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Position-Based Games for Mobile Terminals

Development of a prototype for Pocket PC

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Master's thesis 20p:

Position-based games for mobile terminals

-Development of a prototype for Pocket PC

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Preface

This master's thesis of 20 p is the final work of my education, Computer science/Software Engineering at Luleå University of Technology (LTU). The work is performed at Telia Research AB in Farsta (Stockholm) during the autumn 2001 and it has been a very stimulating and educational time.

To be able to reach the goal within the specified period of time this work has been done together with another person, Niklas Kernby, which is a student at The Royal Institute of Technology (KTH) in Stockholm.

I would like to thank the people that have assisted with their help and knowledge during our work:

Niklas Kernby, my invaluable co-worker during this master's thesis.

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Mikaela Merenyi, colleague at Telia Research AB. Evaluated our game idea and the graphical user interface.

Cecilia von Krusenstierna, colleague at Telia Research AB. Evaluated our game idea and the graphical user interface.

Kåre Synnes, examiner at LTU. Helped us with the communication part between the server and the client.

Finally, I would also like to thank all the other people that I have not mentioned above that have supported and helped us during our work.

Annika von Schlieben
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Abstract

It is predicted that the market for position-based services is going to reach an annual turnover of billions of dollars in a few years. Besides this, also the game industry is estimated to meet a bright future, and there is a great interest already. This master's thesis looks at a service that combines these two areas. The result is a position-based game called *Mystery* that is developed for the handheld computer *Compaq iPaq 36-serie*, which is well suited for this kind of game.

To be able to locate a player we have used Ericsson's Mobile Positioning System, MPS, which uses GSM positioning. The alternative would have been to use the Global Positioning System, GPS, but then the handheld computer would require extra hardware that is not available on the market yet.

The prototype consists of a client and a server application. They are both developed in Java and they are communicating with each other through an http-protocol.

One conclusion we have drawn form our work is that the kind of game we have developed requires higher accuracy than is achieved with GSM today, even though it is still possible to play the game. The disadvantage now is that the players have to move long distances, which is most likely if they are going by train, bus etc. A better accuracy would make it possible to shrink the distances so that it would also be remunerative to walk. When a better accuracy can be achieved a new possibility for this kind of game will open up.

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1 Introduction

1.1 About Telia AB

Telia AB is the leading communication company in the Nordic countries. It was established in 1854 and became a corporation in 1993 [1]. In the summer of 2000 Telia was introduced on the share market, but the government still have the share majority (70,6%). Today there are approximately 30 000 employees working at Telia and their organisation consist of five different business areas: Telia Mobile, Telia International Carrier, Telia Networks, Telia Internet Services and Telia Equity [2].

According to internal information Telia started the corporation Telia Research in 1991 to be able to meet the fast changes in the telecom business. Telia Research AB has about 300 employees today who are located in Farsta, Luleå, Nynäshamn and Malmö. They also started up in Silicon Valley in January this year. Telia Research AB is responsible for research and development within Telia AB. The focus areas for Telia Research are Communications for Home and Enterprise, Personal Communications and Net-based Services.

1.2 Background

People are becoming more and more mobile in their way to communicate, both private and in the working life. Mobility, regarding terminal and user, gives the user freedom of movement but also brings a possibility to obtain information related to individual performance, for example information based on the geographical position of the user. The market for position-based services is predicted to reach an annual turn over of billions of dollars in a few years [3]. Parallel with this also the game industry is estimated to meet a bright future. Within five years (2006), the turn over for mobile online games will reach 17,5 billion dollars compared with 950 million dollars today [4]. These two areas are therefore subjects of an interesting combination.

1.3 Purpose

The purpose with this master's thesis is to study the possibilities to develop a new kind of service that integrates the entertainment area with the positioning technique. This will be done by developing a prototype for a mobile game that is based on positioning. There are a few mobile games available on the market today that uses positioning, but unlike these games our idea will be combined with real time graphics in order to add a new dimension to the game. The prototype may later be shown in Telia Research's Vision Centre to see if there is any interest for this kind of service.

1.4 Objectives

The first objective is to briefly analyse the mobile terminals available on the market today. A choice will be made about which device to use during the development phase of this project.

Another objective is to generate ideas for position-based games and also to choose of these ideas and realize it as a prototype. We shall also take into account the new GPRS[1] technique to see how it can influence this kind of service. Regarding the positioning part we shall study the techniques available, and choose which one to use. As time arises we will in the end of our work perform a smaller test with some users in order to evaluate our prototype. Since this will not be the main focus in our work it will not be a comprehensive, large-scale test with the proper target group.

1.5 Work distribution

Because of the extensive work this master's thesis will be performed together with another person. His name is Niklas Kernby and he is a student at KTH, Stockholm. Since Niklas have studied Human-computer interaction and I have studied Software engineering we have decided to divide part of the work between us to better match our focus areas. This also makes it easier to match the different requirements from respective university regarding the report and the implementation part. In order to get a better understanding for the work and to make sure that we fulfil the requirements from both sides we will make all the important decisions together, and we will regularly try to take part of each others work.

Common parts:

- Generate some ideas for a mobile game
- Select the best of the ideas and realize this as a prototype after we have decided what parts to concentrate on
- Define the target group for our game
- A brief research of the mobile games available on the market today, particularly games based on positioning
- Examine the mobile terminals available, and choose the terminal that is best suited for the implementation of the prototype
- Decide which tools we will use during the development phase (development environment, API, modelling tools and server)
- Decide what functionality the game should have and design the system conceptually
- Procure necessary material (hardware, software, literature)

Annika's individual work:

- Detailed modeling of the program based on our common conceptual design of the system's functionality
- Study how the geographical positioning method and Ericsson's MPC (Mobile Positioning Central) works and how to program systems based on this technique
- Implement the functionality and the logic of the game, in other words the server side of the game
- Implement the communication part between the client and the server

[1] GPRS, General Packet Radio Services, is a packet based, wireless communication service [5]. For further information see section 3.2.5.

Niklas' individual work:

- Design and implementation of the graphical user interface
- Choice of the most suitable way for interaction between the application and the user
- Brief analysis of conceivable social and psychological aspects on this new category of mobile games
- Initiating the communication between the client and the server

1.6 Demarcations

The analyse of the mobile terminals on the market is limited to terminals with a graphical display, in other words not mobile phones and other text based terminals. The reason for this is that we want to create something that is not yet available on the market, and since Telia Mobile recently launched the game *Botfighters* that is developed for text based terminals using SMS we decided to exclude this alternative.

Since our time is limited we only have the possibility to develop a prototype for one of our ideas. We will focus on the basic functionality for this prototype rather than the security, scalability and the stability. Since none of us is a graphical programmer we will concentrate on other factors instead where we believe that we can add value for the users. These factors are mainly the positioning, the functionality and the usability of the game. The graphical user interface is still of great importance to us, but we will mainly concentrate on the functionality and usability instead of the design. Depending on which idea we choose to implement we may have to consider other demarcations regarding the functionality. The reason for this is the limited period of time during which the development is taking part.

1.7 Document outline

The following chapter gives a brief introduction to the positioning techniques that are in use in Sweden today and it also presents a discussion about which system we have used in our prototype. Next to this comes a study of the different handheld computers available on the market to see which one is the most suitable for us to use. Chapter 4 gives a brief description of other position-based games available o the market today. It also gives further details about important factors that the game should contain before introducing the ideas we came up with. Chapter five presents the selected game idea and its functionality and it also states the demarcations that had to be done for the prototype. Finally it gives some suggestions for further development of the game idea. The next chapter describes the system in more detail and it also gives instructions for how to run the prototype. A discussion about the prototype based on our own tests follows this, while the last chapter presents the results of this master's thesis.

2 Positioning techniques

This chapter briefly presents the two most common positioning techniques available on the market today, which can be used to determine the geographical position of a user. It also gives a discussion about which technique that is used for the prototype. There are other positioning techniques as well, but since they are not very common today and since some are restricted to certain areas (e.g. positioning in a Local Area Network, LAN) they will not be considered in this thesis.

2.1 GPS

2.1.1 The system

In 1973 the US Department of Defence initiated the effort to establish, test, acquire and develop a spaceborn positioning system for military use. It was not until 1994 though, that the GPS (Global Positioning System) achieved its initial operation capability when 24 GPS satellites were successfully operating. Ground stations located worldwide continuously monitor the satellites that in their part transmit signals that can be detected by anyone with a GPS receiver. Using the receiver you can determine your location with an accuracy of a few meters. The GPS system consists of three segments: the space segment, the control segment and the user segment [6, 7].

The space segment
The first GPS satellite was launched in 1978 and in 1994 the system was completed with the last of the 24 satellites that orbits around the globe. There are six different orbits, each of them containing four satellites. The reason for this is to make sure that at least four satellites will be in view at any location on earth, in all weather, 24 hours a day since four satellites is required to be able to calculate a position. The satellites orbit at 20200 kilometres above the earth and one orbit takes 12 hours to complete.

The control segment
The control segment consists of ground control stations whose purpose is to control the exact position of the satellites. There are five stations located around the world, one master ground station in Colorado and four monitor stations in Hawaii, Kwajalein in the Pacific Ocean, Diego Garcia in the Indian Ocean and Ascension Island in the Atlantic Ocean.

The user segment
The user segment consists of the users and the receivers with which the users can get their position.

2.1.2 How positioning with GPS works

The principle behind the GPS is the measurement of distance between the receiver and the satellites. Each satellite is equipped with an accurate clock to let it broadcast signals coupled with a precise time message. The satellite signal continuously sends out information that the ground unit receive. The signals travel with the speed of light,

but even at this speed the signal takes a measurable amount of time to reach the receiver. The difference between the time the signal is sent and the time it is received, multiplied by the speed of light, enables the receiver to calculate the distance to the satellite. To measure precise latitude, longitude and altitude, the receiver measures the time it took for the signals from four separate satellites to get to the receiver.

2.1.3 Advantages with GPS

- The accuracy of the given position is less than 5 meters today under the right conditions [8].
- The system works all over the world
- It is for free to request and receive positions

2.1.4 Disadvantages with GPS

- Requires a clear view to at least four satellites, it therefore does not work indoors
- Requires extra hardware that supports GPS
- It can take a couple of minutes to receive the first position

2.2 GSM

2.2.1 The system

The Global System for Mobile communication (GSM) consists of a number of base stations located around Sweden. The country is divided into smaller geographical areas usually called cells, see figure 1. A cell is defined to be the area where the radio coverage is given by one base station. There are two different kinds of cells, omni cells and three-sector cells [9].

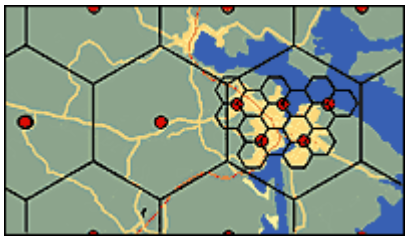

Figure 1: An example of a cell plan showing the different cells represented as hexagons. The base stations are shown as dots.

The first one, the omni cell, covers an area of 360 degrees while the radius can be up to 35 kilometres, see figure 2. These cells are used in rural areas. In urban areas the demand for capacity is much higher than in the countryside, since there are more people using mobile phones. Also the geographical topology matters since for example buildings can affect the signals negatively. In this case the three-sector cell is more suited since many small cells give higher capacity than a few big cells. The higher capacity is due to the fact that each cell uses up to 16 frequencies to send

signals, regardless of the kind of cell. If an area is covered by for instance ten small cells instead of one big, the capacity will be ten times bigger in the first case. A three-sector cell is actually three small cells gathered around one base station with three antennas. Each antenna covers an area of 120 degrees, and the radius is between 100 meters and a few kilometres, see figure 2.

Figure 2: The left picture shows an omni cell covering 360 degrees, while the right shows a three-sector cell with three smaller cells covering 120 degrees each.

2.2.2 How positioning with GSM works

There are two different systems available today that are used to calculate the position of a mobile phone. Different operators have different systems, which means that we have to use the one that Telia uses, the MPS (Mobile Positioning System) from Ericsson [10].

To determine the position of a mobile phone, the MPS uses a method called CGI + TA (Cell Global Identity + Timing Advance). CGI is used to identify which cell the mobile phone is currently located in. The result from this is a circular area or a sector of a circle, depending on the kind of cell, see figure 3. If the area is a sector of a circle (three-sector cell) the edges of the sector are given by two different values, given in degrees. The distance between the two edges that the MPS returns is always 120 degrees.

Figure 3: The result from the CGI represents either a specific circle (omni cell) or a specific circle sector (three-sector cell) in the cell plan.

However, the CGI can be a very large area, which means that the accuracy in most cases is too low. To improve the accuracy the MPS uses TA. TA is a method that calculates the distance between the base station and the phone from the time it takes for the phone signal to travel between them. The distance is given by two values, an inner radius and an outer radius, for the circle or the circle sector. This limits the area where the phone can be located to a ring or an arc, see figure 4. The width of the ring/arc is 550 meters.

Figure 4: In an omni cell, the result from CGI + TA will be a ring around the base station. If the cell is a three-sector cell the result will instead be a third of a circle. This third is usually called a "banana".

2.2.3 Advantages with GSM

- Every device with a GSM card can be positioned so it does not require any extra hardware or software
- The technique also works indoors since the GSM signals is much stronger than the GPS signals
- The time it takes to locate a phone is approximately 2,5 seconds [11]

2.2.4 Disadvantages with GSM

- The accuracy depends on the kind of base station that the phone is currently communicating with, and also the distance between the phone and the base station. Typical values lies between 500 meters in cities and 10 kilometers in the countryside
- There can be some problems with the positioning since the coverage is not perfect all over the country

2.3 Positioning technique used in the prototype

When we started to look at the different techniques mentioned above we soon found out that there were no GPS cards available on the market that we could connect to the handheld computer. Besides the fact that this forced us to use GSM, we also thought it was necessary to be able to use our application indoors. Since GPS does not work inside buildings, this would not have been an alternative for us anyhow. GSM is also more suitable since it only requires a few seconds to determine a position. This is a very important factor in a game where the position needs to be continuously updated. The low accuracy may not necessarily be a problem. This depends on the kind of idea we decide to implement.

3 Mobile terminals

We started our work with a brief analysis of the mobile terminals available on the market today. According to the demarcations made in section 1.6 we concentrated the analysis on terminals with a graphical display. After this we focused on the requirements that we had on the terminal to use for our prototype and we chose the one that best fulfilled these. It is necessary to point out that the choice is based on our requirements during the development phase and not on the requirements that the potential users may have. The reason for this is that if our idea will be implemented in full scale, it is reasonable to believe that it would not be available on the market until a couple of years. By that time new devices will be on the market, and the ones already existing will either not exist any longer or they will most likely be cheaper to buy. This way the requirements change over time, and it is more relevant to take the users requirements into account when and if the idea is considered to be launch.

3.1 Mobile terminals on the market

There are many different types of mobile terminals on the market today, and new ones are coming all the time. The terminals can be divided into three different categories: mobile phones, communicators and handheld computers, see figure 5. Most likely these terminals are going to be integrated into a new kind of terminal in the future. Examples of this are starting to show up already. For example *Siemens* is about to launch a new handheld computer (*Siemens SX45*) that also can be used as a mobile phone [12]. There is also a co-operation going on between Microsoft, Samsung, Mitsubishi and Sendo, and during the autumn 2001 a new GPRS tri-band smart phone will be released. This phone uses the operative system *Microsoft Stinger* (a version of the Windows CE 3.0 operating system found in Pocket PCs) that powers the new generation of colour mobile phones with advanced mobile Internet and personal information management functionality [13, 14].

Figure 5: Here is an example of the different kind of terminals available today. The left terminal is a regular mobile phone, the one in the middle is a communicator and the right terminal is a handheld computer. The sizes are not according to scale.

This trend on the terminal market supports even more our decision to use a graphic based terminal for the development of the prototype. This decision leaves us with two different choices, either a hand held computer or a communicator. Since a hand held computer offers greater possibilities regarding graphical representation this was the natural choice to make.

3.2 Terminal requirements during the development phase

Even if the range of mobile devices now is restricted to comprise only handheld computers, there are still a lot of different brands and models to choose between. To be able to choose the one most suitable for this project we stated the different requirements that the device should fulfil, see figure 6.

• screen size/resolution	• operative system
• colour/black and white	• battery capacity
• background light	• availability
• terminal size/weight	• internal competence
• GSM/GPRS	• technical support
• processor	• accessories
• memory	

Figure 6: The different categories that affected our choice of terminal to use during the development phase.

3.2.1 Screen size/resolution

Since we are going to develop a game with a graphical user interface we do not want the screen size and resolution to limit the possibilities. Small screens and low resolution makes it harder to present the graphical information in a satisfactory way since the graphics get too small and indistinctive. To be able to develop an advanced graphical user interface we therefore need a screen as big as possible with a high resolution. There are number of terminals available with suitable screens that have more than 200*200 pixels. Examples are terminals from Casio and Compaq.

3.2.2 Colour/black and white

To increase the positive experience while playing the game it is desirably to have a colour screen. Colours also give a possibility to add more information/graphics on the limited screen and the feeling of reality increases considerably. It adds another dimension to the game. Casio Cassiopeia, Compaq iPaq H36XX and Palm m505 are three examples of terminals with colour screen. The disadvantage is that a colour screen consumes more power than a black and white screen. However, this will not be a big problem for us during the development phase since we will mostly be connected by a cable. By the time when our game can possibly be on the market the devices will probably have overcome this dilemma, so it should really not be a problem.

3.2.3 Background light

To be able to play the game outdoors in the evening and in the night, it is necessary that the terminal can offer background light.

3.2.4 Terminal size/weight

As mentioned before (3.2.1) a larger screen gives greater opportunities when developing the game. But we also have to take into account the aspects of mobility. The device must still be small enough to fulfil the desired possibility to easily move around with the device, especially since the game will be based on positioning and probably will require movements. This also applies to the weight that should not be too large either. The size of the terminals mentioned earlier does not differ very much. However, Compaq iPaq has an advantage compared to the others. It uses a virtual keyboard that can be hidden in order to maximize the screen area. This means that the Compaq iPaq offers a larger screen even though the terminal it self is not larger than for example Palm.

3.2.5 GSM/GPRS

For this kind of games it would be preferable to use General Packet Radio Service (GPRS). This is a new technique that is a packet switched addition to the circuit switched GSM. GPRS will be used with mobile devices such as mobile phones and handheld computers, and it offers a continuous connection to the Internet [5]. From the users point of view the packet switched technique it to prefer since it is cheaper to use than the circuit switched. They only have to pay for the amount of data sent instead of paying for the time they are connected with GSM. GPRS also offers a higher data rate, theoretically up to 171,2 Kbps [15], compared to 9,6 up to 43,2 with GSM high speed [16]. In the prototype there are a lot of data to be sent with all the positioning requests, and the application itself may be time consuming to download. We therefore like to use GPRS, but unfortunately there are no GPRS cards available on the market yet. However, they are expected to be released during the autumn and we will therefore like to have the opportunity to connect a GPRS card to our device in order to test this technique later on.

3.2.6 Processor

A fast processor offers better real time graphics and makes it possible to create applications with demanding calculations. Since we do not know the requirements for the game yet, it is better to choose a fast processor so it will not limit our ideas. A fast processor consumes more power than a slower one, but as described in section 3.2.2 regarding colour screen, this will not be a problem. Among the terminals we have studied Compaq iPaq has the fastest processor, which is a 206 Mhz StrongARM SA-1100.

3.2.7 Memory

For the same reasons brought up for the processor, it is better to have as much memory as possible. This also offers a greater possibility to use the power of the device instead of sending all the information through the connection. Since graphics require a lot of memory and since it shall be possible to run other applications as well on the terminal, 16 MB will probably not be enough. We will therefore try to use a terminal with at least 32 MB of memory.

3.2.8 Operative system

Today there are three main systems on the market: Palm OS, Pocket PC and Epoc. Since both of us are most familiar with Windows, we prefer to work with the Windows based (Windows CE 3.0) Pocket PC. This makes it possible for us to use development tools that we recognise, and also for future users to easily recognise the interface. The earlier mentioned smart phone (section 3.1) that will be released during this autumn and that uses the Stinger operative system (also based on Windows CE 3.0) is another factor supporting a choice of Pocket PC. It will then be easier to configure the game to suit mobile phones too.

3.2.9 Battery capacity

The higher capacity the better, but the fact that we will use a colour screen limits the capacity considerably. Also different expansion cards like GSM or GPRS consumes more power, but as mentioned in section 2.2.2 we will mostly be connected by a cable during the development phase. However, a minimum criterion is a couple of hours so that we are able to test our application in real situations.

3.2.10 Availability

The terminal we choose must be available on the market now since we have to be able to test our applications during the development phase.

3.2.11 Internal competence

There is a great advantage if we choose a device that someone in the department is familiar with. That way we can easier get support if needed, and also suggestions of suitable development tools to use.

3.2.12 Technical support

The device must support development techniques that are relevant for us to use. The supported techniques must be suitable for game development, and we must be able to learn how to use them during a limited period of time.

3.2.13 Accessories

As mentioned in section 3.2.5, a possibility to use a GPRS card would be to prefer. Even if it is not possible today because of missing hardware we may be able to try this on later this year. Before this is possible we definitely must be able use a GSM card. The GSM card we are going to use is Nokia Card Phone 2.0, which is a PC type II extended card.

3.3 Choice of terminal

If we summarise all these factors we finally end up with the device best suited for our project, the *Compaq iPaq 3660*. It fulfils all the physical and system requirements discussed in the previous section, and we can also get support from the staff at Telia Research, especially our supervisor. However, we are going to use the *Compaq iPaq3630* (figure 7) as far as possible since there are terminals of this type to borrow from Telia Research. The difference between the two models is mainly that the *Compaq iPaq 3660* offers a possibility to connect two different cards instead of one, and it also has more memory. The *Compaq iPaq 3660* has 64 MB instead of 32 MB, but even 32 MB is more than most of the other terminals can offer. Since we are not going to use GPS during the development, we do not need to connect two different cards to the terminal. It shall also be enough with 32 MB of memory and therefore we will manage with the *Compaq iPaq 3630*.

Figure 7: The Compaq iPaq 3630 is the terminal that we chose to implement our prototype for.

4 Game ideas and requirements

4.1 Position-based games on the market

Before we started to concentrate on finding ideas for position-based games we examined the market to see what has already been done. Since the combination of entertainment and positioning is a quite new area, the supply is very limited. We have only found two commercial games that use positioning, one in Sweden and one in Norway. Both these games are mainly developed for mobile phones since they are using SMS and WAP instead of real time graphics. The Swedish game is called *Botfighter*s [17] while the Norwegian game is called *TreasureMachine* [18]. As far as we know, there are yet no position-based games on the market that uses real time graphics.

4.1.1 Botfighters

Botfighters was the first position-based mobile game that faced the daylight. It was developed by the company *It's Alive* and it was launched by *Telia Mobile* during the spring 2001. The players are robots, and their mission is to shoot other robots by sending SMS with their mobile phones. Mobile positioning is used to determine whether the users are close enough to shoot each other. There is also a website where the players may upgrade their robots, buy weapons, chat, view high-score and get the real time position of other players.

4.1.2 TreasureMachine

Soon after the launch of *Botfighters*, the Norwegian company *Unwiredfactory* launched a location-based competition named *TreasureMachine*. The goal is to find a hidden virtual treasure by digging on the right location. To find this location the players pay a small fee and they thereby obtain clues provided via SMS, WAP, e-mail and media spots.

4.2 Game requirements

The focus we had when we discussed different requirements was that it should be a multiplayer game. This is because we think that game ideas that concern only one user and its movements are much too like ordinary games for Pocket PC, Game Boy etc, except for the movement part. It is much more exciting to take advantage of the possibilities with the positioning and we therefore concentrated on integrating several users. It would also be a great advantage to integrate people from the whole country, even people in the countryside, instead of just concentrating on the big cities.

Before different game ideas were discussed we focused on which ingredients our game idea would contain. One basic requirement we had was that the game should be different from other games in the way that it should bring people closer to each other. It should be a social game where people are encouraged to communicate with others and creating new contacts. It should also increase the feeling of presence so the other

players will be persons and not just figures on a screen. One way to attain this is by offering a chat through which the players can communicate, and we also wanted that the game should contain a natural reason to why people shall do this. Another way is to let the players design their own playing figures and thereby making the game more personalized. This also makes it easier for the players to find other players that they are looking for.

It is very important that the players are able to quit the game and then continue from that point later instead of having to start all over from the beginning. Otherwise they will have to do the same thing again and again without making any progress in the game, and this behaviour tends to bore people. Another factor that is important if we want to keep the players for a longer period of time is the degree of difficulty in the game. First of all the rules must be easy to understand from the beginning so that everyone in the target group can join the game without any major problems. However, the game itself should not be too easy to manage. It has to be a challenge to play the game, otherwise the players will eventually feel satisfied and move on to other games instead.

Finally we have to be careful regarding the interaction between the player and the limited terminal. The user interface must be easy to manage and not require too much from the player in terms of interaction with keyboard, pen or buttons.

4.3 Game ideas

With respect to the requirements above we generated two different game ideas. We also had some other ideas from an earlier stage of this work, but since they did not fulfil the requirements I will not consider them in this report. The first one of the two ideas we have called *Movement*. The basic idea is that the players shall eat as many of their enemies (the other players) as possible. Now and then different pills will be randomly shown on the screen and the players can catch these pills by moving to the specific location where they are shown. By eating these pills the players can get advantages compared to the other players, for example a player can be more powerful, faster or duplicate his/hers collected points. To be able to eat another player, a certain level of power is required. This power cannot only be influenced by pills, but also by being active or inactive in the game. If two players that meet are equally powerful they cannot both eat each other. Instead there will be a duel that the players have to fight. This game idea is an action game that requires fast moves and high accuracy in the positioning. Otherwise it can be hard to determine which player that is the first one to reach for example a pill or a specific place. Since we have decided to use GSM positioning that is quite inaccurate today, we came to the conclusion that an action game was not suited for our prototype. Instead, we decided to go further with the second idea we had, the game *Mystery,* and this idea will be fully explained in the next chapter.

5 Mystery

Mystery is the name that we chose for our game. The name is short, easy to remember and easy to pronounce. It also says a lot about the main concept that will be described and evaluated in section 5.2 to 5.6, right after a discussion about the target group. To make it easier to understand the game idea, screenshots from the prototype has been included in the text. However, the language in the figures is Swedish since the game is developed for the Swedish market. Section 5.7 brings up the demarcations that had to be done to make it possible to realize a prototype within this master's thesis, and finally I summarize our suggestions for further development of the prototype.

5.1 Target group

The target group for the game Mystery is primarily people between 15 and 30. The game does not specifically attract girls or boys; it can be of interest for both sexes. Unfortunately this master's thesis does not give the time to analyse the target group in more detail and to let them test and evaluate the prototype. An evaluation would also require hardware that is quite rare in this specific target group today. Instead, this is something that has to be done later on if the game should be launched as a commercial product. However, there will be a smaller evaluation together with a group of voluntaries from Telia Research AB. The purpose with this is to test the functionality, and also to get some opinions on the idea and on the experience from playing. The result of the evaluation will not be presented in this master's thesis since it will be done after my work is finished. This is because we want to evaluate the game together with GPRS, and at the moment we do not have access to the required hardware.

5.2 Fundamental idea

The idea reminds of a board game called *Cluedo*, and the main goal of the game is to solve a mystery by communicating with other players. The mystery can be a burglary, a kidnapping or a murder, and the players are detectives. The detective that first solves the mystery wins the game and receives a reward. To be able to solve a mystery, the detective needs to find some information about the case. From the beginning every detective is given a set of words describing the case, but there are only a few words that are correct information. It is up to the detective to find out which information that is true and which is false. The false information can be excluded from the original set of words, and in the end there are only the correct words that are left. The detective has then solved the mystery by the process of elimination.

The information is divided into different categories depending on the kind of mystery. For example a murder can have the categories name, description and weapon, see figure 8. Each category contains a number of words representing the information given to the detective from the beginning. There is only one word in each category that is correct information and therefore is part of the solution. All the other words are false information.

Murder

name	description	weapon
Jönsson	tall	poison
Tjuvgren	glasses	rope
Kvick	pale	stone
Dyrkmann	bald	gun

Figure 8: A mystery of the kind murder can contain the categories with the respective information as seen here. A possible solution to this mystery could be: Kvick, tall and rope. The detective must therefore find all the other words, the false information, and exclude them one by one.

5.3 The playing area

Now it is time to describe the playing area on the screen. How will it look, and how will it work? There are two different screens that the player can choose between at any time. One is used for the local area e.g. the city where the player is (the real world), and the other one is used to integrate players from the whole country (the relative world). In both cases north is synonymous with upwards on the screen. It is important to point out that this game is based on the geographical position of a player, which means that the player has to move in the real life (by car, train, on foot etc) in order to move the own playing figure on the screen. It is not possible to manoeuvre the figure in any other way.

5.3.1 The real world

This view shows a map over the local area around the player (a town or part of a big city). All players are marked on the point on the map that corresponds to their actual position, see figure 9.

Figure 9: The view of the real world shown as a map. This view shows the players on their actual geographical positions.

5.3.2 The relative world

The relative world is shown as default when the player starts the game. The background is an arbitrary map and players from the whole country are shown on this, see figure 10.

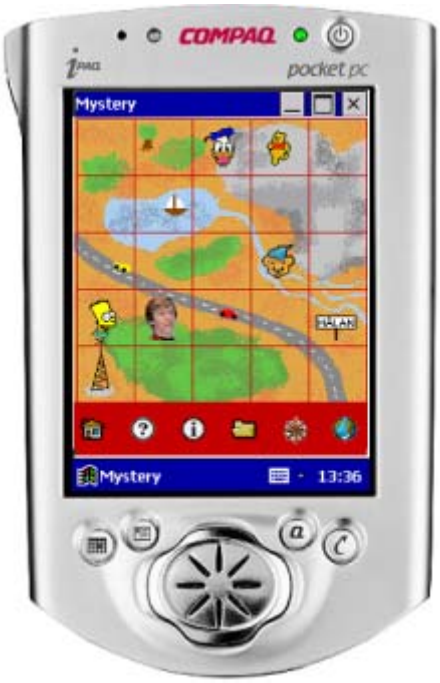

Figure 10: The view of the relative world. Even if two players are near each other on the screen, long distances can still geographically separate them.

Since Sweden has a long narrow shape and since many people live in big cities, this is hard to present on a small screen. There would be several players on the same spot (in a city) and very few in the countryside. The relative world solves this problem by randomly placing all players in different spots on the screen, without consideration for their actual graphical positions. When this is done, the only thing that matters is how the players physically move in reality (how far and in what direction). This means that two players that are geographically separated can still meet each other on the screen. For example, if Anna lives in Gothenburg and Peter in Kiruna they can still play against each other seeing the same view. The system can randomly place their figures on the screen so that they will be separated by for instance one step. Because of the current low accuracy in the positioning system, one step on the screen corresponds to about 300 meters in real life. This means that if both Anna and Peter walk 300 meters (one step) towards one another they will end up in the same place, even though they are geographically separated by 1800 kilometres. Then they are able to exchange information as if they were meeting in reality.

The size of this view is dynamically adaptable to the number of detectives currently playing. The minimum size is one screen size, but if there are many detectives the size will grow until it reaches a maximum limit. Above this limit the view will be restructured and divided in smaller parallel worlds with different mysteries going on at the same time. If there are several detectives in the same geographical area they will be collected in the same world if possible. If a detective reaches the edge and

keep on moving in the same direction, the playing figure will show up on the opposite side of the world (walk through the wall). For example if the figure is currently standing near the right edge and if the player moves to the east, the figure will show up on the left side of the world.

The player can always change view to the real world, the map. The system will also announce when another player is detected in the same geographical area and it therefore can be suitable to change view.

5.4 The goal – Who wins the game?

The overall goal is to collect points, and there are two ways of doing this. The most obvious way is to solve a mystery and thereby receive a reward, but it is also possible to collect points along the way. For every false word that a detective can exclude from the set of information he/she will receive one point. This may encourage detectives to take part in the game even if the mystery has been going on for a while and there are other detectives that are near the solution. There are different high-score lists available where everyone can see how they are placed compared to the other detectives. This will hopefully motivate everyone to play more in order to collect more points and thereby climb higher on the high-score list. There is one list for the total points that the detectives have collected, see figure 11, one that shows the points collected during the last five mysteries and finally one for the city where the detective is playing.

Figure 11: This high score list shows the total points collected by the detectives since they first joined the game.

5.5 How to play

5.5.1 To start playing

The first time when a player joins the game a registration form must be filled in. The information asked for is username, password, name, sex, age, hometown, interests and mobile telephone number. The fields that are required are username, password, hometown and telephone number, the other information is optional. To make the game more personalised the player also gets the opportunity to create an own figure that will represent the player on the screen. One way to do it is by choosing among a set of predefined elements (e.g. a head, a body, feet…), but it is also possible to design a completely new figure in a drawing-program.

A player can join the game at any time, even though other players may already have been active for a while. After the login procedure the mystery is presented for the player, the detective, with a brief description of the case. The purpose with this is to create the right atmosphere and encourage the user to solve the case. After this, the detective can chose to see a view where information about the other detectives is presented. Here it is possible to see how many detectives that are working with the case and also how close to the solution they are (e.g. how many false words they still have to find before they can solve the case), see figure 12. With respect to this information the detective can chose to take the case or to wait until someone else solves it whereupon a new mystery will begin.

Figure 12: View showing the status for the different detectives. The right column shows how many false words the detectives still have to exclude from the information before they can solve the mystery.

If the detective decides to take the case, he/she will be assigned one false word from each category that immediately can be excluded from the information describing the case. This means that if the information consists of four words in each category, the

detective only needs to find two since one word is part of the solution and one is received automatically when the detective chooses to take the case.

5.5.2 The meeting – to exchange information

When two detectives meet in the graphical world (on the screen) they can interact with each other in order to exchange information about the case. From the beginning, the only information that a detective can share with others is the word that he/she received automatically after taking the case. Every time that a detective receives new information he/she gets more knowledge about the case and therefore can share more and more information with the other detectives. An example will illustrate how the exchange of information works:

Suppose that Mr. Holmes is a detective trying to solve a murder. He has got a list of twelve words describing the case, and the words are divided into three different categories, see figure 8. Only one word in each category is part of the solution, so Mr. Holmes have to find out which words that are false information. When he started the game he automatically got one word from each category, for example *Jönsson*, *bald* and *poison*, so these words are marked as false information in the list. If detective Holmes meets another detective, for example Mrs. Christy, in the graphical world they can exchange information with each other through a text based chat channel. A chat channel is opened by clicking on a detective and then selecting "Exchange information with this player". The idea is to ask a question that hopefully results in an answer that makes it possible to exclude a specific word from the solution. For example Mr. Holmes can ask Mrs. Christy if she knows anything about the *gun*. If the answer is positive (all answers is controlled by the system to prevent cheating) it means that Mrs. Christy knows that *gun* is false information, and therefore also Mr. Holmes can exclude the word from the solution. Now there are two words left in the category weapon that are unmarked. When Mr. Holmes has excluded one more of these from the solution there will only be one word left in this category and it must therefore be part of the solution, see figure 13. The next step for Mr. Holmes is to find the false words in the other categories.

It is also possible to ask a question in order to fool the other detective. For example Mrs. Christy can ask Mr. Holmes about a word that she already knows belongs to the false information, just to make Mr. Holmes believe that this word may be part of the solution (if he does not know anything about the word and also thinks that other detectives do not possesses it either). Either Mrs. Christy is bluffing or not, Mr. Holmes can chose to mark words manually that he does not think is part of the solution. This way the detectives can draw their own conclusions from questions received from other detectives. This encourages the detectives to think, but it does not force the one that does not want that to do it. If the user later gets information about a word that is manually marked, the marking will be replaced by a marking made by the system.

Figure 13: The view showing the information given about the mystery. The words that the detective has excluded from the solution are shown in the upper group of words. The rest are shown in the lower group.

During the information exchange the positions for the two detectives will be locked on the screen. This way the detectives can keep moving physically in real life if necessary, without affecting the meeting. Both detectives can during a meeting ask one and only one question each regarding information about the mystery. To be able to ask the same detective for more information, they have to geographically move first.
It is important to point out that when a detective gets a question from another detective he/she can either choose to respond or to stay passive. The response must be sent within two minutes, otherwise only the first detective will receive new information. This way all detectives are forced to be active in the game if they should have a possibility to solve the mystery. However it is still possible to take part in the game even if the freedom of movement is limited to, for example, the office area during the day. The requirement is only that this detective actively responds to other detectives' requests regarding false information. If a detective meets another detective that is currently not online, the information exchange will look the same. The first detective gets the opportunity to ask for information while the other one misses the chance.

5.5.3 To guess the solution

When a detective has marked all words except one in each category as false, it is possible to guess the solution to the mystery. It is only possible to make one guess per mystery, and it is required that not more than one word from each category is manually marked. If the guess is correct and if the detective is the first one to solve the mystery, he/she will receive a reward. If it is wrong, the detective temporarily looses the detective license and will have to wait until a new mystery starts. This prevents players to just join the game and make a guess to win since this would be

unfair to those who have played a long time. The size of the reward depends on the type of mystery in combination with the number of categories and clues. The more categories and clues, the higher reward. A more serious crime like a murder gives a higher reward than a kidnapping. Burglary has the lowest reward.

5.5.4 Tips and tricks

Because of the limited size of the screen, especially when several users are playing, the figures will be very small and it can be difficult to separate them from each other. However it is possible to mark a user on the screen and thereby open a window where information about the chosen user is shown, see figure 14.

Figure 14: A window showing information of the selected user, and also an enlarged picture of the playing figure.

Since the positioning is quite inaccurate today, the player may have to walk a long distance before it will show on the screen. When it finally will show, it is possible that the player has walked in the wrong direction. To help the player to navigate, the game contains a function that represents a sundial, see figure 15. The player shall turn around until he/she can see the sun from the same direction as indicated on the screen if the player was staying in the middle of the sundial and was looking upwards on the screen. The player will then have north straight forward from the point where he/she is staying.

Figure 15: A sundial that shows the player where north is. The player shall stand in the middle looking upwards on the screen with the sun standing as marked in the picture.

5.6 Evaluation of the game idea

5.6.1 The playing area

The playing area consists of a grid with squares representing areas where a player can be. A move will be shown as a jump from one square to another like in an ordinary board game. This is because the inaccurate result given from the CGI + TA method today makes it impossible to move a playing figure continuously like if it was walking. The squares also indicate weather two players are meeting or not. When two players meet they will be placed next to each other in the square. This way it is still possible to click on the other player in order to chat, which would not be the case if they were placed on the same spot, e.g. on top of each other. The square now indicates that the players are meeting, even if they are not in exactly the same spot, see figure 16.

It is very important that the background for the relative world contains different significant elements to make it easier for the players to arrange a meeting. These elements can be for example a big tree or a road sign.

Figure 16: Winnie the Pooh and Bart is standing next to each other, but since they are in the same square they are actually meeting.

5.6.2 The meeting

It can be discussed whether it is an advantage to be the first or the last one to ask for information or to answer a question. The conclusion we made is that this depends on whether the player is bluffing or not. It also depends on the order in which the answers are received. Are they coming in the same order as the questions were sent or not? It is possible that two players that are meeting will both wait for the other one to ask the first question, and they will both wait forever. One way to avoid the problem is to let the system decide which one that should start, and in which order the questions shall be answered. However, we think that in the prototype it will be enough for the players to know that it can be risky to wait too long for the other player to ask a question. For example if one of the players is sitting on a bus, the geographical position will continuously change. If they wait too long the figures will move on the screen, and they will no longer meet. There is also the time limit mentioned in section 5.4.2 that the player must answer a question within. Even this is a help to control that the game continues and does not come to a halt.

To draw any reliable conclusions and to find suitable solutions, it is necessary to study the situation further.

5.6.3 Social aspects

When people are playing computer-based games it can sometimes be hard to imagine that there are actually real people behind the playing figures on the screen. One thought that we had with our idea was that it should bring people closer to each other in a natural and easy way. Here we think that the chat can be of great importance. First of all, the chat is used when two players want to exchange information about the mystery with each other. Since the players are able to create their own questions, the

exchange gets more living than if it would have been done automatically by the system. It is also possible to use the chat to communicate with other players even if they are not meeting at the moment. For example they can agree to meet in a special place on the screen so that they can exchange information with each other.

The players probably want to know to whom they are talking when they are using the chat. Here the opportunity to see information about another player is important. This function makes the game more personal, and it offers a way to find friends or for example players with the same interests.

5.6.4 Always on

The game *Mystery* is intended to be played during a longer period of time. Because of the inaccuracy of the positioning, the player has to move at least 300 meters in the real life in order to move the figure one step on the screen. This makes it almost necessary to play the game for example on the way to school or to the training, when the player is moving a longer distance by bus, train or by car. A typical scenario is that the player is connected to the game during the whole day. The player takes advantage of the usual trips, but he/she does not make a detour just to meet another player. He/she takes a glance at the screen from time to time during the day to see if anyone wants to exchange information or wants to chat. This is also indicated by different sound signals so that the player will not miss any information if he/she does not look at the screen constantly. The player simply lets the game be part of the everyday life, without letting it affect it too much.

In order to be "always on" it is recommended that the player use GPRS. It is possible to use GSM, but it would be too expensive since the player then would have to pay for the connection (price per minute) instead of the amount of data transferred.

Even if the player closes the application (for example during the night), the playing figure will still be "always on" in some sense. It will be locked on the current position and the other players will still be able to see it. Of course the figure will not be able to respond to any messages, but it is still possible for the other players to receive information about the case from it. The reason for this is that it should not be possible to log out in order to make ones own information about the case inaccessible for the other players, so that they are not able to solve the case.

5.7 Demarcations during development

To be able to implement a working prototype during this master's thesis we had to introduce some demarcations to the original idea. Still, the implementation was done as general as possible to make it easier to add more of the functionality later on.

5.7.1 The players

First of all our prototype is implemented for five players. The main reason for this is that we only had access to a few devices, including Nokia card phones and gsm subscriptions that are possible to position. The five players are hardwired in the

system so if there are for example three players connected to the game; the other two will still be shown as passive players on the screen. Since the players are hardwired, it is not possible to register new players or to let a player change the personal information. It is also not possible to design new playing figures since they are predefined in the prototype.

5.7.2 To solve the mystery

The categories and words (as well as the mystery) are randomly selected, so the content will vary from time to time. However, a mystery will always contain three categories and each category will contain four words. The list with information that is presented to each detective from the beginning therefore consists of 12 words. Since three words are marked as false from the beginning (one word in each category) and three words are part of the solution, this means that the player has to find six words before he/she can solve the mystery. It is not possible to mark words manually, so the system will automatically detect when a detective has found the last false word and therefore has solved the mystery. The detective will then receive the reward. Since there is no possibility to mark words manually, there will be no meaning to bluff even though it is still possible.

Due to imperfection in the communication between the client and the server (see section 6.3 for more details) we also had to make some other demarcations in the prototype. First of all there is no time limit within which a player must respond to a request regarding information exchange. Second, the system does not automatically create a new mystery when someone has solved the first one. Instead, the game server has to be restarted and the players will have to log in again. The reason for this is that the server is not able to push out a message to all players in order to notify them when someone has solved the mystery. The players therefore actively have to ask the server occasionally for this information (this is done automatically when the position is being updated). If the server should wait for everyone to do this before it starts a new mystery, it could wait for ever since the server does not know if a user is inactive and maybe will not log in for a couple of days.

Another function that is affected due to the communication is the chat. It is not possible for the server to push out the messages to the clients, so instead the clients must actively ask for the messages (also this is done automatically when the position is being updated). The chat therefore works more like a messaging system than a live chat. However, this means that an information exchange would take too long time to accomplish, so in order too speed this up the system will exchange the information automatically. The detective asks for information by writing a question that includes the word he/she is looking for information about. The specific word is written with a predefined syntax that the system understands (it is enclosed by quotes), so a question about the *gun* can be for example: Do you know anything about the “gun”? Instead of waiting for the other detective to answer the question, the system performs the exchange and shows the result to the first detective. Of course it is still possible for the other detective to answer the question afterwards.

5.7.3 The playing area

Because of the low accuracy in the positioning we have chosen to work only with the relative world. This is also an interesting part of the game since it integrates people from the whole country in a way that have never been done before. However, it is possible to switch to an arbitrary map that shows the concept of the real world, but there is no functionality involved.

As mentioned in section 1.6 we have not looked at the scalability of the game. Since there are always five players on the screen the world is not dynamic. The size is adjusted to the screen size, and the grid consists of 25 squares (5*5).

Finally there is no functionality connected to the sundial in the prototype. It is only possible to look at a view showing the concept of the idea.

5.8 Possible further development

Except from the basic game idea we also have some suggestions for further development. One important thought we had with our idea was to create a social environment where people communicate with each other. It would therefore be of great advantage to offer a possibility to play in teams. It should be possible to create two or more teams that should cooperate between themselves to find the solution to the mystery. One example is to have different detective agencies that the detective can join (or start an own one that other detectives can join). There must be an upper limit of for example 10 detectives working for each agency. There can be two different strategies that the agencies can choose to work from:

1. All detectives are working on their own, just like they would do if they were not working for a detective agency. The difference is that besides collecting points for them selves, the detectives also contribute with their points and rewards to the agency. All agencies will be shown in a separate high score list showing the sum of all points and rewards collected by the detectives.
2. The other alternative requires cooperation between the detectives on the agency. They divide the work between them selves so that one detective will search for the weapon and another for the place etc. When someone has completed a mission he/she reports to the agency which word in the category that is true information (e.g. which word that is part of the solution). When all parts of the total solution have been reported, the agency can make a guess. The first agency that makes a correct guess receives the reward.

In section 5.4 we discussed two ways of collecting points, partly by solving a mystery and receive a reward, and partly by collecting false information that can be excluded from the solution. But we also have a third suggestion. Every detective can publish an accusation anytime during the game (e.g. make a guess for the solution, besides the final guess), and it is possible to change the accusation as time goes by. When someone solves the mystery and gets the reward, there will also be a bonus for the detective that first made a correct accusation. This is also a possibility for new detectives to collect some points even though they have no chance to solve the mystery the ordinary way.

As mentioned earlier, a player must fill in a registration form before it is possible to log in to the game for the first time. In the original idea the player should specify the hometown in the registration form so that the other players can see where he/she is to be found in the country. However this information will be incorrect if the player is visiting another town while playing the game. It could therefore be interesting to use the positioning system even here to automatically update the information with the current position of the players in terms of city, instead of letting them specify this them selves. There could also be a function for showing a specific player on a city map, even if he/she is in another city than the player that asked for the information.

It could also be a good idea to make some of the functions accessible from an ordinary pc. These functions can be for example to register to the game and to design the playing figure, to update the personal profile, to get an overview of the collected and missing information about the mystery and to communicate with other players. Also the accusation for the criminal should be manageable from the computer.

To attract more people and broaden the target group there could be different versions of the game available. For example the mysteries can have different themes that are suited for different age groups, interests or sexes.

As a complement to the chat function the players could be able to call each other anonymous by using for example the Session Initiation Protocol (SIP).

Finally it may be necessary to simulate players if the number of detectives is below a critical point. Otherwise the information about the mystery can contain more words than there are users (including the solution) and it will therefore be impossible to solve the mystery.

6 Implementation of the prototype

This chapter focuses on the different techniques used on the client and the server side and also on how the system is structured. In the prototype, we have chosen to handle only the graphical user interface in the client and all the other calculations in the server. The reason for this is that we wanted the application to be small since it was going to be downloaded into a terminal with limited memory capacity. The last section in this chapter describes how to install and run the prototype and also what is required by the system to be able to do this.

6.1 Client technique

The client application is implemented in java. We have used a java platform called Jeode, which we bought from the company Insignia Solutions [19]. To be able to play the game it is necessary to install this platform on the handheld computer. Information about the choice of platform can be viewed in my co-worker Niklas' report [20].

As mentioned before, we recommend that the game is used together with GPRS. However, it is possible to use GSM, although it will be much more expensive than with GPRS. GPRS also offers a higher data transfer rate than GSM, which results in faster updates and faster responses to actions when playing the game. Unfortunately we were not able to test with GPRS our selves during the development phase. First of all, GPRS was not launched on the market until 11.th November 2001 [21], which was in the second half of our master's thesis. Second, there were no card phones available before the end of this work, and therefore we were not able to test this. However, there is a temporary solution that will be used during the user trial that will take part after my thesis is done. By connecting a bluetooth card to the handheld computer it can communicate with a GPRS phone and thereby take advantage of this technique.

6.2 Server technique

Like the client, also the server is implemented in java. This was a natural decision since it makes the communication easier, but also since java is the programming language that I have most experience from. Java is platform independent, and therefore it should not be a problem to run the server on different operative systems. However, we have only tested with Windows 2000 and Windows NT, which work fine.

All information regarding players and mysteries are stored in a database. The database used is Microsoft Access, and the communication between the server and the database is managed with SQL statements.

6.3 Communication

The client and the server communicate with each other through an http-protocol. This is a one-way protocol, meaning that only one party can initiate a communication by

sending requests to the other party who then answers them. In our prototype the client is the one that initiates a communication by sending requests to the server regarding position, information and updates. Since the server is not able to push out information to the clients by it self some functions in the prototype are limited. These limitations are discussed in the second part of section 5.7.2. The reason for using an http-protocol, even though it brings out limitations in the prototype, is that another solution would require too much time and effort from us since we are not familiar with the way of doing it. We think that this was not the most important part of our work, and in the prototype it will be enough with our solution. We therefore chose to use an http-protocol and to lay our focus on other functions instead.

6.4 System description

This section briefly describes how the system is structured. The focus will be on the server side since this was my part of the work. For more details about the client side I refer to the report written by my co-worker [20]. Figure 17 shows a diagram over the different classes used by the server, and also how they are related to each other.

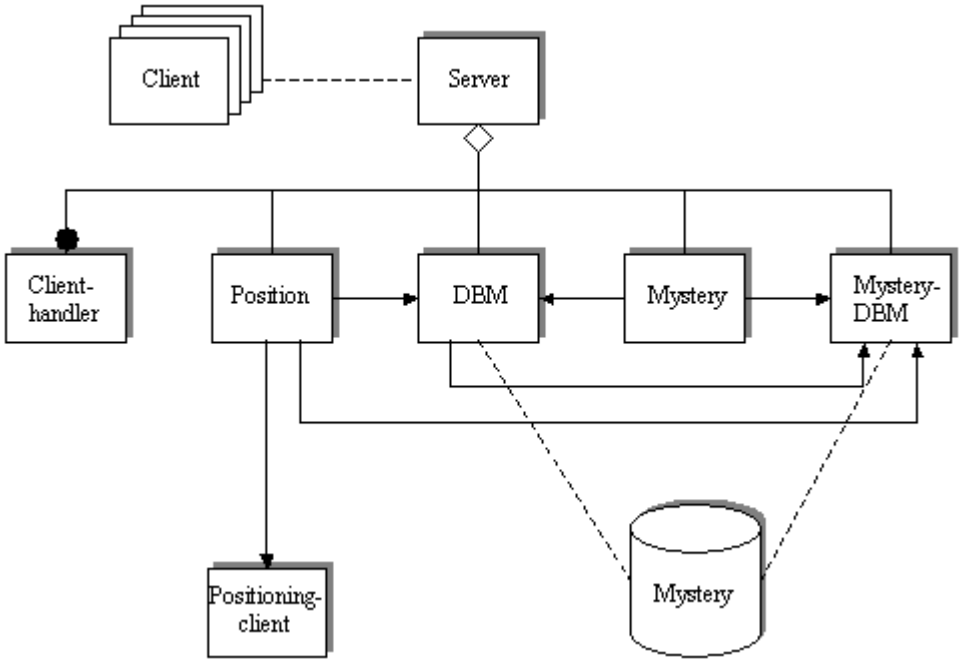

Figure 17: Diagram showing the different classes in the system.

6.4.1 The Server

As mentioned earlier, the clients communicate with a common server through an http-protocol. Before this can be done the server has to be started, and during the start up it creates a static instance of each of the objects Position, DBM, Mystery and MysteryDBM. When this is done it calls a method in the class Mystery that creates a new mystery whereupon it creates a socket and waits for the clients to connect. For every client that then connects to the game the server creates a new instance of the object Clienthandler.

6.4.2 The Clienthandler

The Clienthandler coordinates the different requests from the client by calling required methods in the position and mystery classes. Finally it returns the result to the client.

6.4.3 The Position class

The Position class handles all requests regarding the position of the player. When the player logs in for the first time a method will be called that randomly selects a start position, a specific square on the screen, for the player. There is also a method that calculates the changes of the geographical position. This method is called every minute by the client and it calculates how far and in what direction the player has moved since the last update. This distance and direction is then translated into a change of square on the screen. To update the database with this information the DBM is called.

6.4.4 The DBM (Data Base Manager)

The data base manager contains a range of different methods that are used to update the database with information about the players and their positions. For example there are methods that are called during log in to check if the username and password is correct, and also methods that update the database with both the geographical position and the current position on the screen.

6.4.5 The Mystery class

Everything that concerns the mystery is handled via the Mystery class. The method createMystery is called when the server is started and this method creates a new mystery. There are methods that randomly selects the kind of mystery and also what information that shall describe it. Also the solution to the mystery is randomly selected by a method in this class.

6.4.6 The MysteryDBM

This class has same purpose as the DBM, to update the database with new information. The difference is that the MysteryDBM handles all updates regarding the mystery. When the Mystery class has created a new mystery, the MysteryDBM will update the database with this information. It also handles the updates of the player's known information. Every time a player gets new information, this will be registered in the database.

6.4.7 The Positioningclient

The positioningclient is a separate application that is developed in Telia Research AB. This application is called from the position class in our prototype with the telephone number to be positioned, a username and a password. The positioningclient then calls the MPS that returns the positioning result. This result is actually a file containing a range of information from which the positioningclient selects what is desirable (inner

radius, outer radios and two angles). This information represents the right of the areas shown in figure 4, the banana. However, this area is hard to present in the game prototype and we therefore need to recalculate the result. The positioningclient will do this for us by, simplified explained, drawing a circle around the original area and then returning the coordinates for the centre of the circle. These are the coordinates that are used in the prototype to locate the player. Together with this result the positioningclient also returns a value representing the inaccuracy. This value can bee seen as the radius for the circle where the player is located. This value is not considered in the prototype since we only compare the coordinates for a new point with an old point to see how far the player has moved since the last update.

6.5 Database organisation

The database *Mystery* is created in Microsoft Access and it consists of six different tables. Here I give a brief description of the tables, but as in chapter 5 it must be pointed out that the figures are extracts from the prototype so the text in the figures is in Swedish. The first table, *users*, contains the registered information about the players, and also the total amount of points they have collected, see figure 18.

id	Pswd	name	sex	age	base	interest	gsm	score
arne	A	Arne	man	19	Arboga	äta pastej	0703443515	0

Figure 18: This is an extract from the table users, which contains information about the registered players.

Position, the second table, keeps track of the position, both on the screen and in reality, see figure 19.

id	code	longitude	latitude
arne	B1	1631199.5	6571461.75

Figure 19: Here the actual geographical position of the players is stored together with the code representing their current position on the screen.

There is also a table where messages are stored until the receiver has got them. This table is called *messages,* see figure 20.

id	sender	msg
arne	berit	Hej Arne! Så du spelar idag ser jag. Vad kul!

Figure 20: Here a message has been sent from Berit to Arne. When Berit retrieves this message, it will be deleted from this table.

Cluelist is a static table containing all possible categories and words that can describe a mystery and also which mystery they belong to. For example the category *spoil* can be relevant for a burglary but not for a murder, see figure 21.

category	mId	0	1	2	3	4	5	6	7
Vapen	2	kniv	pistol	rep	sten	yxa	gift	händerna	batong

Figure 21: The table cluelist contains for example the category weapon. The number in the second column, mId , indicates that the category belongs to a murder.

The fifth table, *mystery*, also has a static part with short descriptions of the different mysteries, see figure 22. When a mystery has been solved, the table will be completed with information like at what time it was solved, the correct solution to the mystery and also the id for the detective who solved it.

mId	case	reward	startTime	solution	solverId
1	Efterlysning! Lilla Anna, 6 år, försvann igår spårlöst från sitt hem. Enligt vittnen har en mystisk person setts i området dagarna innan. Lösensumma har krävts och polisen behöver nu din hjälp med att finna kidnapparen.	6			

Figure 22: This row in the table mystery describes a kidnapping. Since the last three columns are empty, nobody has solved the case yet.

Finally there is also a table named *view* that keeps track of which information that the detectives have found or not found, see figure 23.

id	fyrtiotre	tjugotvå	sextiofem	sjutton	Gren	Jönsson	Hammare	Björnligan	skägg	tjock	lång	blek
arne	fyrtiotre					Jönsson			skägg		lång	

Figure 23: Here it is shown that the player Arne has excluded the words "fyrtiotre", "Jönsson", "skägg" and "lång" from the solution. Yet he does not know anything about the other words.

7 Evaluation and discussion

As mentioned in section 5.1 there was not enough time to let users evaluate our prototype within the scope of this master's thesis. However, we have regularly tested the prototype our selves during the development and from this evaluation we have been able to draw some conclusions that will be discussed here. I will also mention some problems that arose and how we tried to solve these.

First of all we have established the fact that the size of the terminal and the screen seems to be sufficient for this kind of game. A bigger terminal would probably feel ungainly to carry around, while a smaller terminal with a smaller screen would make the interaction more complicated. Unfortunately the rest of the equipment does not give such a good impression in this case. First of all we had to connect a GSM card to the iPaq to be able to connect to the server, and with this card the terminal gets about four centimetres longer. However, this would not have been a problem if it were not for the extra mobile phone that we had to carry around too. This is because we had to use the GSM card strictly for the connection, and then a mobile phone with a different number that we were able to position.

Since GSM positioning is quite inaccurate today we had some problems with how to present movements for the players. First of all we had to combine the parameters length and time in order to get as accurate updates as possible. The results we get from the positioning client are sometimes incorrect due to errors like for example missing coverage. We therefore only pay attention to values that differs form the old position with at least 300 meters. If the difference is more than 300 meters in either direction, the playing figure will be moved one square in this direction and the new position will be stored in the database. If not, the old position will be kept in the database so that the next value can be compared to this. It does not matter how much more than 300 meters a player has moved. The playing figure can never be moved more than one square at a time, otherwise there is a big risk that the playing figure will jump over another figure instead of jumping to the same square so that they will meet. However, the limit of 300 meters is not always enough. There are places where two or more cells are overlapping, and the positioning client may then return different results depending on which base station that the player is currently communicating with. This means that even if the player is standing still, the positioning result can vary a lot. Sometimes the difference between two positioning results exceeds 300 meters when it should be zero. The playing figure will then move one square, which may seem strange. This could be avoided if the limit was set to be a value higher than 300 meters, but we decided not to do this since this would also require longer movements for the players.

In the prototype the position is updated once every minute. We have tested different intervals and we have come to the conclusion that one minute is suitable. There is no point in updating the position more often since the player must have a chance to move the required distance to be able to take advantage of the update. It is not preferable to have longer intervals either since the game will then be perceived as too slow when nothing happens for long periods of time.

The feeling we got when we tested the game was that the direction was most important the first times we played the game and also at the end of each mystery. The

first times we played the game we tried to walk in a specific direction and thereby move the playing figures to a specific point on the screen. After a while this was not so important anymore. Instead, it was more a matter of chance if we met another player while, for example, we were sitting on a train with a fixed route. It did not feel necessary to meet a specific player as long as there was someone at all that we met. However, at the end of each mystery when a player is near the solution, it can feel more important to meet a specific player in order to receive the missing information.

The relative world adds a great value to the game. We have tested to play the game while we were in different cities and it still felt like we were close to one another.

The functions that were limited due to the one-way communication are working better than expected. For example I can mention the chat function that works more like a mailbox. Since a player does not know when somebody sends a message he/she never gets the feeling of the delay even though the message shows at what time it was sent.

We have noticed that it is difficult to interact with the game while you are walking. This specially concerns the chat since the virtual keyboard is very small and requires a lot of attention while writing. It was therefore easier to stop walking when we wanted to use the chat.

The biggest problem we had when we tested the prototype was to maintain the connection with the server. The GSM net does not have 100% coverage everywhere and there may also be problems with hand-over between base stations, so if you are travelling a long distance the connection may go down a couple of times along the way. It is then necessary to open a new connection and then start the game again, which may take a couple of minutes. Unfortunately this is nothing that we can do anything about, but hopefully this will get better with GPRS since it only requires a connection while sending packets with information. If a packet does not reach the receiver due to an error in the connection the packet will be sent again.

8 Results and conclusions

The result of this master's thesis is a working prototype of the position-based game *Mystery*. There is one position-based game available today on the Swedish market, but unlike this game *Mystery* uses real time graphics. To be able to present the graphics in a good way we decided to use a handheld computer for our prototype. After a brief analysis of the terminals available on the market we decided to use the *Compaq iPaq 3630.*

In the prototype we have used GSM positioning even though the accuracy is lower than with GPS. GPS requires extra hardware and it does not work inside buildings and furthermore there are no GPS cards available on the market yet.

Because of the low accuracy in the positioning the game requires that the players move long distances. It is therefore suitable to play for example on the way to and from the school/work. It is almost necessary to go by train, bus etc in order to move the playing figure on the screen now and then. Walking makes the game very slow, and it is not recommended to play in the car unless someone else is driving. For this purpose the accuracy in the positioning is enough, but a higher accuracy would add much more value to the game. Especially if a player is standing next to another, he/she should be able to get to that square without having to take the bus. Higher accuracy would also make it easier for the players to control the playing figures. Now the players are bounded to fixed bus rides and train-journeys and they are not in a position to control these.

As mentioned before we did not have time to perform a user study of our game during the time of my master's thesis. However, my coworker Niklas will extend his work with a couple of weeks in order to accomplish a study involving some co-workers at Telia Research AB. For further information about the preparations and the result of this study I refer to Niklas' report [20].

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Appendix A: How to use the prototype

To be able to run the prototype, there are different requirements that must be fulfilled by the system. This appendix describes these requirements before going into details about how to install and to run the software.

System requirements

Since the prototype is implemented in java it is platform independent. The requirement on the server side is therefore a pc that supports java and is connected to the Internet. During the development we have used Java 2 SDK Standard Edition version 1.3.1 on the server side. This software is developed by Sun Microsystems and it can be downloaded for free from their homepage [22]. One more requirement that the prototype has on the system is that the pc must have Microsoft Access installed since the database is created with this program.

Since the handheld computers that are available on the market today does not support java it is necessary to install extra software even here. We have used JeodeRuntime that we bought from the company Insignia Solutions [23]. The client side also requires a GSM/GPRS/WLAN[2] connection to be able to connect to the game server. The prototype has only been tested on a Compaq iPaq, but there should not be a problem to use another device. However it is strongly recommended to use a device with at least 32 MB RAM and with a large, colour screen.

Installation

First of all one has to buy Jeode, the Java software mentioned above. It costs $19,99 (nov -01) and it is downloadable from Insignia's homepage. After downloading the file to the pc, unzip it and then run the file JeodeForArmPocketPC.exe while the iPaq is connected to the PC. The program will then automatically be installed on the iPaq. Next step is to install the game client on the iPaq. Download the folder named *MysteryClient* and place it in the root directory on the iPaq. The client is now ready for playing.

To be able to set up the server on a pc, it is required that the pc has a Java SDK installed. As mentioned in the section above, this can be downloaded for free from Sun Microsystems' homepage. The last step is to download the folder named *MysteryServer* to the pc.

To clear the database

Before the server can be started it is necessary to remove old information from the database. To simplify this step the folder *MysteryServer* contains a program that handles the most of this automatically. Run the program *ClearDB.java* in a dos

[2] WLAN is a Wireless Local Area Network to which a mobile user can connect to through a radio connection [24].

window (for Microsoft Windows) and the tables will be cleared. The only thing that has to be done manually is to create a new table, *view*. Open the database *dbMystery* and chose to create a table in design view. In the form that will be shown the word *id* shall be written in the first column in the first row. By clicking in the second column on the first row the word *Text* will be shown. Finally, click with the right mouse button to the left of the first column on the first row (a gray field) and chose the alterative *Primary Key*. Save the table as *view* and close the database. It is now possible to start the server and then log in to the game as one of the five predefined players.

However, it is possible to modify some of the personal information for these players if desired. By double clicking on the table *users* a view with information will be shown, see figure 18. The values in the columns *name, sex, age, base and interest* can be changed to fit the person that is going to run the prototype. However, the *id* and *pswd* must be left unchanged since these values are hardwired in the system. To be able to receive correct positioning results and thereby move the playing figure on the screen, the column *gsm* must contain a telephone number that the player has been allowed by Telia Mobile to position. Finally, the rightmost column, *score*, keeps track of the total rewards and bonuses. The values can be set to zero (0) but this is optional.

To run the prototype

First of all the server has to be started. This is done in for example a dos window with the command *java Server.* This window will work as a log for the program, and the first status that is shown is how many categories and words that the new mystery contains. Here it is important to control that the number of words is equal to 12. If not, the server has to be restarted due to an error in the database. Repeat the steps in section 6.6.3 and then try to start the server again with the command *java Server*.

When the server is running it is time to start the game. First of all a connection (GPRS/GSM) has to be opened on the handheld computer. When this is done, the file EVM4ProtoConnected.java can be started from the file explorer. A console window will be opened where the communication between the client and the server is logged. After the communication is established and information has been retrieved form the server a window will be shown where the player can log in to the game.