DESIGNING FOR LOCAL INTERACTION

johan redström, per dahlberg, peter ljungstrand & lars erik holmquist

Abstract

Much development of information technology has been about reducing the importance of distances and user location. Still, many important activities and events are of local nature, for instance serendipitous face-to-face communication. In order to support such communication, as well as other examples of local interaction, we have developed three prototypes all based on wireless short-range communication. The prototypes are functionally self-contained mobile devices that do not rely on any further infrastructure, making the system inexpensive, flexible and easy for users to manipulate. In these experiments, the limited communication range is not conceived as a problem, but rather as a property that can be explored. We present and discuss the Hummingbirds, Generalised Hummingbirds and the NewsPilot, as well as the implications of this approach for human-computer interaction design

1 Introduction

Information is generally not propagated very far from its origin. Signs can not be read if they are not within sight, signals can not be heard unless within hearing distance, and so forth. In this way, the limitations of our perceptual systems in combination with certain properties of information propagation in physical space (i.e. different kinds of carrier waves travelling through obstacles like walls, floors and outdoor topology) can be said to act as information filters. In order to take part of different sources of information, we have to move around in the environment and in order to talk to each other we have to be co-located.

These limitations are shortcomings of physical spaces that we have been trying to eliminate by the use of information technology. The telegraph made it possible to send messages over long distances, the telephone enabled persons at different locations to speak with each other, and more recently the computing industry introduced us to global networks that make it possible to instantly communicate and share information with people all over the world. The introduction of mobile devices that are carried by their users at almost all times, e.g., pagers and cellular phones, have decreased the importance of location even further.

Still, at times proximity is a rather good measure of relevance. We tend to place important objects near us or near the place we are going to use them. Documents and books lying on someone's desktop are more likely to be related to current work than documents placed in filing cabinets or bookshelves. Considering almost ubiquitous resources (at least in office environments) such as power outlets, water taps or rest rooms, proximity is often the main criteria for relevance. We also move around in our environment in order to get a chance to talk people etc. [3, 4, 30].

The usefulness of location as a constraint for information distribution is perhaps best seen when it is removed: now when we can contact almost anybody any time and instantly access information everywhere we are beginning to experience information overload [21] and communication overflow [19]. Given the apparent importance of local interaction, such as face-to-face communication, and local mobility or "roaming" in search for people and resources, rather little has been done to support it [cf. 3, 4, 30].

In this paper, we describe our explorations of the usefulness of proximity as a constraint for information distribution, starting with development of support for awareness of co-located people. We will begin with presenting related work and then report from three projects all aimed towards supporting local interaction. We conclude with a discussion of our experiences and outline their implications as well as future work.

2 Background

2.1 Local Interaction

Although informal communication *per se* is not our main interest here, research on this topic presents a number of relevant themes. In occurring definitions of informal communication, it is clear that local interaction plays an important part. For instance Whittaker *et al.* [30] uses a wide definition as "taking place synchronously in face-to-face settings"; Fish *et al.* [11] mean that while meetings are pre-planned with a predefined agenda, informal communication is a social event, work related or not, that takes place ad hoc when there is an opportunity for communication. The importance of being co-located has been reported in several cases. Relevant studies include Bergqvist *et al.* [4] who studied ad hoc mobile meetings in a work place; Covi *et* *al.* [7] who studied the effects of dedicated project rooms; Fitzpatrick *et al.* [14] who discussed the difficulties in designing co-operative buildings with support for awareness and serendipitous interaction for distributed groups and Whittaker *et al.* who argued that physical proximity is crucial for informal communication [30].

Extensive research has been done on how to support informal communication using IT. However, in most cases the aim has been to support distributed rather than co-located groups [cf. 9, 12, 14, 20]. The rationale for this is that many incitements for occasional communication are lost when people are not co-located. Thus, support for awareness about peoples whereabouts that could compensate for not having corridors, lunchrooms etc. as sources of such information have been developed. The notion of proximity has also been used as a metaphor in virtual environments designed for social interaction, for instance in Chat Circles [26] and FreeWalk [20]. One of the main differences between these projects and the work presented here is that in a face-to-face setting, the technology does not *mediate* the communication. Therefore, our focus has been on how to *support* communication, for instance by means of providing relevant information.

Another aspect of informal communication is that it is often serendipitous. Hence, technology should support on-the-fly communication, without any need for time-consuming and complex actions on behalf of the user. There are several related attempts to support awareness of colleagues in an office environment [cf. 25, 28]. These systems differ in that they rely on a fixed infrastructure at a number of specific locations, meaning that they only support spontaneous meetings at certain places. Our aim was to support such communication regardless of any specific locations.

2.2 Ad Hoc Networks and Context-Aware Computing

Ad hoc networks are self-organising wireless networks composed of mobile nodes that do not require a stationary infrastructure. They are designed to be rapidly deployed to provide robust communication in a variety of environments, which often lacks a supporting infrastructure [15]. Unlike the work presented in this paper, the objective is to allow for communication between all devices, regardless of the present location. Current research on ad hoc networks is highly technical, mostly about network protocols, rather than taking social considerations or novel applications into account.

Besides communicating, the devices have to make use of what information they send and receive in order to support local interaction. The term "context-aware computing" was introduced as a part of the ParcTab ubiquitous computing experiment [28] to describe mobile and wearable systems that collect data from their environment and use it to adapt their behaviour [1, 24, 28]. A system is said to be context-aware if it keeps track of any aspect of its present context, most commonly location [2, 27, 28]. Thus, being "context-aware" does not imply that the system in question is aware of all aspects of its context.

The prototypes described in this paper are not aware of their absolute position, but only how they are positioned in relation to other devices. A similar approach has been used in a number of cases, perhaps most notably in the LoveGety [18], a recent commercial success in Japan. The LoveGety is a small, wirelessly communicating device that detects other LoveGetys within a certain range, in order to support social encounters between people. Other examples of related systems include the Thinking Tags [6] and GroupWear [5], which tell about relationships between people engaging in face-to-face conversations.

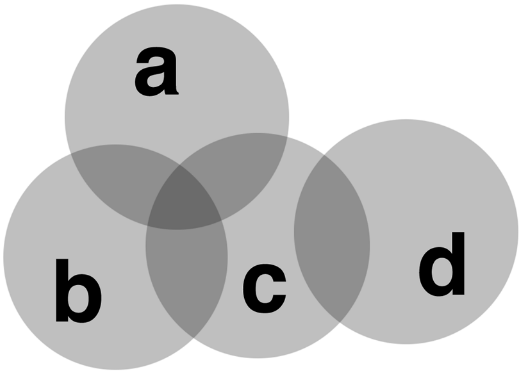

Figure 1: Figure illustrating four devices,
their relative position to each other and what information is available to each of them. The circles represent their respective communication range. In this case, A and B both have access to information distributed by A, B and C; C has access to A, B and D; D has access to C.

3 Experiments

Beginning to explore the possibilities in designing for local interaction, the field of informal face-to-face communication seemed to be an interesting domain due to its dependence on local interaction and serendipitous communication. We have developed a number of applications all using short-range radio-transceivers (Fig. 1). Below, we will describe the Hummingbirds, the Generalised Hummingbirds and the NewsPilot.

The range of the communication varied from about 100 meters in the case of the Hummingbirds, to approximately 10 meters in the NewsPilot, and was deliberately chosen to suit each application.

3.1 Hummingbirds

The Hummingbird [17] is a small wearable device equipped with a short-range radio transceiver, through which it broadcasts its identity and receive information about other Hummingbirds in the vicinity. The devices are functionally self-contained, i.e. non-dependent of surrounding infrastructure. The overall objective is to support awareness of "who's around" within an established group of people. Whenever two or more Hummingbirds are close enough to communicate, the devices give a subtle audio signal and display the identity of the other devices in the proximity. In this way, it is possible for users to know which other Hummingbird users are in the proximity.

Inspired by what is often within "shouting distance", the communication range is set to approximately 100 meters (depending on the number and nature of obstacles like people, walls etc.). The rationale for this range is that as the Hummingbirds do not show in what direction other users are located, the space in which to search for them must not be too large if information about their presence should be

Figure 2: Picture showing the Generalised Hummingbirds,
i.e., GameBoys fitted with radio transceivers.

useful. The reason for not presenting directional cues on the Hummingbird is partly due to technical difficulties, but more importantly the wish to make the devices as unobtrusive as possible, regarding their use as well as the perception of them. It is important that the Hummingbirds are not perceived as surveillance devices.

In studies of user experiences we have found that the Hummingbird is particularly useful in situations where a group of users are outside their normal environment, e.g., when travelling [17, 29]. The Hummingbird experiment has shown that for mobile users, it can be valuable just to have the knowledge that other users are in the vicinity, although it is not possible to use the Hummingbirds to mediate communication.

3.2 Generalised Hummingbirds

The results from the experiments with the Hummingbirds inspired a more general platform. The hardware is based on the Nintendo GameBoy, a hand-held video game. The GameBoys are fitted with small radio transceivers that are connected to the devices' serial ports (Fig. 2). The range of communication is about 50 meters. The reason for decreasing the range compared to the original Hummingbirds, is the fact that more sources of information would be used and that information therefore had to be filtered to a greater extent. Modified game cartridges are used for installing custom software.

The Generalised Hummingbird enables users to give their devices arbitrary names, making identification easy. As with the original Hummingbird, Generalised Hummingbirds are only able to communicate by means of sending and receiving their digital signatures (i.e. their “names”). In order to support events over a wider time frame than the present, the names received are displayed as being in one of two states: “active” when the Generalised Hummingbird is currently picking up the signature in question, and “inactive” when the device recently has picked up the signature but ceased to do so (within the last half an hour or so). This enables users to see a trace of what has happened recently.

Applications

The Generalised Hummingbird enables users to obtain further awareness about activities in their near surroundings using both the "trace" functionality and the possibility to associate devices not only to people, but to places and artefacts as well. For instance, when a user enters a building, an ordinary Hummingbird will pick up what other devices are present, but not which have been there recently. However, if a user places a stationary Generalised Hummingbird at a certain location in the building, its display will show what signatures it has received recently, thus showing a trace of recent activities at that location.

Certain places, like the corridors, act as informal meeting places [cf. 3, 30]. In order to make information about activities in the lunch room available, users can connect a Generalised Hummingbird to a movement detector, ensuring that whenever there is any activity in that room the device is turned on and, thereby, broadcasting its signature. Correspondingly, the activity of some artefacts might be of interest. For instance, it is possible for users to monitor the availability of fresh coffee using a Generalised Hummingbird connected to a coffee machine, so that whenever fresh coffee is available, a device named "Coffee" becomes active.

This experiment illustrates that it is possible to add a variety of information sources to the network using both mobile and stationary devices, without making the human-computer interaction any more complex than in the original Hummingbird example. Adding new information sources is not any more difficult than moving them into the place in question, and if the devices are to be used for keeping track of some activity, ordinary, affordable and easy-to-manage solutions can be used.

3.3 The NewsPilot

The next step of development is the NewsPilot [8], a design based on implications from an empirical study at a Swedish radio station working with broadcast news, conducted by the MobiNews project at the Viktoria Institute. The NewsPilot is based on the 3Com Palm III PDA (Personal Digital Assistant) fitted with a radio transceiver (Fig. 3). The communication range is decreased even further compared to previous experiments, to about 10 meters, since that was a more appropriate range for how far away proximity was relevant at the radio station.

People

The journalists at the station relied on a large number of information resources to select and compile news stories, e.g. local newspapers, television, fellow journalists, etc. The discussions among the colleagues were an important part of the local news dissemination. Often, several journalists had been involved in various related topics, making for fruitful discussions. To help initiating such discussions each NewsPilot user is able to enter a short message stating what he or she is currently working on. By sending out the message together with name of the user, users can obtain information not only about which colleagues are in the proximity, but also what they are working on.

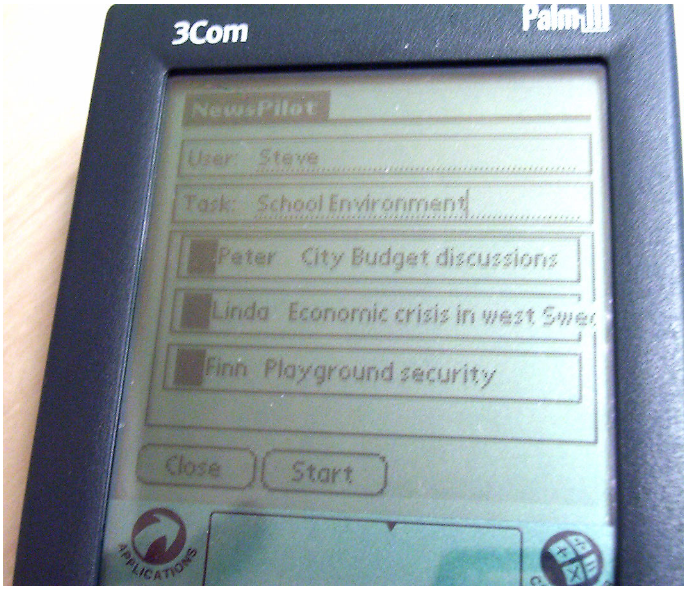

Figure 3: Picture showing the NewsPilot (main screen),
i.e., a 3COM Palm III fitted with a radio transceiver similar to the ones used with the Generlised Hummingbirds (Fig. 2)

Places

The second important finding during the study was that it seemed like different types of information were important at different locations. For instance, there was a table and a shelf with newspapers in the centre of the office used for reading and annotating recent newspapers. When a journalist attended this location, he or she was generally interested in getting information about related stories produced both internally and externally. By fitting transceivers to the walls, messages can be distributed to NewsPilots at specific locations. At the newspaper-table, the task-message from the NewsPilot is received by a wall-mounted transceiver connected to a stationary PC, which is used to search local network resources for relevant information. An additional server is used as an interface between the transceivers and network resources. Short messages about findings are sent back to the NewsPilot and presented to the user. Each message contains an abstract and information on where the full story can be retrieved. Although a user hardly wants to walk to a specific location just to filter out information, if viewed as a complement to traditional searching and browsing, location-based filtering might assist the user in her work.

4 Discussion

4.1 Supporting Serendipitous Communication in Face-to-Face Settings

There seems to be at least two reasons for initiating occasional communication: either (1) that at least one of the participants has a question or subject that she or he wants to discuss, or (2) that the situation as such is an incitement for a conversation. In the first case the subject of the conversation is “known” before the conversation takes place; in the second the subject will be chosen according to the situation more or less spontaneously. While these two cases are superficially similar, the underlying properties differ and will have to be acknowledged in the design of a supporting system.

The first situation is in many respects similar to more “explicit” communication such as phone calls or e-mail, as there are a rather well defined subject and a target person. The main difference is that the property of talking face-to-face is so valuable, that other variables, e.g., when or where to talk, can be left open. A person might choose slightly different strategies in order to catch a talk with her target. Staying in her room will probably mean fewer encounters with other people including the target, than walking around in the office more or less searching for the target. There seems to be a continuous scale of more or less explicit actions in order to make the meeting happen. The key factor for initiating such a conversation is presumably knowledge that the target person is in the vicinity and available for a chat. This is probably one reason why awareness about other people's whereabouts seems important. However, if the proposed discussion target is not available for the time being, there is always a risk that the idea sinks into oblivion. We all need a reminder from time to time, and this is one reason why calendars and to-do lists (electronic or paper-based) are so popular. A future implementation of a support for this first kind of situation might therefore be a context sensitive “to-do-list” that reminds its users when the appropriate context for completing the task turns up [cf. 23].

While the first situation bears on one of the participants having an interest in talking about something, the second one seems to arise out of the interest in talking as such. This might be due to being in a place where social interactions commonly take place, or because the situation as such is suited, or demands for that matter, that people initiate conversations. Consider for instance the following common scenario: a person A walks down the corridor and meets another person B. As they begin to talk A notices that B carries a certain book that she is reading too. As a result they begin to discuss the book, and both A and B might get useful information about aspects not thought of, related references etc. Unless B had carried that book, the discussion might never have taken place. This useful sharing of experiences among co-workers obviously does not rely on one of the participants already knowing what to talk about, but on the situation as such in combination with certain resources present. Thus, a support for this kind of situations will not be in the form of a reminder service, but rather some way of presenting relevant information based on criteria such as the participants present tasks, interests, projects etc. Selection of such information could for instance be a matching between current interests of the users in order to find out the least common denominator and present relevant information, functioning in a way similar to carrying around books in the example above. The NewsPilot was an attempt to provide such a tool for journalists at a news agency.

As we have shown, systems based on locally communicating devices can be used in both cases. The Hummingbird supports an awareness of who is in the proximity assisting a person that has a predetermined wish to communicate. However, it does not provide any help for picking a topic once the parties have met. The Generalised Hummingbird and the NewsPilot provides similar awareness, but with different ranges. Further, the NewsPilot can support persons in choosing a topic to talk about by providing information on what topics other participants are working on. Most of this can be, and have to some extent been, realised using other techniques than local communication between functionally self-contained devices. However, there are some advantages with the strategy employed here that are interesting from a human-computer interaction point of view, some of which will be discussed below.

4.2 Implications for Human-Computer Interaction Design

Let us first sum up a few of the properties of local interaction between devices that we have tried to exploit in order to design easy-to-use technology. The radio transceivers enabled us to use the limited range of communication to create something similar to an adaptive location-based information filter. The communication between the devices was established on the fly, and did not require any explicit actions on behalf of the users. Since the devices are functionally self-contained, users did not have install, configure and maintain any additional infrastructure, except for the stationary information servers used in the NewsPilot, making the systems as a whole easy to manage, move and manipulate.

Our experiences suggest that the principle of *proximity as a constraint for information distribution* can have a wider applicability than what has been presented here. In the Generalised Hummingbirds, we introduced sources such as places and artefacts, and in the NewsPilot users could have information sent to their PDAs when visiting a certain place. The usefulness of these additions suggests that it is interesting to support local interaction not only among people, but with other "resources" in the vicinity as well. For instance, we can use local communication between devices in order to let the user combine their respective functionality in the manner Norman suggested "information appliances" to behave [22]. We can also imagine a scenario where users can create computationally augmented, or rather "amplified" [10], environments using "building blocks" that keep their functionality when moved to new locations: if two units work in a certain way together, they will continue to do so when moved somewhere else.

This stands in contrast to most implementations of ubiquitous computing, in which the rather simple devices users interact with, rely on an advanced "hidden" infrastructure. As the behaviour and functionality of their devices will change radically depending on what hidden resources or infrastructures are there to back them up, users

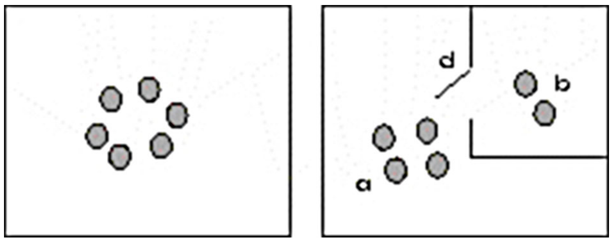

Figure 4: These figures illustrates the problem of proximity in terms of two different scenarios where different verbal communication ranges apply. In the figure to the left, the relevant cell encompass all six people; in the right one there are two independent groups (a and b). Further, the degree of independency between the two groups of people partly depends on whether the door (d) is shut or open.

will have to care about something that originally was designed to be invisible. This is not very fortunate, considering the aim to hide complexity away from the user. The absence of such hidden resources might help users to build, manipulate and understand their computational environments. Of course, such strictly local networks of devices will not be able to solve all the problems dealt with in ubiquitous computing and intelligent environments, but they might serve as an interesting complement.

4.3 Spaces and Places

When discussing wirelessly communicating devices, the notion of range is often used to describe the size of a cell, i.e. a certain area with a set of devices (people) that all can directly communicate with each other. The term "range" refers to physical distance in space, and it is natural to use this term when discussing spaces. However, the spaces we move about in are, when a social context is applied, perhaps better be understood in terms of *places* [16] or *locales* [13]. A place is the understood reality, e.g. a room, an office or a building, while space only contains spatial measures [16]. Since we are no longer strictly talking about spaces, but rather about perceived places, i.e. a combination of a physical location and a social context, the notion of range becomes somewhat inappropriate.

Consider for instance a group of people sharing a room, where all participants can talk to and hear each other. This can be seen as a communication cell. Suppose we break the group into two smaller groups. Now we have two smaller cells, independent of each other. This makes very much sense when we only use verbal communication, but current wireless communication devices would not follow these changes as the size of the relevant communication range changes depending on context. This is even more obvious in the case of dividing spaces into different rooms (Fig. 4). Developing technology that communicates within a given place (or part of a place, if that is more appropriate) instead of communicating within a certain space would add new possibilities to this kind of technological support. In other words, we want a notion of "proximity" that is more complex and incorporates more than just the physical distance between things, for instance in what social context they are located. To complicate things, different applications might want to use proximity differently. Sometimes the actual physical (spatial) proximity is preferred, as in the case with the Hummingbirds, while other situations might require more adaptive techniques. Clearly, much remains to be done in this area.

5 Conclusion and Future Work

We have tried to make the case that limited communication range is an interesting constraint when designing support for local interaction. We have also discussed some implications of the experiences we have had with our prototypes and discussed the ideas that have arisen during this work. As we have tried to argue, there are a number of interesting properties associated with local interaction between devices, for instance aspects such as information filtering and the possibilities of transparent human-computer interaction.

We have mentioned future projects such as dynamic and context-sensitive to-do-lists and supporting people engaging in spontaneous meetings with relevant information that could enhance applications similar to the ones described here. In order to investigate such applications, the design efforts, combined with user studies and evaluations, will continue. Important issues for future projects do not only include exploring new services for local interaction, but also to develop a "smarter" notion of proximity in order to acknowledge properties of space that are of social importance. Some easily perceived cues, like open and closed doors, windows and walls, are within reach. Designs for more subtle properties, such as different groups talking to each other within a certain room, will be harder to achieve. However, having a technology that could cope with such aspects of the context would enhance its usability dramatically, given the purposes proposed in this paper.

The suggested approach will also have to be evaluated on other domains than face-to-face communication. For instance, the easy-to-manage (from certain points of view, that is) nature of systems composed of communicating and functionally self-contained devices can make it easy for users to create and manipulate their own “smart” environments using a variety of devices. Other important issues in future work include security and privacy issues. So far, the need for authentication or a high security level has been rather small due to the nature of the information distributed. However, when developing other applications those issues must be dealt with.

We believe that support for local interaction is an exciting area. Further development in the areas of wireless networks and mobile computing will make many new types of devices that support local interaction possible.

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