Pushing location based games further How to gain end user suitability

Stephan A. Drab
Upper Austria University of Applied Sciences Hagenberg, Mobile Computing
Softwarepark 11, A-4232 Hagenberg
stephan.drab@fh-hagenberg.ac.at

Christoph Grün
Vienna University of Technology, Insitute of Software Technology and Interactive Systems
Favoritenstr. 9-11/188, A-1040 Wien
christoph.gruen@ec.tuwien.ac.at

Jens Kroesche
Upper Austria University of Applied Sciences Hagenberg, Mobile Computing
Softwarepark 11, A-4232 Hagenberg
jens.kroesche@fh-hagenberg.ac.at

Andreas Jakl
Upper Austria University of Applied Sciences Hagenberg, Mobile Computing
Softwarepark 11, A-4232 Hagenberg
andreas.jakl@fh-hagenberg.ac.at

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ABSTRACT
In recent years, mobile gaming has been believed to be the next hype after the great success of the short messaging service in Europe. Especially location based games (LBGs) were said to be the next breakthrough for mobile gaming, as those games exploit the location of the players during the game flow. Although those kinds of mobile games are able to offer a new and exciting experience, not many LBGs have yet entered the market. According to this fact, the authors believe that revenues created from this type of mobile applications only make up a minor part of the whole mobile games market, which is assumed to hit 7 billion € [42] or 10 billion USD [22] in 2009. The reason for the small market share of LBGs is that several additional aspects that have to be considered, adding to the large amount of restrictions already present for conventional mobile games. This makes it even more challenging to successfully market LBGs.

Conventional mobile games suffer from diverse constraints that cushion their success, comprising high device fragmentation, compatibility issues, difficulties of targeted advertising as well as distribution over the network operators' portals and channels. LBGs have the additional requirements for location-sensing or other context-acquisition technology. This might either be provided as a feature by the mobile device itself and/or by the infrastructure, which has to be set up and operated by a service provider. The end user, on the other hand, is often required to use special hardware in order to play those kinds of games, e. g. GPS-equipped mobile phones. Since wireless handsets, which are equipped in this manner, currently are not even close to be widespread, their impact on the entertainment business is negligible compared to the conventional mobile game market. As a result, LBGs have yet failed to reach the expectations of market analysts generating high revenues. Recent research in this area has been mainly focused on the development of prototypes.

We think that location based gaming can go much further than its current state. This paper addresses the need for identifying the challenges in the development of LBGs and presents concepts that can run on ordinary mobile phones. In particular, the paper sheds light on location based gaming concepts that are based on different positioning technologies: a) approaches that make use of existing location sensing technology such as Cell ID; b) self-reported positioning; c) proximity sensing, e. g. measuring the distance between two gamers over Bluetooth.

In light of these points, this paper therefore seeks to: a) Identify positioning technologies. b) Evaluate LBGs including our approaches *SpaceRace* and *The Journey* with respect to the previously identified positioning technologies. c) Highlight those interesting features and design elements that have to be taken into account when designing LBGs for the mass market.

Summarized, the goal of the paper is to determine the best practice of how to utilize location context on mobile phones targeted for the mass market. LBGs do indeed have a very high potential, but this has not yet been either fully realized or utilized by today's game creators. By lowering the technical-, design- and social barriers for playing LBGs using the identified design elements, they have the potential to be more successful in the future.

1. INTRODUCTION

According to a study by Nielsen Entertainment [34], the top two situations where people in Germany play mobile games are while travelling / commuting (85%) or while waiting (54%). These two possibilities are generally most relevant for LBGs, while the other situations (at home: 41%, at work: 22%, other: 10%) are less likely outdoors – one of the main requirements of current LBGs.

Many of the currently available LBGs are using multiplayer functionality in some way. According to the same study [34], 45% play multiplayer games at least once a month on a worldwide average. As discussed in section 5 and 6, this can however be also one of the major factors limiting the social acceptance of LBGs.

Based on these statistics, one could be inclined to believe that LBGs are very popular. Unfortunately, this does not seem to be the case, as these games have clearly not reached their full potential yet. Most current surveys do not even include LBGs (e. g. [17, 34]). This is not surprising, given the current market situation of LBGs as described later on.

1.1 Availability

Handango[1] is one of the world's largest mobile game distribution sites featuring over 75.000 mobile applications. It allows developers to add their own games for free. Well-known distribution sites like this significantly decrease the hurdles to make LBGs available to the public. In contrast, it is often difficult for an independent developer to get into game distribution channels maintained by operators – as we experienced when releasing our game *The Journey* [21]. Therefore, it is likely that LBGs are first available on "open" sites such as *Handango*, before they are listed on operator channels, which are usually tailored to games appealing to the mass market.

This leads to the question: How many LBGs are publically available through public channels? In an experiment, we searched for several terms on *Handango*, which should be included in names, descriptions or keywords of LBGs. These were: *location*, *GPS* or *multiplayer*. The disappointing search results at the time of writing revealed that in the several hundred hits returned in total for all categories for these keywords and on all platforms, the only LBG that was found was our game, *The Journey*.

1.2 Universities

As companies have to stay profitable, development of an LBG would be more risky than conventional mobile games and more and more difficult due to the additional factors that have to be considered (see section 5). On the other hand, it is a very interesting topic, seen from a research perspective. Looking at the currently available LBGs (see section 3), most games have been developed at universities or research facilities.

Taking a more general approach, many topics like the direct manipulation of graphic objects, the mouse, windows or text editing have first been researched at universities. Years later, they were picked up by commercial companies to be prepared for the mass market [33]. Other examples are the first game on a computer-like device called *Tennis for two*, which was developed 1958 by William Higinbotham or the first ever computer game called *SpaceWar!*, which was developed by the Massachusetts Institute of Technology [18] in 1962.

The same might be true for LBGs, which can currently be considered to be still in the research phase.

1.3 Social Acceptance

After giving a short overview of currently available LBGs and technologies in the following sections, the main part of this paper is related to the social acceptance and end user fitness of LBGs. What has to be done so that these games can reach the public in a bigger scale through the commercial mass market? How do they have to differentiate to the currently available research prototypes? Which infrastructure has to be in place and do consumers really get the chance to play LBGs?

2. POSITIONING TECHNOLOGIES

As stated above one of the main issues in LBGs is the knowledge about the position of the player resp. the players. There are many different ways to determine these positions and these techniques are commonly divided into five categories (cp. [28]): proximity sensing, lateration, angulation, fingerprint and inertial navigation. In addition to these five we add the technique of manual interaction.

2.1 Proximity Sensing

One of the easiest to use methods is proximity sensing. Here, the main approach – to derive a position fix – is to evaluate if a signal is available or not. As shown in Figure 1 the extracted position itself is matched with the position of the signal emitter in the centre of the "cell" shaped transmission area. Different known technologies can be and are used to implement this strategy.

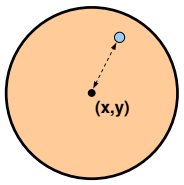

Figure 1: The principle of proximity sensing

Even though it is not known to most of its "users", RFID is one of the most commonly used methods today to derive the user's position. That is, whenever one opens a door by a smart card or uses some other kind of RFID equipped tag, the position of the user is known, i. e. he or she is standing right in front of the reader. This is based on the technical restrictions of the commonly used passiv variant of the RFID technology, which operating distance lies within a small centimetre radius. Nevertheless, this small operating distance has one big benefit, the position of the user is know quite accurate, which is not the case for many more positioning technologies in general.

[1] www.handango.com

With other technologies like WLAN or Bluetooth the precision or RFID can not be matched this exactly. But there is a huge advantage when using WLAN or Bluetooth, the user doesn't have to virtually touch the reader with a tag to get localised by a system. This is due to the much greater operation radius (from a few metres to about 100 metres depending on the environment) of WLAN or Bluetooth. For a gamer this means more freedom of movement but for the system the gaining fuzziness of the position information has to be incorporated.

One other – even more imprecise – technology wich can be used for proximity based localisation in games is GSM, which has one big advantage, i. e. it is available nearly all over the country, hence it could be used for games nearly everywhere. Nevertheless, there are some disadvantages, for instance, based on the different cell sizes ranging from a few hundred metres to a few kilometres in urban and rural areas, the imprecision of GSM can be quite high and varying. Another disadvantage is, that the operators do not wish to share the idea to use the GSM network to enable gaming with independent game developers, which results in much greater efforts for the game developers. Nevertheless, there are examples (see section 3) where games effectively used the Cell ID/proximity based GSM localisation mechanism.

2.2 Angulation

In angulation – commonly known as triangulation – one takes into account the direction a signal is coming from. If the sender isn't moving and two different directions (taken from a well known and fixed position) are known, the position of the sender can be derived as shown in Figure 2.

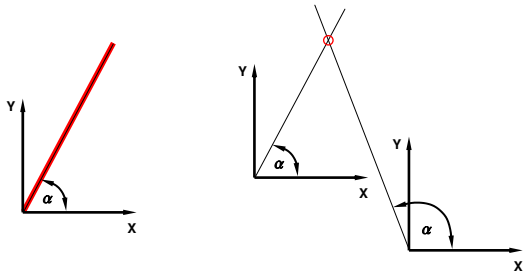

Figure 2: The principle of angulation

Even though triangulation is a well known technique it is not used in many games due to the nature and technical restrictions of the position acquisition. One of the biggest disadvantages is: to obtain the direction, signal antenna arrays are required, which are complex and cost intense. Even so, some positioning systems like the UbiSense system use angulation (in combination with other mechanisms) to obtain a very precise position information about the user in a regional area.

2.3 Lateration

The most frequently used approach to calculate a users position is by "lateration". Here, one takes into account the distance between a transmitter and a receiver based on the signal propagation delay. If one receiver utilises – using circular or hyperbolic approaches – different distances to multiple transmitters (as shown in Figure 3) its position can be calculated.

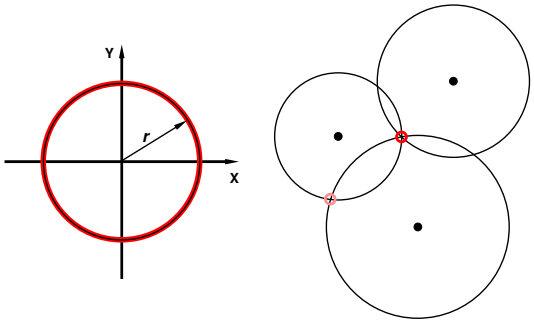

Figure 3: The principle of circular lateration

One of the most commonly known technology using the circular lateration approach, due on its usage in car navigation systems, is the American Global Positioning System (GPS). Here, the position of the receiver is determined based on the propagation delay of the signals transmitted by the GPS satellites. Based on the propagation delay the distance between sender and receiver can be calculated. The calculated distances to every satellite define different circular spheres around the satellites (see figure 3) which intersect in one point (when receiving and taking into account at least four satellites), namely the position of the receiver. Even though this system is used world wide and in diverse scenarios, it has some severe disadvantages for mobile games. Particularly in city centres and for pedestrians the precision of GPS deteriorates enormously. For one thing this is due to the high shadowing and the multipath scattering effect, for another thing algorithms which can be used in car navigation systems can not be applied in pedestrian scenarios. Due to the fact that pedestrians can walk freely in city centres and are not bound to the streets, more complex mechanisms must be found to cope with the diverse problems [31]. Another problem using GPS in mobile games is the lack of appropriate hardware. Even if its numbers are rising, only a few mobile phones incorporate GPS today and only a few gamers are willing to invest in additional hardware like Bluetooth enabled GPS mice. Nevertheless more and more operators and manufacturers offer GPS equipped phones and developments like GPS/SIM card hybrids are delivering additional impulses.

In addition to GPS other technologies use lateration too. For instance Ultra Wide Band (UWB) systems use lateration in combination with angulation to enable very precise indoor positioning. In theory lateration can also be used with Wireless LAN (WLAN) or Bluetooth, but diverse projects have shown, that due to the signal characteristics the lateration approach isn't showing promising results for these technologies. Another technology using lateration – in most cases not circular but hyperbolic lateration – is GSM/UMTS.

2.4 Fingerprint

The main idea of the fingerprint approach is to use the negative side effect of the multipath scattering effect and utilize it as a key feature. Interestingly enough, the multipath signature in most places is quite unique for most of the time.

If one knows (calculated or gathered) the multipath characteristics of the area in which the positioning should be conducted, this information could later be used to compare a fresh (newly recorded) signal characteristic – namely the fingerprint – of the mobile with the recorded/calculated ones to derive the user's current position. For instance, when using WLAN a fingerprint consists out of the received signal strength of different receivable WLAN access points which are visible to the user. One popular system which uses this approach is the Ekahau system. Other technologies which could be used the same manner are Bluetooth, ZigBee, GSM etc. The biggest problems of the fingerprinting technology in context of LBGs is the collection of the fingerprints itself, to compare the newly recorded data with. A lot of effort would have to be made in order to allow a good availability, which makes it relatively unattractive as positioning technology for LBGs.

2.5 Inertial Navigation

One of the oldest known localisation techniques is inertial navigation. Starting from a known position, taking into account time, velocity and direction one can determine his/her current position quite easily. This approach has long been used for navigation purposes and works quite well if all four factors are known very precise and the calibration intervals are short. Today inertial navigation plays an important role in e. g. car navigation systems to compensate errors resulting of the mentioned multipath effect in urban environments or the loss of satellite signals in tunnels. To gain the knowledge about all the needed factors additional hardware is needed, due to this fact inertial navigation is not playing a very important role in mobile gaming today.

2.6 Manual Interaction

An approach which can be used with a minimum of hardware recourses is the manual interaction (also known as self-reported positioning) approach. Here, the player is used to derive his or her actual position. Different forms have been tested in diverse research prototypes. The easiest way is the use of street intersections which can be looked up in an appropriate database to derive the users position. Another version is the indication of landmarks nearby questioned by the system or integrated (e. g. by photograph) by the user. Or the user is questioned to mark his or her actual position on a map, so the system can use this information to derive the players position. Some of the biggest problems is the very imprecise position information (which is the same for most of the positioning techniques used today) and the active interference of the user with one main function of a mobile game.

2.7 Summary

As shown above, there are many ways to determine the position in mobile games, all of them suffer from diverse problems like imprecise positioning, partially poor availability, additional hardware in the environment, additional hardware on the gamer's device, interaction of the user or high calculation costs. Nevertheless if these known problems are taken into account in mobile game development or even incorporated into the storyline mobile LBGs can become a success, even if simple approaches like proximity sensing or manual interaction is used.

3. OVERVIEW OF LBGS

Many LBGs have been recently developed. Since there is no best practice guideline on how to design a LBG, most of them are prototypes trying to address problems concerning the positioning technology or the game strategy, for example. In this section, mobile LBGs are listed with respect to the positioning technologies described before.

Can You See Me Now [7] is a catching game created by the artist group *Blast Theory*. Online players can move their avatars through a virtual counterpart of the playground, which matches a certain area of a city. Their goal is not to be caught by mobile players, called runners, who move physically through the city streets and can see the positions of the online players on a mobile device. If a mobile player approaches an online player and their distance is less than 5 meters, the online player is declared to be caught. The mobile player takes a picture of the real situation with a digital camera to let the online player see how the location, where he/she is caught, looks like in reality.

Uncle Roy All Around You [8, 9] is a successor of the game Can You See Me Now. Again, it is a mixture of both online and mobile players. In this game, mobile players have to find the office of a mysterious person, called Uncle Roy, within 60 minutes. They are equipped with a mobile device that shows a map of their surroundings and that enables them to communicate with online players who guide them through the city streets. In this game, the players explicitly declare their position by clicking on a point of the map rather than having it obtained by the system automatically through GPS. In return to declaring their position to the system, the mobile players get clues from the stranger Uncle Roy concerning the location of his office and where to go next.

Feeding Yoshi [4], a collaborative project of universities in UK, is a mobile multiplayer game that makes use of private and public wireless hotspots scattered within a city. For playing the game, a GPS and WLAN-equipped mobile device is needed. The PDA's WiFi controller is constantly scanning the area in order to find an available access point. The secured wireless hotspots are becoming the Yoshis whereas the open ones act as plantations. The mobile players earn points by feeding Yoshis with fruits they collect from the plantations. Opposite to other games that try to hide uncertainty regarding location and network connectivity, this game explicitly exploits the gaps in the network connectivity. In this way, this game approach follows the concept of "seamful design" which is discussed by Weiser [47].

GeoTicTacToe [24], developed by the University of Bamberg in Germany, is a multiplayer game that follows the concept of a geogame. A geogame is a special class of LBGs which are created based on the metaphor of mapping classic board games to the real world. Opposed to the classic version Tic Tac Toe, the game board is mapped to a city area. Teams of players have to move to certain locations within the game area. The team with the highest amount of visited locations wins. In order to balance the game between a chase and a strategy game a synchronization time interval is included that forces mobile players to wait a certain time interval at

the specific locations. This waiting time is used to present cultural heritage information to the users before they move on.

PAC-LAN [37], developed by the University of Lancaster in Great Britain, is a location-based version of the video game Pacman. The player who acts as the PAC-LAN can collect game pills - yellow plastic discs which are placed in the game area and equipped with RFID tags. Four other players take the role of the ghosts who have the goal to chase the PAC-LAN player. By tagging the game pills, the PAC-LAN player gets to know the positions of the ghosts. They also have to tag the game pills in order to obtain the position of the PAC-LAN player and to reset a kill timer that prevents them from killing the PAC-LAN player as soon as it expires.

Mobslinger [11] is a multiplayer game developed by the University of Lancaster in Great Britain. It uses Bluetooth for proximity detection. It is run as background application on a mobile phone, which periodically scans for other mobile users in the surroundings that are running Mobslinger, too. As soon as this happens, a countdown timer is initiated and the two players have to grab their mobile phone and enter a randomly generated number that appears on the screen. The person who succeeds in entering this number faster is the winner.

The Journey II [21] is a LBG where the mobile user takes the role of a detective who has to find a mysterious person. Along this storyline the user has to move to certain locations in order to get some clues that help to solve the mystery. As the user starts the game, the real location becomes the office and as soon as the game detects a change in the location based on Cell IDs, the story unfolds and integrates the new locations into the game story by mapping them to virtual places (e. g. the bar, the park) which stay there through the whole game.

Spacerace [15] is a location-based hunting game that uses Assisted GPS to provide location information. The goal of the game is to collect virtual crystals that are placed in a small real-world area. Two kind of users exist, namely the captain and the navigator. The captain has the ability to collect crystals whereas the navigator can support him by giving him directions in terms of points of the compass. The navigator's application delivers a complete map of all the positions of the crystals and the navigator, whereas the captain's mobile device is only capable of showing the distance between him and the crystal which is selected to be collected. Being close to the position of the virtual crystal it is collected and the team scores points. The team with the highest amount of points in the end wins.

4. MARKET SITUATION

According to *IGN Entertainment*, there are 2 billion mobile phone users world wide. Forrester Research concludes that in Europe and Northern America nearly 90% of all teenagers own at least one mobile phone. According to Fritsch et al. [16], the overall mobile games revenues in Europe alone literally jumped from 0.3 billion USD in 2000 to 6.17 billion USD in 2006. At least 80% of all mobile gamers play once a week and 35% once a day [34]. All these statements indicate a very successful mobile market. However, we think that the overall potential of the market is not fully developed yet, since there are several factors that hinder a more developed growth of the mobile games market. LBGs – being a subgroup of mobile games – by default have to deal with the same problems, but are especially sensitive to some of them:

4.1 Billing Models

Koivisto states in [26] that the currently widely used billing models with a single price for mobile games are relatively unflexible and therefore form a possible barrier for the end user to acquire a game. Operators will most likely provide more flexible billing models for mobile games in the near future. Possible options, including both promising billing as well as revenue models, could be: group billing models, games subscriptions, promotional games, game renting, paying for content and gifting. A study [34] revealed, that 43% would like to try a trial of a game before buying it, which could also be an interesting model to convince mobile players to buy the game. But since the mentioned alternative billing models models are only partly implemented, no broad experience has been made in this field yet. For LBGs these models apply directly, but the pricing will likely be higher due to the higher implementation costs.

4.2 Distribution Models

There are various distribution methods for mobile games, each of them providing mobile games with different benefits for the user and the distributor. The end user is able to download mobile games over the providers network, *OTA* (over the air). In the desktop computer domain, the main distribution channels are shifted towards *OTI* (over the internet) distribution [20]. For mobile games, OTA distrubution is the most common (45%), with OTI distribution following close behind (34%) [34]. Other distribution channels practically do not exist in the world of mobile gaming.

OTA using the operators network channels by default can generate download costs, which some users may want to prevent. Even though there are some billing and distribution models not charging the user with extra costs, they are not very common up to now. OTI distribution is a way to avoid the mentioned extra costs, and is relatively popular in countries with high data traffic costs. But the end user still has to transfer the application from the desktop computer to the wireless handset, which may be a technical or motivational barrier for some users. For LBGs, the same restrictions apply as for conventional mobile games, thus there is no preferred distribution model to utilize for LBGs.

4.3 Advertising Channels

The mobile games market is a business trying to sell micro products. An interesting factor in this context is the usage of advertising channels, since not every single micro product, namely a mobile game, can be promoted individually. This led distributors to create platforms, where the big masses of mobile games are distributed. These are provided either by network operators (mostly on their own network portal site), or by independent distributors, like Handango. Naturally, there are some exceptions to this, but the vast majority of mobile games is in fact distributed over these

platforms. Advertising for more than a handful individual products on either of these platforms is simply not possible. Therefore, mainstream advertisement is taken a level higher, from individual products to the platform-level. There, only the platform itself is advertised, maybe using a few mobile games titles to attract new customers.

Aside from conventional mobile advertising methods done by the network operator, others like print and television are becoming more common in the mobile games business [26] – but John Sacks, former president of AOL Interactive Services states in a *Business Week* article by Kris Graft that *no one really understands how you advertise to people on their cell phones* [19]. This means that producers and distributors don't have any fully functional and working method to push individual mobile games to the end users. For LBGs, being a minority within mobile games, the exact same situation applies.

4.4 Distribution Channels

The distribution channels of mobile games state another problem. As already mentioned, mobile games are micro products. To generate valueable revenues and stay profitable as a company, a big quantity of products has to be sold. This leads to a very short turn-around time of mobile games. The very small half-life period of mobile games being on top of the portals (mostly working similar to a FIFO-queue) leaves very short time for the content being in the user's field of perception. The more frequently games are pushed into this queue, the faster others vanish into the depths of the platform archives. There, they are only available through a search function that has to be used explicitly. Similar as stated in the advertisement section above, the distribution of single individual mobile games is practically not significant for the companies using the platform as distribution channel. More important is the frequency of mobile games produced and the number of them pushed into the market on the whole to stay on top of other competitors.

But what does this mean for LBGs? Compared to the currently available mini mobile games, more resources have to be spent on the implementation of LBGs. This makes it simply impossible for organisations that have to stay profitable, to push a large number of LBGs with a high frequency into the market, even for a short period of time. Therefore, profit oriented distribution of games with high implementation costs like LBGs is not possible with current distribution models. [23] The authors of this paper identify this as the major reason why LBGs do not make it to the mass market or the end user respectively.

5. EVALUATION CRITERIA

This section gives an overview of the evaluation criteria we have developed for our analysis of LBGs. These will be used as a basis for the successive main parts in section 6. Subsequently, we will analyse the state of the art of LBGs. Unlike classification in other literature, our evaluation criteria are specifically focussed on the end users. The following categories have been picked to fit this context:

5.1 Destination Platform

The destination platform has to be considered very carefully, in order to reach the end user on the mass market. In fact, the mobile games segment, especially when talking about LBGs, is very sensitive to the platform question. This results from the inhomogeneous device platform environments, i. e. the operating system, the runtime environment of the devices or the hardware device fragmentation respectively. For the operating system alone there is a very strong fragmentation.

The only option to gain mass market suitability for a mobile game is to use Java ME, since *ABI findings* [1] points out that open platforms like Java will be deployed in 85% of all handsets shipped by 2008. Unlike for desktop PCs, where many strong conventions apply, on the Java ME platform the hardware components of mobile devices as well as runtime implementations of the virtual machines often vary from device to device. Therefore, even though originally being the fundamental idea of the Java family, there is no real device independence on Java ME. *ABI research* also denotes that Java ME remains too fragmented to be mass deployed as a standard middleware among all devices.

However, Java ME is the only option to maximize the number of wireless handsets to support, as Symbian OS and Windows Mobile are currently no real alternative in terms of reaching the mass market [1]. According to studies of Gartner and Canalys (as published by Symbian) 528,3 million phones were sold worldwide in the first half of 2007. 47,9 million smartphones sold in this period result in a smartphone market share of about 9%. Symbian OS-based phones have the biggest smartphone market share, in Q2 2007: $72,4\%$ (34,6 million Symbian OS smartphones were shipped in the first half of 2007). While this makes Symbian OS the second-most attractive platform for deploying mobile games, it still means that it only allows reaching up to $6,5\%$ of the total market [43].

5.2 Game Related Costs

Another aspect of mobile games are the game related costs that accumulate when playing the game. We identified several different types of costs, each being a possible obstacle for the end user to play the game:

- On Handango the price of a standard mobile game application ranges between €5 and €15. Looking at the current audience, most mobile games customers are casual players [34], which cannot be expected to pay an even higher price for a LBG, which covers the increased implementation costs[2].
- The aquisition cost of possibly necessary (additional) hardware is another barrier for the user. Michael Zhang working at SiRF technologies states in [30] that he believes by 2010 about 40% of all sold handsets will have a GPS receiver integrated. This means that the current spread of GPS enabled handsets is a minority. Therefore, to be able to play a LBG, an external GPS receiver has to be acquired. Currently, prices are falling – however, cheap receivers are still at around

[2]We assume higher implementation costs for LBGs over conventional mobile games from our experience as developers of some conventional mobile games and our LBGs *Spacerace* and *The Journey I* and *II*.

€70. The same situation applies for any location sensing technology requiring additional hardware.

- Some location sensing technologies are not free to use. Assisted GPS implementations for example, need to transfer assistance data to the user's handset or let the network operator do the location fix calculations respectively. The data transfer is done over the air through the operators network in both cases, possibly inducing data taffic costs for the user, depending on the user's data traffic billing model.
- Mobile games may create costs of operation when using other resources during the game. If a LBG needs to transfer game data to propagate player positions in multiplayer games for example, the application generates data traffic over mobile networks. Some games use SMS, MMS or telephony for communication between players. Again, depending on the billing model, this usually generates costs for the end user.

5.3 Positioning Technology

Choosing a specific positioning technology for the LBG is a crucial task. Several considerations have to be made, such as the costs implied using it, the uncertainty [6] and availability of the utilized location sensing technology, as described in section 2. We assume that most users do not know the limitations of a positioning technology, therefore they will not relate any accuracy and availibility problems to the technology itself – instead, it will inflict on the user's perception of the robustness and operational reliability of the game. Therefore, the system must be designed to be somewhat fault tolerating towards the location sensing. Benford et al. have written an article describing their experiences with uncertainty in their game *Can You See Me Now?* [6], which states interesting facts in this context. Optimally the game concept should exploit the mentioned positioning related errors, as described by Weiser [47].

5.4 Application Setup

Before being able to play the game, the end user has to install the acquired mobile game. According to *Nielsen Entertainment* [34], 45% of mobile games are downloaded over the air, and 34% over the internet on the desktop computer. Games that were downloaded over the air are simple to install, as the binary or byte code is already located on the wireless handset itself. For internet downloads through the PC, a suitable method of transfer to the handset has to be used before being able to install the mobile game. In times of Bluetooth being widely available on desktop computers and wireless handsets, this does not state a technical problem. But because not all users are experienced using this technology, some may not be able to perform this task without problems.

When defining the deployment according to Alan Dearle [14], namely as being the processes between the acquisition and execution of software, the application setup does not only consist of the installation alone, but also of any configuration of the LBG until it can be played. This may involve configuration of hardware dependent parameters in some cases, e. g. any form of connection setting to access the location information. This task may also discourage users to play the LBG.

For some LBGs, the automatism to generate a play field automatically, does not work. Imagine an dynamically generated play field spreading throughout several city blocks. Inside this area, points of interest are generated dynamically. Unfortunately, it can happen that the created items are virtually inside a building in this scenario. Assuming that the game uses GPS, which does not work indoor in most cases, the player could never reach an item located there. To avoid this problem, those kinds of games allow or even require to predefine an area representing the play field, before being able to play the game. This gives the player the ability to setup the game inside an area, where the availability of the positioning technology, like GPS, can be ensured. This is a very common approach to this general problem in many LBGs and works well in fields of research projects or demonstrator games implemented at research facilities or universities. But for an end user this means that he also has to setup the game area in the same manner, in order to be able to play the game. However, the tool chain for defining those areas is often proprietary, not very user friendly and designed to suit the needs of the game developers, not the end user. Therefore, the process of setting up a game area cannot be accomplished by the common end user, even it would be supported by the tools of the game developers.

5.5 Network Aspect

A networked game depends on a network connection over the cellular network, in order to transfer its game data to another network component. The costs for data traffic services have become cheaper in the recent years, partly also because of the introduction of 3G UMTS networks. As stated by Roto et al. [39], users may have a wide range of different perceptions of billing models for data traffic, which is not strongly depending on the actual costs. We think that arbitrary negative perception of these billing models are due to some kind of the user's suspiciousness towards the network operators. Trying to avoid data traffic costs, these users may not want to play a mobile game using a network connection. This is a substantial drawback for the networked LBGs category, which has to be taken into account regarding the mass market fitness of mobile and location based games.

5.6 Multiplayer Aspect

Previously we defined criteria, which have a negative impact on the end user suitability of LBGs. The multiplayer capability of a LBG does not fit exactly into this category. In general, the game experience of a real-time multiplayer game is greater than for single player games. This means a multiplayer capability can be implemented for LBGs to enhance the user experience. Negative consequences of this feature are the implied network costs, that come with the presumably required data traffic.

Another aspect to consider is the experience of users with real-time multiplayer games on other platforms, such as desktop computers or various consoles. The users may have a high expectation from games played on the mentioned platforms. These often implement various mechanisms to reduce the negative effects of network latency and jitter [2]. As described by Armitage [3], the greatest problem of real-time multiplayer games is the network latency. This states a problem for networked multiplayer games, because the mobile network's latency is usually much higher than land line inter-

net connections. Additionally, with most networked mobile games lacking the latency compensation technique, this may lead to a disappointment of the user's high expectations of the real-time aspect of the location based multiplayer game.

While multiplayer games can offer an interesting game experience, this can also limit the mass market reach of the games. Certain games may require multiple players to be online at the same time. This concept only works if the game has reached a critical mass and enough players are playing worldwide around the clock. Otherwise, the motivation of a user might drop radically if he has to abandon his plans to play a game just because he finds out that he is the only person online at the moment.

The location aspect adds another issue in some game concepts. If games require multiple persons to play the game at the same time *and* at the same location, it is ultimately even less likely that a user can successfully play the game. Essentially, it might only work in large cities, and the game needs a lot of publicity to reach enough people so that several persons are playing at the same time in the same city. On the countryside or in smaller cities, it may never be possible to play the game.

Some games solve this issue by making it possible that players are not online at the same time. For example, they could record their own movements and upload them to a game server, so that others can download this data and play against the recordings without the other person being active at the same time, but this may not be applicable to every single multiplayer game concept.

5.7 Availability

During our research about existing LBGs, we noticed that availability of the games is a big issue. This includes several problems, which can potentially limit the mass market acceptance and impact of LBGs. If a game is available for public download, it is obviously the best choice, as everyone interested in playing the game can start right away. However, some games only work in certain countries or with special network operators, thus severely limiting the reach of the game. Thinking about mass market acceptance, it is even worse if games are only available at special events. Usually, only a handful of people can participate, which essentially locks out most of the world. The worst option is if a game is not publically available at all, as it has already been removed by the company or if it is only a research project that has never been publically released – allowing not a single person to experience the game concept.

6. GAME ANALYSIS

The previous section worked up different general factors that we believe to be representative for an analysis regarding the end user suitability and mass market fitness of LBGs. Subsequently we will analyse the games in terms of these criteria and give a summary of the results. First of all, here is an overview of the analysed LBGs in context of our evaluation criteria in table 1. The criteria we defined are described in this section, an overview can be found in table 2.

6.1 Platform

As already described in section 5.1, we regard Java ME as the one and only alternative in terms of reaching the mass market. This is reflected by the platform evaluation, as 65% of the reviewed LBGs are implemented on a Java ME basis. The Short Message Service (SMS) is not a platform in strict terms. Although, when the LBG doesn't include a client on the user's handset and the comunication is therefore handled over sending SMS, it fits our definition of a platform criterion. The number of LBGs using the SMS-"platform" (17%) is not negligible. Looking at Symbian's market shares, we expected it to be represented by at least a few games, however there are only two single games in our evaluation list, which is equivalent to 9%. Windows Mobile based games take a share of 13%, therefore also being rated far behind Java ME. As expected most evaluated games are based on the Java ME platform, which is a good choice to make the LBG suitable for a big number of end users.

6.2 Positioning Technologies

Regarding the current hype and trends in GPS, surprisingly 43% of the LBGs use Cell ID as positioning technology. Looking a bit closer this is not as surprising, since Cell ID is the positioning technology with the best availability and comes for free in every cell phone by default. In contrast to that, GPS and all its derivatives require an external receiver in most cases, since very few currently deployed phones are equipped with an internal GPS receiver. The relatively high fraction of GPS based games (39%, with overlaps towards Cell ID) may come from the fact that GPS provides a higher accuracy than Cell ID. As expected, the number of LBGs using Assisted GPS is a minority, therefore they are already included in the conventional GPS share. Of course, developing LBGs using other positioning technologies like any form of optical marker tracking, Proximity Sensing (Bluetooth, RFID) or self-reported positioning are also possible. Though being interesting concepts, complex computer vision algorithms (optical markers), not very common external hardware (RFID), an additional external system (Bluetooth) or not yet fully proofed concepts (self-reported positioning) are required. Therefore, these games have to solve a lot of issues as well, in order to create an enjoyable experience for the users.

6.3 Phone

For the phone device criterion we marked the games with grades from 1 (good) to 3 (bad). Because there are only a few categories, we defined templates including school grades for each of them. The first category is any phone that supports Java ME, which we mark best (1). The Symbian OS or Windows Mobile devices were graded a little less, because of the smaller market shares (2). If a special model of propriatary prototype device must be used to play the LBG, where only a few models exist, we gave an even worse grade (3). Here the Java ME phones make up 54%, the Symbian and Windows Mobile section are only 23%, and the other LBGs on propriatary devices make up 23%. Initially we were surprised by the high number of LBGs using propriatary devices. This comes from the fact, that most of these LBGs were developed in research projects or at universities, where no mass market suitability is required – or network operators use a LBG to promote some special devices or their newly implemented services.

Game title	Platform	Positioning	Ph	H	T	S	P	MP	A	Inst.?
Conqwest[a]	MMS/SMS	Semacodes	1	1	GPRS	2	n/a	4	3	–
Botfighters 1[b]	SMS	Cell ID	1	1	SMS	2	3	4	4	–
Gunslingers 1	SMS/Java ME	Cell ID	1	1	SMS/GPRS	2	4	4	2	0
Gunslingers 2[c]	SMS/Java ME	Cell ID	1	1	SMS/GPRS	2	4	4	2	0
Botfighters 2	Java ME	Cell ID	1	1	GPRS	2	3	4	4	–
Undercover 1	Java ME	Cell ID	1	2	GPRS	2	3	4	1	0
Undercover 2[d]	Java ME	Cell ID	1	2	GPRS	2	3	4	1	0
Mogi[e]	Java ME	Cell ID/GPS	3	2	GPRS	2	3	2	2	–
Tron[f]	Java ME	GPS	1	2	GPRS	1	1	3	1	0
RealReplay[g]	Java ME	GPS	1	2	GPRS	1	1	2	1	0
RayGun[h]	Java ME	GPS	3	2	None	1	n/a	1	4	–
GeoTicTacToe[i]	Java ME	GPS	1	2	GPRS	2	1	4	3	–
Swordfish[j]	Java ME	A-GPS	3	2	GPRS	1	3	1	2	–
Torpedo Bay[k]	Java ME	A-GPS	3	2	GPRS	2	3	1	2	–
Mobslinger[l]	Java ME	Bluetooth	1	1	n/a	1	1	4	1	0
PAC-LAN[m]	Java ME	RFID	1	2	GPRS	3	1	4	3	–
The Journey 1[n]	Symbian OS	Cell ID	2	1	None	1	1	1	1	0
The Journey 2[o]	Symbian OS	Cell ID	2	1	None	1	2	1	1	0
SpaceRace	Apoxi	A-GPS	3	2	GPRS, Tel.	2	n/a	4	4	–
Can you see me now[p]	Win. Mobile	GPS	2	2	GPRS	4	1	3	3	–
Uncle roy all around you[q]	Win. Mobile	Self-Rep.	2	1	GPRS	4	1	3	3	–
Feeding Yoshi[r]	Win. Mobile	WLAN	2	2	n/a	2	1	1	1	0
Songs of the North[s]	Java ME	Cell ID	C[t]						4	–

Table 1: Evaluation of LBGs according to the defined criteria.

[a] http://homepages.nyu.edu/~dc788/conqwest/
[b] http://www.gamespot.com/mobile/action/botfighters/index.html
[c] http://guns.mikoishi.com/
[d] http://www.undercover2.com/
[e] http://www.mogimogi.com/
[f] http://gpstron.datenmafia.org/
[g] http://realreplay.mopius.com/
[h] http://www.glofun.com/
[i] http://www.kinf.wiai.uni-bamberg.de/geogames/
[j] http://www.blisterent.com/swordfish/
[k] http://www.blisterent.com/torpedobay/
[l] http://www.mobslinger.com/
[m] http://www.pac-lan.com/
[n] http://journey.mopius.com/
[o] http://journey2.mopius.com/
[p] http://www.blasttheory.co.uk/bt/work_cysmn.html
[q] http://www.blasttheory.co.uk/bt/work_uncleroy.html
[r] http://dolak.dcs.gla.ac.uk/yoshi/
[s] http://www.uta.fi/hyper/projektit/mogame/english.html
[t] This is only a concept game, therefore we cannot evaluate it further.

Abbrev.	Description
Ph	**Phone**
1	Any phone (Java ME)
2	Any phone (Symbian OS / Windows Mobile)
3	Only special phones (limited to a few models)
H	**Hardware** – Is any form of external hardware required?
1	No additional hardware
2	Additional hardware (GPS receiver, W-LAN, etc.)
S	**Application Setup** – Type of setup required prior to playing the game?
1	No setup required
2	Initial setup for each play field
3	Initial setup for each game
4	Operator services are required during the game
P	**Game Price**
1	Free
2	Single purchase required
3	Costs during the game (subscription and/or data costs)
4	Purchase & Costs during the game
MP	**Multiplayer** – The game supports multiple players.
1	Single player possible
2	Multiplayer, not at the same time
3	Multiplayer at the same time, location irrelevant
4	Multiplayer at the same time and same location
A	**Availability**
1	Publically available
2	Only available in certain countries / network operators
3	Only available at special events
4	Not / no longer publically available
Inst.?	The game could be played instantly.

Table 2: Overview of the evaluation criteria.

6.4 Hardware

Evaluating the hardware criterion, we also used templates as described above. The templates can be reduced to LBGs not requiring any additional hardware (40%), which is good in terms of making it suitable for the mass market (1), and those which are dependent on additional hardware, i. e. an external GPS receiver, a new phone with an integrated GPS receiver or any form of W-LAN capability (60%), which possibly induces additional cost and effort for the end user (2).

6.5 Data Traffic Costs

The actual data traffic costs for the user cannot be listed here because of different billing models. It is also not possible to determine an average data rate for network traffic. Thus, we defined the following different categories representing different types of billing entries on the user's telephony bill: If no data traffic costs accumulate, we designated the column in 1 with *None*, which are about 15% in our evaluation. The data traffic costs from *SMS* communication makes up only about 15%. Most LBGs use *GPRS*, which are over three-fourths, which is equivalent to 80% with overlaps towards SMS and one additionally using Telephony. This means that most LBGs create costs for the user, almost all of them utilizing a GPRS connection. As already discussed in section 5.2, such operational costs may discourage users to play LBGs.

6.6 Application Setup

In section 5.4 we described the deployment process of the application as installation and setup of the LBG. Because installation is necessary for every LBG, we will skip this factor in our evaluation. The more interesting part in this context is the setup process, that has to be performed in order to be able to play the game. Therefore, we defined four categories as follows: For some LBGs there is no explicit setup required to be done by the user (1). In our evaluation data in table 1 these games are 32% of all. The games, where an initial setup for each play field is required (2), make up 55%. An explicit setup for each game instance (3) is required by a single game. Operator services (4) are required by 10% of the LBGs.

6.7 Game Price

The effects of the user behaviour towards different pricing models of mobile and LBGs was discussed in section 5.2. Therefore we classified the game pricing strategy into one of the four following categories: About 47% of the LBGs are free (1), which should satisfy those end users who do not want to pay any amount for a mobile or location based game. Only one game requires a single purchase without any subscription and/or data costs during the game (2). The rest of the evaluated games (again 47%) require an explicit subscription and/or produce data costs during the game (3, 4), creating some form of costs for the end user. Similar to section 5.2, also accumulating game costs may discourage users to play LBGs.

6.8 Multiplayer

There are several different variants of multiplayer types, therefore we identified different forms of multiplayer capability in LBGs: A multiplayer mode where the users do not

have to play simultaneously is very rare and supported by only one game. Another interesting multiplayer mode is a time simultaneous game, where the users can be situated in different locations, but playing together on a virtual play field. Again, only one game supported this kind of multiplayer mode. The vast majority of evaluated games, where the players have to be in the same location and play at the same time respectively, make up exactly 50% (4). The number of single player games, where no multiplayer capability is used at all, is about 27% (1). About 14% of the LBGs require a simultaneous game, where the location is irrelevant (3). 9% of the LBGs support a free multiplayer mode that does neither have to run simultaneously, nor at the same location (2).

To ensure that a LBG can be played anytime, anywhere, it has to offer a singleplayer mode, as all multiplayer modes require at least one other person to play the game. If neither the location nor the time has to match between both players, this would not be much of a problem – however, not a single game exists that makes use of this mode.

If either the location or the time has to match, it is a lot more difficult. Depending on the study, the average length of time spent on a mobile game is either 15–20 minutes or 28 minutes [26]. Let's assume we want our game to run 24 hours a day, where there's always a game running, this would allow any player to join instantly, not having to wait for other players. If we take an average game session length of 20 minutes, this would require at least 3 games per hour. Assuming that two joined players are enough to play the game, then we would require at least 6 players per hour or 144 players per day. In this theoretical approach the players would have to be equally spread over the whole day, to make sure that there's always a game running. Without a decent marketing budget and broad compatibility of the game, this is difficult to achieve.

6.9 Availability

For our analysis regarding the possibility to play LBGs, the availability is one of the most obvious and relevant criterion. Again, we created four different levels to rate them. The best option (1) is if they are publicly available, regardless of their price. A little over a third (34%) of evaluated games fit into this category. If games are only available in certain countries or only work for a single network operator, this severely limits the number of potential players – lowering the score to (2). This option is a little less frequent amongst the LBGs we evaluated (22%). Even more restricting are games that are only available at special events (3). Usually, only a few people can participate, reducing the importance of the game for the mass market nearly to zero. Of the games we considered, also 22% fall into this category. However, the previous situation is still more favorable, than the game being not or no longer available to the public at all. For example when the game is implemented within a research project and/or it has not been released at all. Unfortunately, with 22% there are some games falling into this category.

7. CONCLUSION

The most interesting question for an end user is not whether the game he wants to play fits the above mentioned criteria, but if he can play the game right away, instantly so to say. In our terms this means that the game is end user suitable and therefore fit for the mass market. Thus, we defined an overall end user suitability criterion, based on our previous evaluation model. This is based on three different classes:

- The class of LBGs that are not suitable for the end user at all, is marked with a "−"-sign. The critera for a game to fall into this category are if the platform is propriatary (section 6.1), the positioning technology is not GPS or Cell ID (section 6.2), the game is bound to run on a propriatary phone device (section 6.3), some form of play field has to be set up on a per-game basis (section 6.6) or the game is only available at special events or even not at all (section 6.9).

- The class marked with a "0"-sign may be suitable for the end user, but has several drawbacks. We define games to fall in this class when they run on Symbian OS or Windows Mobile phone devices (section 6.3), they require some form of external hardware like a GPS receiver or W-LAN capability (section 6.4), generate any form of data traffic costs (section 6.5), an initial setup of a play field is required (section 6.6), the game generates consecutive game costs (section 6.7), the game only supports multiplayer modes where the players have to play simultaneously (section 6.8) or the game is only available in certain countries or in association with special network operators (section 6.9).

- The most interesting class, marked with a "+"-sign, consists of games suiting the following criteria: The game does not run on a proprietary platform i. e. runs on SMS/MMS or Java ME (section 6.1), the positioning technology is Cell ID or GPS (section 6.2), the phone device is Java ME capable (section 6.3), no special or additional hardware is required (section 6.4), no traffic costs accumulate while playing (section 6.5), no application setup has to be performed (section 6.6), the game is available for free or only requires a single purchase (section 6.7), the game comprises a singleplayer or multiplayer mode where the players don't have to play simultaneously (section 6.8) or the game is available publicly (section 6.9).

According to the definition of the above classification, table 3 contains an overview of the criteria allocation to a specific class. Based on this definition, we evaluated the LBGs based on their feature with the lowest score. The final classification level is represented in rightmost column, marked "Inst.?" in table 1. The number of evaluated games out of all evaluated LBGs that can in fact be played instantly ("+") as defined above is zero! The LBGs having potential, but still drawbacks ("0") make up 43% and the games not being end user suitable at all are the rest, with 57%.

The above analysis shows that current location based games only have a limited potential ("0") or are not end user suitable at all ("−"). Similar to our intuition and in contrast to numerous statements, which predicted LBGs to be the next hype in mobile gaming, the analysis shows the expected results: There are promising approaches in current LBG developments – however, none of the LBGs are ready to be

Class	Platform	Positioning	Phone	Ext. H/W	Traffic	Setup	Price	Multipl.	Avail.
–	proprietary	others	3	–	–	3, 4	–	–	3, 4
0	–	–	2	2	any cost	2	3,4	3, 4	2
+	others	Cell ID, GPS	1	1	no costs	1	1,2	1, 2	1

Table 3: Criteria assignments for end user classification.

deployed into the mass market. This shows that most of the current LBGs are only in the prototype or research phase and a lot more work needs to be done. We predict that it will take at least two more years until companies will start to pick up and utilize the LBG concept. During this time, the general conditions will most likely improve as well, with more GPS receivers being built into mobile phones, data tariffs getting cheaper and more developed concepts of LBGs evolved. When those games are finally deployed, they will gain the potential to have an enormous impact on the mobile gaming market.

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