Chasing *the Fugitive* on Campus: Designing a Location-based Game for Collaborative Play

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Abstract

We report on our experiences with building and deploying a collaborative location-based mobile game. *The Fugitive* is a multiplayer game that is played using mobile TabletPCs in a natural campus environment. The objective is to track and capture a hidden object called *the Fugitive* on a digital campus map using annotations for communication among one's teammates. We discuss the design, development, and network infrastructure as well as focus group and observational findings from our field study. Our findings suggest that the effect of location-awareness on collaboration and game play strategies is an intriguing area for study, and we share our insights from this project with the Canadian Game Studies community.

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Introduction

Games are an integral aspect of human civilisation and culture. Their popularity has inspired ethnographers to generate taxonomies that organize different features of games (Roberts, Arth, and Bush, 1959), such as physical skill (simulates hunting), strategy (simulates chase or hunt), and chance. Many popular games such as Hide and Seek and Capture the Flag incorporate such elements within their game objective. As computing devices become increasingly ubiquitous, they are more frequently vehicles for mixed digital- and physical-based entertainment (mixed reality gaming). To aid other researchers and designers in building such games, we present our experiences with the development and evaluation of a collaborative location-based mobile game in a mixed reality scenario. The foundation of our game model (see Figure 1 below) draws from three diverse fields of study: *mobile environments, collaboration,* and *location-based services.*

As computer technologies have advanced, so have the diversity of game platforms available for user engagement. Games originally designed for one's desktop have been adapted for mobile devices, providing additional environments for game play activities. *Mobile applications* are being used to complement the shared experience of outdoor games, for example to coordinate strategies by aiding in location awareness (e.g. New Mind Space, 2006). Because previously distinct environments (digital and physical) are being interwoven into the fabric of an existing public space, we perceive this new game genre (mixed reality) to be unique.

What relationships may emerge when mobility and *collaboration* are explored within everyday cultural and social places (Dourish, 2006)? Mobile multiplayer games provide an opportunity to study collaborative human experiences and shared communication in natural co-located and distributed environments.

Location-based services use the location of an individual to deliver context sensitive information. In *the Fugitive*, this information is simply the player's position in the game space.

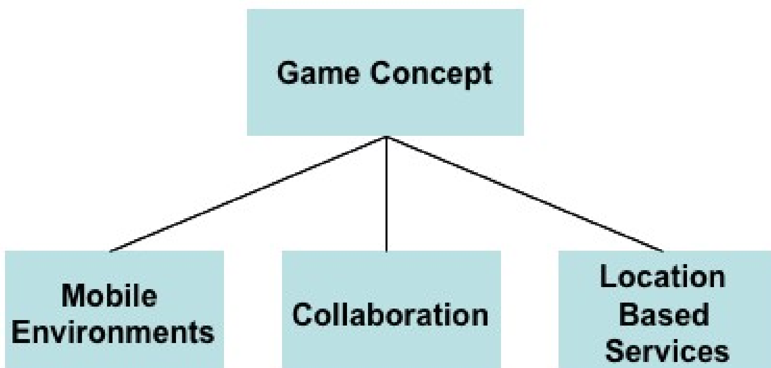

Figure 1: the Fugitive game model

We believe that the next generation of games will incorporate elements of these three distinct units. Recent advancements in technology and infrastructure are providing tools to design and explore collaborative location-based mobile games. This paper begins with a discussion of the research that motivates us within the areas of games, mobility, collaboration, and location-based services. We then describe our experiences in designing and implementing our game, and then describe our observations of how the game was played. We conclude with a reflection on the lessons learned and future work.

Related Work

Mobility

We define a mobile game as one which integrates aspects of the real world and mobile network infrastructure into a game environment. One such game developed under the Mobile MUSE Project (Mobile MUSE, 2006) is called the Digital Dragon Boat Race (Jeffrey, Blackstock, Deutscher, and Lea, 2005). The goal of Mobile MUSE is to explore how mobile applications can enrich cultural experiences and build community by engaging people on the street and other public places. The Digital Dragon Boat Race engages the public in an exploration of Chinese culture using a location-based game. The objectives of the project are to understand: 1) how play can be embedded into the design of mobile applications that educate and entertain; 2) how mobile technologies can extend the reach of cultural festivals; and 3) how technology may enhance place and community.

Collaboration

Location-based games are gaining visibility in Computer Supported Cooperative Work (CSCW) (see Benford, 2005; Crabtree, Rodden and Benford, 2005; Barkhuus et al. 2005) because they provide a context to explore social interactions, the influence of location-awareness, and the effects of mobile technology in shaping collaborative strategies. Dillenbourg (1999) defines collaboration as a situation involving synchronous communication in which participants (two or more) of equal status interact as group members to perform a joint activity. In *Rules of Play*, Salen and Zimmerman (2004) discuss internal and external levels of social interaction that occur within the boundaries of the game space, defined as a "magic circle" (p. 95) (also see Huizinga, 1995, p. 10 for original definition). Interactions between players which emerge out of rules of the game are defined as internally constructed.

As an example, *Live Action Scotland Yard* (Live Action Scotland Yard, 2006) involves at least three participants playing the role of detectives tracking and chasing Mr. X around Toronto's transit system in an attempt to capture Mr. X. Each detective's movements are coordinated by a Dispatcher player who communicates via mobile phone from a base location, and who speculates on the present and possible future locations of Mr. X. Similarly, Mr. X has a Dispatcher who is trying to help Mr. X evade capture. The game begins after Mr. X is told to head to a transit stop, and then to phone headquarters when s/he arrives. During each step, s/he informs the Dispatcher where s/he is, and which method of transportation s/he will be using in her/his next three moves. The game ends after a time limit has expired or Mr. X is caught. Communication between players and partners is a one-to-one relationship (e.g. detective to Dispatcher, Mr. X to Mr. X's Dispatcher) using voice communication over mobile phones in order to coordinate strategy and provide for the self-reporting of location information.

Location-based Services

Using location information in real world game environments is not a new thing. An old, non-technological example would be *Macro Polo*, a multi-player children's game played in a swimming pool (Marco Polo, 2006). One player is labelled "It" and their objective is to tag the other stationary participants while moving around the swimming pool and shouting out "Marco!" with their eyes closed. The other participants respond in kind with "Polo!" Using these auditory cues, the "It" player attempts to tag another player in order that they will become the new "It". Although communication doesn't occur between the non-It participants, the rules enable information about players' location to be shared vocally upon request.

Location-based services provide data using a wireless local area network (e.g. WiFi) or a positioning system such as GPS. The general objective is to support an enhanced mobile experience for the person interacting within their physical environment. The following two examples of location-based games (*Can You See Me Now?* and *Catch Bob!*) further elaborate on this. In *Can You See Me Now?* (Benford et al., 2004; Crabtree et al., 2005), participants engage in a game of chase involving digital and physical space using WiFi and GPS technology. Four runners navigate urban streets using handheld devices which display on a city map their location as well as avatar representations of the other players online. Runners communicate with one another using text messaging on their mobile devices as well as walkie-talkies, whose audio can be heard by the online participants.

CatchBob! (Nova, Girardin, and Dillenbourg, 2005) is a location-based game where three team members move around a campus with the objective of finding and capturing a stationary, hidden, virtual object (*Bob*). The game is played on the EPFL campus in Lausanne, Switzerland. Each player's physical position is replicated on a TabletPC campus map as an icon representation. Participants are able to coordinate their activities by communicating through annotation on the digital map using a stylus. The game requires all 3 team members to physically surround the virtual object by creating a virtual triangle of a certain size. Within the location-awareness condition, players can manually press a refresh button to get a team mate's updated positioning; in the other experimental condition, team mates are not visible.

A key theme that has emerged in the study of location-based games is a focus on human experiences rather than the traditional emphasis on the network infrastructure used to support the game. Over the last few years, research groups have been investigating the collaborative experiences of users playing location-based games in a variety of fields such as exploring the effects of location-awareness on group processes (Nova, Girardin, Molinari, and Dillenbourg, 2006) emerging strategies that develop through the experience of repeated game play (Bell et al., 2006), and observations of behaviour in a co-located, educational role-playing activity (Benford et al., 2005).

Studies within the area of location-based games occur primarily within Europe, especially the United Kingdom (e.g. Barkhuus et al., 2005; Benford et al. 2005; Nova et al. 2006). Although the focus of Canadian games research is on digital spaces, specifically video games, we are encouraged by the emergence of games that use mobile technology for the self-reporting of location (Live Action Scotland Yard, 2006; New Mind Space, 2006).

Game Design

In the summer of 2005 we established a ubiquitous computing group at the University of British Columbia (UBC) (UBC Ubicomp Group, 2006), with the intent of exploring how location-based services may be designed to educate, entertain, and enable collaboration among users. The general idea was to form an interdisciplinary group composed of students, professors, and researchers from different departments to share and discuss experiences gained from our individual and collaborative projects. In order to gain experience, we designed *the Fugitive*, a mobile game based on *CatchBob!* (Nova et al., 2006) where 3-person teams seek out and chase a fictional, digital entity on the UBC campus.

Figure 2: the Fugitive User Interface + GPS Unit

In *the Fugitive* (see Figure 2 above) a 3-person team attempts to locate an object (*the Fugitive*) that is initially hidden on a digital map of the UBC campus displayed on each participant's TabletPC. This playing field (see Figure 3 below), shows a player's present position while providing visual cues that signal one's proximity to *the Fugitive*. The objective of the game involves two parts, a *catch* phase and a *chase* phase. In the *catch* phase, players physically move around the environment with their position being updated accordingly on their digital map. The objective is to trap an invisible, stationary object by forming a triangle as in *CatchBob!*. After this phase, *the Fugitive* jumps to another location on campus and the *chase* phase begins. In the *chase* phase, participants re-position themselves on the digital map to chase and trap the now visible, moving object by again forming a physical triangle. Map and ink messaging are tools used to enable communication. This communication is augmented by auditory beeps to alert players of incoming messages from other team mates.

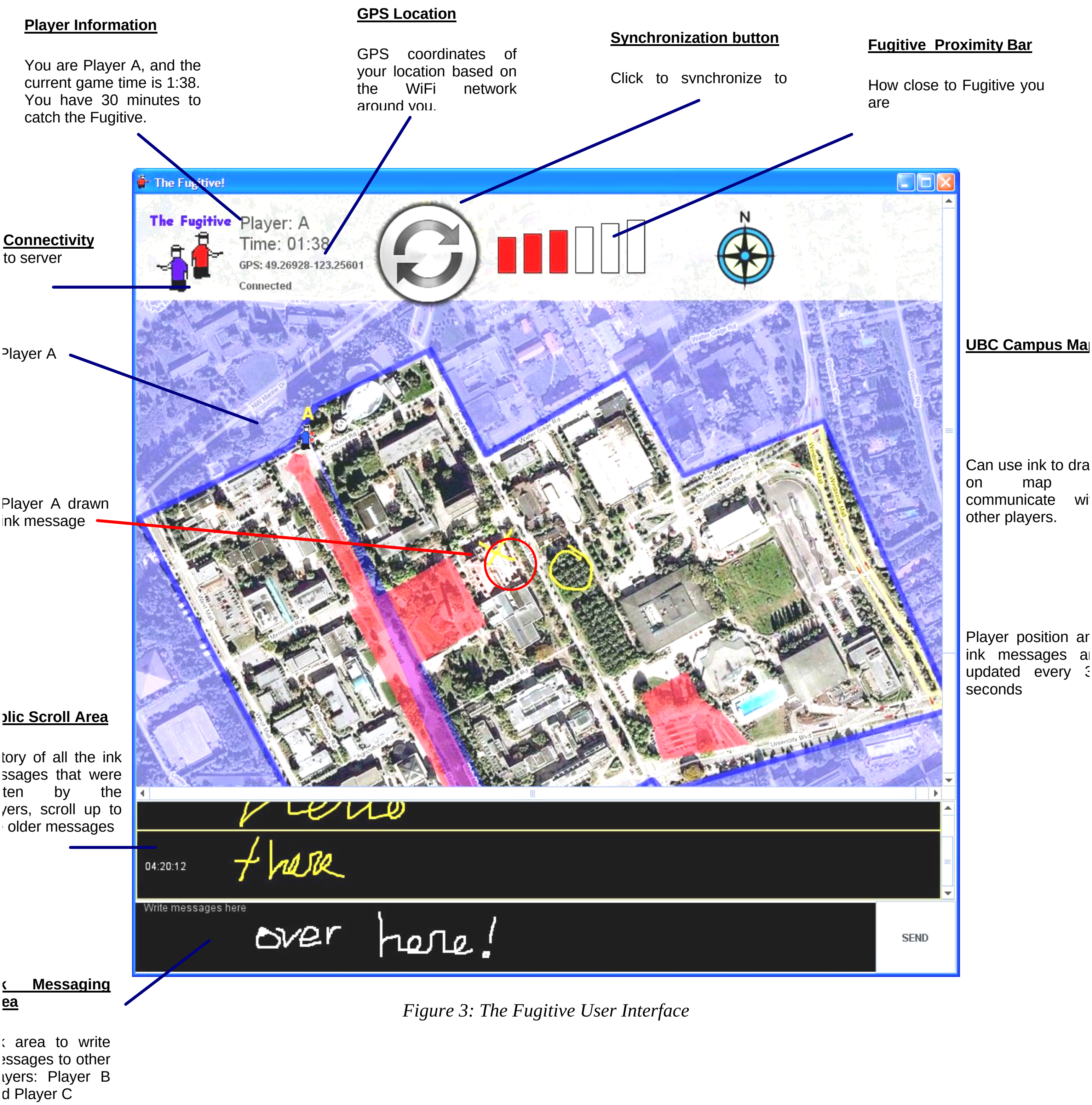

Figure 3: The Fugitive User Interface

Game Infrastructure

The University of British Columbia campus has over 3000 wireless access points. The dimensions of our game field are approximately 700 by 700 meters; however, not all areas of the playing field have WiFi coverage. With these infrastructure limitations, we set about re-designing the game and user interface (UI) to create a study that investigated the different strategies and performance of players with both location-awareness and no location-awareness conditions.

Based on a number of iterative design sessions, we agreed upon the following modifications to the *CatchBob!* platform:

- Make the player location updates automatic rather than on request.
- Add the ability to communicate in a special area off the map (ink messaging area) rather than just through map annotations (see bottom area of UI on Figure 3 above). We believed annotating maps enhanced the ability to communicate user positions by marking locations on the map.
- Create a mobile *Fugitive.* We hypothesized that real time location-awareness would be more critical if the task required real time tracking of the target. Rather than trying to find a fixed location, making the target move would require the participants to coordinate their positions in real time with this moving object.
- Extend the analysis tool and server to capture all forms of communications onto the server such as map annotations and ink messages from the TabletPCs, rather than only the position of users and when annotations occurred.
- Integrate audio indicators of activity on the UI (e.g. a new ink message has been received. This could decrease the time a user spends on the UI to check for new messages. Furthermore, audio feedback is a great method to confirm that, for instance, an annotation made on the UI map has been successfully transmitted to the server.

The CatchBob! platform provides a web services interface to the game client implemented in Java. The web service interfaces was extended and additional features added to the server to support ink messaging, stroke and ink message capture for analysis, and other features listed. The Java client was extended extensively to add additional user interface widgets associated logic and to handle disconnections and reconnections to the wireless network more gracefully.

Since we could not control the UBC WiFi network used in our game, we could not have complete confidence in the stability of the network for accurate location information and communication between players. However, we argue that our own campus provided a more realistic network scenario, one comparable to the real world. Previous examples of location-based game scenarios, such as in an urban field (Barkhuus et al., 2005) or schoolyard (Benford et al., 2005), were conducted using a network controlled by the researchers.

During the development of *the Fugitive* we did not fully appreciate how environmental conditions would impact game play. During the day, the sun created bright spots on the screen preventing proper viewing. We determined that it was best to play the game later in the afternoon or during the evening. Rain and heavy winds increase the likelihood of the TabletPCs becoming wet and decreased players' visibilities. In fact, during our evaluation, our third test group had to be cancelled due to an extreme heavy rainstorm on the scheduled night.

As the game relied on WiFi, it is possible to be disconnected from the network as one navigates the game space. Initially, losing connectivity required re-logging into the game. This required participants to log in through a browser using a password. We found this cumbersome and did not want to disrupt the feeling of 'being in the game' by forcing the user to take care of this technical issue. To resolve this issue, we developed an auto log in system that automatically logged the TabletPC into the WiFi network once the network was found again. On disconnection, the UI displayed a message to the player that stated they were disconnected from the network but this was also found to be unreliable. We asked UBC IT to allow us to roam on a separate research SSID than that used by the UBC community. This solved much of the concerns related to connectivity.

During our testing phase, we used Intel Place Lab software for WiFi access point-based positioning (LaMarca et al., 2005) to show a participant's location on the game map. This software requires a calibration process called *war driving* (War driving, 2006) to be conducted once. To calibrate, we walked around campus logging GPS coordinates and the signal strength of nearby WiFi access points. These logs were then uploaded to a central database, and using the coordinates and signal strength data, the location of the access points were estimated. This data could then be downloaded by the Place Lab application for use in estimating a device's location using only its awareness of surrounding access points and simple averaging. However, since access point locations were only estimates, we had ongoing problems achieving adequate positioning during testing. Avatar positions on the maps jumped to incorrect positions indiscriminately. To resolve this issue, we switched to using pocket-sized Bluetooth-enabled GPS units (as visible previously in Figure 2) for more accurate positioning.

Field Study

Recall that Salen and Zimmerman (2004) discuss internal and external levels of social interaction that occur within the boundaries of the game space. Familiarity and friendship are two examples of external conditions that may be carried by participants into the game space. We do not know if people unfamiliar to their surroundings would behave differently playing the game, so to provide consistency between groups, we only recruited participants that were UBC students. This is similar to the recruitment of *CatchBob!* participants (Nova et al. 2006), where team mates were required to have prior familiarity with the campus area used for game play. Specifically, we recruited our participants from the UBC student community through a graduate residence mailing list, word of mouth, and two departmental mailing lists (Interdisciplinary Studies and Electrical and Computer Engineering). The ages of the participants ranged from 19 to 25. Three groups were recruited although due to a rainstorm that night, only two could be evaluated. Both of these groups were composed of two males and one female.

Participants were given a 10 minute introduction to the game in which they were provided with instructions about how to use the TabletPC and stylus, an explanation of the game objective, and the maximum time limit (30 minutes) provided for the game. During testing we found that carrying the TabletPC longer than thirty minutes could create a strain on one's arm Further game and UI usage instructions and tips (e.g. to stay close to buildings) were given and users were able to practice using the stylus (see Figure 4 below). Participants were also told to return to the starting point after 30 minutes even if the game was not completed. Mobile phone numbers were supplied in case of emergency and it was stressed that players should walk *not* run while carrying the TabletPCs. We emphasised that our interest was in how the game was played, not the speed with which participants completed their task.

Figure 4: Group 1 pre-game instructions

Observations

Once participants had received their TabletPCs, both groups briefly, although not told to do so, formed a physical triangle to coordinate a strategy (see Figure 5 below) before venturing out in separate directions to find *the Fugitive*. During Group 1's session, one of the GPS units failed and we replaced it with another. After 30 minutes, the group members returned to the starting point without being able complete the game in the allotted time period. In Group 2, a player's position improperly jumped to an incorrect location during the *chase* phase.

Figure 5: Group 1 planning game strategies

Focus Group Discussions

Positive Aspects of Game

Participants stated that they had a good experience playing the game and liked the game context, especially the ability to see as well as communicate with one's team mates using map annotations. The UI was found to be well designed and easy to use. The mobile experience provided bystanders with the opportunity to observe and possibly comment on their game play.

Group 1 Male #2:

> *"...I like that it felt kind of like 'Hide and Seek' when you're a kid except they took away the boring part which is the guy who just hides and doesn't do anything. So it was sort of, you know, a grown up advanced version of that."*

Group 2 Male #2: *"...I think it's fun because you play with other people, not only with a computer"*

Group 1 Male #1: *"Yeah I enjoyed the experience. I thought it was cool, some people would say, 'oh nice computer'. (all laugh a bit) "'Yes this is nice…we are playing a game…'"*

Negative Aspects of Game

Participants disliked having to deal with network and technical failures which disrupted their game play and this may have affected their level of enjoyment. GPS disconnections occurred at least once within each group. Both groups expressed frustrations in the inaccurate positioning received from team mates because of this. In addition, there were time lags reported between writing an ink message and having it transmitted to the other team members.

Group 1 Male #2: *"The characters would sort of jump all over the place a lot and it made it really difficult to find out where you actually were…and that made the game frustrating to the point where it wasn't enjoyable."*

Group 2 Female:

> *"....I'll write a message or I'll write a message and walk at the same time and I will try to send it and I won't be able to or it will take a really really really long time for me to do that so it was kind of frustrating and well…it's a computer so you can't expect too much but it was a little bit slow…the reaction time was a bit slow so sometimes that can be a little bit confusing."*

Collaborative Strategies

Each group had a similar in-game strategy to capture *the Fugitive* by initially travelling in opposite directions and then communicating with each other in order to form a triangle around it. The UI provided information among team members through annotations that were used while attempting to surround *the Fugitive*. For example, Group 2 players used annotations to share the status of their proximity indicators (bars indicating the distance from *the Fugitive* – see Figure 3 above) while forming a triangle.

Group 1 Male #2: *"...hopefully one person would start getting closer to the objective and then be able to communicate with the others to come towards their location."*

Group 2 Female:

> *"...When we were all connected, we would send messages to each other saying how many bars we had and so that's how we know…and…by the time, I think I was at 5 bars, I was disconnected, but the 3 of us were in close enough proximity that we could yell to each other saying that 'I'm disconnected but I have 5 bars'..."*

Suggested Features

Participants felt that additional channels of communication such as voice would make the game easier to play and allow for interactions when disconnected. As stated earlier both groups experienced being disconnected from the GPS and WiFi networks for short periods of time.

Group 1 Male #1: *"I'd rather talk than write."*

Group 1 Female: *"...also safer because you don't always have to look down at your tablet while you are like...crossing the street...walking around people..."*

Group 2 would have preferred voice communication between players, as simple as using walkie-talkies as a complementary communication tool.

Group 2 Female: *"...[ink messaging] is not very reliable especially if the other players are disconnected..."*

Group 2 Male #1: *"...it's better than writing instant messages and we can instantly report where we are..."*

Interpretations of Gameplay Behaviour: Lessons Learned

From a technical perspective, being disconnected from the WiFi network or having positioning errors because of the problems with the GPS units provided temporary levels of frustration. However, this did not cause anyone to quit playing and all groups stated that they liked playing the game, and were willing to play it again. The desire of participants to always have an open communication channel, especially when disconnected, emphases our game's dependence on network coverage.

Figure 6: Group 2 team members

The application provided a "disconnected" message and reconnected automatically when the WiFi network was found again, but perhaps voice communication through mobile phones would also be useful in these instances. The question then is whether designers should consider using a backchannel as part of the game or provide a dedicated communication source as an external element. For example, in the game *Can You See Me Now?*, runners navigate urban street using handheld devices equipped with WiFi for text messaging with other participants, but also use walkie-talkies for communication between runners (Crabtree et al., 2005).

We discovered that participants developed different purposes and strategies for the use of the map annotation area and the ink messaging area. The map area was used by the groups to convey location and positioning information ("I am here – X"), while the ink messaging area was used for communication regarding strategies between team mates.

There were not any complaints about carrying the TabletPC for 30 minutes, nor were there any accidents during campus navigation. One member in Group 2 was especially excited to use a TabletPC for the first time. We believe the TabletPC to be valuable for games that require displaying maps (e.g. a treasure hunt game involving the map of a neighbourhood) and for applications that showcase large displays. It is not heavy to carry for short periods of time and was observed to be easy to hold (see Figure 6 above) and read when provided with appropriate environmental conditions.

From a social perspective, although only given brief pre-game instructions, participants understood *how* to play the game the first time. They understood the functionality of the game and how to effectively use and understand what the different UI features meant. Participants loved the idea of a mixed reality in which they interacted in the real world while chasing a *virtual* character. The motivation for playing the game was high throughout the entire time period and everyone expressed a desire to play the game again despite the technical difficulties experienced.

Recall that *the Fugitive* involves two distinct phases of game play and correspondingly we observed qualitatively different strategies being employed by the participants. In Phase one (*catch*), the focus was on answering location questions (*Where do I go? Where are my team mates?*), so that the virtual, invisible *Fugitive* could be found. In Phase two, (*chase)* one is already in physical proximity to one's team mates and the strategy changes. One wants to communicate, either face-to-face or through TabletPC annotations, the desire to reduce everyone's distance from the visible *Fugitive* to enable capture.

Future Work

To date, we have only explored the location-awareness condition with participants, however we expect further study of the no location-awareness condition in which one's team mates are not visible on the map. The objective of our game was to provide insight into how the TabletPC and network technology influenced players' ability to collaborate and develop strategies. From our observations and focus group discussion, we realise that technological failures did affect how groups played the game. We are considering how these technological limitations might be incorporated into our game. This is the idea behind the concept of *seamful design* (Barkhuus et al., 2005) in which inaccurate positioning, gaps and limitations of the ubiquitous computing infrastructure are taken advantage of as seams rather than hidden. This provides an opportunity to explore the possible strategies and collaborative behaviours that may emerge from mobile games designed with this new approach (Barkhuus et al., 2005; Bell et al., 2006; Broll & Benford, 2006).

Our evaluation found that participants expressed motivation throughout the game and used the TabletPC to develop and plan in-game strategies to locate *the Fugitive*. We are currently exploring the development of a new pervasive game in which we can explore our hypothesis regarding the cognitive load, perhaps using peer-to-peer mobile technology.

The theoretical framework that will inform our future research is cognitive load theory. Cognitive load theory (Sweller, 1988; Sweller, 1994) uses an information processing model of cognition which focuses on the cognitive structures that compose of a person's knowledge base. It emphasizes the limits of working memory and provides techniques for reducing working memory load (Sweller, 1988). This is so that in learning environments, conditions that create undesired cognitive load can be controlled based on Sweller's theory of schema acquisition that is associated with the structures of long term memory (Sweller, 1994; Sweller, 1999)

Cognitive load theory has primarily been associated with educational multimedia environments such as hypervideo (Zahn, Oestermeier, & Finke, 2006) and as yet has not been explored with location-based environments. We suggest that how location-awareness affects collaboration and game play strategies could be an intriguing area for further study. This paper has provided us with an initial opportunity to explore user experiences in a collaborative location-based environment, to discuss our game design, and to share our insights with the Canadian Game Studies community.

Based on our experience with the *CatchBob!* game platform, the UBC wireless network and Place Lab, we have begun work on a more general purpose platform for large scale ubiquitous computing environments (Blackstock, Lea, & Krasic, 2006). Unlike the *CatchBob!* and *the Fugitive* web service, this platform aims to provide an interoperable general purpose interface and model for all context aware computing environments based on a comprehensive survey of existing systems. We intend to use this new platform for future game development.

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