TeamTags: Domination – An A-GPS game for mobile phones

Andreas Ritzberger
Upper Austria University of Applied Sciences
Media Technology and Design
Hauptstr. 117
A-4232 Hagenberg
andreas.ritzberger@fh-hagenberg.at

Stephan A. Drab
Upper Austria University of Applied Sciences
Hagenberg
Mobile Computing
Hauptstr. 117
A-4232 Hagenberg
stephan.drab@fh-hagenberg.ac.at

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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 *TeamTags: Domination* – 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 [7] 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 [6]. 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 [8] and *Tinmith*, a mobile location based outdoor modelling system for augmented reality environments in [9].

3. GAME DESCRIPTION
TeamTags: Domination is a location based multiplayer game for GPS enabled devices. The goal is to capture Hotspots in a real environment, similar to capture the flag parts in ego-shooters.

The most interesting fact of the game is, that it takes place in real outdoor environment. There, within a radius chosen by the players, but with no limitations to the players location, are the Hotspots which have to be conquered by the teams. A little map and some information is displayed on the mobile display for assisting the players in finding the Hotspots, as shown in figure 4.

At the beginning of the game, each team starts with the

same amount of score points. If one team owns more Hotspots than the other team, the points of the inferior team are reduced depending on the difference between the numbers of the Hotspots of each team. So, the more Hotspots a team owns in comparison to the other team, the faster it will win, and the more the other team has to increase their efforts to turn around the game.

A team has lost if its score reaches zero. Therefore, to win the game, you have to decrease your opponents score by conquering more Hotspots.

Rules

It is up to the players and the teams, how they reach a Hotspot. Whether it is by foot, by car or even by plane, if they are running jumping or crawling, it is up to them. The only rules that are necessary are, that a player has to stand near a Hotspot for 20 seconds to capture it and that he has to select that Hotspot on his display in order to capture it. Further no player can capture a Hotspot twice in a row. The last rule is that, when two teammates of different teams arrive at a Hotspot simultaneously, more players are needed to conquer the target. That means, the team that has the most players standing near to that Hotspot for 20 seconds wins.

Starting a game

Starting up a game should be quick and simple, but bearing enough information to distinguish different simultaneously running games and the players belonging to them. The procedure for starting up and joining a game is described below.

1. A player starts a new game by submitting
   - a nickname
   - the total amount of players
   - the radius to be played in
   - and finally the team he wants to join.
2. That player receives the session-id, which he passes on to the other players.
3. For joining a game, the other players just have to submit
   - their nicknames
   - the session-id they got told by the one who started the game
   - and the team they want to join.

These are several parameters to configure, but according to tests, the whole process of starting up a game with the players joining only takes a few minutes. Furthermore the concept of the session ID enables the creator of the game to choose who is allowed to join the game. Uninvited players or players that only want to observe the game instead of playing it can be left out using this concept.

4. SYSTEM ARCHITECTURE

This section gives insight on how the game system is structured to get the most benefit for the players. Due to the fact,

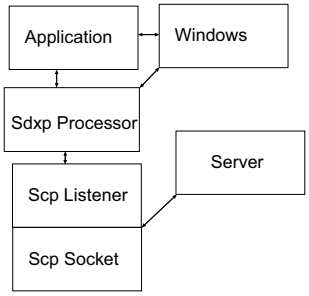

Figure 1: Architecture of *TeamTags: Domination* client implementation.

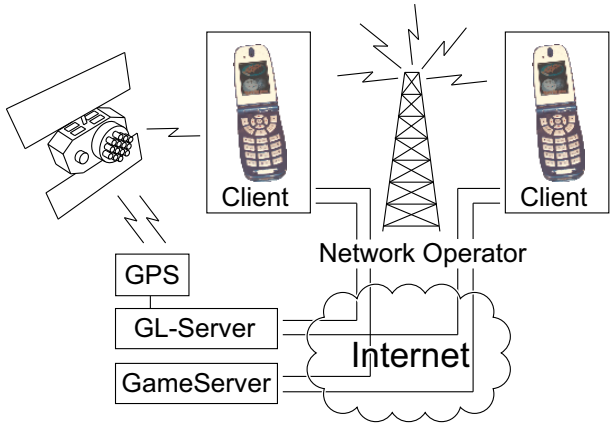

Figure 2: The system architecture of *TeamTags: Domination*.

that CPU power and memory size of mobile phones are very limited, a server was decided to be used to deliver Hotspots and do the rest of calculations necessary for the game as well. The only calculations the mobile has to conduct are scaling computations and rendering the game data, e.g. the Hotspots, and handling the network traffic. For communication with the server, the light-weight protocol *SCP* was developed using *UDP* in order to save network traffic costs. On top of *SCP* the Game Protocol called *SDXP* is running, which is designed to deliver game specific data between the server and the clients.

The mobile phone application

The game *TeamTags: Domination* was developed using the *APOXI Framework*[4]. The dependencies of the implementation specific game components are shown in figure 1. The restrictions of the *Apoxi* platform forced us to use certain patterns for implementation of the application, which is the central data structure of the game. We used the application implementation to hold the network processor *SdxpProcessor* which is responsible for the *SDXP* specific transmission of the data received and sent through SCP, that in turn uses the *Apoxi UDP* interface. Furthermore the application is responsible for executing the game logic, in other words it is designed to control the active window, for example the start window, the game screen. The windows are designed to process input from the GUI which they forward to the

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

msg_id	nr_of_ multipart_pckgs	nr_of_ curr_multipart	senderlength	sessionlength	payload

Figure 3: fig:Sdxp Package

application if a game action has been executed, for example to choose a Hotspot. The windows only have indirect contact with the *Sdxp Processor* through the application, they do not send network messages for themselves.

Protocol Implementation

The *Sdxp Processor* is responsible for sending and receiving game data and is a simple interface for the application to rely the game logic on. A socket implementing *SCP* is used as the underlying protocol. *SCP* is a *Simple Connection Protocol* that ensures arrival of the data, but is not stream based like *Tcp* and does not preserve the sequence of the sent data. *SCP* is implemented on top of the Apoxi's *Udp Socket*, therefore it incorporates all features of this protocol like preservation of data integrity through a CRC.

The *Sdxp Protocol* has been designed to send and receive data packages of various length, which ensures lower network traffic and reduces GPRS-costs. As shown in figure 3, a typical *Sdxp Package* consists of the message ID, the number of the multi-part packages, the number of the current multi-part package, a sender and a session length. Dividing the data into multi-part packages and checking their completeness was necessary to ensure even long packages reach their target. In UDP implementations the maximum number of bytes of a package that is not broken up into several packages is guaranteed to be at least 8Kbyte. Therefore the implementation avoids a UDP based dividing of packages larger than 8Kbyte by using the multi-part concept.

The server

The Hotspots are the key element. At the beginning of the game the server chooses suitable Hotspots from its Database that are within the radius given by the initiator of the game instance. On initializing and starting the game the server distributes information on the chosen Hotspots to all registered players, e.g. the position and a description containing a picture.

To minimize CPU usage of the game client in order it is able to run on a mobile phones the server is designed to execute both, the game logic and calculations. When the server receives a new GPS positions of a player it has to run several checks, for example if the player is within the capture radius of a Hotspot. If this is the case for over 20 seconds the server acknowledges the capture of the Hotspot to all players in the game. It would have been possible to implement a timer on the mobile that carries out the task of acknowledging the server of a captured Hotspot after 20 seconds. Although, to prevent cheating and remain consistent the server decides who owns the Hotspots. Therefore it is the server's task to keep track of the player position for 20 seconds.

The server also checks, if there are two rivaling players trying to conquer the same Hotspot. It also takes care in order a player cannot choose Hotspot that are already pursued by a teammate.

Figure 4: The play screen.

Developing Process

The system architecture of the game in terms of network components is depicted in figure 2. As it can be observed there are two servers: The GameServer is responsible for the game logic and the GPS Server provides Assistance Data to the mobile phone which is required for Assisted GPS receiver to work properly.

In the beginning of the project it was clear that all the Hotspots are displayed on the display of the mobile phone as shown in figure 4. As observable in this screenshot the position of the player is situated relatively to the Hotspots. The player does have information of his position but not about the environment like the terrain, highways and buildings for example. Therefore it takes some time to get used to the environment.

Because of the fact that it is not possible to get Assisted GPS position fixes within the width of footsteps the playing area has to be quite large (about 500 meters minimum in radius) in order to be able to play the game smoothly. Thus the player needs information about the Hotspot's name and a picture showing it. This assures, that players without experience of the game and the environment can be as successful as veterans of *TeamTags: Domination*.

In the design phase the game concept could not be tested. Therefore we investigated the following issues:

- How can the Hotspots can be captured and how that will work with more players. Soon it was obvious, that Hotspots can be captured when the player's position is within a certain distance of the Hotspot. In order to keep the game dynamic, but still retain the tension before capturing we chose the delay to be 20 seconds.
- The dynamics of the game was the key for bringing up another rule. One player cannot conquer a Hotspot twice in a row. When a player has captured a target, he has to go after an other Hotspot. That results in keeping the players move.
- Another concern we had was to keep the motivation to capture a Hotspot high at all times in the game. Therefore the winning event and the scores were designed similar to the concept in the game mode *Domination* in *Unreal Tournament* or *Battlefield 1942*.
- After having dealt with the basic questions, it was time

for working out how the tension could be increased and motivation-killers could be avoided. To increase the tension, the case was brought up that two players from rivaling teams want to conquer the same Hotspot at the same time. By giving the target to the team that has more teammates standing near the Hotspot, the tension in the final minutes of the game can be significantly increased, because taking that target could probably decide about win or lose. During the game, that case can enable the teams to work out special tactics, whether they try to conquer the targets by outnumbering the others, or if they split up to try their luck in conquering the Hotspots with a single person.

- Not to raise the tension but to prevent demotivation it was ensured that not all the members of a team try to conquer the same Hotspot. So each player is requested to select a certain Hotspot on the display in order to conquer it. When a Hotspot is chosen that is already selected by another teammate already, a warning is displayed. That decision was made, because the game could be quite exhausting and people quickly would lose interest when they are constantly running to Hotspots that are already about to be captured by teammates.

Assisted GPS

Our first tests concerning the precision of the Assisted GPS position fixes indicated the quality of the position fixes to be within the expected scope. 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 test cases.

During the development phase in the years 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 A-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, therefore *Global Locate*[5] implemented a server that could provide the phone with the Assistance Data needed for A-GPS calculations. The server does not know the position of the client, consequently the implementation required the client to deliver his approximate position before the server can provide the phone with the local Assistance Data in order it can get position fixes. See figure 2 for the Global Locate server's place in the system.

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

Figure 5: Comparison of Assisted and conventional GPS.

5. DEVELOPER'S GOALS

Out goal was to implement a multiplayer game utilizing modern technology, that does not restrict the player to stay indoors. Because of the higher precision and quantity of position fixes the game works better outdoors. Of course, using notebooks for computer games does not restrict anyone to stay indoors, but we needed something different. The device the game runs on should not do most of the gaming while the users are condemned to just press some buttons. The game should assist the player in gaming and break with the stereotype that computer games have nothing in common with sports or outdoor activities. So the primary goal was to develop a game, that takes place outdoors, that motivates the participants to do at least a little bit of physical activity. It should be able to be played in teams, and above all that is a lot of fun.

Having all these goals in mind, the requirements for the device that was going to be used for the game were defined. It had to be as light and small as possible and there was no need for high performance CPU or graphics processors, because the game play was our priority, not the game itself. The conclusion of our goals was very simple: The goal was to implement an easy to understand multiplayer game full of tension, competition and emotion for mobile phones.

6. CONCLUSIONS

We developed a stunning real-life location based multiplayer action game for mobile devices that is easy to understand and fun to play. Nonetheless following adjustments will have to be made in order the game is ready for the market:

- If there are not any Hotspots stored at the server for

a certain playfield, random points have to be created. The main problem with that lies in the fact, that random generated Hotspots could be situated on the freeway or right in the middle of a lakes for example. Besides the dangers that might come along with that, it just does not make any fun running to capture a Hotspot to find your self in front of a lake.

- A client implementation for mass market phones in order everyone can play the game.
- If the game should be played in smaller areas than a circle with the radius of about 500 meters a GPS receiver has to be used that provides more precise position fixes.
- Integrating Push-To-Talk into *TeamTags: Domination* would be necessary in order the player does not have to carry two phones while playing.

The game concept of our A-GPS based mobile game *TeamTags: Domination* turned out to be working very well. It could be 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 about 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 will be accepted by a large number of users. In general, we believe that the workshop at the Pervasive 2005 offers great possibilities to talk about mobile games and every participant will possibly gain new ideas and new views on certain issues.

7. ADDITIONAL AUTHORS

Gerald Binder (Comneon, email: gerald.binder@comneon.com), Christoph Pacher, Nicolas Pühringer, Frank Thomas (Upper Austria University of Applied Sciences, email: [christoph.pacher | nicolas.puehringer | frank.thomas]@fh-hagenberg.at)

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