Spacerace – A Location Based game for mobile phones using Assisted GPS

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ABSTRACT
Mobile devices and wireless data connectivity are getting more and more common nowadays. In this networked world there are going to be dozens of new applications. Location Based Services will play a major role in this area. Especially, with the current and upcoming UMTS enabled mobile phones these applications are going to be available to a larger number of customers. The most promising approach to get accurate position data on a phone is to use GPS or the enhanced Assisted GPS which is part of the UMTS standard. We developed a mobile game especially designed to demonstrate the possibilities of an Assisted GPS empowered mobile phone.

1. INTRODUCTION
There are a great chance for location based games on mobile phones in pervasive environments. Considering the revenues generated by downloaded ring tones and logos, it is obvious that also games will have a great and rewarding future in the wireless world. In this paper we present the concepts of *Spacerace* – a mobile location based game using Assisted GPS. This game was implemented by Comneon Electronic Technology GmbH & Co. OHG[1] and the Programs *Mobile Computing*[2] and *Media Technology and Design*[3] of the Upper Austria University of Applied Sciences Hagenberg for demonstration purposes of the Assisted GPS functionality of the UMTS prototype phone Comneon used for Assisted GPS development.

[1]http://www.comneon.com/
[2]http://mc.fh-hagenberg.at/
[3]http://mtd.fh-hagenberg.at/

2. RELATED WORK
There is a wide range of GPS receivers available. The main manufacturers of conventional GPS receivers are *Garmin International Inc.* and *Magellan*. When it comes to mobility one needs to be able to connect the GPS receiver to your PocketPC for example using the Compact Flash or SDIO slot. There are a few companies distributing GPS receivers connectable via Bluetooth, which makes it possible for Bluetooth enabled mobile devices like cell phones and PocketPCs to use the GPS data.

Nisi et al. present a Narrative Location Based game in [8] called *Hopstory* using the RFID Technology to locate the player. Andreas Jakl developed Location Based Games called *The Journey* and *The Journey II* detecting the user's location through *Cell id*. The games can be found in [4] and [5] respectively. The Royal Institute of Technology in Stockholm developed a location based treasure hunt game using GPS in cooperation with *Ericsson*, see [3] for details. Benford et al. published an interesting article about uncertainty in location based games in [1].

Milgram and Kishino published their taxonomy of Mixed and Augmented Reality devices in [7]. Foxlin et al. present an approach to track the user's position inside buildings using markers in [2]. Piekarski et al. published their concept of an outdoor augmented reality version of an ego shooter called *ARQuake* in [9] and *Tinmith*, a mobile location based outdoor modelling system for augmented reality environments in [10].

3. GAME DESCRIPTION
The goal of the treasure hunt game *Spacerace* is to collect as many virtual crystals as possible in a small outdoor area. In order to collect a crystal, the Captain has to get near the virtual position of the selected crystal. He is guided by an Assisted GPS phone which shows the current distance to it. He is supported by the Navigator who has an overview of the position of the Captain and all the crystals they have to collect.

The Navigator tells the Captain which crystal to go after and where it is located by giving him directions in terms of points of the compass. The captain selects the suggested crystal number and tries to find it using the Navigator's directions and the distance displayed on the screen of the

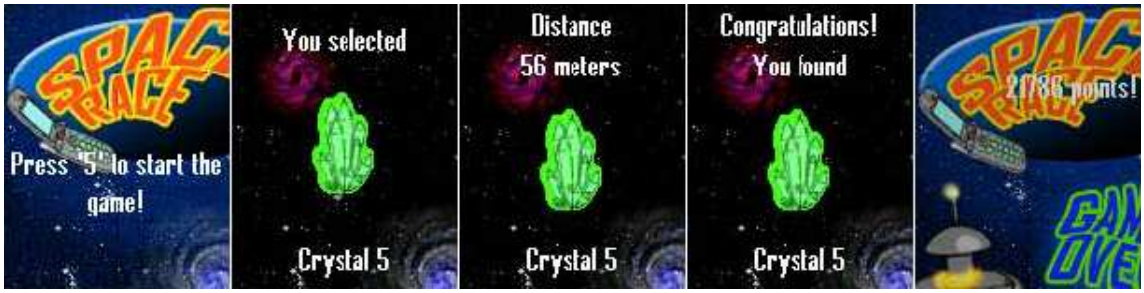

Figure 2: Screenshots of the Locator during a game in which the Captain hunts crystal number 5.

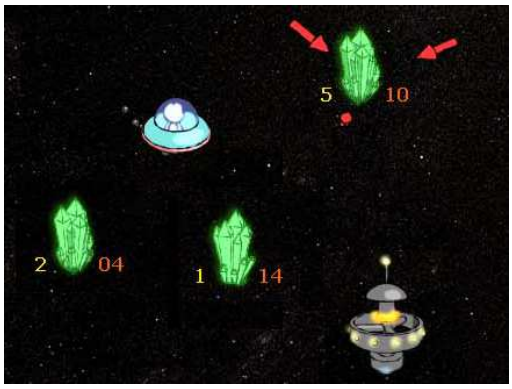

Figure 1: A part of a the NavigatorMap.

Figure 3: Our Assisted GPS prototype phone.

mobile phone. After getting close to the desired virtual destination the crystal is collected and the team scores an amount of points. Crystals have a lifetime after which they disappear. The amount scored by the team after finding a crystal is dependent on the remaining lifetime. The faster the team finds the crystal, the more points they get.

We chose to visualise the game using the space metaphor. The Captain is travelling through space in the starship. The Navigator is located in the space station guiding the Captain. The NavigatorMap showing the most important game elements is depicted in figure 1. Several screenshots of the Captain's Locator showing several game events can be viewed in figure 2.

A main game element is the verbal communication between the captain and the navigator. In the first tests it turned out that the simple idea of the navigator telling the captain to go a to certain place when the navigator does not know the real environment is quite hard but funny. For example the following dialogue could occur in the game depicted in figure 1: Navigator: "*You have to go south-west, quick!*" - Captain: "*I can't go south-west, there's a fence!*".

4. PROJECT DEVELOPMENT

The concepts of Location Based Games are far from ready for commercial use and there is not much state-of-the-art literature available yet. Therefore, we want to show how *Spacerace*, i.e. its concepts and architecture, evolved in the development process.

In an early phase of the project there was a request for *Spacerace* to be shown as a demonstrator for an Assisted GPS prototype phone, which is shown in figure 3. The first draft of the game was a single player game for a mobile phone only. Although, a game on a mobile device with a small display would not be capable of being presented to more than one person very well, let alone showing it to a large audience.

Therefore, we integrated the Map concept, which is a simple piece of software that visualises current parameters – e.g. state of the game, position of the player and the crystals. This makes it possible to play the game outdoors, where the signal strength of Assisted GPS is strong enough for regular position fixes, and at the same time show it to a large audience using the Map.

Even before the implementation we figured that an optical appealing visualisation will motivate the viewer to interact with the other player; for example to tell the player where to go. For this reason we reduced the amount of information shown on the mobile phone in order to make the captain dependent on the navigator's directions which he derives from the NavigatorMap (formerly only "Map"). For simplicity we used a regular voice call between two mobile phones for the communication of the two players.

Of course we wanted the game to be working anywhere – in other words to be pervasive. IP-based networks and its

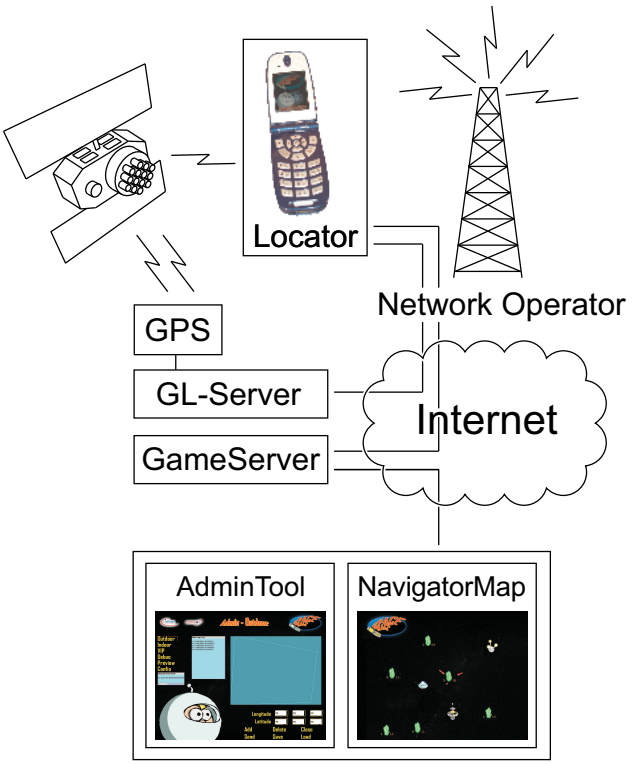

Figure 4: System architecture of *Spacerace*.

mechanisms like firewalls blocking all incoming connections forced us to use a server to be able to establish an indirect connection between the mobile and the NavigatorMap in all network environments. The Server which was solely there for network-connection reasons became a central software element carrying out most of the game logic.

Additionally, we developed a tool that can be used to configure the current maps and parameters for the game being hosted by the GameServer to be able to administrate the game setup remotely. This software tool, called AdminTool, enables the players to set up an instance of the *Spacerace* game wherever an internet connection is available.

5. SYSTEM ARCHITECTURE

In this section the system architecture of the *Spacerace* software is described that consists of multiple server-client concepts as sketched in the previous section. In terms of classification of the network components there is one server – the GameServer – and three clients: the AdminTool, the Locator and the NavigatorMap. The overview in figure 4 shows a simplified version of the sophisticated network architecture of *Spacerace*.

The AdminTool has to be used to upload maps to the server and configure the game parameters before being able to play *Spacerace*. Thereafter, the NavigatorMap and the Locator can start the game when connected to the GameServer hosting the instance of the game.

Configuration

Spacerace can be configured through the *AdminTool*. It connects itself to the GameServer in order to be enable the user to configure the game. The following list show the game parameters configurable through the AdminTool. The playfield consists of three maps, each of which is defined by polygons that consist of multiple GPS-Points.

- The *outdoor map* defines the area where crystals can appear.
- The *indoor map* defines an indoor area, e.g. buildings etc., where no crystals will be placed because of the bad quality of position fixes indoors. This area is visualised as an asteroid field on the NavigatorMap.
- The *VIP map* is a smaller version of the outdoor map. Its purpose is to restrict crystal positions to a smaller area if the VIP mode of the game is activated.
- The GPS coordinate of the space station which represents the actual position of the NavigatorMap.
- The number of crystals on the playfield that is maintained at all time during the game. If a crystal is collected or times out, it is replaced by new one instantly.
- The lifetime of a crystal in seconds after which it expires and disappears to be replaced by another one positioned randomly in the outdoor area.
- The number of asteroids to fill the indoor area. This parameter defines the density of the asteroid field.

Network Connections & Delay

The connection quality is a crucial parameter of the game. If the GPRS network is overloaded, the connection quality between the GameServer and the Locator decreases which delays the display of the position of the captains starship on the map. Therefore, the navigator's view is always a certain amount of time delayed.

The navigator has to give the captain directions. These commands have to pass across the cellular line. This means the Assisted GPS position fix and the reactions of the Navigator have to go through certain channels with the respective delay. The following list shows the delays of a whole reaction cycle which will be explained later. The computing times of the software of the Locator, the GameServer, and the NavigatorMap are not included in this list.

- GPRS/UDP connection Locator – GameServer: Sending a position fix from the Phone to the GameServer takes 500 to 2000 ms. In case of the *3GSM World Congress* in Cannes, where cellular base stations were overloaded permanently, there were several seconds delay between the Locator and the Server for example.
- TCP connection GameServer – NavigatorMap: This connection certainly depends on the type of internet connection, but the delay will range from almost 0 ms for a GameServer on the localhost to up to 500 ms in the worst case.

- NavigatorMap – Navigator Command: The Navigator's reaction delay after a position change of the starship on the NavigatorMap is strongly dependent on the player's experience with the game. It ranges from 500 ms to several seconds.
- Communication line Navigator – Captain: The delay of the voice connection which is about 200 ms for a cellular voice call.
- Navigator Command – Execution: Assuming the captain is loyal, he carries out the navigator's commands which results in a physical movement of the Assisted GPS cellular phone. From our tests we know that the delay of the captain's reaction is approximately 1 second at least.

Then the captain moves the Assisted GPS receiver situated in the phone and a new reaction cycle begins with a new position fix taking its way through the above given list. A cycle takes approximately 3 seconds at best. In suboptimal cases the reaction of the starship on the NavigatorMap to the Captain's movement takes more than 3 seconds and interacting becomes more difficult. Therefore, the interactivity and game quality is directly dependent on the connection quality and reaction time of the two players.

Assisted GPS

After a few problems in the beginning of the project the quality of the position fixes was within the expected scope of a few meters. In figure 5 a comparison between Assisted and conventional GPS position fixes is depicted. Our analysis tool shows Assisted GPS and conventional GPS position fixes recorded walking around the same block on exactly the same path. Especially, in the lower part of the figure one can observe the inaccuracy of conventional GPS particularly in proximity to high buildings. In comparison to position fixes of the utilised high quality GPS receiver, Assisted GPS was more accurate in all of our tests.

6. FUTURE WORK

For real interactive mobile location based games we need higher precision like for example Differential GPS. Nevertheless, we think that the current version is a state-of-the-art location based mobile game that shows the future directions of concepts for location based games and applications.

During the development phase in the years 2003 and 2004 the coverage of UMTS networks, and accordingly the availability of Assisted GPS, was not very widespread. In the UMTS solution the base station supplies local *Assistance Data* to the consumer phone which it needs for the Assisted GPS calculations. This data is only valid for a small area of a few kilometers and short time slices of a few hours. However, the mobile phone must be registered with the base station and can be assumed to be located within the area the *Assistance Data* is valid for.

Comneon implemented a version of Assisted GPS on prototype phones without using the Assisted GPS specification from the UMTS standard. This implicated that the *Assistance Data* could not be retrieved from the network operator,

Figure 5: Comparison of Assisted (green) and conventional GPS (red).

therefore, *Global Locate*[4] implemented a server that could provide the phone with the *Assistance Data* needed for Assisted GPS calculations. The server does not have information about the position of the client, consequently, the implementation requires the client to deliver his approximate position before the server can provide the phone with the local *Assistance Data* in order to enable the mobile phone to acquire position fixes. See figure 4 for *Global Locate's* server's place in the system.

Global Locate claims that the accuracy of their new Stingray GPS chip is 2 meters under best conditions in [6]. Despite this superior precision of Assisted over conventional GPS is not possible to detect single footsteps made by a user from the position fixes. Players of *Spacerace* often make the mistake to assume the positions of the Captain on the NavigatorMap is exact down to a few centimeters and does not have a delay. This often lead to very amusing conversations between the Captain and the Navigator, which is the most fun part of the game.

We are planning many improvements and extensions for future implementations, which are listed below:

- Real multiplayer capability with various game modes like: Cooperative, Teams or Every player by himself.
- A single player version where all information of the crystals is displayed on the screen of the mobile.
- A client implementation for mass market Assisted GPS phones using the UMTS standard.

[4]http://www.globallocate.com/

- Integrating Push-To-Talk into *Spacerace* would be necessary to play the game and communicate with the Navigator using a single mobile phone.

7. CONCLUSIONS

The game concept of *Spacerace* turned out to be working very well. After presenting it at the *3 GSM World Congress 2004* in Cannes/France and the *CTIA Wireless 2004* in Atlanta/USA the game was also used for several presentation events at Comneon and the Upper Austria University of Applied Sciences in Hagenberg.

Our Assisted GPS based mobile game *Spacerace* is an interesting starting point in our discussion of location based games. Undoubtedly, everyone who ever thought about computer games in a real world environment will be able to contribute valuable ideas and opinions. It would also be interesting for us to debate new ideas and concepts for location based mobile games.

As both of the authors have experience with Augmented Reality this would be an interesting topic to talk about. We would like to address topics like the future tracking, display and interaction technologies as well as theories about AR games and whether AR is going to be accepted by a large number of users.

8. ADDITIONAL AUTHORS

The mobile location based game *Spacerace* was developed by the authors of this paper and additional authors, we want to mention here: Florian Bacher, Andreas Jakl, Andr Lichtenecker, Wolfgang Hochleitner, Bernhard Wally (Upper Austria University of Applied Sciences Hagenberg, email: [florian.bacher | andreas.jakl | andre.lichtenecker | wolfgang.hochleitner | bernhard.wally] @fh-hagenberg.at)

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