The Fugitive:
Location-Based Game for Wi-Fi Devices

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by

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ABSTRACT

To develop a fun location aware game, the accuracy of the positioning software, Place Lab, was characterized and refined by obtaining better access point locations and fine tuning the coordinates of the map being used. Since connectivity is one of the most important aspects of a mobile location based game, maintaining the connection is of utmost importance. Different methods of reconnecting to the UBC wireless network are explored. A server replay tool which reconstructs a game based on the server logs is improved to display ink messages and annotations drawn from a tablet PC.

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GLOSSARY

Tablet PC: A mobile computer similar to a laptop except it has the extra functionality of allowing a user to write on the LCD screen using a specialized pen.

Wi-Fi: A local area network that uses high frequency radio signals to transmit and receive data over distances of a few hundred feet; uses the Ethernet protocol.

LIST OF ABBREVIATIONS

CWL:	Campus-Wide Login
GPS:	Global Positioning System
LEAP:	Lightweight Extensible Authentication Protocol
PEAP:	Protected Extensible Authentication Protocol
VPN:	Virtual Private Network
Wi-Fi:	Wireless fidelity
WPA:	Wi-Fi Protected Access

1.0 INTRODUCTION

The Fugitive, formerly Chase Bob, is a location-based game where a team of three players must collaborate to track down and trap a virtual object which is the fugitive named Bob. The game is played using *tablet PCs* on the UBC campus using the *Wi-Fi* network. The Place Lab Wi-Fi positioning software is used to calculate the position of the players; this is used to determine whether players have successfully trapped Bob, who has been placed at a predetermined location. Using various communication and location tracking functions, the players must collaborate in order to surround Bob. This report presents the changes and improvements made to The Fugitive location based game so that it will be playable and will be ready for use in usability tests.

The objectives during the course of this semester were to validate the positioning system and resolve the connectivity issues through field testing and changes to the code. The requirements of the game must also be evaluated; the appropriate changes were made to ensure that the requirements were met. A revamped replay analysis tool will also be needed to analyze a game after it has been played.

The purpose of designing this game is to study how communication and location awareness affects user strategies and their ability to complete a collaborative task. Thus, it is important to improve the accuracy of the positioning because inaccurate positioning data will lead to confusion and have an effect on the team's performance. Maintaining connectivity to the server in the game is even more crucial because if a user loses their connection, they will not be able to see where their team-mates are located nor would they receive any messages from them. Moreover, the user will not be able to send any messages or update their own position. The revamped replay analysis tool is critical to the analysis of the user experiments since it is currently the only way to view everything after the game has been played.

Prior to the work done this during the 496 project, The Fugitive had been fully developed but was unrefined. Besides the positioning and connectivity, appropriate game parameters had to be selected so that the game will not be too difficult or too easy to play. The game parameters include the size and location of the playing field and the distance to trap Bob among others. Much of the work accomplished during the course of this project was done in collaboration with Colleen Qin, the other 496 student working on the same project this semester.

The information included in this report focuses on the testing and modifications made to improve the usability of the game so that it will be ready to be played for the user study. Except for a few occasions where the details and questions of the user study are appropriate, they have not been included in this report since they are not as relevant here.

This report divides into the following primary sections: characterizing the Wi-Fi positioning accuracy; the UBC wireless network coverage and connectivity; the map, playing field, and game parameters; other game improvements; and the replay analysis tool.

2.0 CHARACTERIZING THE WI-FI POSITIONING ACCURACY

Software libraries called Place Lab are used in The Fugitive to obtain the locations of the players in the game. Place Lab calculates a user's position based on the strength of the signals that the wireless network card on the tablet PC detects from all the nearby Wi-Fi access points. The accuracy of the estimated positions depends on the known GPS location of all the access points in the area. Using the estimated position, the location of the player is shown on a map in the game.

2.1 Initial Tests and Accuracy

Several tests were performed to analyze the accuracy of the positioning of Place Lab. The tests involved walking around the UBC campus using a tablet PC and the existing version of The Fugitive to compare the actual location and displayed location of the player.

The initial round of tests showed that the positioning was very poor inside buildings. Most of the time, the positions displayed in the game were about forty to fifty meters away from the actual location of the player. In some cases, the displayed location was as much as 200 meters away from the actual location. This amount of error in the positioning is unacceptable when playing the game in an area the size of UBC. Figure 1 gives an example of the error in position.

Figure 1. Error in displayed location

Playing the game inside buildings also resulted in consistent skips in position. Sometimes the player position will be estimated pretty well, but then the player's displayed position suddenly skips to a location that could be 50 to 200 meters away. This behaviour was sometimes exhibited outdoors, but was a major problem inside many buildings in the south side of campus. This skipping behaviour would occur every few seconds which makes the game unplayable. Figure 2 shows a situation where skipping frequently occurs.

Figure 2. Skipping behaviour

Outside of buildings, the positioning was a little more accurate and the skipping behaviour was less frequent. However, the positioning was still not good enough to play the game. A couple possible reasons for the inaccurate positioning and skipping behaviour exist. The first reason is that there is insufficient access point data in the Place Lab libraries. Some access points may not be in the Place Lab database, or if the access point is in the database, its position is not very accurate. Improving the access point positions is discussed in the next section.

2.2 War-Driving

The access point database of Place Lab is based on data that user's submit online. To obtain the positions of the access points located on UBC, a program called Network Stumbler was used in conjunction with a DeLorme GPS unit. Using the GPS unit, the Network Stumbler knows your current location. Using your known location, and the signal strength of a particular access point, the Network Stumbler will be able to estimate a location for the access point as you move to different locations. Network Stumbler does this for all the access points that it detects; this process of moving around and finding the location of the access points is called war-driving. The data obtained from Network Stumbler was uploaded to a Wireless Geographic Logging Engine (WiGLE). The data is then downloaded and added to the Place Lab access point data for use in The Fugitive.

In order to obtain the most accurate access point positions, it is best to move around to as many locations as possible. However, since the GPS unit only works when there is a direct view of the sky and does not work indoors, some access points deep inside buildings might not be detected; this is one of the reasons the positioning is not as accurate inside buildings.

2.2.1 War-Driving Results

War-driving was initially done on a small section of UBC along Main Mall. Field tests performed after this war-driving showed that the accuracy of the positioning everywhere had improved at least slightly. The positioning of some areas had improved significantly; this is most likely due to insufficient access point data from the war-driving performed prior to the 496 contributions. The skipping behaviour of the positions has also been reduced.

Since the initial war-driving had shown improvements to position accuracy, more war-driving was done on UBC between West Mall and Westbrook Mall, and between Northwest Marine Drive and Thunderbird Boulevard. After the war-driving was

complete, roughly 1000 new access points were discovered and added to Place Lab. The war-driving had significantly improved the accuracy of the access point locations, as well as increased the number of detected available access points.

After the war-driving, the positioning typically had an error of roughly fifteen to thirty meters. The skipping behaviour was also reduced. Some areas that were not reachable while war-driving still showed skipping behaviour. If the position still skipped, it did not skip as far away as it did before. Even though the skipping is less frequent than before, it is still noticeable. However, it happens quickly enough that it does not seem to affect the play of the game.

The positioning inside buildings on the south side of campus still exhibits skipping, thus playing the game in buildings such as Kaiser, MacLeod, and CEME is not recommended. Buildings on the north side of campus seemed to be better with positioning. In the latest round of testing, it was determined that the game can be played inside the buildings on the north side of campus; this is particularly useful because all the access points are located inside buildings so the signal strength and connection will be better.

2.3 Change to a New Map

Half-way through the semester, the game was changed so that it will only be played on the north side of the UBC campus. The reasons for changing this will be discussed in later sections of the report. Because of the above change, a new map was required for the game that only included the north side of campus.

While calculating the map coordinates for the new map, it was discovered that the coordinates for the original map were off by twenty meters in both the latitude and longitude direction. This error was corrected for the new version of the map thus increasing the accuracy of the positioning again.

2.4 Choice of Wireless Network Cards

The type of wireless network card used for the game affects the positioning accuracy of Place Lab. The Place Lab libraries are very picky and only work with a few types of wireless network cards. The following sections discuss the types of wireless network cards used.

2.4.1 Intel Centrino Wireless

Since most tablets PCs and laptops today have built-in Intel Centrino Wireless cards, an attempt was made to try these cards for the game. Using the Intel cards, Place Lab was still able to calculate the correct position of the player. As long as the player stops moving, the position was calculated correctly. However, after several tests, it was determined that if the laptop or tablet PC was moving, the position would not update; Place Lab was unable to calculate a new position using the Intel wireless cards. The Intel cards seemed to lock onto a particular access point and did not automatically reconnect to another access point right away. Because the Intel Centrino Wireless cards did not allow a player to roam, it could not be used for the purposes of The Fugitive.

2.4.2 Avaya Wireless

The Avaya Wireless network card worked well with the Place Lab software. The positioning using the Avaya card seemed inaccurate at first; however, updating the driver for the wireless card improved the accuracy enough for the purposes of the game. Unlike the Intel card, the Avaya card allowed the player to roam across parts of campus without getting disconnected and continually updated the player's position. The Avaya card still got disconnected sometimes, but this was due to the network and not the card itself. A drawback of using the Avaya card is that it is an older wireless card and does not support the 802.11g wireless technology; this it also does not support Wi-Fi Protected Access (WPA) and the Protected Extensible Authentication Protocol (PEAP) required to connect to the 'ubcsecure' network. Section 3.3 discusses the significance of this.

2.5 Final Results on Positioning

After all the changes to improve the accuracy of the positioning, most of the time the displayed position of the players was less than ten meters away from their actual location. The error in positioning was usually never more than twenty meters with a few exceptions during the course of a game when the player is in an area which was not reached during war-driving. The positioning accuracy is now at a point where it is good enough to be used for playing a complete game.

3.0 UBC WIRELESS NETWORK COVERAGE AND CONNECTIVITY

Characterizing the connectivity and coverage of the UBC wireless network is just as important to The Fugitive as the positioning. As mentioned in the introduction, it is crucial that the players maintain their connection to the server otherwise they will not receive any updates from their team-mates, nor would their team-mates be able to receive any updates from them. The goal is to maintain connectivity at all times; however, this may not always be possible. In cases where it is not possible to maintain connectivity, the time in which a player is disconnected should be minimized. The solution to maintain connectivity at all times is to ensure that the game is played in an area where there is good wireless network coverage; that is, the signal strength in the play area is consistently strong enough so that the player will not get disconnect as they walk around.

If a player gets disconnected in an area with weak wireless coverage, they should automatically be able to reconnect if they return to an area with stronger wireless coverage. The goal is to reconnect as quickly as possible. Since the game is played on the unsecured ‘ubc’ network, users are required to login using a web browser before they can connect to the network and the server. Opening up a web browser to manually login to the network while playing in the middle of a game is extremely inconvenient and takes too much time. Moreover, the user will not know if they have returned to an area with good network coverage; if this was the case, they would not even be able to login if they wanted to.

The areas with good and bad wireless network coverage, and the solutions to reduce the disconnected times are discussed in the next couple of sections.

3.1 Areas of Coverage

Through several rounds of field tests, areas where the game could be played were determined. Since most of the buildings that have wireless coverage are between West Mall and Westbrook Mall, the playing area was restricted to be in between these two streets. There were several areas in which connectivity was consistently lost; these areas must be avoided when playing the game. The main areas where connectivity was poor were around the Life Sciences Centre, and by the Biological Science Building near Main Mall and University Boulevard. Figure 3 shows the original playing area. The areas to be avoided are shown in red. The blue areas are considered out of bounds.

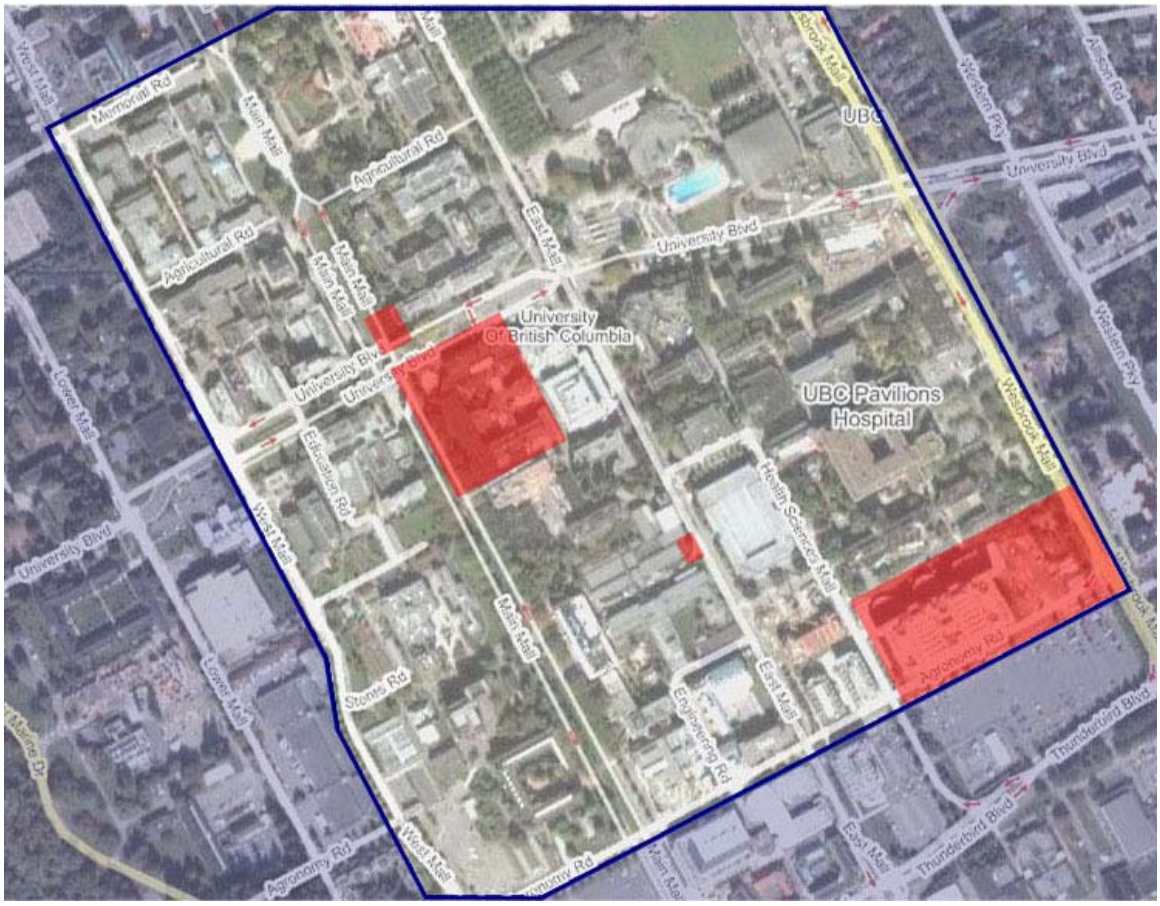

Figure 3. Original map with areas of bad coverage

Midway through the semester, the playing field was reduced so that the game was only played on the north side of campus. Further tests to the north side of revealed more areas

where the connectivity was poor. Walking along Main Mall resulted in constant disconnections; this is most likely due to the fact that the access points are located too far away. Because of the disconnections, the players should avoid walking along Main Mall; if they still needed to walk down Main Mall, they should try to stay close to the buildings since they are more likely to maintain their wireless connection there. The parking lot by East Mall and University Boulevard and the area between Main Library and Koerner Library also have bad connectivity and should not be played in. Figure 4 shows the new map of the playing field with the areas of poor connectivity marked in red similar to figure 3.

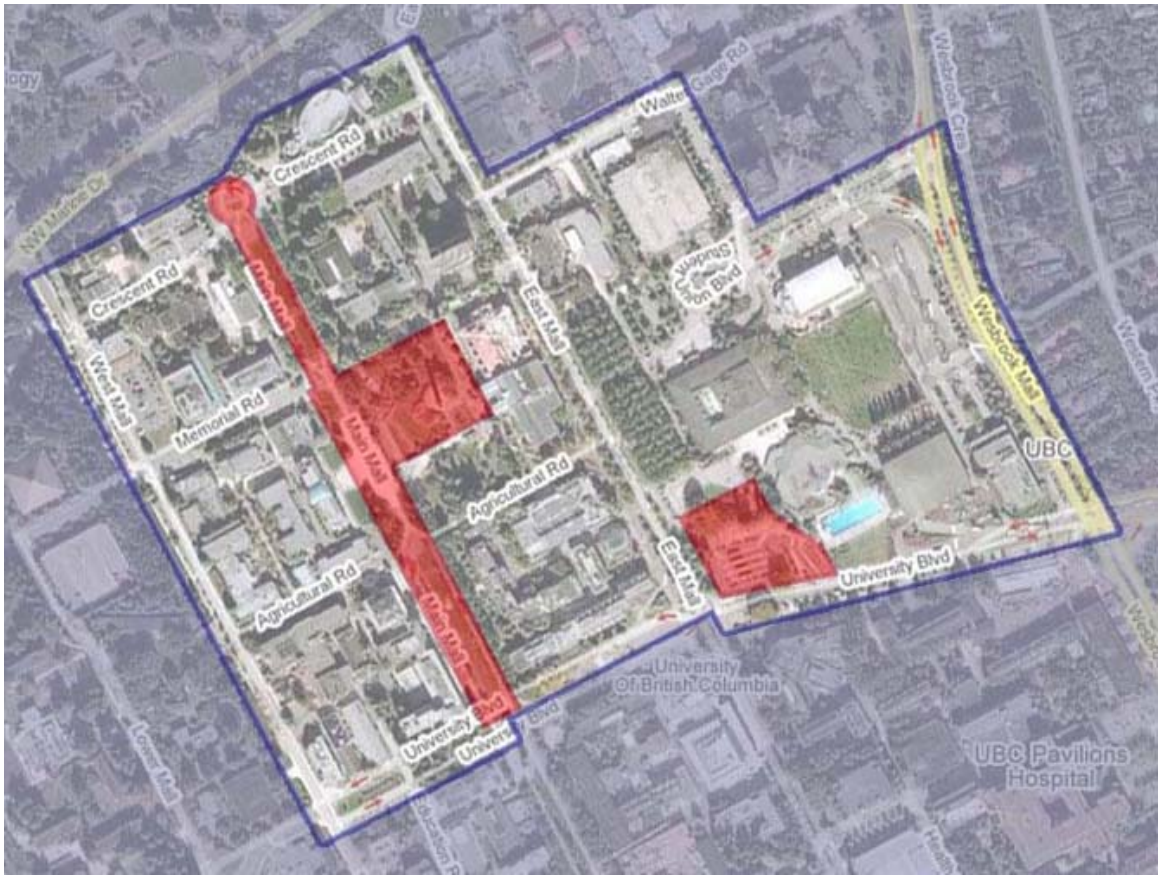

Figure 4. North side campus playing field with poor connectivity areas

3.2 UBC Wireless Network Upgrades

Half-way through the semester, it was discovered from one of the IT services technicians that UBC was performing upgrades to its wireless network. At the time, half the campus was equipped with the new upgrades, and the other half still needed the upgrades performed. Thus the ‘ubc’ network was split between the north and south side of campus. The north and south side of campus was split at the Aquatic Ecosystems Research Laboratory (AERL). Any time a player crosses this area, they would be disconnected. Because the buildings on one side of AERL have the network upgrades, and the buildings on the other side of AERL do not have the upgrades, the players can not roam across this area. Any time a player crossed this area, it took a long time to reconnect.

Because of the upgrades to the network, the game could only be played on the north or south side of the campus, but not both. It was decided that the north side of campus would be used for the game because there were more buildings that were equipped with wireless coverage. Since the original playing field was too big, reducing the size of the playing field to use only the north side of campus made sense.

3.3 Automatic Reconnection

As mentioned above, it is important for players to stay connected in the game as long as possible; this means that if the player is disconnected, they should be reconnected once the wireless signal is strong enough. The following sections describe the different solutions to stay connected.

3.3.1 UBC Wireless Login

As mentioned earlier, the ‘ubc’ network requires authentication using a player’s campus-wide login (CWL) ID. When a user is disconnected for a short period of time and then gets reconnected, the connection will be restored without needing to login again. However, if the user is disconnected a little longer, even when the wireless card has

reconnected with the network, the connection will not be fully restored because authentication is required again. To restore the connection, the user must open up a web browser, and use their CWL to login at login.wireless.ubc.ca. This was not a reasonable solution to restore the wireless connection while playing a game. Furthermore, the players of the game would not realize that they need to log back into the network. Using the UBC wireless login was not acceptable, a different solution was needed.

3.3.2 UBC Virtual Private Network (VPN)

The UBC VPN was used with the hopes that it would only require the player to connect and enter their login ID once. Using the VPN, the connection was maintained longer than using the UBC wireless login. The VPN sometimes reconnected itself when the network card was reconnected. However, if the 'ubc' connection is disconnected long enough, the VPN also required the user to login manually. Figure 5 shows the login screen to connect to the VPN. Even though using the UBC VPN required logging in less than using the UBC wireless login, it is not a viable option to reconnect the game.

Figure 5. Connecting to the UBC VPN

3.3.3 Using ubcsecure

After failed attempts to use the UBC VPN, the ‘ubcsecure’ network was tried. Using the ‘ubcsecure’ network does not require a user to login manually if the connection is lost; re-authentication is all done automatically. As mentioned in section 2.4.2 the Avaya wireless cards that were currently being used did not support WPA and PEAP; thus different wireless cards needed to be obtained.

After talking to an IT technician, he provided us two Cisco Aironet wireless network cards that were supposed to support WPA and PEAP. According to the Place Lab documents, the Cisco network cards should also be compatible with the Place Lab software.

The first Cisco wireless card was an older 802.11b wireless card. After many attempts to connect to ‘ubcsecure’ using this card, it was determined that this card supported WPA and supported the Lightweight Extensible Authentication Protocol (LEAP), but it did not support PEAP. The second Cisco wireless card was an 802.11g compatible card. This card was able to successfully connect to the ‘ubcsecure’ network. Tests around UBC were performed using this card, and it turned out that they behave similarly to the Intel Centrino Wireless cards mentioned in section 2.4.1. Despite the fact that Place Lab claims that the Cisco Aironet cards were compatible with their software, the card did not seem to work for the game.

Since all the regular ways to connect to the UBC wireless network did not automatically reconnect when the connection was lost, an application had to be developed to perform the login automatically.

3.4 UBC Automatic Login Component

Prior to developing an application to automatically login to the ‘ubc’ network, a request was made to the UBC IT department to allow the tablet PCs used in the game to have unauthenticated access to the network. There was no reply to this request, so the UBC automatic login component was implemented. The UBC automatic login detects when a connection has been lost, and when the connection has been restored. When the connection is restored, it checks whether login is required, if it is, then the player’s CWL username and password are sent to login to the network. For exact details on how the UBC automatic login works, and how it was implemented, please refer to Colleen’s report.

3.4.1 Results of the UBC Automatic Login Component

Using the UBC automatic login, if a disconnected player moves to an area with better wireless signal strength, they will be automatically reconnected within seconds. Using the automatic login, the players can keep the game window open and still focus on the game. With the positioning and connectivity issues resolved, the game is now playable without major interruptions. For the game to be fun, it must not be too easy or too difficult, thus choosing the size of the playing field and the game parameters needs to be done with care.

4.0 THE MAP, PLAYING AREAS, AND GAME PARAMETERS

Choosing appropriate areas to play the game and the size of the playing area affects how the game will be played. The game parameters will also determine if the game is too difficult or too easy. This section discusses the choices of the game parameters and why they were chosen.

4.1 The Playing Area and Length of the Game

The area where the game is to be played needs to have good connectivity, as well as good positioning. As shown in Figure 5 above, the playing area was chosen to be on the north side of campus. The map was shaded in such a way so that the users will know exactly where they can play the game. Blue areas are out of bounds, and red areas were areas with poor connectivity which should be avoided.

The time allowed to complete one game of The Fugitive is thirty minutes. In order to be able to find and trap the fugitive within the time limit, the size of the playing field needed to be reduced; the original plan to use all of UBC to play a game was not feasible since it was way too large. The size of the playing field was another reason for using only the north side of campus to play the game. Increasing the game time will allow the use of a larger playing field; however, after several rounds of tests, it was observed that holding a tablet PC for periods of more than thirty minutes at a time resulted in very sore wrists.

The most recent tests indicate that the size of the playing field might still be too large for a full game of the Fugitive. A full game of the Fugitive involves two phases. In the first phase of the game, the find phase, Bob is invisible and stationary; the players must first find Bob and trap him. In the second phase of the game, the chase phase, Bob is visible but he can run; he will attempt to move in a direction away from all three players if any one of the players gets too close to him. Figure 6 shows a partial screenshot of the players

trying to close in on Bob. Reducing the size of the playing field further might not be a good option because that could limit the amount of moving needed which also reduces the need for location awareness. A possible solution is to play only one phase of the game in the thirty minute time limit.

Figure 6. Screenshot of Bob in the chase phase

4.2 Game Parameters

The values for the various game parameters and why they were chosen are given below. All of the parameters listed in this section have been simulated several times; however, actual field tests of these parameters after the latest changes are still in the preliminary stages. Since the connectivity issues were not resolved until near the end of the semester, the affects of the changes to the game parameters were not extensively tested.

4.2.1 Bob Speed

The Bob Speed is the speed in meters per second that Bob moves at during the chase phase of the game. The initial value of Bob Speed was 2.0 m/s; this is equivalent to a light jogging speed which is obviously too fast for the players carrying around a tablet PC.

Bob's speed was then reduced to 1.25 m/s, or roughly walking speed. This seemed like a good number for this parameter since there are three players working together that can close in on Bob from different directions. This speed also seemed reasonable because it was not too easy. While testing the game, it was soon realized that Bob moving at walking speed was still too fast because the players are not constantly walking. The players need to stop often to look at their screen and write messages. The Bob Speed has now been reduced to 0.75 m/s; which is a slow walking speed. This value should challenge the players while still allowing them to play at a comfortable speed.

4.2.2 Catch Distance and Max Distance

The Catch Distance is the maximum distance between the each of the three players and Bob such that Bob will be trapped. This means that if all three players are with in Catch Distance meters of Bob, they will have successfully trapped him. The Max Distance is the maximum distance between any two players before they can trap Bob. The original value of Catch Distance was 100 meters, but since the size of the playing field was reduced, this value was reduced to 80 meters. After some difficulties were encountered while testing the game, the value of Catch Distance was increased to 90 meters. This new value still needs to be tested.

The Max Distance is just double the Catch Distance since this is the furthest two players can be apart if they are both within the Catch Distance. Thus the current value of Max Distance is 180 meters.

4.2.3 Safety Distance

The Safety Distance, which is used only in the chase phase, is the minimum distance between any player and Bob before Bob starts running away. The value of this parameter has to be greater than the Catch Distance otherwise Bob will be trapped before he even has a chance to run. The original value of Safety Distance was 150 meters; this was 50 meters more than the catch distance. Having the Safety Distance 50 meters more than the catch distance was too much ground to make up for the players while chasing Bob at walking speed. For this reason, the Safety Distance was reduced to 100 meters. Initial tests indicate that this value is not too high. And since this parameter must remain higher than the Catch Distance, this value is appropriate.

4.2.4 Bob Starting Locations

Two locations needed to be chosen for Bob. The first location is where Bob is hidden in the find phase. The second location is where Bob jumps to at the beginning of the chase phase after he has been caught in the find phase. These two locations need to be chosen carefully so that the connectivity and positioning in those areas are good. Also, the two positions should be relatively close to each other so that time isn't wasted walking across campus. The GPS coordinates for all these locations were determined and entered into a configuration file.

When the game was played using the entire campus, Bob's starting location was at the Cairn, on Main Mall outside of the Kaiser building. In the chase mode, Bob would jump to the main entrance of the Wesbrook building.

When the game was played using the north side of the campus only, Bob's starting location was chosen to be the middle of the Buchanan courtyard. This area had good connectivity and positioning. It also provided several different directions in which the players could approach Bob. In the chase phase, Bob would jump to the area between the

Frederic Wood Theatre and the Lasserre building; this less than a 5 minute walk from Buchanan so the players can start chasing Bob really quickly.

5.0 OTHER USABILITY IMPROVEMENTS

Aside from the major enhancements mentioned above, other minor changes to the game greatly improve the usability of the game. These changes were part of the functionality requirements in the game specifications. The improvements include putting the game parameters in a configuration file, and including a ‘Start’ indicator for the client.

5.1 Game Parameters Store in a Configuration File

Since the game parameters are constant during a single game, the values of those parameters can be read from a configuration file. By changing the code to read the parameters from the configuration file, the values of the parameters can be changed without recompiling the code for the game; the parameters can be changed independently of the code. Another benefit of using the configuration file is that all the parameters are located in one place so that the .java files do not need to be searched to find out which parts of the code need should be changed.

5.1.2 Client Configuration File

The game parameters that have been stored on the client configuration files are the proximity sensor range, the length of the game, and the server address. The proximity sensor indicates how close the player is to Bob. The proximity sensor range is the minimum distance before the sensor gives any indications. By default, this value is 200 meters. The players should not be allowed to change these three parameters, but including these parameters in the configuration file allows testers to quickly change the parameters if problems are discovered during testing or during the user experiments.

5.1.3 Server Configuration File

The server configuration file contains all the game parameters mentioned in section 4.2 to allow easy changes. In addition to the game parameters, the configuration file also includes options to enable or disable message an annotation logging. Since logging the ink messages and map annotations puts a lot of load on the server, these options can allow the logging to be turned off if it is causing problems.

5.2 Client Start Screen

Initially, the client application had no indication that the game has begun. To give a clear indication to start the game, a short instruction message is given when the client application is opened. Upon clicking the synchronization button, a start message is displayed for a couple seconds before the game starts. Figure 7 shows the two messages displayed at the start of a game.

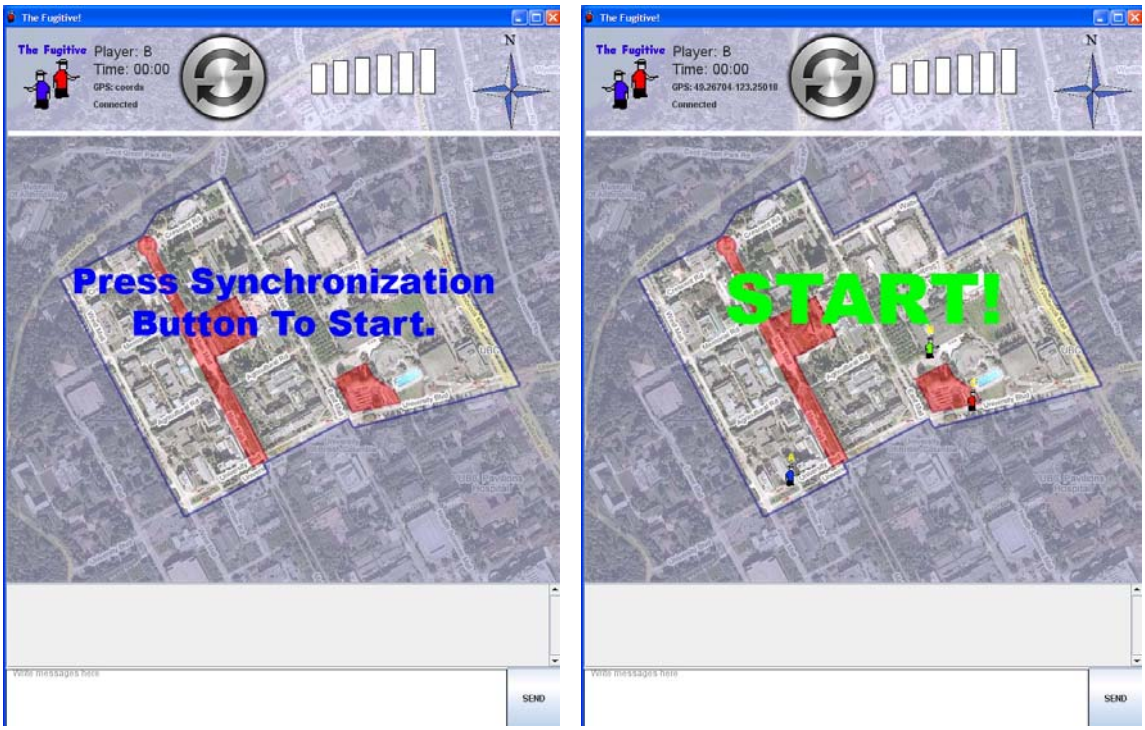

Figure 7. The start indicators on the client

6.0 THE REPLAY ANALYSIS TOOL

The replay analysis tool is a crucial tool needed for answering the research questions regarding collaborative strategies and location awareness. The replay tool is used to analyze a game after it has been played. Based on the data from the server data logs, the game is reconstructed to appear in a way similar to what the players see during the game. In addition to what the players would normally see, the replay tool allows you to view the paths that all the players took during the game. It also calculates the total distance travelled by each player. The additions and improvements that were made to the existing replay tool will be described in the following sections.

6.1 Strokes and Ink Message Logging

The original server logs only logged instances of when strokes and ink messages were sent. Strokes are the annotations that players draw on the map. Ink messages are similar to the handwritten messages on MSN Messenger. The screenshot in figure 8 shows a map annotation in red, and an ink message in green at the bottom of the screenshot. In order to recreate the strokes and ink messages in the replay tool, the data from these messages must also be logged. Modifications to the server logic now allow you the option log the strokes and ink messages. The data which are logged are two-dimensional coordinates where pixels are drawn. Appendix A provides a sample server log file.

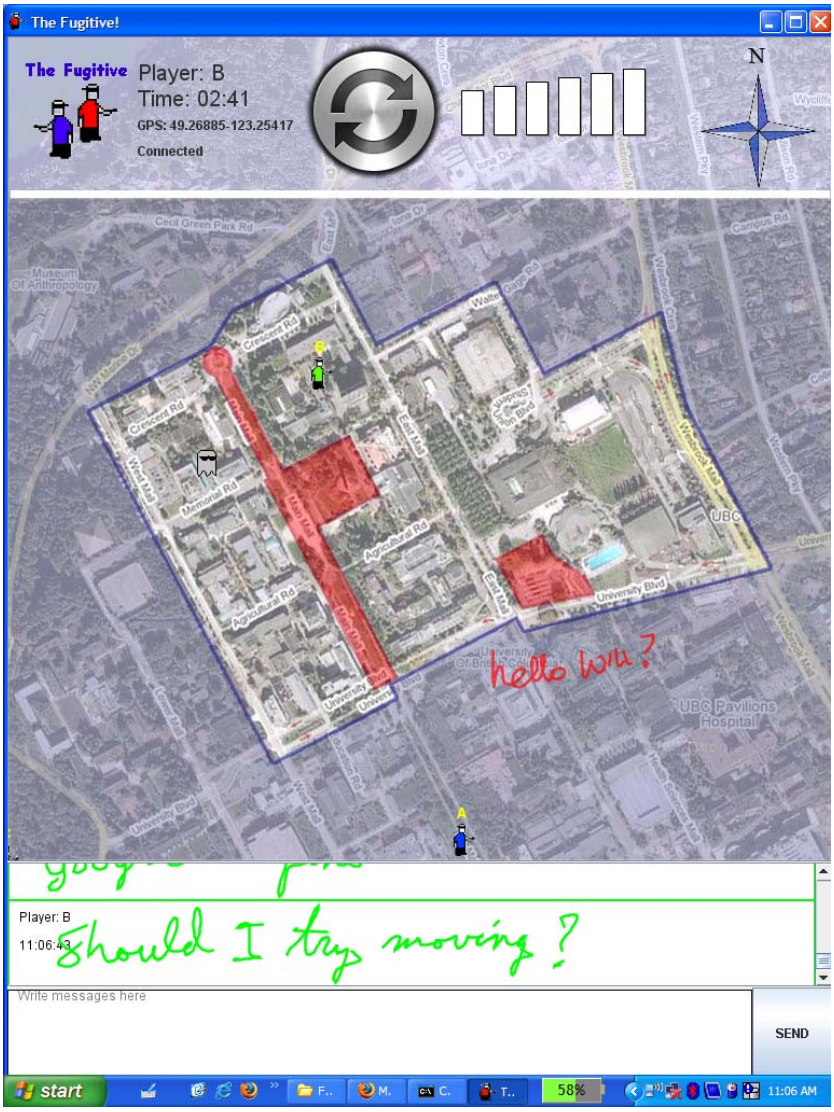

Figure 8. Map annotations and ink messages

6.2 Displaying Strokes

In the replay tool, the strokes are recreated from the data in the log files. When running the replay tool, the strokes are displayed at the time which they are sent. Similar to the client, the strokes fade after four minutes so that the screen does not get populated with map annotations; this gives a better understanding of what the players are seeing as they're playing the game. Displaying the strokes also provides insight into how well the map annotations are used to assist the players in completing the game.

6.3 Displaying Ink Messages

Unlike the strokes, the ink messages are not display on the map, but rather, in a separate window. Similar to the strokes, the messages are not displayed until they are sent. Again, the ink messages allow you to see what the players are seeing which will help to answer questions related to how using messaging will affect the team's performance to complete the task. Figure 9 shows the ink message window of the replay tool.

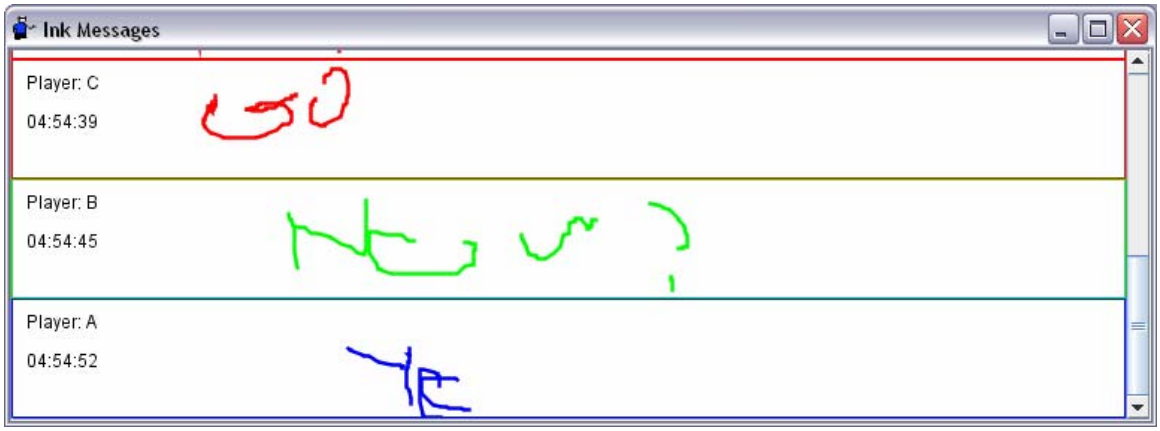

Figure 9. Ink message window

6.4 Slider Tick Marks

Whenever strokes or ink messages are sent, coloured tick marks are labelled on the time bar at the bottom of the replay tool. Strokes are indicated using a "|", while ink messages are indicated using an "!". The colour of the marker represents the player who sent the stroke or ink message. This feature allows the frequency and bursts of strokes and messages to be observed. Figure 10 shows the slider tick marks.

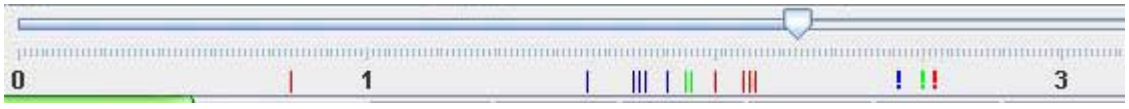

Figure 10. Slider tick marks

6.5 Visible Bob and His Movement

A main difference between the client application and the server replay tool is that the replay tool gives you the ability to see where Bob is located even if he's invisible. The replay tool also tracks Bob's path when he runs in the chase phase of the game. His position is tracked by logging his position as he moves. The path that Bob takes is then reconstructed the same way as the path of other players. Seeing Bob's path provides a better idea of how the player's work together to try and surround Bob as he is moving.

6.6 Distances Travelled and the Time of the Game

The distances travelled by each player can be viewed at any time by pointing the mouse over that player. Knowing the distances travelled by each player is important for answering questions related to performance and location awareness. The time to complete a game can be seen by shifting the slider all the way to the right. Figure 11 shows that Player C has travelled 933 meters, and that the length of the game was 8 minutes and 59 seconds.

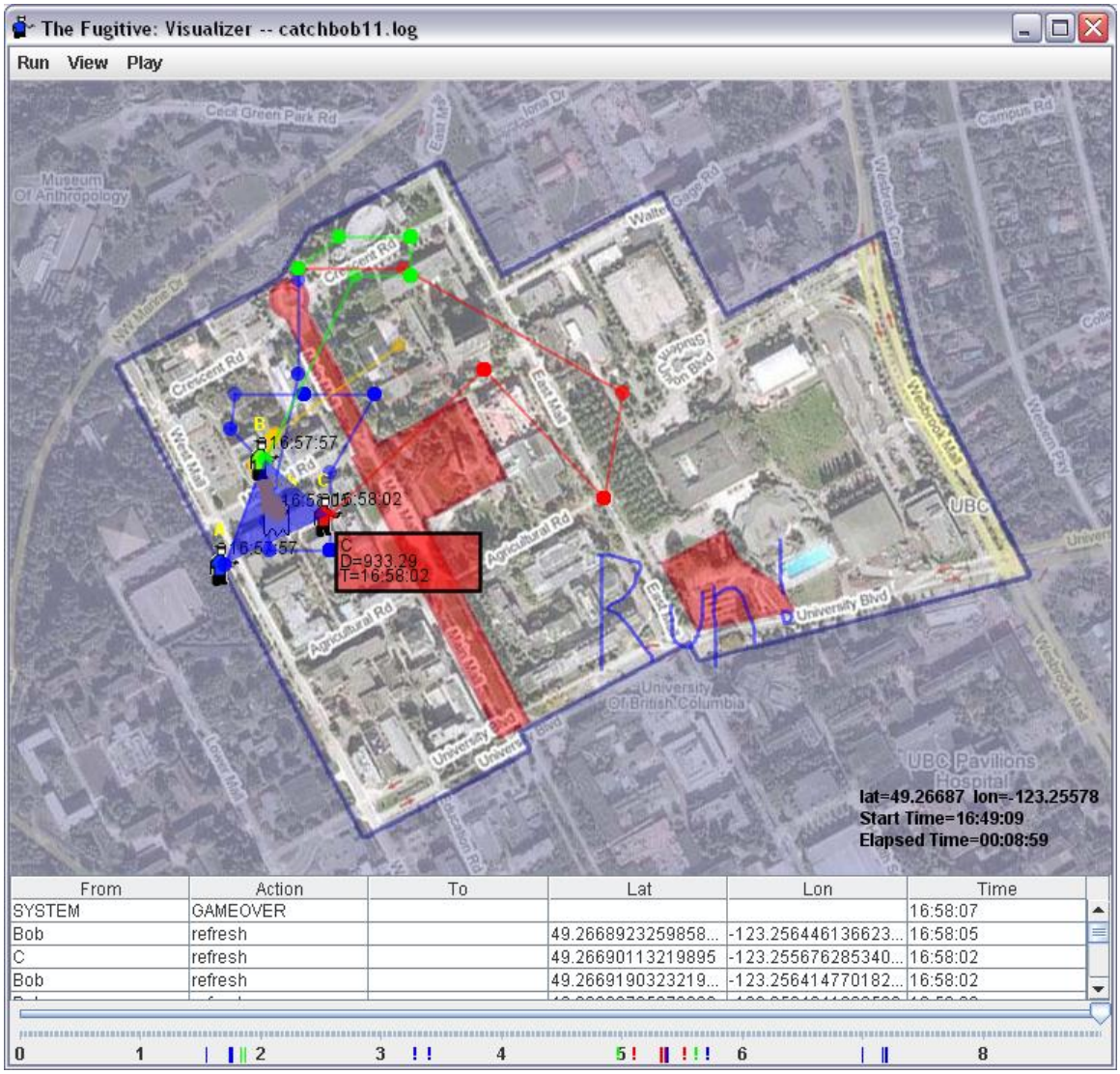

Figure 11. Screenshot of distance travelled and length of the game

7.0 CONCLUSIONS

This report investigated the different changes and additions to improve the usability of the Fugitive so that it will be ready to be used in user experiments. After extensive tests and refinements, any errors in the positioning are rarely noticeable. Lost connections reconnect seamlessly; thus the issues with connectivity have been resolved. The game parameters have been carefully chosen and adjusted based on field tests. Finally, the server logs and the replay analysis tool are ready to be used; thus any games that are played can be reconstructed and replayed. With all the above changes to game, The Fugitive is now playable and equipped for the user study.

Future improvements that have been mentioned in this report could include further refinements to the game parameters, and unauthenticated access to the UBC wireless network.

APPENDICES

Appendix A: Server Data Log Sample

```
16:49:09,046|49.268563;-123.25462|Bob|refresh|
16:49:09,125|49.269293565445025;-123.2561272356021|A|refresh|
16:49:09,156|49.269293565445025;-123.2561272356021|B|refresh|
16:49:11,093|49.269293565445025;-123.2561272356021|C|refresh|
16:49:17,968|49.269293565445025;-123.2561272356021|A|position|
16:49:19,140|49.269293565445025;-123.2561272356021|B|position|
16:49:19,937|49.269293565445025;-123.2561272356021|A|refresh|
16:50:31,046|49.26961535471204;-123.25443080366493|B|position|
16:50:32,234|49.267083013089;-123.25155331151834|C|position|
16:50:33,046|49.266579342931934;-123.25655671204188|A|refresh|
16:50:33,093|49.26961535471204;-123.25443080366493|B|refresh|
16:50:34,234|49.267083013089;-123.25155331151834|C|refresh||
16:50:45,890|49.267083013089;-123.25155331151834|C|refresh|
16:50:51,093|49.266579342931934;-123.25565481151833|A|refresh|
16:50:51,937|49.26961535471204;-123.25443080366493|B|position|
16:50:52,109|49.266579342931934;-
   123.25565481151833|A|stroke|328,328,332,336,337;625,636,683,696,702|
16:50:52,187|49.266579342931934;-
   123.25565481151833|A|stroke|458,457,455,455,454,453,453,455,464,473,
   487,500,487,468,443,443;664,664,665,674,683,694,705,710,710,710,704,
   689,664,664,658,663|
16:50:53,937|49.26961535471204;-123.25443080366493|B|refresh|
16:50:54,015|49.267083013089;-123.25155331151834|C|position|
16:50:54,187|49.266579342931934;-
   123.25565481151833|A|stroke|449,449,454,459,472,481,487,489;451,452,
   455,458,467,472,474,473|
16:50:56,015|49.267083013089;-123.25155331151834|C|refresh|
16:50:59,171|49.266579342931934;-123.25565481151833|A|position|
16:51:00,968|49.26961535471204;-
   123.25443080366493|B|stroke|291,293,295,297,299,301,303,305,307;312,
   317,319,321,323,322,320,317,309|
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16:51:01,203|49.266579342931934;-123.25565481151833|A|refresh|
16:51:03,937|49.26961535471204;-123.25443080366493|B|position|
16:51:04,125|49.267083013089;-123.25155331151834|C|position|
16:52:23,484|49.266579342931934;-123.25565481151833|A|refresh|
16:52:25,703|49.266579342931934;-
   123.25565481151833|A|inkMessage|59,60,60,61,62,62,63,64,68,72,89,95,
   102,106,112,118,125,134,145,146,157,166,174,178,183,187,187,191,192,
   198,202,209,218,227,231,240,248,252,264,275,281,290,296,303,309,318,
   322,331,337,341,342,346,347,348,352,352,352,353,357,358,359,363,369,
   373,377,386,390,394,401,405,409,410,411,417,421,432,441,447,452,453,
   457;72,72,71,71,70,66,66,65,64,63,57,55,51,51,47,43,43,38,38,37,37,3
   7,37,37,37,37,38,39,40,49,50,56,63,67,67,69,69,70,70,70,70,66,64,62,
   58,55,51,47,45,44,40,40,39,39,40,41,42,42,46,46,47,48,50,51,51,53,53
   ,53,53,53,53,53,53,53,53,53,53,53,52,52,52|
16:52:27,453|49.26961535471204;-123.25443080366493|B|position|
16:52:27,578|49.267083013089;-123.25155331151834|C|position|
16:54:09,734|49.26961535471204;-123.25443080366493|B|position|
16:54:10,093|49.267083013089;-123.25155331151834|C|position|
16:54:11,734|49.26961535471204;-123.25443080366493|B|refresh|
16:54:12,078|49.267083013089;-123.25155331151834|C|refresh|
16:54:14,468|49.267083013089;-
   123.25155331151834|C|inkMessage|44,45,46,50,50,54,58,58,65,71,78,82,
   83,84,85,85,86,86,87,87,88,88,92,94,98,99,101,102,102,103,103,107,10
   7,111,115,116,116,117,118,120,121,121,123,123,123,124,125,125,125,12
   6,127,127,129,129,129,129,129,129,129,129,130,130:149,149,149,149,14
   9,149,149,149,149,149,149:152,153,153,157,158,162,163,167,168,169,16
   9,170,171,171,172,173,173,173,173,173,173:148,148,149,149,154,155,16
   1,165,169,170,171,175:211,212,214,214,215,215,215,215,216,216,216,21
   7,218,218,218,219,219,219:239,243,243,243,243,247,247,247,247,247,24
   7,247,247:227,232,236,240,244,244,248,252,256,261:280,281,281,281,28
   2,282,283,284,284,284,285,285,285,285,286,286,286,286,287:291;23,24,
   25,29,30,31,35,36,42,46,53,57,61,65,66,67,68,69,69,68,64,63,57,51,44
   ,40,31,30,29,28,27,28,32,36,40,41,42,43,47,53,57,58,64,65,66,66,70,6
   9,68,64,63,57,51,47,42,38,34,30,29,28,28,27:51,52,53,57,58,62,63,67,
   68,67,66:47,47,48,48,48,49,50,50,50,51,52,52,53,54,55,55,56,57,58,59
   ,60:53,54,54,55,56,57,59,59,59,59,59,59:32,32,38,39,40,44,45,46,50,5
   4,58,62,66,67,68,72,73,74:33,37,41,45,46,52,53,57,61,62,63,64,65:56,
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   55,55,55,55,54,54,54,54,54:19,20,21,22,23,24,28,32,33,37,41,42,43,47
   ,48,49,50,51,52:56|
16:54:14,906|49.266579342931934;-123.25565481151833|A|position|
16:54:16,921|49.266579342931934;-123.25565481151833|A|refresh|
16:54:19,906|49.26961535471204;-123.25443080366493|B|position|
16:54:20,859|49.267083013089;-123.25155331151834|C|position|
16:54:21,781|49.26961535471204;-123.25443080366493|B|refresh|
16:54:24,687|49.267083013089;-123.25155331151834|C|refresh|
16:54:26,578|49.266579342931934;-123.25565481151833|A|position|
16:54:27,734|49.267083013089;-
   123.25155331151834|C|stroke|417,416,415,415,413,413,413,405,393,369,
   337,313,307,304,303,301,299,297;406,405,399,385,368,354,345,344,345,
   350,358,367,369,368,362,356,350,347|
16:54:27,765|49.267083013089;-
   123.25155331151834|C|stroke|291,292,305,327,340;349,349,349,349,345|
16:54:27,781|49.266579342931934;-123.25565481151833|A|refresh|
16:54:27,843|49.267083013089;-
   123.25155331151834|C|stroke|267,267,267,267;346,349,352,358|
16:54:28,750|49.267083013089;-
   123.25155331151834|C|stroke|266,267,273,282,288;352,352,352,352,352|
16:54:30,593|49.26961535471204;-123.25443080366493|B|position|
16:54:32,812|49.26961535471204;-123.25443080366493|B|refresh|
16:54:34,796|49.267083013089;-123.25155331151834|C|position|
16:55:11,921|49.26922361125654;-123.25443080366493|B|position|
16:55:13,906|49.26922361125654;-123.25443080366493|B|refresh|
16:58:05,328|49.26744677486911;-123.25659965968588|B|position|
16:58:06,531|49.26645342539267;-123.25685734554975|A|position|
16:58:07,250|GAMEOVER
16:58:07,250|49.26645342539267;-123.25685734554975|A|refresh|
```