Rendezvousing with Location-Aware Devices:

Enhancing Social Coordination

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Abstract

Emerging technologies such as location-awareness devices have the potential to significantly impact users' social coordination, particularly while rendezvousing. It is important that we explore how new technologies influence social behaviours and communication in order to realize their full potential. This paper presents a field study investigating the use of mobile location-aware devices for rendezvous activities. Participants took part in one of three mobile device conditions (a mobile phone, a location-aware handheld, or both a mobile phone and a location-aware handheld) and completed three rendezvousing scenarios. The results reveal key differences in communication patterns between the mediums, as well as the potential strengths and limitations of location-aware devices for social coordination. The paper concludes with a discussion of relevant design issues drawn from observations gathered during the field study.

Rendezvousing with Location-Aware Devices: Enhancing Social Coordination

Mobile devices today come with many features and gadgets such as digital cameras, text messaging, email, web browsers, games, and personal organization tools, just to name a few. As new features continue to be introduced, some will become core components, while others will have minimal impact on users' interactions. Location-awareness information is one such feature that is becoming more prevalent on mobile devices. However, the best way to utilize this information, and the corresponding social implications of its use, remains unclear.

The overall goal this research is to explore how mobile technologies can enhance social coordination (specifically rendezvousing) between users and better understand the benefit that these emerging technologies can provide to our everyday lives. This paper presents our examination of how location-awareness information impacts social coordination when people need to meet up with one-another. One obvious advantage of location-awareness information is that it can provide users with an awareness of their own physical location as well as the location of others. However, it is less clear how this information will impact social behaviours. Location awareness is fundamentally different than active verbal communication with a mobile phone and may significantly alter users' actions.

Earlier research on technology to support rendezvousing indicated that mobile phones were the preferred method of communication (Colbert, 2002). However, contextual information such as location is difficult to convey accurately through dialogue. The verbal exchange of locations, instructions, and descriptions between people can be ambiguous, misinterpreted, or misunderstood. Location-aware computing minimizes these complications by providing visual cues and references.

In our study, participants carried out three typical rendezvous scenarios, in one of three device configurations: mobile phones, location aware handhelds, or both mobile phones and location aware handhelds. Results from this work provide important insights into the differences between mobile phone and location-aware device usage and the impact on users' social coordination. In addition, we believe that merely providing users with access to new technology is not enough. Appropriate design of applications will also significantly impact both the uptake and subsequent usage of new technologies. This paper reflects on the observations gathered from the field study and discusses relevant design issues for mobile location-aware systems.

We first present related work in the area of rendezvousing and discuss previous applications of location-aware systems. We then present a description of the methodology used in our field study including a description of our Wizard-of-Oz approach to provide location-awareness. The results of this work are then presented in a narrative form with a discussion of the social interactions observed in each scenario. Finally, we reflect on the results and discuss how this information informs future considerations for location-aware mobile devices.

Related Literature

Rendezvousing

Rendezvousing is the social activity of people meeting at a predetermined location and time. Group behaviours related to rendezvousing have been explored extensively by Colbert (Colbert, 2001, 2002, 2004) through detailed diary studies. Colbert comments on the importance of conducting user-centered research to identify the effects of location-awareness on rendezvous behaviour (Colbert, 2001). Colbert's work illustrates common rendezvousing behaviours and various challenges that frequently arise when two people attempt to rendezvous. The rendezvous process is dynamic in nature. While meetings often occur as originally planned, some are

problematic and may be delayed, restructured, or cancelled, resulting in lost opportunity and stress (Colbert, 2001).

A follow-up investigation of technology to support rendezvousing (mobile phones, text messaging, email, and voicemail) demonstrated that mobile phones are the current preferred method of communication (Colbert, 2002). Other work by Ito and Okabe (Ito & Okabe, 2005) investigated how mobile communication can alter rendezvousing behaviour. For example, rather than agreeing on a landmark and specific time to meet, mobile users can initially agree upon a general time and place and exchange several messages to further refine the rendezvous location and time, finally terminating in an eventual meeting (Ito & Okabe, 2005).

Location-awareness

Location-aware mobile devices have been explored by a number of researchers for a variety of activities including gaming (Benford et al., 2004; Björk, Falk, Hansson, & Ljungstrand, 2001; Cheok et al., 2004; Flintham et al., 2003), support for communication and collaboration among distributed groups (Griswold et al., ; Pousman, Iachello, Fithian, Moghazy, & Stasko, 2004), and support for awareness and collaboration among proximal groups (Holmquist, Falk, & Wigström, 1999).

Location aware devices can provide absolute or relative information. The Hummingbird system (Holmquist et al., 1999) is an example of technology that provides users with relative or proximity location-awareness. For example, when one Hummingbird comes within the vicinity of another, it “hums” indicating another Hummingbird is nearby. While beneficial in some situations, as shown in this work, relative location-awareness can sometimes be insufficient to allow people to find one another.

Several applications that have explored absolute location awareness include ActiveCampus (Griswold et al.) and Pousman's location-aware event planner (Pousman et al., 2004). These systems provide their users with location-awareness of both themselves and other group members. In addition, the devices also provide an active communication channel (i.e. text messaging, voice). ActiveCampus provides services in addition to location-aware ones such as ActiveClass (Griswold, Boyer, Brown, & Truong, 2003) used to encourage participation between students and professors during lectures. Pousman's location-aware event planner (Pousman et al., 2004) allowed for the spontaneous and planned scheduling of events. Events with a specific location associated with them can be annotated on a map along with the location of friends and event participants.

ActiveCampus and Pousman's location-aware event planner applications have been field tested in situations that are reminiscent of rendezvousing. The combination of location-awareness and communication channels provides the ability to actively initiate a rendezvous with a partner (they describe an example of seeing a friend nearby and then suggesting they go for lunch) (Griswold et al.). Although applicable to rendezvousing, the focus of this previous research was on the design (Fithiam, Iachello, Moghazy, Pousman, & Stasko, 2003) and iteration (Griswold et al.) of the technology.

A more abstract representation of location-awareness information can be seen in Marmasse et al's work on WatchMe (Marmasse, Schmandt, & Spectre, 2004), a contextually aware personal communication device (in the form of a watch). Contextual information is extracted by comparing user movements to previous patterns terminating at user-defined locations. The context of the user's location is then displayed in a descriptive manner, such as "gym", and not in absolute coordinates or as annotations on a map. The device was proposed to

facilitate communication within an “inner circle” (intimate friends, family members, etc.), not the general public.

Augmentation of Social Activity

Introducing a new technology that is meant to support or augment a social activity is not without effect. The term hyper-coordination has been coined to refer to expressive use of mobile phones for emotional and social communication (Ling & Yttri, 2002). Hyper-coordination has arguably augmented our social interactions (Ito & Okabe, 2005; Ling & Yttri, 2002). Ambient virtual co-presence (Ito & Okabe, 2005) is the perception of maintaining a background awareness of others by enabling a continuous social awareness. The ability to text message allows users to maintain a continuous awareness of the people they are messaging back and forth with (Ito & Okabe, 2005).

Location-aware technology can provide users with hyper-coordination and ambient virtual co-presence similar to what is offered by mobile phones. Although not as socially rich, users can maintain constant awareness of others simply by viewing and communicating via their location-aware device.

The constant awareness inherent with ambient virtual co-presence raises privacy concerns. In many situations (including rendezvousing) technology is useful; however, the design of such technology can be in conflict with personal privacy issues and requirements. Privacy concerns for location-aware computing are complex given its social applicability. Different social groups or communities have varying requirements and attitudes toward privacy (Hong, Ng, Lederer, & Landay, 2004). As described by Palen and Dourish (Palen & Dourish, 2003), individuals have disclosure boundaries where they determine what information will be made public and what information remains private. The choice of where to draw this disclosure

boundary can have a direct impact on the overall effectiveness and, consequently the benefit of location-aware technology. If the application is useful and provides an added benefit, we are less concerned with the disclosure of our location (Barkhuus & Day, 2003). In the case of a rendezvousing application, the more publicly available we make ourselves the greater benefit the application will provide us and our partners. To better enable these applications, perhaps privacy can be forgone given an appropriate audience. It has been suggested that people may be comfortable sharing location information with their "inner circle" (Marmasse et al., 2004), specifically immediate family, or persons within a location specific social network (Jones, Grandhi, Whittaker, Chivakula, & Terveen, 2004). Persons at work may be more willing to share location information with colleagues at work, than persons not within their work social network.

The Rendezvous Study

The methodological challenges of conducting mobile research in the field are well known (Abowd & Mynatt, 2000; Kjeldskov, Skov, Als, & Hoegh, 2004). We believe that it is important to provide sufficient details of methodological approaches so that the validity of the work can be accurately assessed and that others can learn from the approaches taken. Where appropriate, we reflect upon the impact our study design had on our ability to observe and analyze the effect of location-awareness on the social coordination of participants during rendezvous activities.

Study Design

An experimental simulation was conducted in the field to explore how technology impacts social coordination. Participants took part in one of three different technology conditions: mobile phones; location-aware handheld computers; or both mobile phones and location-aware handheld computers. Three rendezvous scenarios were simulated so that a range of behaviours could be observed.

The use of location-aware software is not limited to a particular setting and is applicable to a range of social activities. It was therefore important that we observe usage in a realistic setting, despite the fact that experimental precision and control would be sacrificed (Kjeldskov et al., 2004; McGrath, 1995). An urban environment was chosen to provide realistic observations; however, the dynamic nature of the setting meant that the study environment (e.g. amount of pedestrian and vehicle traffic, red lights) was not constant across pairs of participants. As a result, quantitative measures, such as the time it took for participants to rendezvous, were not directly comparable.

Participants

Forty-eight participants (28 male, and 20 female) ranging in age from 18 to 56 (mean 26) took part in this study. Recruitment notices were sent to the Dalhousie University community (faculty, staff, and students). Participants provided informed consent and were compensated $10 for participation in the study. Some of the participants signed up as pairs (often with family or friends external to the university community), and therefore had a previous relationship with their partner. Other participants signed up individually and were assigned a partner who, in most cases, was unknown to them. Of the groups, 4 had no relationship with the other participant, 1 were acquaintances, 11 were friends, 2 were family members, 5 were a spouse or a significant other and 1 group indicated their relationship as ‘Other’ and was not clarified.

The mobile phone experience of the participants was varied. Twenty-nine participants indicated that they use a mobile phone frequently (at least a couple times a week), while the remaining nineteen indicated infrequent use. The majority of the participants were inexperienced with handheld technology with thirty-five participants indicating that they do not use a handheld

at all, four indicating infrequent use (at most a couple of times a month), and the remaining nine indicated that they use a handheld device frequently (at least a couple times a week).

Most of our participants were familiar with the study area. Twenty-eight participants indicated that they shop/walk there frequently (one or more times a week), sixteen indicated that they shop/walk there monthly, and the remaining four indicated that they rarely or never shop/walk in this area.

The study took place in August 2004, within a four block radius encompassing the Spring Garden Road district in downtown Halifax, Canada. This area of the city is a busy shopping district with lots of shops, prominent landmarks, and pedestrian and vehicle traffic.

There were several social considerations associated with conducting the study in a busy downtown area. Participants had to dodge pedestrians as they navigated using their maps or handhelds. Curious passers-by and shop owners sometimes stopped to watch, or to ask what was going on. Encounters also occurred with people on the street such as buskers and panhandlers. Being in a public place also increased the potential for embarrassment and feelings of self-consciousness on the part of the participants, particularly because they were equipped with voice recorders and were trailed by researchers.

Weather conditions were an issued throughout the study. Participants were rescheduled when it rained, because the study materials and technology would be damaged by the rain. Wind and sun also affected the study. Wind made it difficult for participants and researchers to handle paper forms. Bright sunlight made it difficult at times to view the handheld displays. Other environmental factors also created problems, as when tree sap dripped on the equipment while in the urban park used for pre- and post-session questionnaires and interviews.

Running the study in the field also meant that the researchers did not have access to a "home base" which impacted study procedures. Equipment and paperwork had to be carried throughout the experiment. There were no power outlets, requiring careful management of battery power during long study days. Experimental conditions were assigned, in part, based on the level of battery power available for the various devices. Park benches were used for interviews and clipboards were use to manage paperwork.

Technology Conditions

Mobile phone. The mobile phone condition was intended to be the control group from which we could examine how location-aware technology on a handheld differed from previously identified rendezvousing behaviours (based on Colbert's earlier work (Colbert, 2001, 2002)). In the mobile phone condition participants were provided with a mobile phone programmed with their partner's mobile phone number. The participants were also given a laminated paper map of the area identical to the one provided on the handheld. The map also showed most of the buildings in the area (without names).

Location-aware handheld. In the location-aware handheld condition participants were provided with an HP iPAQ h4155 handheld computer. Each handheld ran custom location-awareness software that enabled participants to view a street map of the area annotated with the participants' locations as well as the rendezvous location (see Figure 1). Each participant was represented by a different coloured dot on the map. Approximately 1/6 of the map was visible at a time and participants panned the display to see the rest of the map.

The location-aware software also provided participants with the ability to request a rendezvous location. To suggest a new rendezvous location, participants selected the rendezvous icon (an 'X') and moved it to the desired location. The participant then selected the 'ask' option

from the rendezvous menu at the bottom of the screen. This caused a message to pop up on their partner's screen indicating that a rendezvous location had been requested. The partner then viewed the suggested rendezvous location and responded by accepting, rejecting or ignoring the request (through the rendezvous menu). The rendezvous 'X' remained red until both participants agreed upon the location, at which point it turned green.

Mobile phone and location-aware handheld computer. In the mobile phone and location-aware handheld condition, participants were provided with both a mobile phone and the handheld running the custom location-aware software (as described above). The participants were told that they were free to use either device at any time during the study.

Wizard of Oz Approach to Location-Awareness

We initially envisioned our location-aware handheld computers being GPS-equipped and connected via a Wi-Fi/cellular network to automatically provide location-awareness information. Early on in our testing it became evident that using GPS technology to provide location-awareness information on the handhelds would be extremely challenging. The urban environment of the study, as well as the technology to which we had access, was not adequate to provide the location-awareness information at the level of granularity required. This is not an uncommon problem as other researchers have similar problems using GPS in a city environment (Flintham et al., 2003). Additionally, the Spring Garden Road district of Halifax does not have widespread publicly accessible Wi-Fi hotspots. Given these limitations, we chose a Wizard of Oz approach to provide the illusion of GPS and Wi-Fi/cellular connectivity.

The wireless connectivity and location-awareness in our study was provided by two Wizards. The Wizards were equipped with Bluetooth enabled handheld-computers that also ran the custom location-aware software. Each Wizard was assigned one participant to track and

walked a short distance behind that participant (see Figure 2). A Bluetooth connection was established between the participant's handheld computer and the corresponding Wizard's handheld computer. This provided the Wizards with the ability to update the participant's handheld indirectly. The two Wizards themselves were in constant contact via 2-way radios, communicating location information of the participant they were following, along with any rendezvous requests or acknowledgements. Although this approach may appear unreliable, it has been shown to be credible in previous research (Benford et al., 2004) and worked very effectively in our study. When the participants were within sight of each other, the Wizards were able to very accurately position both participants on the map. When out of sight, small inaccuracies in position caused by lags in communication between Wizards were not apparent to the other participant as they could not see their partner's precise location.

Procedure

At the beginning of each session the researchers met the participants in a small park located at the edge of the study area. Each participant was first asked to fill out a background questionnaire. Following this they were given an introduction to the technology they would be using in the study (a mobile phone, a location-aware handheld, or both). To ensure that the participants were familiar with the devices, they were asked to complete a practice rendezvous task which required each participant to both request a rendezvous location (at the Dairy Queen across the street, marked Start in Figure 3) and acknowledge their partner's request. In the case where participants were using both the mobile phone and the location-aware handheld, they were instructed to use each device, but separately. After the rendezvous was agreed upon, the participants were instructed to proceed to the rendezvous location.

After the practice rendezvous, participants were informed they would be taking part in three different scenarios where they must meet up with their partner after completing individual tasks. These tasks were designed to separate the participants so that they could then rendezvous. The tasks were assigned to the participants individually, both verbally and on a task card that listed a business name and its civic address. Participants were unaware of their partner's task location unless they chose to communicate that information. Once the individual tasks were completed, the participants were required to negotiate a rendezvous location or meet up at a predefined rendezvous location. Figure 3 shows the map of the study area, annotated with the task and rendezvous locations. After completion of all three scenarios the participants took part in semi-structured interviews with the researchers to gather additional information and discuss the social interactions exhibited in each scenario.

Given that the area where our study took place was a high traffic area (both in terms of pedestrians and vehicles) participants were instructed to not run, and to obey all local traffic laws for their safety and for that of the researchers following them. We frequently had to remind participants of this during the scenarios. In one instance, a participant became completely separated from the observer after darting out as a traffic light was changing. Connectivity issues with the Bluetooth devices occurred when participants were out of range of the Wizards which meant that researchers sometimes had to interrupt sessions to reset the equipment. In two cases, the interference was great enough that participants commented that it affected their behaviour. These sessions were discarded and additional participants recruited.

Rendezvous Scenarios

Three scenarios were drawn from the set of rendezvousing behaviours identified by Colbert (Colbert, 2001, 2002); (1) arranging a rendezvous while separated, (2) negotiating a new

rendezvous when one partner is unresponsive and a previous rendezvous has already been negotiated, and (3) one partner is delayed while the other is waiting at the rendezvous location

Scenario 1: Let's meet here. In this first scenario, participants were instructed that they would each be given a task (1a and 1b, Figure 3) to complete after which they were to arrange a rendezvous location (either partner could initiate the rendezvous). After successfully negotiating the rendezvous they were instructed to proceed to the rendezvous location. The goal of this scenario was to see if two distributed people could easily arrange and carry out a rendezvous. We observed how the participants negotiated the rendezvous, the location and nature of the rendezvous selected, how they made use of the technology provided (depending on the condition), and recorded any difficulties they encountered while completing the task.

Scenario 2: Why won't they respond? In the second scenario, participants were asked to complete individual tasks (2a and 2b, Figure 3) and then rendezvous at a pre-determined location (R2a, Figure 3). After completing their individual tasks, one participant was told that the rendezvous location had changed and was asked to proceed directly to the new location (R2b, Figure 3). The other participant was also told of the change and was instructed to communicate the change in location to their partner; however, we did not allow this communication to succeed. If the cell phone was used, the call was automatically forwarded to voice mail. If the location-aware handheld was used, no acknowledgement was sent. The goal of this scenario was to observe what the requesting partner would do when their partner was unresponsive and a previous rendezvous had already been negotiated. We observed the behaviours of the participants, how they made use of the technology provided, where they chose to go to meet their partner, and recorded any difficulties they encountered while completing the task.

Scenario 3: Why are they late? In the final scenario, participants were again asked to complete an individual task (3a and 3b, Figure 3) and then rendezvous at a pre-determined location (R3, Figure 3). After completing their individual task (3b, Figure 3), one participant was told that they needed to complete an additional task (4b, Figure 3) before proceeding to the rendezvous location. The goal of this scenario was to force one partner to be late for the rendezvous and observe what both partners would do. We observed the behaviours of the waiting participant and the delayed participant, examining how they made use of the technology provided (depending on the condition), whether or not the waiting participant chose to stay at the rendezvous location, and recorded any difficulties encountered while completing the task.

The unpredictability of the setting and the response of users to the activity patterns of the environment meant that the scenarios of use often did not occur precisely as planned. However, even when a scenario did not happen as planned, the participants ultimately did rendezvous, so we were able to observe a broad range of behaviours.

Data Collection & Analysis

In order to capture the behaviours of the participants, a variety of data collection methods were employed. Data was collected via field notes, audio recordings, data logging, questionnaires, and semi-structured interviews. Pertinent data from these sources were aggregated into a single, linear narrative, enabling us to understand how participants proceeded, given the device condition. The multiple data sources were invaluable as the quality of individual data measures was often low due to the difficulties of mobile data capture in an urban environment. (Kellar et al., 2005) provides further discussion about the challenges we encountered conducting mobile research in an urban setting.

Audio recording. Each participant was equipped with a digital voice recorder in order to create a record of all comments and conversations. The recordings were transcribed and pertinent comments and conversations were added to the linear narrative of the rendezvous.

Scenarios were piloted to measure audio quality and appropriate placement of recording equipment on participants. The quality of audio recordings was low due to background noise. When participants walked on crowded sidewalks, their recorders picked up third-party conversations. Environmental noises such as construction, tour bus commentaries, large trucks, and traffic were continuous and often drowned out the voice recordings. As both participants had microphones, sometimes what was missed on one recorder could be picked up on the other.

Field notes. Observing mobile participants in an urban setting made data collection difficult. Observers trailed participants so as not to influence their behaviour, but it was often hard to stay close to participants in crowded areas. This unconstrained mobility made it difficult to monitor interactions with materials and to interpret gaze (e.g. was the participant looking at the handheld or down the street).

Observers made field notes recording participants' actions and verbal comments. These observations provided context for the audio conversations recorded. Timing data was recorded, but since the scenarios were difficult to control, timings were highly variable. The timing data was primarily used to provide "landmarks" when integrating the various sources of data.

Coding sheets were created on the assumption that entering structured observations would be easier for recording observations while in motion. Pilot testing revealed that detailed observations were extremely difficult to capture on the street while trailing behind a participant and avoiding pedestrian and vehicle traffic. Observers were unable to count interactions (e.g. map glances) precisely, so coding sheets were reformulated to capture more qualitative user

behaviours. These behaviours included the participant's level of confusion about their current and destination locations, and their patterns of map interaction. Ample room was included for free-form notes. To reduce the amount of paper to manage, coding sections were integrated with researcher scripts and checklists for each scenario.

Field notes taken while walking were often terse and messy, and therefore difficult to transcribe. Due to the difficulty of note taking while mobile, often the notes were made when the participants were stationary, which was not necessarily when something was observed. The field notes were also used to supplement participant comments on the audio recordings that were sometimes incomplete or misleading.

Data logging. All actions performed using the location-aware handhelds were recorded. The logging allowed for a more concise analysis of the rendezvous locations negotiated and general interaction with the system. This data was also used to confirm user interactions that were noted by observers and to shed light on comments made during interviews.

Self-reported data. A demographics questionnaire was administered to gather background information on participants. Following each rendezvous scenario a simple questionnaire was administered to determine users' perceptions pertaining to the rendezvous just completed. A post-session semi-structured interview was conducted to further probe the participants' rendezvousing experience. Questions were designed to identify participant's choices in given situations and how the available technology affected their actions.

Results

This section presents the results and behavioural observations of the study as abstracted from the linear narratives. Despite the fact that participants' individual differences shaped their social coordination, common patterns were clearly evident. The behavioural data, as interpreted

and presented in this section, provides important insights into how location-aware technology can impact social coordination. Common behaviours and issues observed for each rendezvous scenario, in each of the mobile device conditions, are characterized through narratives and associated discussion. All of the narratives represent real data collected in the study. In each case, a rendezvous occurred, although not always as originally planned.

Scenario 1: Let's meet here

In the first scenario, participants arranged a rendezvous location after completing individual tasks.

Condition 1: Mobile phones. Using mobile phones, all participants easily managed the social coordination necessary to negotiate the rendezvous location. Table 1 demonstrates a typical communication exchange for participants in this condition. One striking pattern that was observed was the amount of phatic communication. Phatic communication involves the exchange of "small talk" in order to establish a rapport with one another when initiating and ending a speaking relationship (Laver, 1975; Myers & Myers, 1976). This form of communication was observed in all conditions that used mobile phones across all three scenarios. Although phatic communication can be used to enrich a conversation and give it a more personal feel (i.e. "Hey, how are you doing?"), it also relies heavily on clichés and superfluous conversation exchanges. As evident in our observations, phatic communication caused the conversations to be longer and more drawn out than strictly necessary.

The desire to communicate location information was evident in this condition. Before arranging the rendezvous location, all pairs either explicitly asked their partner where they were located or offered their location without being prompted. The exchange of location information often required further dialog to clarify the precise location (similar to excerpt from Andrew and

Tina's narrative, see Table 2). This ambiguity was common and demonstrates the difficultly participants had articulating their physical location. Once the location was agreed upon, they had no difficulty completing the rendezvous.

Although an awareness of their partner's location appeared to be important to participants, only two groups actually used the paper map to visually reference their partner's location. This suggests that the remainder of the pairs either felt they had an adequate understanding of where their partner was located or they didn't actually care, merely asking the question as part of the phatic dialogue.

All groups chose a rendezvous location that was familiar to both partners or was a well-established landmark. The reliance on landmarks is consistent with previous literature that has shown that people typically use landmarks to navigate (Evans, 1980; Goodman, Brewster, & Gray, 2004). Additionally, research has shown that people are better able to recall and relocate locations/landmarks if they are close to well known or important intersections (Evans, 1980).

Condition 2: Location-aware handheld. All of the pairs relied on the location-awareness information during the rendezvous negotiation process (similar to Renee and Todd's narrative, see Table 3), and all felt that they picked mutually beneficial locations for the rendezvous. The usefulness of the location information in selecting a rendezvous location was explicitly noted by seven of the eight pairs; "It was useful to see where your partner was.", "It was nice to see she was here and I was there … I just picked a middle point." The remaining participant commented that he "just chose a location then looked to see where [his] partner's location was".

Only one pair selected a physical landmark on the map (a building midway on the main road) as the rendezvous location. The remaining pairs selected a street corner on the main street between the partners' locations (which was relatively equidistant to both). This suggests that the

participants felt comfortable using the icon representing the rendezvous location on the map as a point of reference (or 'virtual' landmark) to facilitate navigation.

Condition 3: Mobile phone and location-aware handheld. Despite being given both devices, six of the eight pairs used only the location-aware handheld to negotiate the rendezvous. These pairs exhibited similar behaviours to those in the handheld only condition. One pair used only the mobile phone to negotiate the rendezvous. The final pair used both devices – the mobile phone to first negotiate the rendezvous followed by the handheld to confirm the location.

The pairs that chose to use the handheld computer commented that they felt it would be easier and more convenient. The pair that chose to use the mobile phone commented that they wanted to ensure an exact location was chosen. The pair that chose to use both devices used the mobile phone initially because they felt it would be easier to converse and wanted to check and see if their partner needed anything.

Scenario 2: Why won't they respond?

In the second scenario, participants were asked to rendezvous at a pre-determined location, the Fireside Restaurant, which was then changed to Deco Restaurant. One participant was asked to notify their partner of the new location, but no response was received.

Condition 1: Mobile phone. All of the participants tried to initiate communication with their partner multiple times (similar to Nathan's narrative, see Table 4). Four of the pairs called 2-3 times while the remaining four pairs called continuously.

Although we instructed one partner to inform the other of the location change, only half of the participants actually left voice messages for their partner. However, all of the participants proceeded to the new rendezvous location rather than the original meeting place. It is understandable why the participants who left a message proceeded to the new location—they had

communicated their intent in a form they perceived would be accessible by their partner (voice mail). However, the participants who did not leave a voice mail message also chose to proceed to the new location, despite the fact that they had not notified their partner of the change. Only one of these participants exhibited any hesitation as to where to proceed. We speculate this may be attributed to the artificiality of the scenario.

All rendezvous excluding one were accomplished easily since both partners proceeded to Deco. One rendezvous was classified as difficult because a participant became increasingly agitated that his partner would not answer the mobile phone or return his messages. This was the same person who was unsure of whether to proceed to the old or new rendezvous location.

Condition 2: Location-aware handhelds. All the pairs made use of the location-awareness information provided on the handhelds to observe their partner's movement and infer whether or not the request had been received (similar to Glen's narrative, see Table 5). All the groups except one chose to proceed to Deco after viewing their partner heading in that direction, "I saw [my] partner's dot move towards the location, confirming that he was heading there." The remaining participant headed directly to the new location, before receiving any indication that their partner was going to the new location. All of the pairs met up at Deco successfully.

The number of times the new rendezvous location was suggested varied between groups. Half the groups made requests once or twice while the remaining four groups made several attempts. It appeared that most of the groups stopped suggesting the new location after they observed their partner heading to the new rendezvous; "I looked at where he was going and saw that he was heading towards the new rendezvous [location], so then I went there."

Condition 3: Mobile phone and location-aware handheld. Seven of the eight pairs chose to use both devices to arrange the new rendezvous location while the remaining pair used only

the mobile phone. Six of the pairs initially used the location-aware handheld to suggest the new rendezvous location and then followed-up with the mobile phone when no response was received (similar to Michael's narrative, see Table 6). When no response was received from the phone call, several of the pairs switched back and forth between the handheld and mobile phone attempting to reach their partner; "I tried the handheld, then the cell, then the handheld again, then the cell again. I then saw where her dot was and I went there."

All of the groups used the location-awareness information provided by the handheld to decide how to proceed, and easily met up with their partner. Similar to the handheld only condition, all pairs chose to proceed to the new rendezvous location after observing their partner's location or movement. Even the participant that relied strictly on the mobile phone to communicate the new location used the location-awareness information on the handheld to monitor their partner's progress.

Scenario 3: Why are they late?

In the third and final scenario, one partner was intentionally delayed by being asked to count a bag of pennies before proceeding to the rendezvous location (London Hair Design), making it difficult for them to arrive on time.

Condition 1: Mobile phone. Three participants chose to call and check in when their partner was late for the rendezvous (similar to Laura's narrative, see Table 7). They all inquired where their partner was and why they were delayed. Two other participants chose to call their partner to let them know they were running late and would be late for the rendezvous. For the remaining three pairs, no calls were made. In the post-session interviews, two participants indicated that if the wait-time had been longer, they would have called their partner. A participant from the third pair indicated he would have called if he knew his partner was waiting

at the rendezvous location. Interestingly, in both cases where the participant called to inform their partner that they would be late, the caller was not the partner that we intentionally delayed. These participants were running late because of navigational errors they committed. The participants who were delayed for reasons outside of their control (i.e. we asked them to count pennies) did not choose to call their partners to let them know they would be late.

None of the participants left the rendezvous location to find their partner. One participant continually looked down the street trying to see their partner approaching; however, they were looking down the wrong street and were unaware of their partner approaching in the other direction. Despite the delay in completing the rendezvous, all pairs meet without difficulty.

Condition 2: Location-aware handheld. All participants who arrived first made use of the location-awareness information while waiting. Upon arrival at the rendezvous location, they immediately checked their handheld to determine the location of their partner. These participants continued to monitor the progress of their partner until they made visual contact. In four instances, the person waiting at the rendezvous location chose to walk toward their partner's location (similar to Emma's narrative, see Table 8). The remaining four pairs waited at the rendezvous location for their partner to arrive.

Besides general concern over their partner being late, the location-awareness information did contribute to some uncertainty and confusion when the partner's location-indicator wasn't moving (while they were counting pennies). One participant explained that she was frustrated that her partner's location-indicator was not moving and she wanted to tell her to move up.

Condition 3: Mobile phone and location-aware handheld. All participants who arrived first utilized the location-awareness information and immediately checked their handheld to determine the location of their partner. Four pairs also chose to communicate with their partner

using the mobile phone. In three cases, the waiting participant placed a call to her partner to inquire where they were and why they were delayed (similar to Jessie's narrative, see Table 9). In the fourth case, the delayed participant used the mobile phone to call his partner to say he was running late and would arrive shortly. The remaining pairs simply monitored their partner's movements with the handheld and did not use the mobile phones. None of the participants who were waiting left the rendezvous location to attempt to meet up with their partner.

Participant Comments

Participant feedback was collected during post session interviews. The participants provided comments and suggestions concerning a feature set that they believed would aid rendezvousing and better facilitate communication and coordination between partners. Many of the groups remarked that a text messaging system using pre-defined messages would be beneficial. They felt that typing full messages would be time consuming, but that navigating a simple, appropriately grouped, pull down menu with pre-defined messages such as 'behind schedule', 'forgot something', 'can't make it' would allow for quick communication. Most agreed that a system for sending a message that was unique to the situation would sometimes be needed, but thought appropriate pre-defined messages would be useful in many situations. Some suggested that rather than navigating menus or entering text, simple map annotation could be used. Annotating the map would allow users to write messages directly on the map (e.g. 'behind schedule'), draw arrows providing direction or symbols suggesting places to avoid (e.g. construction, traffic) or places of interest (e.g. sale at a store, interesting street performer). An additional suggestion was to have the location indicator representing each user convey additional information. Rather than a non-descript dot (as used in our study), additional contextual information could be conveyed by using an indicator similar to an emoticon (e.g. an emoticon

flexing its bicep could indicate at the gym, an emoticon with a text bubble coming from its mouth could indicate talking). In such a case, the observing partner would be able to ascertain both user location and contextual information without obscuring additional map and screen information.

Discussion

All of the pairs were able to complete the rendezvous tasks without much difficulty, regardless of the technology provided to the participants. However, close observation of the behavioural and communication differences demonstrates that the technology available significantly altered how the participants' managed their social coordination. This section discusses differences in four key areas: communication efficiency; utilization of location awareness information; different information leads to different behaviours; limitations of location-awareness information, and privacy concerns.

Communication Efficiency

Mobile phones are a familiar technology which most people are well accustomed. Because of this, there are standard communication protocols that people use when communicating over phones. For example, it is well known in the literature that people engage in phatic communication when they want to establish a speaking relationship (Laver, 1975; Myers & Myers, 1976). As such, arranging a rendezvous using a mobile phone naturally follows these social norms.

Although phatic communication aids in the initiation and flow of verbal communication, in general, it provides little benefit to the rendezvous process. Non-phatic communication provided by location-awareness information or from simple, pre-defined text messages has the potential be much faster and more streamlined compared to standard verbal exchanges. The

results from our study suggest that in some instances, this communication efficiency is desired. When participants had the choice of either device, they often chose to use location-awareness information over a verbal exchange with their partner. In addition, several of the participants expressed a desire for short, pre-defined text messages or map annotations to augment the location-awareness information available on the handheld devices. Some of the participants suggested pre-defined text messages such as ‘stuck in traffic’, ‘running late’, and ‘behind schedule’. It is interesting to note that these suggested messages are devoid of phatic structure; they are brief messages conveying only context.

It was also more efficient to gather information from the location-aware handheld devices than from mobile phones. Social norms influence how comfortable people are making inquiries as to their partner’s status (Colbert, 2004). For example, in the mobile phone condition, when one partner was late for the rendezvous, the other partner always waited before calling to inquire about their state. In contrast, in the conditions involving the location-aware handhelds, upon arriving at the rendezvous location, if the person’s partner was not at the location, they immediately used the device to view their partner’s location. In addition, the participants frequently (or constantly) monitored their partner’s location using the handheld device. It would typically be considered rude to continue calling someone on a mobile phone to maintain a similar state of awareness. It is interesting to note that there can be a large variance in the length of time people feel it is appropriate to wait before engaging in a call (or a follow-up call). This individuality was clearly observed in our study.

Utilization of Location-Awareness Information

Having access to location-awareness information has obvious benefits. Users can make more informed decisions and have a stronger sense of ambient virtual co-presence. The

participants in our study made extensive use of location-awareness information as a background communication channel to monitor their partner's location (as well as their own) in an unobtrusive manner. When people had access to both the location-aware handheld and a mobile phone, they tended to use the handheld first to gather all relevant information and then followed-up with the mobile phone if needed.

Different Information Leads to Different Behaviours

The amount and type of information available to people can influence their behaviours. This was evident from our observations of the third scenario (for all three conditions). In the mobile phone condition, when one partner was waiting for the other, none chose to leave the rendezvous location in an attempt to meet their partner. This is not surprising given that without location information they may not have known where their partner was. Even if they used the mobile phone to determine their partner's location, it would still have been difficult to infer the direction they would proceed in and subsequently be able to intercept them.

In the location-aware handheld condition, half of the participants chose to leave the rendezvous location to attempt to meet their partner. Being aware of their partner's location allowed them to easily find (and intercept) their partner. However, in the final condition when the participants had access to both a mobile phone and a location-aware handheld, none of the participants chose to leave. This suggests that the reason the participants left the rendezvous location in the location-aware handheld condition may have been more a result of missing contextual information (gained using the mobile phone) rather than the ease with which they could meet up with their partner.

Limitations of Location-Awareness Information

The results from our study clearly demonstrate that mobile phones and location-aware devices have different roles in rendezvousing behaviour. Mobile phones are an easy medium to assist people in communicating information about actions and intentions (i.e. ‘what are you are doing?’ or ‘where are you planning to go?’). In contrast, sensor-based devices are very good at gathering overt contextual information, such as location, in a very unobtrusive manner. However, they provide little assistance in interpreting the associated state of the person. In our study, when participants were given both devices, they recognized the strengths of each device and utilized each appropriately (i.e. monitoring their partner’s location with the handheld and using the mobile phone to clarify what the person was doing).

In the location-aware handheld condition, several participants were confused about their partner’s actions or believed that they were lost. As a result, these participants chose to leave the rendezvous location to try and meet up with their partner. In contrast, in the mobile phone and location-aware handheld condition, the participants used the mobile phone to call their partner and gather this information. This potentially gave them a better understanding of how their partner was proceeding, allowing them to make a more informed decision as to how the rendezvous was progressing. In our study, when phone communication was initiated, all of the delayed partners indicated that they would be at the rendezvous location shortly so none of the participants waiting at the rendezvous location seemed to feel compelled to leave.

Before running this study, we felt that location-awareness information would always be beneficial to people attempting to rendezvous. In our third scenario, we observed instances where location-awareness information was extremely beneficial and other instances where it was detrimental. It was beneficial because participants could see their partner’s location and track

their progress in an unobtrusive manner. This arguably provided the waiting partner with enough information to wait contently. However, when their partner appeared to be lost or not making progress, it was very disconcerting to the waiting partner because they did not have enough information to determine what the problem was. This uncertainty was strong enough in some cases to actually draw the waiting partner away from the rendezvous location.

Privacy Concerns

During post session interviews a few participants commented on their concern over the continuous location-awareness that our application provided. One comment made by a participant was the Orwellian “big brother” effect of location tracking technology. The same participant additionally commented that there are two sides to the location tracking issue. A guardian of a child might see this technology as a blessing, whereas the child could view it as an invasion of their independence.

In our system, monitoring a partner’s progress was possible without interruption to the partner, or any indication that they were being monitored. Privacy concerns of background monitoring must be addressed given that technology adoption can be significantly affected by perceptions of the public. However, location-awareness does not need to be continuous. It is a tool that can be used periodically to reinforce social activities such as rendezvousing. Prior research has shown that if users perceive the service to be useful, they are less concerned over their location being tracked and disclosed (Barkhuus & Day, 2003). Outside of the context of the social activity, the location-awareness feature could be turned off. People wanting the benefit of location-awareness can actively choose to forgo their privacy during the rendezvous with a distinct group of people and regain their privacy upon completion. Obviously, hardware and device protocols must ensure that only the distinct groups would have access to the information.

Design Implications

The two devices examined in this study (mobile phones and location-aware handhelds) represent different ends of the communication spectrum. Mobile phones are an active communication channel that supports rich verbal communication but are also obtrusive. Location-aware handheld applications provide a passive communication channel that facilitates background monitoring of users' locations. As demonstrated in this paper, both have specific advantages and disadvantages that users generally understand and utilize. However, by recognizing these differences, we can improve on their strengths, minimize their weaknesses, and recognize the value of their boundaries. We reflect on the results of our study to provide insights into design implications for location-aware devices to support social coordination.

Encode Additional Information into the Location-Awareness Representation

Although, location-awareness information was beneficial in our study, it was also limiting because it provided users with only two pieces of information: where the participants were and in which direction they were moving. It would be beneficial to encode other pieces of information into the representation of the participant's location, such as temporal movement, or indication of their state (e.g. "I'm hurrying", "I'm lost"). The additional information could provide observers with the context necessary to make better or more appropriate actions during the rendezvous process. However, the presentation must be managed appropriately ensureing the representation is intuitive and easily understandable, and thus beneficial for social coordination.

Provide Multiple Levels of Detail for Communication

The results of our study demonstrate that in some instances (e.g. scenario three), location-awareness is not enough. While an augmented representation as discussed above may provide basic context, users will sometimes need richer channels of communication. Understanding

users' actions is easier with verbal communication over mobile phones; however, social protocols often limit when people feel comfortable using this medium. This is partially due to the large overhead involved in initiating and participating in a phone conversation. Location-aware applications should provide users with additional communicative functionality to enable them to provide and receive contextual information. For example, text messaging with either pre-defined or free-form messages can be an efficient communication method and is sometimes more appropriate than verbal communication. Providing multiple communication channels would allow participants to select the most appropriate channel for the message and situation of use.

Ease of Monitoring

In our study, any time a participant was waiting, they took advantage of the location-awareness information to observe their partner's progress. Although there was likely a novelty factor in our study, keeping users informed of the status of the rendezvous may be a priority. Therefore, it is important to design the location-aware device to facilitate monitoring. This includes the physical form-factor of the device, the representation of the information on the screen, and any interactions with the device. A user should be able to quickly glance at the device and gather the necessary information.

Managing Privacy

As previously mentioned, privacy concerns must be recognized and appropriate support must be given to enable users to manage their privacy. Within our context of rendezvousing, we made the assumption that a user who wanted to use location-awareness information to rendezvous with friends would accept the short-term privacy implications. It is important to recognize the relationship between users since privacy concerns change when the relationships between users change (Hong et al., 2004).

General suggestions to manage the privacy concerns associated with location-awareness include providing users with control over whether or not their location is broadcast and to whom the information is sent. Additionally, subtle feedback could also be provided to a user to indicate that their location is currently being monitored, such as with Marmasse et al.'s "thinking of you" system (Marmasse et al., 2004).

Conclusions

The results presented in our study clearly demonstrate that technological choices can significantly impact an individual's behaviour during social coordination. Mobile phones, although a rich communication medium, enforce social protocols which aid in initiating and continuing verbal communication. Location-aware technologies can avoid these social protocols by providing simple communication methods while still conveying location and basic contextual information. The design implications drawn from our study are important for the evolution of location-aware technologies that aid social coordination.

There is a great deal of future work that needs to be conducted. Privacy and its management is important for the adoption of location-aware technologies for use in social coordination situations. We need to further address this issue to understand appropriate privacy measures. Additionally, we need to examine the effectiveness of communication methods such as pre-defined text messages and map annotations to better understand the messaging requirements of users.

Table 1

Amanda and Jason's Narrative (Scenario 1: Mobile Phone Condition)

Amanda and Jason each went off to perform their individual tasks. Amanda arrived first at her task location and picked up the mobile phone to call Jason.

A: "Hey, how are you doing?"

J: "Hello, how are you?"

A: "Good, good. Where are you?"

J: "I am at John Allan's Cigar Emporium."

A: "Alright."

J: "Where are you?"

A: "I am down at Clyde and Dresden."

J: "You're down at Clyde and Dresden?"

A: "Hair Design Centre."

J: "What are you beside?"

A: "Across from the liquor store."

J: "Ok, I can be there. Do you want me to meet you?"

A: "I can meet you at Shoppers. Is that better?"

J: "Shoppers is fine."

A: "Ok, I'll meet you at Shoppers then."

J: "Shoppers, I can be there. Wait for me there."

A: "Ok. Bye."

J: "Ok. Bye."

Amanda and Jason headed to Shoppers Drug Mart and rendezvoused successfully.

Table 2

Andrew and Tina's Narrative (Scenario 1: Mobile Phone Condition)

A:	"Where are you?"
T:	"I'm on Dresden and Clyde. Just behind the Shoppers on Spring Garden, which is the corner of … Dresden and Spring Garden."
A:	"What? So you are at the Shoppers?"
T:	"No, I'm about half a block away."

Table 3

Renee and Todd's Narrative (Location-Aware Handheld Condition)

Renee and Todd both arrived at their task locations at similar times. Todd decided to initiate the rendezvous with Renee. He looked at the handheld screen and noticed that Renee was just two blocks away on Dresden Row. Todd selected the top-left corner of the intersection of Spring Garden Rd. and Dresden Row for the rendezvous location. This point was midway between Renee's and Todd's locations. In the meantime, Renee looked at the screen on her handheld computer in preparation for requesting a rendezvous. A message appeared on Renee's screen indicating that Todd had suggested a rendezvous location. This looked fine to her so she acknowledged, accepting Todd's request.

Table 4

Nathan's Narrative (Mobile Phone Condition)

Nathan picked up the mobile phone to call Robin and let her know about the change in plans. The call was not answered and was forwarded to a voice mail box. Nathan left a message for Robin:

N: "Hey. Fireside cancelled. We're going to have to go to Deco which is on the south side of Spring Garden, just beside Rockport. I will be hanging around out there. I will try to get a hold of you again. Cheers."

Nathan walked to Deco but continued to try to get a hold of Robin on the mobile phone (6 times). He didn't stop calling until he was close enough to Deco and could see Robin standing in front of the Restaurant.

Table 5

Glen's Narrative (Location-Aware Handheld Condition)

Glen used the handheld to move the rendezvous point and suggest to Jill that they meet at the new location (Deco). Glen received no response from Jill so he continued to suggest the new location (using the handheld) as he walked toward Deco. He assumed that Jill would see the new location on the map and head there, even if she hadn't acknowledged his suggestion. Shortly thereafter, Glen saw Jill's location indicator moving towards Deco on the map, indicating to him that she received his message.

Table 6

Michael's Narrative (Mobile Phone & Location-Aware Handheld Condition)

Michael used the handheld computer to suggest the new rendezvous location to Bill. No response was received from Bill. Michael decided to call Bill on the phone. Bill didn't answer and the call was forwarded to voice mail. Michael left a message for Bill:

M: "Hi Bill. This is Michael. We are supposed to meet at 5518 Spring Garden Rd., Deco. So let me know. Bye."

Michael glanced at his handheld and noticed that Bill was now at Deco and walked there.

Table 7

Laura's Narrative (Mobile Phoned Condition)

Laura arrived first at London Hair Design (the rendezvous location). Four minutes later when Vanessa still hadn't arrived, Laura took out her mobile phone and called Vanessa.

L: "Hello."

V: "Hello."

L: "Hi. Where are you?"

V: "I am trying to find Curry Village. Brenton St. I can't find it. Where are you now?"

L: "I am at South Park. London Hair Design. I'm waiting for you."

V: "So you made it. Ok. I'll be there in about five minutes."

L: "Ok. Goodbye."

Laura continued to wait until Vanessa arrived three minutes later.

Table 8

Emma's Narrative (Location-Aware Handheld Condition)

Emma arrived first at the rendezvous location, on time. She checked her handheld computer to see where Natasha was. "Uh oh. Where is she going?" Emma looked up and down the street and frequently looked down at the handheld. Emma started making noises ("Whoa whoa whooooa") as Natasha appeared to be going the wrong way. Emma suggested a new rendezvous location on the corner of South Park St. and Brenton Place. She indicated that she wanted a quick rendezvous. She began to walk toward the new rendezvous location and saw Natasha approaching. They met up and walked to the final rendezvous location together.

Table 9

Jessie's Narrative (Mobile Phone & Location-Aware Handheld Condition)

Jessie arrived first at the rendezvous location. She observed her partner getting closer on the handheld. The next time she looked at the handheld her partner's location-indicator was no longer moving. Jessie picked up the mobile phone and called Sandy.

J: "Hi. Are you still coming?"

S: "Hello. Hi. At some point. I have to count pennies first."

J: "Ohhh, ok. Have fun."

S: "Ok, I will."

J: "Call me if anything changes."

S: "Alright. Bye."

Jessie waited and shortly afterward Sandy arrived.

Figure 1. Interface for the location-aware device. (a) Partner's dot; (b) participant's dot; (c) rendezvous 'X'.

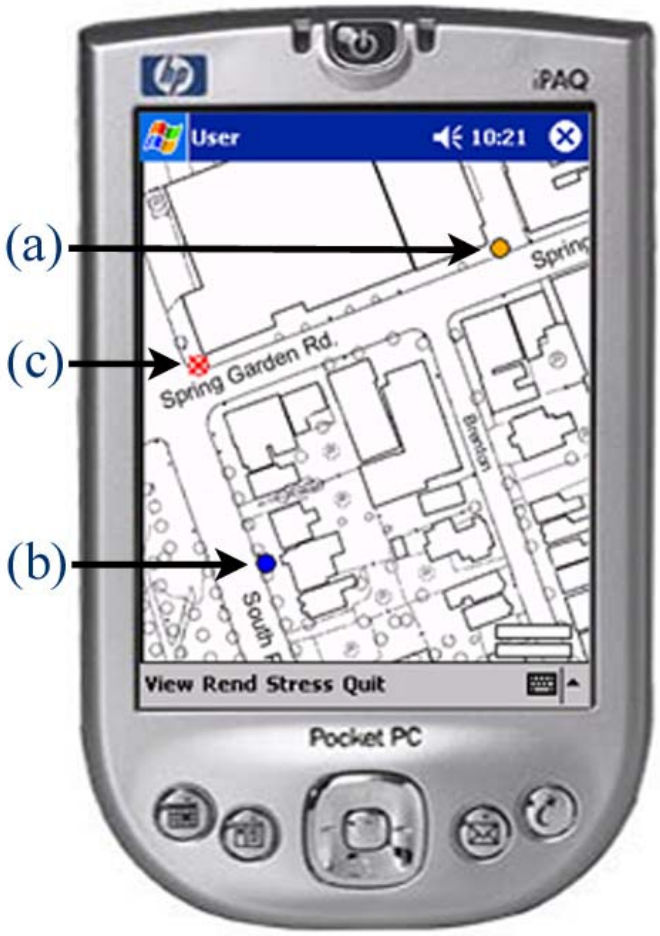


Figure 2. Wizard-of-Oz approach to providing location-awareness.

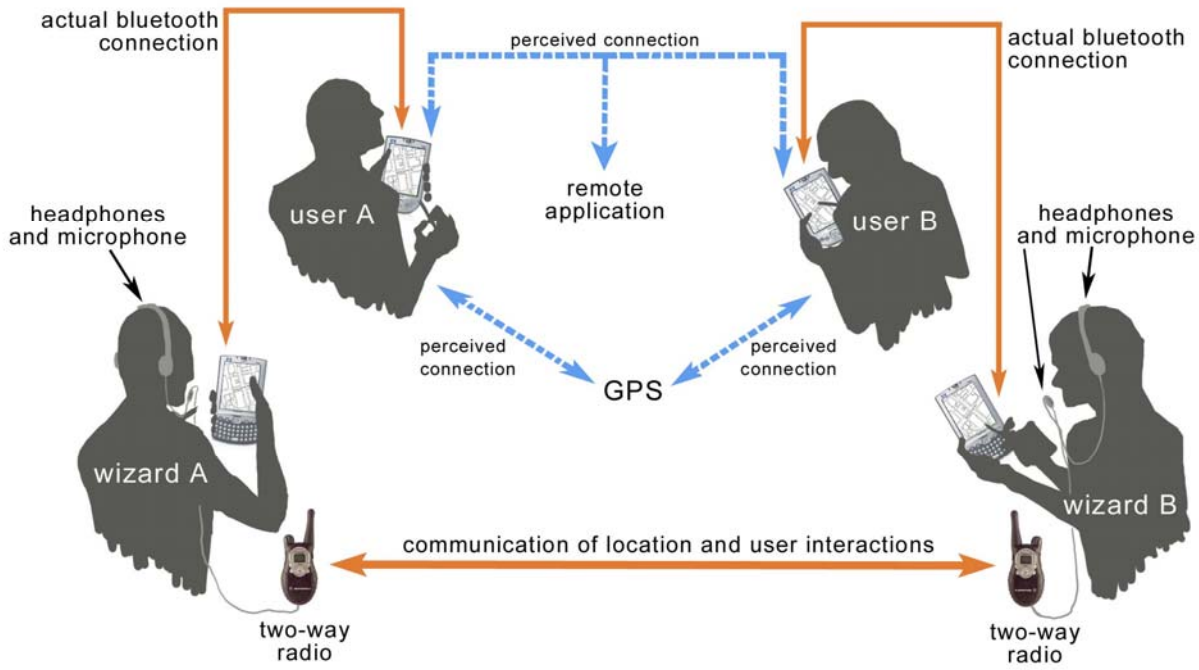
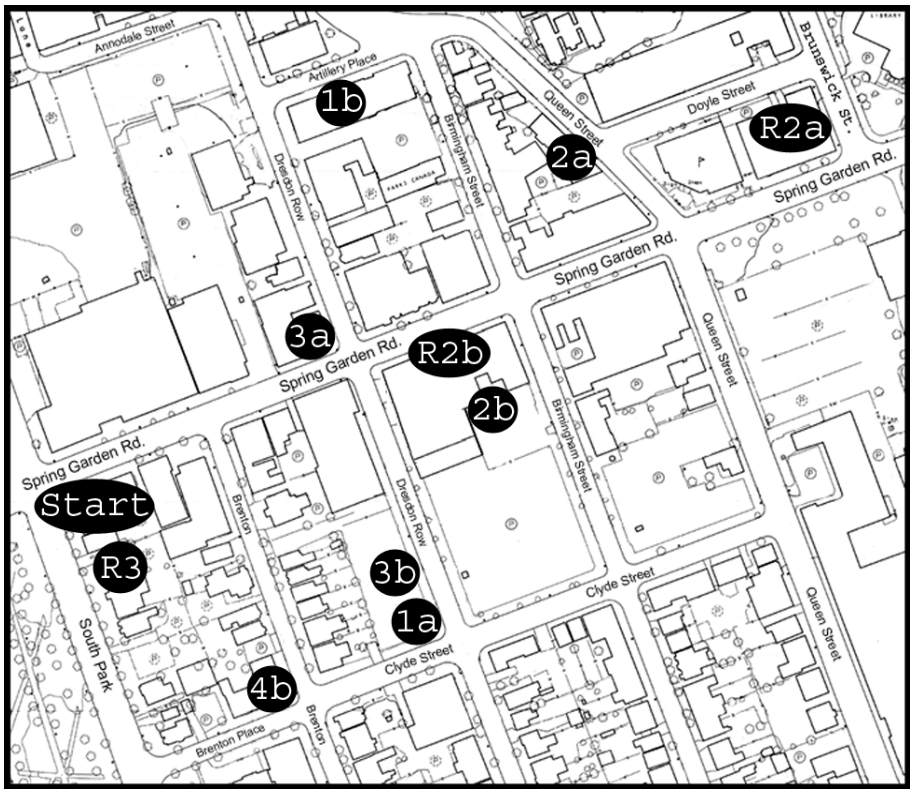


Figure 3. Complete map used by participants. (1-3)a and (1-4)b represent the task locations for each partner. R(2-3) represent provided rendezvous locations. Start represents the initial starting location.



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