interviews. Self-logging has been an important data collecting mechanism, and allows subjects to express their thoughts wherever and whenever they think of them.

Peripheral displays are notoriously difficult to evaluate, as most evaluation techniques draw attention to a display, making it no longer peripheral [18]. In Marmasse's WatchMe project he placed an importance on evaluating all parts of system, but then simply does a lab based usability study, with reporting on quantitative responses. This could be due to the difficulty of evaluating such systems.

A more comprehensive attempt to measure awareness was made in a recent study by Dey and Guzman [18], where a combination of quantitative and qualitative measures were used in awareness artifacts (picture frames) that broadcasts status icons between intimate couples. Their hypotheses were the following:

- H1: Presence Displays support better awareness of presence information than traditional GUI-based presence displays.

	Project	Published	Evaluators	Videotape	Logs	Interviews	Survey	Electronic Feedback	Self Logging
[9]	Bly et al.	1993	20–30	√					
[23]	Erickson et al.	1999	~5–20			√			
[27]	Greenberg and Rounding	2001	Unknown						
[54]	Mitsuoka et al.	2001	15			√			
[66]	ConNexus et al.	2001	3		√	√			
[73]	Hindus	2001	Internal Only			√			
[38]	Isaacs et al.	2002	32 (28)	√		√		√	
[73]	Zhao and Stasko	2002	60				√		
[65]	Ståhl and Höök	2005	12	√		√			
[43]	Kaye et al.	2005	10		√	√	√		√
[18]	Dey and Guzman	2006	9					√	

Table 2.1: Evaluation Techniques Used in Key Projects

- H2: Correspondingly, Presence Displays help the user to feel more connected to the remote friend or loved one whose activity is being displayed.

These questions relate closely to the research questions in this proposal, but instead of focusing on mobile settings and location, they focus on awareness in the home. The used an experience sampling method to gain a mixture of quantitative responses, e.g. "how many status messages have you observed since last time" and "what is the loved one's current state?". Scores are recorded over time, with the system and without. Qualitative measures ask "how aware are you of your loved one's status?" and "how connected do you feel right now?". To ensure the user is not simply reading off values as the questions are given, the authors use an experience sampling method which shows pop-up messages on the user's mobile screen at random times. Each evening, users were asked to respond to an electronic survey asking more general questions about connectedness.

Dey and Guzman's hypotheses were confirmed, but were **not statistically significant due to small numbers of testers**. Still evident in such recent work, there has yet to be confirmations of the real-world utility of awareness systems in an extended longitudinal study. This is representative of other work done [65, 43, 66].

2.6 Chapter Summary

This section has been lengthy, but has been an essential overview of social presence theory, how this relates to connectedness oriented communication. We have described ambient virtual copresence, examples of awareness appliances, and discussed how the intimacy of relationships can be supported by communications systems. A key point here is the aspect of visualisation, as a **careful balance needs to be made between representation granularity and accuracy**, as it directly effects privacy issues.

The next chapter is on location in HCI research, as we talk about using location as a factor of mediating awareness and supporting the task of geographically separated individuals keeping in touch–ambiently.

Chapter 3

Location in HCI Research

3.1 What Makes Location Interesting?

Location is an important part of social discourse, and is relevant in mediated communication [64], so automatic location sensing combined with a communications interface can be convenient in communication. Grinter *et al.* found that teenagers used text messages to "arrange and adjust times to talk, coordinate with friends and family, and chat"; at least two of those involve location. Location is heavily tied in with context, and so can help in communicating interruptability and support social rendezvousing [16]. Previous projects have given design guidelines that supporting systems should not infer high level information, but visualise low-level information that takes advantage of **our natural ability to infer from knowledge of past context and social knowledge** [43] [11]. There are sensitive privacy issues related to giving away location information, but the granularity of disclosure can be controlled, which can alleviate some concerns. Furthermore, examining social software tells us that people are willing to let go of some of their concerns in return for some kind of social reward, and there is not always a match between perceived privacy issues and actual behaviour on these sites [1].

Location information can be mined and adapted in different views. We can infer activity from movement from location to location and recording the history of locations of an individual can tell us how "interesting" a person is, in the context of system built for social needs.

3.1.1 Location in Social Awareness Systems

We believe that location plays a key role in communicating social information to help geographically separated people feel closer. There are some aspects of location as part of a communications visualisation that make it interesting:

Activity Inference: We can infer activity from movement from place to place

(are you doing anything interesting?

High Level Abstractions: People can extract high level information from geospatial positions (are you likely to be busy?)

Social Navigation: Socially dense places may be more interesting to explore, especially if the people present are friends

Filtering: Locations are trivial to filter and conceptually sound

Group Visualisations: We have the capability to visualise groups of locations at one time

Ease of Granularity Adaptation: We can soften location granularity easily, to adapt to privacy concerns (blurring, uncertainty)

Context Adaptation: We can enable context-dependent modes of interaction

Prediction: Spatial analysis with history can be used to predict location

Playful Visualisations: Location, visualised properly, can be a playful representation of social presence

3.2 Context-aware Computing

Earlier systems in CSCW (Computer-Supported Co-operative Work) research used location tracking as a dimension of context to facilitate serendipitous interaction in the workspace. Researchers at Olivetti Research Ltd. and Xerox PARC Laboratory pioneered the context-aware computing area with Active Badge [69] (from [14]), and ideas have been formulated on how to use contextual data to improve human life in Mark Weiser's discussions on ubiquitous computing [70]. There are many misconceptions of what the word context means, and while many researchers have attempted to define context in their own work, they find it hard to elucidate. Dey [17] gives an overview, and gives their resulting definition:

> "Context is any information that can be used to characterise the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves."

The key point here is that the computer system has the ability to disambiguate and customise the experience depending on context. This is a real problem with clear goals, and any further understanding of how to handle context in HCI will contribute greatly to practical applications.

3.2.1 Gaming

The concept of location is just as important in the absence of physicality–in virtual worlds. Bungie Studios, creator of the Halo first-person shooter series on Microsoft's gaming console the Xbox and its successor, the Xbox 360, are currently undertaking the task of improving on the hugely successful Halo 2[1]. Microsoft's state-of-the art testing lab records every last movement, button press and event while professional game testers run through the game. Monsters and puzzles deemed too difficult due to repeated deaths are optimised, and sections of the level easy to get lost are redesigned to guide the player through. Bungie have used classic visualisation techniques by designing tools that show heat maps–areas of levels moved over by the player over time–that tell them exactly where the events happen. Location is one of the core aspects of game play, and as gaming often attempts to replicate reality as closely as possible, inspires the possibility of mining actual location data for other uses. With location data, urban designers and town planners can see which areas are most popular to optimise the layout of new developments, road designers can look at how best to improve traffic flow, and we as HCI researchers can explore the social meaning of inhabitants in spaces through visualisations of their location through sensor technologies [4] [58] [20].

Steve Benford has discovered that location-based gaming can introduce a new "spatiality of thought". In his game, "Can You See Me Now?" [6], players with GPS-equipped PDAs hunt the city for players who manipulate their geo-spatial position using a separate interface on the web. He discovered through mining the location data of players that strategies were being deployed that take advantage of "GPS shadows", caused by buildings bouncing electromagnetic signals which affect the accuracy of the positioning device. The strategies allowed players to appear to "jump" across locations. Benford writes that "GPS line-of-sight is thoroughly a physical phenomena" and that what **the layering of the physical and virtual provides is a new way to think about space–"a new spatiality of access, presence, and interaction"**.

3.2.2 On Place and Space

Being people that inhabit space, when we talk about location we are talking about places and spaces. The very definition of space lies in physicality, and not on any knowledge associated with it, whereas place is defined by what people understand to be the affordances and uses of a particular space [31]. Place is different to space, in that it is about persistent social meaning, and how that meaning is defined over the course of interaction within the space. The relationship between space and place is created only after it is used, resulting in the place being layered over a space. Recent discussions by Dourish discuss how space is just as important and can be every bit as social as place; the reason being that space is a social product too, as

[1] `http://www.wired.com/gaming/virtualworlds/magazine/15-09/ff_halo`

"when we describe spaces they are products of social practise, for example in land management, commercial exchange, cartography and navigation" [19].

Virtual spaces carry the same affordances as real ones, and we can learn from MMORPGs (massively multiplayer online role play games) like SecondLife[2] that try to replicate the social, physical and economical world that we see around us. This bridge between the virtual and physical can be illustrated in terms of gaming, such as in Halo, a popular first person shooter. Geographically separated players, represented in different ways such as dots on a radar, use microphones to coordinate strategic movements. These games are incredibly immersive, and the better players maintain spatial awareness within the environment as they would in reality. Ignoring spatial cues such as the radar have significant consequences not just on the timing of strategies, but the whole game. We argue that the effect also happens in the real world, and **we should make use of these spatial cues in awareness systems to significant effect**.

Brightkite[3] is a new startup company envisioning their location-based message streaming concept. Their idea is logical: if Twitter, an social activity notification system, answers the question "what you are doing" and Facebook answers the question "who are your friends?", Placestreaming answers the simple question "where are you?". Placestreaming puts the focus on places, and the things we do in them shared in a stream pushed to our mobile handsets or other electronic methods. Development information is being kept sparse, but the attention the idea is attracting is an indication where social software is heading, and its relation to this proposal warrants a mention here.

3.3 Acquiring Location

Acquiring location is the core aspect of detecting context, and the characteristics that come with the technologies limit the accuracy, cost and scope of systems built using it. For example, some methods detect the relative physical proximity between sensors, while others detect absolute locations. Table 3.1 is a comprehensive listing of the key commercial and research technologies used for tracking locations (adapted from [33]). Others include motion detecting technology and camera-based methods, but were omitted due to the nature of this application on mediating intimacy using ambient methods. Furthermore, technological goals are becoming less important, and instead a shift has been made towards solving sociological problems in terms of mediated communications use and privacy. We touch upon a few of the location acquisition methods in detail that bear practical relevance to our research.

In the early exploratory phases of context aware computing, **tests were typically carried out in controlled indoor environments**. Active Badge [69] required a

[2] A virtual world where scripters and 3D modellers can infinitely extend its features. Objects are often sold in online auctions for significant amounts of money

[3] `http://blog.brightkite.com/2007/07/08/its-all-about-placestreaming/`

Technology	Technique	Physical	Symbolic	Absolute	Relative	LLC	Recognition	Accuracy and Precision	Scale	Cost	Limitations
GPS	Radio time–of–flight triangulation	√		√		√		1–5 meters (95–99%)	24 satellites worldwide	Expensive infrastructure, 30 receivers	Not indoors
Active Badges	Diffuse infrared cellular proximity		√	√			√	Room size	1 base per room, badge per base per 10 sec	Administration costs, cheap tags and bases	Sunlight and fluorescent light interfere with IR
Active Bats	Ultrasound time–of–flight triangulation	√		√			√	9cm (95%)	1 base per 10 sq m, 25 computations per room per sec	Administration costs, cheap tags and sensors	Required ceiling sensor grid
MotionStar	Scene analysis, lateration	√		√			√	1mm, 1ms, 0.1° (nearly 100%)	Controller per scene, 108 sensors per scene	Controlled scenes, expensive hardware	Control unit tether, precise installation
VHF Omni–directional Range	Angulation	√		√		√		1° radial (= 100%)	Several transmitters per metropolitan area	Expensive infrastructure, inexpensive aircraft receivers	30–140 nautical miles, line of sight
Cricket	Proximity, triangulation		√	√	√	√		4 x 4 ft. regions (= 100%)	≈ 1 beacon per sq ft.	$10 beacons and receivers	No central management receiver computation
MSR RADAR	802.11 RF scene analysis and triangulation	√		√			√	3–4.3 meters (50%)	3 bases per floor	802.11 network installation, ≈ $50 wireless NICs	Wireless NICs required, dense network nodes
PinPoint 3D–iD	RF triangulation	√		√			√	1–3 meters	Several bases per building	Infrastructure, installation, expensive hardware	Proprietary, 802.11 interference
Avalanche Transceivers	Radio signal strength proximity	√			√			Variable, 60–80 meter range	1 transceiver per person	≈ $200 per transceiver	Short radio range, unwanted signal attenuation
Easy Living	Vision, triangulation		√	√			√	Variable	3 cameras per small room	Processing power, installation cameras	Ubiquitous public cameras
Smart Floor	Physical contact proximity	√		√			√	Spacing of pressure sensors (100%)	Complete sensor grid per floor	Installation of sensor grid, creation of football training dataset	Recognition may not scale to large populations
Automatic ID Systems	Proximity		√	√	√		√	Range of sensing phenomenon (RFID typically <1m)	Sensor per location	Installation, variable hardware costs	Must know sensor locations
Wireless Andrew	802.11 proximity		√	√			√	802.11 cell size (= approx. 100 m indoor, 1 km free space)	Many bases per campus	802.11 deployment , ≈ $100 wireless NICs	Wireless NICs required, RF cell geometries
E911	Triangulation	√		√			√	150–300 m (95%)	Density of cellular structure	Cell infrastructure	Needs cell coverage
SpotON	Ad hoc triangulation	√			√		√	Cluster size dependent	Cluster at least 2 tags	$30 per tag, no infrastructure	Attenuation less accurate than time–of–flight

Table 3.1: Commercial and Research Methods of Detecting Location

sensor base in every room, Active Bats [32] an ultrasound-based sensor infrastructure and Smart Floor [57] a grid of pressure sensors. These methods were found to be highly effective in controlled indoor environments, but they were never designed to be used outdoors or as part of a larger system. Technological developments mean that mobile phone handsets are ubiquitous. As such, experiments on location-based systems are now much easier to carry out.

3.3.1 GPS

Taking into account cost, accuracy and ease of integration, GPS (Global Positioning System) is by far the most favourable system for outdoor use. It offers 1–5 meter accuracy with a reliability of 95–99%, and as it is based on low-orbit satellite time-of-flight triangulation, the ≈£30 units work worldwide without the prerequisite of any changes of infrastructure.

Mobile handset manufacturers are pushing GPS as a ubiquitous platform for location tracking by incorporating the technology into its modern handsets. For example, Nokia's N95 handset takes advantage of cell tower triangulation, which, using a database of expected satellite positions, is capable of obtaining a location fix within seconds compared to minute. By offloading the bulk of the computational work to central servers with additional sensor sources, This technique, named Assisted GPS (A-GPS), obtains more accurate locations by factoring in ionospheric conditions. Hence, the main disadvantage is GPS occlusion (also called urban canyoning), where shadows of GPS signals in urban environments affect accuracy and the ability to obtain a fix.

CSR, a Cambridge-based company acquired Cambridge Positioning Systems Ltd and NordNav Technologies aiming for a $1 per unit cost of GPS-based positioning in mobile phones and other portable devices. NordNav Technologies' software GPS solution reduces hardware footprint by 80%, and Positioning Systems Ltd uses cellular towers to reduce location fix time to less than 3 seconds, meaning that power requirements reduce by a factor of 10.

3.3.2 E-911

The FCC required US cellphone networks to give the emergency services the ability to locate any mobile handset within 300 meters and 150 meters for handset-based tracking (FCC 94-102). Network operators can now offer location-based services with no change to handsets. Loopt[4], set up by a Stanford graduate, is a friend-finder location-based service, but due to nature of the technology behind location tracking, is currently only available on Sprint and Boost Mobile in the US. Similar deals with network operators are currently being made by Socialight[5] [52] to offer

[4]Loopt Location-based Service: `https://www.loopt.com/`

[5]Socialight Location-based Sticky-notes: `http://socialight.com/`

location-based information services in the UK.

3.3.3 802.11-based Systems

802.11 (Wi-Fi) based solutions obtain similarly accurate locations to GPS, with its main advantage being indoor functionality. The drawbacks are the requirement for the ubiquity of 802.11 access points in the area, calibration and equipment in the device being tracked. Hence, such a technique does not scale up to large areas. Examples of this is Microsoft's RADAR prototype [3] and and Ekahau, Inc, who develops a WiFi signal-based positioning solution designed for healthcare, manufacturing and other industries[6].

3.3.4 WiFi BSSIDs + Community Databases

Meetro and Plazes[7] also use 802.11 but instead of triangulating signal strengths, they approximate location by mapping the BSSIDs of visible wireless routers onto a database maintained by the community. A BSSID is a globally unique 48-bit identifier, the Basic Service Set Identifier, that is in the same format as an IEEE 802 MAC address. The Place Lab initiative also proposes this method to be used, recognising the trend of increasing coverage of 802.11 signals, especially in urban areas [62]. This method works well in situations where a user has a list of frequently visited places, that are geographically separated so their WiFi coverage does not overlap. An integrity problem arises when routers are physically moved, as the link between the place and the BSSID no longer is accurate.

Commercially, there are efforts of companies such as Skyhook mapping urban areas in the US. Skyhook claim to have covered areas where 70% of the US population live by hiring dedicated "Wardrivers", equipped with GPS-enabled PDAs that scan for WiFi signals. Loki uses the Skyhook database in a browser toolbar. Loki-enabled websites use location information provided by the toolbar software to modify pages relevant to the user's location.

3.4 Working With Location

It has become apparent that depending on the design of the system in mind, variations in accuracy and cost have to be considered, but hybrid systems may play a large part in solving part of the dilemma [10]. For example, Place Lab uses GSM cell towers and fixed bluetooth devices in combination with 802.11 access points to help in less WiFi-populated areas, as while many built-up cities have near perfect coverage, rural area coverage is close to zero.

[6]Ekahau WiFi Positioning System: `http://www.ekahau.com/`
[7]Plazes: Location-based Sticky-notes: `http://www.plazes.com/`

Mobile phones are becoming ubiquitous so have become an ideal platform for testing functional prototypes of location-aware systems. Readily available Bluetooth GPS modules can track locations, and the latest chipsets can obtain a fix within seconds. The advantage of this method is that test subjects can use their own mobile phone, thereby creating more realistic use scenarios that cannot be replicated in controlled lab experiments.

When working with location one of the most important considerations must be made with regards to representation (visualisation), filtering and privacy. From here, we discuss how uncertainty is an important dimension of representation, and look into how existing research has tackled similar visualisation problems.

3.4.1 Privacy

Privacy in location-based systems is heavily related to the granularity of representation in terms of what others can infer from it, and access control. Work in privacy in such systems is an ongoing research effort, for example an asymmetry in social networking user's thoughts on privacy of disclosure of personal information compared to what they actually disclose was found [1]. **A careful balance is to be found between social utility and privacy**.

Interestingly, Consolvo *et al.* found that users share less detailed location information not because they are concerned with privacy, but they thought that the requester would find it more useful. For example, telling someone which state you are in is more useful than an exact city, when you have been travelling across three states in the past two days [15]. The relationship between location and perceived reason for request is important in this respect. There are certain situations when we want our whereabouts to be hidden or purposefully made ambiguous [2], for example to prevent errand request on route back from work, or when you consider it to be your "private time" or "me time". Of course, sometimes we are at places we do not want others to know about. Therefore, the relation between current activity is related to needs for privacy control. Isaacs *et al.* argue that privacy features are important so they know they can control privacy, even though they rarely do [38].

From this brief overview of privacy in location based systems, we argue that an approach of communicating the minimum amount whilst maintaining the utility of the system is important.

3.4.2 Uncertainty

Girardin discusses the implications of uncertainty in location-aware computing, arguing that uncertainty of location is an important factor to design for, and that there is currently an inadequate understanding of this socio-technical gap [26]. There is a conceptual understanding of the limitations of location technology that helps create

a mental map of how systems work, therefore building indicators into the user interfaces are important. It has been shown that giving users uncertainty information increases performance in a memory task, but contradictory results have been shown that users spend slightly more time and create more errors when uncertainty in the system is visualised.

It is argued that the reason for this is that the researchers failed to consider the inherently uncertain aspects of location, and fall into the trap of considering uncertainty and context as a whole. Benford *et al.* suggest that designers have five different ways of dealing with uncertainty: remove it, hide it, manage it, reveal it, and exploit it [5]. In this light, Chalmers and Galani suggest that we design in the system ways of revealing limitations that support interactions that take advantage of them [12].

3.4.3 Visualisation

In the literature, both spatial and non-spatial visualisations have been used to convey location-based information. Spatial methods include maps or semantic representations that use spatial connotations [50, 48]; whereas non-spatial methods include distance-ordered lists, derived indicators transforming location into sub-symbolic or ambient representations such as light patterns or manipulating physical orientations of everyday furniture [68, 35].

Maps are the most straightforward way of presenting location-based information for the user. However, the more information the map view contains, the more difficult it is to present an overview of the information and to support easy access to information the user is interested in. Lemmelä and Korhonen created a visualisation of user-submitted location-based content that indicated the density of postings as varying shades of colour and intensity based on overlapping spheres of influence and their strengths, using the notion "spheres of influence" [48], see Figure 3.1. However, map-based methods are difficult to work with, as there are problems with map orientation when used in a mobile setting, ambiguities of scale and representation density. Compromises have to be made, especially on a mobile screen.

Figure 3.1: Map-based Visualisation Using Heat Maps

Maps with fine amounts of detail is not always needed, and can often confuse users depending on the nature of the task. A visualisation must be simple enough to understand, and **it is important to use a natural mapping**. When exact locations are not required, for example to answer questions such as "who is within close proximity to me and available for lunch?", a simple radar, or list of people ordered by physical distance, is sufficient. Information on the use scenarios of the visualisation must be attained prior to designing the visualisation. For example, the evolution of the radar visualisation in Counter-Strike can be seen in Figure 3.2. Both are similar in that they show the locations of team members, but the second improves on the cues it provides that enable players to establish current context by comparing the 3D view to an image of a faded map. Obviously, a careful balance must be made between realism and representational simplicity.

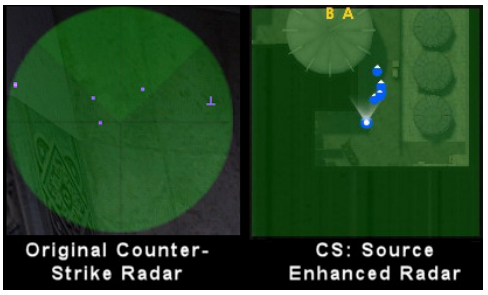

Figure 3.2: Incremental versions of a radar visualisation showing team members and enemies in the multiplayer game Counter-Strike

Location information does not have to be visualised directly; **it can be transformed into another representation, such as inferring activity or contextual information**. Where this would be useful can be illustrated with a simple example. Interruptions are less likely to be annoying when users are transitioning between tasks. Ho and Intille use two wireless accelerometers to infer three postural types: sitting, standing and walking, on the basis that messages can be set to be activated when users are transitioning between physical activities. Similarly, WatchMe indicates the activity of users inferred from similar sensors with icons on its wristwatch [50] (see Figure 3.3). This signifies the importance of space in relation to activity, and the visualisation of movement should be recognised as being different to being still [35].

As of yet, there is no literature on abstracting away absolute location, movement, and activity in a way that has been comprehensively proven to be easy to understand and use efficiently in everyday situations, by ordinary people. That is, no systems of this type have attempted to combine the natural abilities of humans to process spacial visualisations, whilst removing the difficulties of unnatural map visualisations. There is sufficient room for new research in trying to understand the factors of location that are most useful for communication, that can be factored into a visualisation optimised for the task.

In the literature on space and place [31] [19], one of the key points is that the meaning of location is different depending on the reason that it is being used for.

Figure 3.3: WatchMe Functional Prototype: Activity Indicators

Visualisations must be changed to suit human abstraction of locations (spaces) into meaningful "places". How that works with our existing social practises is something key we need to understand.

3.5 Inadequacies of Previous Research

Certain patterns have emerged from reviewing the literature and trying out commercial location-based systems. Firstly, there is **insufficient conclusive results from research on how uncertainty should be visualised**, only design principles of how we could deal with it [5]. Although researchers have found that visualising uncertainty can lead to better performance [26], these measures are problem-specfic. They do not generalise and give heuristics as to how we should design the uncertainty indicators. Work has failed to comprehensively take into account social behaviour; as such, we need to draw in theories from sociology. Lemmelä and Hannu J. Korhonen attempted to show how these visualisations could be designed and evaluated, but have offered no conclusive results [48].

Secondly, recent findings with users of social networking websites [1] show that there is an **asymmetry between perceptions of privacy issues and actual actions**. In HCI we need to explore the extent of how these results can be problematic or advantageous to location-based systems that inherently have social aspects.

Thirdly, there is still room for novel ways of mapping multiple individuals' location coordinates onto a visualisation. A **comprehensive comparison of the effects of various mappings** would benefit the design community.

3.6 Summary of Section

This section has been important in creating a theoretical and practical grounding of location-based systems. Firstly, the aspects of location that makes it interesting from a HCI point of view is explained, relating to gaming in the completely immersive sense, then proceeding to look at how the virtual and physical can be combined, in location-based gaming.

We continued with our overview of the theoretical notions of space and place in the context of HCI, and discussed how this relates to location-based systems. A consolidation of various location-tracking technologies is given, and the importance of GPS in experimental studies of this kind is discussed.

Uncertainty is discussed as an important issue in location-based systems, and design considerations as in the light of the unavoidable uncertainty present in location-based systems were briefly discussed in the context of this proposal. Finally, we note a pattern of inadequacies in previous research in location-based systems regarding taking into account social practises, privacy and location mapping that we aim to address.

Chapter 4

Design Guidelines

Through reviewing the literature we observed patterns in the guidelines given through experimentation with functional prototypes, user studies and focus groups. These include privacy guidelines, visualisation guidelines, technological guidelines, marketability guidelines and conceptual guidelines. We review the main privacy, visualisation and social guidelines here.

4.1 Privacy

Privacy is heavily tied in with visualisation as the representation relates to the amount of information disclosed. How the representation is derived from location and activity has to be carefully balanced with what information users want to see.

In the Casablanca project, one of the functional prototypes, RoomLink was modified from its original design to require intentional input to depict activity rather than regulating brightness through sensor inputs (active sensing). Some systems deliberately make the representations course-grained [7], such as defining fixed categories of home, work, school or elsewhere [11] or transferring only one bit of information at a time [41]. These techniques make use of the fundamental ability of humans to derive low level information, through having social knowledge, into high level conceptions.

Some researchers claim that privacy issues are not as important as they may first seem. For example, Consolvo *et al.* classify people into three groups characteristic of their privacy concerns: fundamentalists, pragmatists and unconcerned. Fundamentalists are skeptical–they feel that their privacy is very important and are passionate about what they see as being privacy threats. Pragmatists were the largest group, always asking the question "what's in it for me?". Others have argued that people are willing to trade privacy in exchange for relevant services [1]. It has been argued that privacy should be a visible option, even though people tend to not modify them [38]. A common guideline with these types of systems is to design in plausible deniability; that is to have ambiguity as a primary feature of the system so that

people feel safer. It is argued that we must "balance the utility of ambiguity against the utility of usability and communicative clarity" [2].

Older, traditional awareness systems used media–text, video, images, but almost all have not reached further than the labs because of constant interruption and privacy issues [60, 56]. Generally, abstract and sub-symbolic representations help to alleviate privacy concerns.

4.2 Visualisation

By far the most popular guideline with visualisations is that they must be conceptually simple and let people derive the semantics themselves [22]; they have social knowledge which computer systems cannot emulate satisfactorily. Even low level details like cross-roads and neighbourhood names are useful [15]. Others show that factors of uncertainty can be designed into the system itself and can make for a more engrossing experience [5, 6].

Everybody is accountable to their every action, and so a shared awareness of the constraints imposed on the system is important [22]. For example in WatchMe [63, 51] the system's derivation of activity is displayed on the user's own display so they know what other people can see. This is important for privacy, as well as meaningful accountability.

Hindus *et al.* advise that awareness systems need to **maintain perceived simplicity in its representations, but keep enough complexity to enable expressitivity** [34]. In this light, Ståhl and Höök devised a messaging system where text can be sent with coloured patterns depicting emotion–the sub-symbolic representation is conceptually simple but has enough complexity to represent a feeling in surprising detail. This point can also be illustrated by the Counter-Strike radar discussed in Chapter 3 which showed the evolution of an in-game radar to show more subtle cues.

4.3 Social

Social interaction shuld not be imposed on users–people are busy, and need to allow users to fulfil existing practises. Communication cannot be an extra responsibility [34]. The core use scenario is helping small intimate groups to be more aware of each other without suggesting social change. In small, intimate groups, friends need less explicit information to be aware [60]. Huijnen *et al.* note that "clearly, finding the optimal balance between immediacy, relevance, and obtrusiveness in designing awareness applications remains a considerable challenge" [36]. This challenge is social, and within a computer system lends itself to be ideal for HCI research.

Social navigation papers have guidelines relating to revealing info from others. Erickson argues that social software should reveal just enough information for us to

maintain social awareness and make decisions based on mutual knowledge of accountability. We should apply this to our visualisation so that users know what they are revealing, and know that others know what they are revealing–meaningful accountability [22, 21].

Chapter 5

Related Research Methodologies

This area of HCI makes use of a full range of research techniques. Here are a few of the most important ones.

5.1 Cultural Probes

Cultural probing is a "user-centered inspiration" research methodology proposed by Gaver *et. al* [25], and used by many other researchers [45] [67]. Designing for people can always be aided by knowing about how people think—taking advantage of local knowledge, social experience and individual thoughts. Other methodologies such as questionnaires, interviews or ethnographic studies can attain similar results, but cultural probes have shown to be a helpful way for people under the experiment to **fully express their culture**.

Gaver *et. al* were working on a research project that aimed to design technologies for the elderly to try and increase their presence in communities. They gave packs, or as they put it, "gifts" [25] to three separate groups containing postcards, notebooks, photos, a camera amongst other things that are designed to provoke creative thought. They left the materials with them for a month, by which time they had received most of the materials back. The results of the probes were not designed to be analysed, but serve as inspiration that directly fed into the design of the new systems.

The first group showed a "paradox of strong community in a dangerous area", leading to the designers proposing a network of computer displays that help inhabitants of the town communicate their attitudes and values about their culture. The second group was "affluent, well educated and enthusiastic", which the designers proposed them to lead a community-wide conversation about social issues, publishing questions meant for public response to electronic systems in public spaces.

5.2 Usage Logs

When working systems of this type are deployed in the real world, it is essential to employ a logging mechanism to capture events so that we can compare actual behaviour to qualitative responses from subjects. The user interface evaluation is of secondary importance to the affective measures of connectedness and awareness, which will be used as a metric of the success of the system.

5.3 Reversal Design

Reversal design, also called ABAB design [61, 36, 18], is often used in social psychology and HCI. This method gives better control for extraneous events by adding a second baseline phase (A) and a second intervention phase (B). This design assumes that if the intervention caused a change in our measurement in the first stage, the effects should reverse when the intervention is taken away. Once re-introduced, the effects should be visible as the results are shifted [61]. The advantage of repeating this method is the probability of an extraneous event affecting the results is reduced, as by repeating the experiment there is more causal evidence to show that the system is making a difference.

5.4 Wizard-of-Oz

Wizard-of-Oz is a rapid-prototyping method normally used for systems too costly to build. They can help refine design criteria without the risk of a full implementation. This is especially useful in HCI when you wish to evaluate a system that is impossible to implement, such as a completely intelligent avatar or interface system. A real intelligence "the wizard", is shielded from the view of the test subject. From the their point of view, they are interacting with a computer system. Wizard-of-Oz is also useful in situations where a full system takes too long to implement, and the actual goal is to just refine a design by quickly testing the system in use.

5.5 Applications of Research Methods

Table 5.1 shows a comparison of some recent projects and the methods they used. This is a very basic comparison, but what we can draw from this is the importance in HCI research of using many different methodologies to cover a broad spectrum of analysis, as we are dealing not only with technological issues, but also cultural, social, psychological and ergonomic. A more comprehensive review, analysis and comparison will show similar patterns.

	Project	Published	People	Focus Group	Contextual Interviews	Cultural Probes	Personas	Participatory Design
[34]	Hindus	2001	40					√
[45]	Kjeldskov	2004	6		√	√		√
[65]	Ståhl	2005	1				√	
[71]	Williams	2006	12	√			√	
[18]	Dey	2006	8/5/7	√	√	√		

Table 5.1: Projects and Their Design Methodologies

Chapter 6

Statement of Proposed Research

6.1 Overview of Stages of Research

6.1.1 Stage 1: Existing Cultural Practises and Privacy

Questionnaire

Rationale

It is important in interdisciplinary research to identify the context surrounding the problem, in terms of the main social issues at hand and how people perceive the role of technology in supporting their daily lives. A questionnaire is an quick, cost-efficient way to target a wide demographic and straightforward to analyse.

The questionnaire will be designed to address the following base questions:

1. Demographics
    - Establish context by identifying self-reported connectedness levels with friends and family
2. Social practises
    - Gain an idea of how existing social practises of location disclosure and communications media choice
    - Find out when location can be useful in existing social scenarios
    - Characterise the importance of spaciality in depicting activity/location
3. Media
    - The relationship between modern social media usage (blogs, online social networking) and the desire for hyper-awareness

4. Privacy

    - Find out what people disclose in terms of detail, choice of granularity, blurring and reasons of falsification
    - What is the benefit of real-time locations as opposed to a history, and is supporting both ideal?

Subjects

Several relatively disjoint social networks will be targeted using a variety of methods, as subjects should ideally vary in age, social popularity, stages in life, profession and role in the family.

Firstly, we target the common social network user group of ages 16–25. This should be a relatively straightforward group to target, as such contacts exist in my own social network. A target of 50% response rate from a pool of 200 users is set, with contact to be made with direct contact. Family members will be encouraged to answer, especially parents and non-colocated families. A user group of HCI professionals and practitioners can be obtained by placing an subject call on `http://www.usabilitynews.com`, and has proven to be successful in previous projects. Because the survey is so easy to fill in—it can be accessed online—an aim for 30 responses is set. Previous demographics obtained using this website varied between 20–40 years of age, giving positive criticism and feedback on design parameters.

Materials

An online survey service provides the required ease of questionnaire publication. `http://www.questionform.com` is such a service, that focuses on Web 2.0 principles to interaction design making it easy to create and analyse responses.

Analysis

The export data feature of the Question Form service provides the necessary data feed as a foundation for analysis. Questions will be designed using the Likert scale (5–7 distinct steps between, for example, extremely agree–extremely disagree) , lending room to detailed analysis to identify the statistical significance of correlations in the dataset.

Possible Issues

The main issues that would delay the execution of this phase is having trouble getting subjects to fill in the questionnaire. However, even 100 responses should be sufficient to uncover the required patterns to prove or disprove my hypotheses.

How Does This Experiment Address Problems?

The questionnaire results should give a clear idea of the main problems associated with keeping in touch across distance, and will help identify whether there is a

correlation between certain demographic sets and which problems they face. Additionally, the survey should help us ascertaining patterns on privacy issues of location disclosure. What are the actual human needs of feeling close to someone, and how does this relate to age group? In what situations do knowing locations help, and how does the perception of how someone wants to use private information change what level of information you disclose? When is the truth told, and when are lies seen to be more important? The questionnaire should hopefully instantiate some intriguing problems probing into the lives of people, whilst leaving enough room to imagine future technologies.

Cultural Probe

Cultural probes, outlined in Section 5.1 is a "user-inspired design" method first put to use by Gaver *et al.* [25] in 1999. Packs of material are given to subjects and left with them for a period of time. The materials are used to express thoughts on a given topic, and questions are designed to be open-ended and provoke creativity. They have proven to be an effective way of probing deep into the culture of subjects that can feed directly into the design process, and should help with building a picture of the role of technology in established or intimate relationships.

Rationale

I propose to use a cultural probing technique, on a relatively small scale, to discover existing practises of location disclosure used to raise connectedness between non-colocated individuals. It would be important to identify mismatches between the questionnaire analysis and the cultural probe analysis, as this could lead to major modifications to the experimental designs.

Subjects

Ideally subjects would be people who have just been geographically separated with their family or friends, as they would have considered other means of communication such as webcams, VOIP and Facebook. This will serve as a healthy comparison that would be important at this stage. People newly attending Universities would be an ideal group to target, and studies would involve both sides of the communications chain. Participants would not be screened for diversity at this stage, as a specific problem will be targeted.

Materials

A materials pack will be designed, consisting of:

Capture Photo capturing equipment (if required)–subjects take photos when they think of another person's location or activity

Noting Small tags to be attached to belt/item of clothing–subjects record when they experience communications or thoughts related to location and connectedness

Envisioning/Designing Small pack of paper materials and pens for users to design future awareness systems

The pack will allow participants to record their thoughts *in-situ*, and help them think about possible designs that would work for their particular problem.

Process

A one week probe should be sufficient, as it is not the fluctuations of communications use or desire we are trying to find out in more detail, but the problems that people have with communicating presence, awareness and maintaining connectedness with other people. The probe will be handed out at the beginning of the week, and will be self-sufficient, so no contact should be required. At the end, a post-briefing interview will be carried out to assess the experience and discuss the logs, pictures and designs.

How Does This Experiment Address Problems?

This experiment will comprehensively tackle the question of "what if?". Users envision their own design of a system that help them with the task of keeping in touch. Other than some essential bounding constraints, their creativity is allowed to roam free. This should result in some designs that will either contrast with our initial thoughts or agree with them. Either way, it is an important stage to validate our thoughts on the utility of location to help with awareness and connectedness and expand our design opportunities. The following stages will be more comprehensive, and tackle how we should go about measuring affect.

6.1.2 Stage 2: Small-scale Study

Wizard-of-Oz

We will use a Wizard-of-Oz approach because of the advantage of not needing to spend as much time implementing technologies that might fail early in design. This study involves having two sets of subjects: a) data inputters, who manually input locations and b) users of a simple location-based social visualisation who record manually to what extent they feel connected to or are aware about other people on a day-to-day basis.

Process

The social visualisation is the main aspect. For this, we will adapt a simple version of visualisation designed by our users in stage 1. The length of the study will be around two weeks, and should be sufficient to get enough data and modify design as a result of lessons learned. Post experimental interviews will be useful at this stage, concentrating on usability of system, and how compared to what they thought it was going to be like. Issues of privacy and sociability will be key issues here.

6.1.3 Stage 3: Large-scale Study

Functional Prototype

Lessons learned from the Wizard-of-Oz study would feed into an adapted version of the experimental design and prototype. The prototype will be deployed and tested using reversal design (ABAB) for **2 weeks**, with the system in use or not being the primary independent variable, and the type of visualisation as the secondary independent variable. A mixed experimental design will be adopted, which will be flexible to modification depending on the success of subject acquisition, with our dependent variables being the perceived values of awareness and connectedness under our measuring methodology.

Implementation Details

The core part of the system will be an application residing on the subjects' mobile phones, and will handle the two aspects of the experiment; a) providing an awareness visualisation showing an aggregation of friends' statuses and movements and b) providing a platform for data acquisition using the experience sampling method (random questions). GPS is the proposed technology used for positioning, with modules provided to subjects who have Bluetooth-enabled mobile handsets. Subjects who do not have Java phones with the Bluetooth API will need to either have an internal GPS module or borrow from a limited supply of compatible phones.

Two versions of the visualisation will be implemented to explore the research questions of how a difference in semantic representation of location affects our dependent variables.

Choosing Subjects

Users who do not actively use social networking websites such as Facebook would be ideal, as users who spend large amounts of time on the systems gather large amounts of social information anyway. Payment could be £20 per person per week, as an incentive plus GPRS/3G data costs. We justify a relatively low financial incentive because such a social utility should be useful to them anyway, and parallel developments in commercial systems tend to raise levels of interest.

Process

The experiment will be carried out using reversal design, also called ABAB design (see Section 5.3). The intervention here is the mobile system, which the presence of is the independent variable, to be measured within-subjects (subject responses are measured with both the system in place, and without). Subjects use the system over the experiment time period, and a mixture of self-reported and quantitative measures are taken using experience sampling methods. The exact nature of the questions will be finalised after reviewing the results from stages 1 and 2, but will generally ask about the whereabouts of the other subjects, how emotionally attached or connected they feel with them and enquire about current activities.

Depending on the number of subjects we are able to recruit, the same experiment will be repeated with a separate group. The independent variable in this case would be the change in visualisation, comparing a map-based approach to a semantic, spatial-based approach. The results should provide, in detail, heuristics on the best way of presenting location-based information for fostering connectedness and awareness. If there are not enough subjects, the most interested from the first group will be asked again to repeat the experiment, but with a different visualisation type independent variable.

Potential Issues

The main issues would be not being able to find enough subjects to compare results effectively, but the experimental design has been engineered to cater for these problems. Insufficient equipment would also be a problem, but secondary to the number of subjects. However, as the experiment should be fun to use by nature, and caters for a well-defined, existing problem, we can make the assumption that people are more likely to want to participate. The right amount of financial incentive would need to be carefully balanced.

Expected Results

We are evaluating the affective benefits of the visualisations, not the visualisations themselves. We expect the results to show increased scores in the experience sampled responses when the intervention is introduced. When the system is taken away, it is expected that scores will still be higher than the first baseline phase, similar to the results shown in Dey [18], where the increased amount of information subjects were receiving about remote loved ones meant that they memorised routines. However, during the second intervention phase we should see scores increasing again. This is the ideal result, and will show the significance of our system.

Comparing visualisations in the second part of the mixed experimental design should show us an increased difference of scores in one type of visualisation over the other. Post-experimental interviews will be carried out to ascertain the reasons behind visualisation preferences, and will concentrate on the nature of improved communication rather than the visualisation's usability.

6.1.4 Stage 4: Longitudinal Study

Functional Prototype Extended Test

It is too early to plan the exact details of the longitudinal study, but we will extend stage 3 into a 1 month long trial, which should help attain statistically significant results.

Chapter 7

Evaluating Success of Proposed Research

7.1 Research Questions

It is useful at this point to summarise the research questions. The preceding sections explain how location can be used as a salient dimension to emotional communication within non-colocated groups of already attached individuals. At this point, it would be useful to remind the reader of the research questions outlined in the introduction:

RQ1: What is the favoured visualisation type for location information used for the social utility of being aware and connected?

RQ2: Can we formulate an effective measure and devise a relevant evaluation technique for connectedness and awareness?

RQ3: Can location information designed into a visualisation increase a sense of awareness and connectedness, and increase group identity?

RQ4: How does the representation of location and activity affect the feelings of social presence and awareness/connectedness?

The main criteria for evaluating whether this research has been successful are:

1. *Do the experiments yield statistically significant results?*
2. *Does the experimental evaluation method yield accurate measures?*
3. *Do any of the experiments produce "positive" effects?*

7.2 Criteria Analysis

Research Question 1

What is the favoured visualisation type for location information used for the social utility of being aware and connected?

Research question 1 will be tackled in stage 1 (questionnaire and cultural probe).

We have shown in Chapter 3 that location can be interesting for social awareness as location is an important of social discourse, and is an inherent part of context. We gave examples of how the bridge between virtual and physical boundaries are crossed in games, becoming immersive. There have been many examples of visualisations in gaming, and location based research, but not many of different types of spatial visualisations being compared. The questionnaire and cultural probe set in **stage 1** will help in moving towards finding a scope for design, focusing privacy criteria and attaining fine-grained use scenarios. This stage is to obtain cultural grounding– important, effective, and simple to deploy.

From this we form **hypothesis 1:** The favoured visualisation type will be of spatial nature, and involve visualisation indicators of activity. Map-based visualisations will not be favoured due to representational complexity and conceptually difficult to understand.

Research Question 2

Can we formulate an effective measure and devise a relevant evaluation technique for connectedness and awareness?

This question will be tackled in stage 2 (attempted for Wizard-of-Oz experiment). Chapter 2 discusses how awareness systems have been measured in the past, and notes the inadequacies with previous methods. We have discussed how social presence theory can be used to help refine measurement methods.

This is a problem of considering the variables that affect perceived measures of awareness and connectedness. The Wizard-of-Oz experiment will be the ideal point to address this, considering results from stage 1. The measurement method will be measured in performance when we question the users after the experiment on how successful they think the system was. If the performance measurements taken during the experiment correlate with the users' opinions afterwards, it should be an indication of the success of the measuring method. Furthermore, the second baseline and intervention stages should show expected results, further validating the success of the measurement method.

From this we form **hypothesis 2:** A mixture of quantitative and qualitative measures (self-report) can be validated to be a successful measure compared to those used in the literature.

Research Question 3

Can location information designed into a visualisation increase a sense of awareness and connectedness, and increase group identity?

Research question 3 will be tackled in stages 2, 3 and 4 (Wizard-of-Oz, functional prototype, and refined in the longitudinal study).

Awareness, as explained in Section 1.2.1 is the "state of knowing about the environment in which you exist, the surroundings, and the presence and activity of others" [18]. A mixture of qualitative and quantitative measures of awareness will be used in stages 3 and 4 using the (random) experience sampling method to attain in-context results without being effected by the interface itself. Connectedness has been defined as "degree that a person feels in touch with somebody", and can only be measured with self-report measures.

This is the main performance criteria. The questions are yet to be defined, but will follow a further comprehensive literature search and adaptation of questions used in the presence literature (from both HCI and psychology of the mind).

From this we form **hypothesis 3:** Knowing about location of non-strangers increases feelings of connectedness and awareness of those people, and this can be appropriately measured and found to be statistically significant in longer trials.

Research Question 4

How does the representation of location and activity affect the feelings of social presence and awareness/connectedness?

This question will be tackled in stages 3 and 4 (functional prototype, longitudinal study). Using the ABAB reversal design method (see Section 5.3) we apply an additional intervention and baseline stage in addition to introducing a second independent variable–a different visualisation type. The exact visualisation type will be determined during stages 1 and 2 (cultural probe and Wizard-of-Oz post-experiment interview). Repeating the measures with both visualisations means we compare the performance of both.

From this we form **hypothesis 4:** Spacial metaphors used in an abstract, subsymbolic visualisation creates statistically similar measures of awareness and connectedness compared to absolute, map-based visualisations

Chapter 8

Timetable for Thesis Production

1. October 2007–December 2007 (3 months)
    - Stage 1: Existing Cultural Practises and Privacy
        - Questionnaire:
            * Deploy Questionnaire
            * Analyse Questionnaire
        - Cultural Probe:
            * Design and produce cultural probe packs
            * Deploy cultural probes
            * Write up results in parallel with deployment
2. January 2008–March 2008 (3 months)
    - Stage 2: Small-scale Study
        - Wizard-of-oz
            * Design and implement wizard system
            * Deploy in field
            * Analyse results
3. April 2008–July 2008 (4 months)
    - Stage 3: Large-scale Study
        - Functional prototype
            * Design and implement prototype
            * Deploy for 1 month
            * Analyse results
                · Check whether visualisation is suitable for task
                · Check whether location fosters social awareness and connectedness

4. August 2008 - October 2008 (3 months)
    - Stage 4: Longitudinal Study
        - Extend study depending on results
        - Refine design of functional prototypes
        - Deploy for 1 month on two most interesting groups
        - Analyse results
            * Check whether location fosters social awareness and connectedness over a longer period of time
5. November 2008–April 2009 (6 months)
    - Thesis Writing - Draft
        - Complete draft of thesis
        - Get feedback
6. May 2009–October 2009 (6 months)
    - Thesis Ammendments
        - Make amendments to thesis and submit when completed

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