Cell info road tracker
CiRt

Project Report
Location Aware Systems

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Acknowledgements

Developing ideas and programs in such a virgin environment as mobile positioning is not easily done alone if you want to maintain a certain level of quality and more importantly quality control. Such was also this case in this project and there are some people who deserves a sincere thank you or to be mentioned. Who they are and what I want to thank them for will be added later when I make up my mind and they still have a chance to redeem themselves.

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Chapter 1

Introduction

Twenty-four Navstar satellites constantly orbiting our planet makes it possible to decide an almost exact position in latitude, longitude and even altitude. Of these 24 satellites the last was launched on June 26, 1993 and the Global Positioning System[1] was born. Using only a couple of hundred dollars, every Tom, Dick and Harry can simply buy a GPS device and instantly get access to positioning information.

Today GPS is not as mainstream as one would think. However it is a fact that more and more people buy GPS navigation systems for their cars, and that many new cars are delivered with GPS as an integral part of the interior. However, in comparison with mobile phones, GPS receivers are in short supply with the public. Whereas, in Norway, there are sold more mobile phones than there are inhabitants, GPS is far from even reaching this mark in the years to come. Then the question arises; Would it be possible to use a mobil phone in the same manner as a GPS? That is, can mobile phones provide positioning information?

The sole way of positioning a mobile phone through the phone net today is with use of cell info. Cell info gives a position based on the nearest GSM[2] antenna. This position is however almost always inaccurate, that is it gives an estimate ranging from 25 meters to a couple of hundred. The latter more than the first. The innovative part of our project is to use additional information, mainly geographical road information to get a better fix on out actual position. Based on GSM antennas in the vicinity we should be able to provide a system close to GPS in accuracy. At least, it should be more accurate than existing systems.

[1] Global Positioning System, or GPS, uses 4 satellites to determine an almost exact position all over the world. It was after the introduction of the atomic clock that this system was made possible. For more information have a look here: http://www.beyonddiscovery.org/content/view.page.asp?I=1275

[2] GSM, or Groupe Spcial Mobile is a standard for digital phone communication.

1.1 Motivation

This projects motivation is based on Project OneMap. Project OneMap is a long term effort contributing to the fusion of standard web technologies and geographic content. In other words contextual hardware and software. The OneMap project is a non-profit project. It is hosted by and coordinated from Ostfold University College, Faculty of Computer Science.

1.2 Expected outcome

This project can be used to determine positions in cities and in houses where GPS is inaccurate or useless. GPS requires a free line of sight to the sky (satellites). The usage of a mobile positioning system will be cheaper than using a GPS system and the fact that there are more phones than there actually are people in Norway says a lot about its market value.

1.2.1 Key Literature

This particular field of interest, cell info, is not very well documented in either books nor articles. However there are some ongoing projects that are open to the public. For instance PlaceLab[1], an Intel research project, uses cell info, wireless networks and GPS to estimate positions. They base their work on several research papers. Some of these are highly relevant for our project. ”Place Lab: Device Positioning Using Radio Beacons in the Wild”[2] and ”Lighting the way with radio beacons: A global positioning system from WiFi and other radio sources”[3] both provide essential information. In general, the paper ”Learning and Recognizing the Places We Go”[4] is a must read to all people in the field of context aware applications.

Furthermore, Johannes Koolwaaij, the driving force behind ”MobiLife”[5] and ”Context Watcher” has documented his findings and published them on the net. The ”Context Watcher” software uses cell information to decide an approximate position.

Telenor however, Norways dominant phone and network company, do not share their knowledge in this matter. They are holding information about antennas and signal strengths close to their chest for, as they say, one major reason. The reason being that cell-info requests makes their network suffer heavy loads. As a matter of fact, cell info requests are not charged, thus promoting cell info as a useful tool for the public would not be the wisest business move.

Where does this lead us? Nokia, the Finish mobile phone company saves the day. They deliver free Software Developer Kits (SDK) which can be used to program their phones. Additionally, they tell you how to do this and that, and suddenly cell info usage is handed to us on a silver plate.

Chapter 2

Background

Some start text here

2.1 Mobile phones

2.1.1 History

Total Access Control System(TACS) where introduced in the UK early 1980. TACS allows both inbound and outbound connections and could make use of small base stations with low power consumption. As its popularity grew the need for a better systems rose and we saw the birth of the GSM system. Other systems where also tested; in them in for example NMT, DCS, PDC, NADC and AMPS. Most of these are in little or no use today and we will not look into them, except for NMT[1]. NMT was common in Europe while TACS was used in the USA.

Eventually the need for more connections won trough. Hence we went from analogue TACS to digital GSM. GSM went active 1989 and is still the major technology of the scene. The differences between countries are mainly which radio frequencies (bands) the bases use. Today we have four GSM bands. When it comes to different services, beside standard calling, we have some popular examples; SMS[2], MMS[3] and WAP[4]. SMS is firstly a European phenomenon, also known as texting. SMS makes it possible to transfer text between phones. Americans are not using this service to the

[1]Nordic Mobile Telephone was a cooperative mobile phone network for the Nordic countries.

[2]Short Message Service, a standard which allows for text to be sent over the GSM net.

[3]Multimedia Messaging System, makes it possible to sendt both pictures, animations and sounds between mobile phones.

[4]Wireless Application Protocol, enables a phone to access the internet

same extent as Europeans. Why? Well, there seem to be a matter of old habits. Americans seem to still use voicemails, as they did with answering machines on standard phones.

When it comes to data transfer speeds we have something called HSCSD[5] and GPRS[6]. Both these provides greater data rates than standard GSM. The need for speed is always present as services are demanding all the bandwidth they can possibly get. Also 3G[7] is getting more and more a part of daily mobile phone use. Sending video over the GSM system is really pushing the envelope. Mobile phones where late in the 1990s also broadly used as modems for portable computers. Now handheld computers, advanced phones and 3G network cards requires larger bandwidth for the services of tomorrow.

[5] High Speed Circuit Switched Data. Higher data transfer rates than normal GSM rates.

[6] General Packet Radio Service is yet another system for higher bandwith

[7] Third generation GSM net. By third generation it simply means that the speed is increased in comparison to the former GSM network, which was known as 2G.

2.2 Research Methodology

Mobile phones are connected through a GSM network. They are interconnected through a net of antennas, routers and cables. Every antenna contain a unique ID which can be used in positioning. When a antenna is identified we know its position and its range. With this information it is possible to roughly estimate the phones position. This information in conjunction with geographical road information might be sufficient for mobile phone car navigation. Our main goal is to provide road position information without the use of a GPS.

2.2.1 Signal Triangulation

Use of inactive cells in mobile networks for positioning from GSM bases. By use of both cell info and GSM signal strength it may be possible to make a position more accurate.

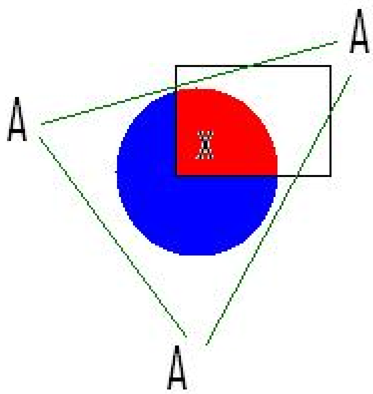

Figure 2.1: Triangulation

The above figure shows three antennas A. These antennas are used to triangulate the position of the cellular phone X. The blue area represents the deviation/uncertainty in position. The square shows the active cell area. The red area is where the triangulation and the cell interconnect. This way it should be possible to increase the position accuracy by using ”tools” and methods that already exists. Our main concern however, is that the cell info area by far outgrows the area of signal triangulating.

2.2.2 Overlapping cells

Weighing signal strengths to determine an accurate position on a road when you receive cell info and signal info from more than one GSM antenna.

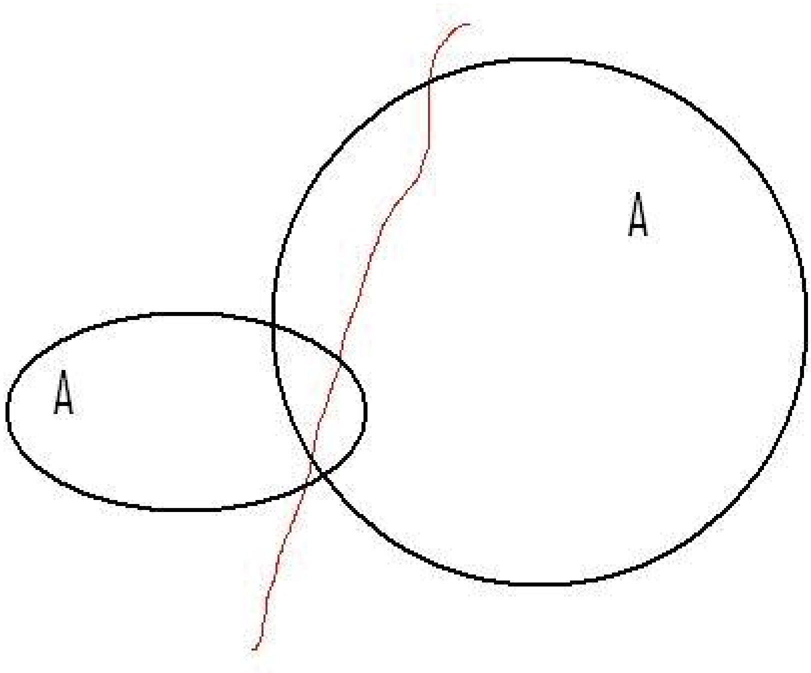

Figure 2.2: Triangulation2

Above illustration shows how 2 antennas (or more) can be used to determine a position along a road. The antenna on the right gives a large margin of error, although being the dominant one. With use of a second antenna, the one on the left, it is possible to determine the position quite accurately in comparison to using only one antenna. This method however requires the road to be scanned first, mapping the antennas available. Also it may be possible to weigh the interconnected areas and thus find an even more accurate position.

Based on either suggestion one or suggestion two, it might be possible to transfer cell ID and triangulated positions into NMEA signals and in this way connect a phone directly to a map tool. Doing this a cellular phone can be used as a GPS without ever having to connect to a single satellite (phone emulates satellites).

Chapter 3

Design - for users and programmers

Finding the correct approach in a system development project is a riddle with no obvious answer. Based on earlier results and experiences one may be able to decide what will result in a good result, but is it good enough?

Taking design, which is a difficult concept, into consideration we should keep in mind that a working design usually is not discovered on the first try. On the other side, what if it is found and we change it again thinking that we can do better? Well in either situation, an iterative approach to design would be the way to go.

3.1 The design problem

The design problem implements new concepts; Usability, functionality and dependability. Each of these deal with specific development approaches. The reasons for dividing the design into these three categories are:

- Each part deals with a specific approach to the design. Usability is all about user interaction. Functionality describes what the program can and cannot do and dependability gives an indication on the programs performance.

- They are easy to separate from each other thus possible to divide between developers in the project.

- Even though they have a clear connection they can be measured and tested alone which is a clear advantage.

3.1.1 Usability

User involvement and user understanding are the key words here. Usability deals with the difficulty of the program, how easy it is to use and more importantly how easy it is to learn. How difficult the usage is should be measured by either a quick and dirty test or an assessment test. Quick and dirty test is performed in a fly and requirers little or no preparation. By the use of a test-person one can simply surrender the product and see how the test-person interacts and understands it. Assessment test on the other hand requirers a little more planning. More about assessment testing here...

3.1.2 Functionality

Functionality describes the level of usefulness in the product. For instance, if we could make the CiRt display road houses and coffee shops, that would be another function added and more users might find it interesting. Functionality is very bound by usability. If CiRt is superior in its number of functions that is of little value if the product is impossible to use. The funtionality we want for CiRt is:

- Resizeable map. Users should have the possibility of choosing how much road they want to see.
- Preferences enabling or disabling road names and attributes.
- Possibility for the user to interact and correct CiRt if that is necessary.
- Time

There are however many other function we would suggest added to CiRt. Many of these are covered by programs like Context Watcher. Due to the short time span of the project we find that what we expect from the functionality so far is more than enough for a decent platform.

3.1.3 Dependability

Dependability deals with the aspect of thrust in the product. A user want to be certain that the CiRt displays position correctly in most or all situation. If the users do not believe in the product they subsequently will not use it. Being more programming oriented than the other two, dependability is still a part of the overall design. Dependability aspects will be an important part of the design, specially on the graphical presentation of position. Lets have a closer look at what this means.

3.2 Design process and conceptual models

As earlier mentioned the design process should be iterative. We would like to have the possibility to correct what we think can be done better or to rollback to a previous solution if needed. What we need to establish before the graphical design is implemented is a conceptual model. The conceptual model is in fact a mental image of a process, a system or even an object. It is a model that describes the general functional relationship among components of a system. Our conceptual model can be summed up in a few sentences.

Place conceptual model here!

3.3 Graphical representation

Our primary concern is the map overlay. By map overlay we mean how geographical information is represented on the screen. The map will need much of the available screen to be showed properly. This leaves little room for optional information and user interaction. For instance, a single map representation on the screen will look something like this.

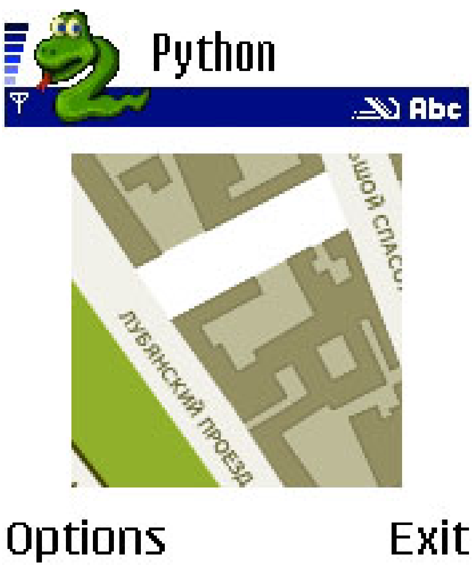

Figure 3.1: Standard map overlay

Moreover roads need to be showed accordingly. That is, we would like roads showed as an overlay map on the geographical information. By doing this we are able to show road information (names, house numbers etc) in the map. This is made possible with Arealis WMS service. Road overlays will look something like this.

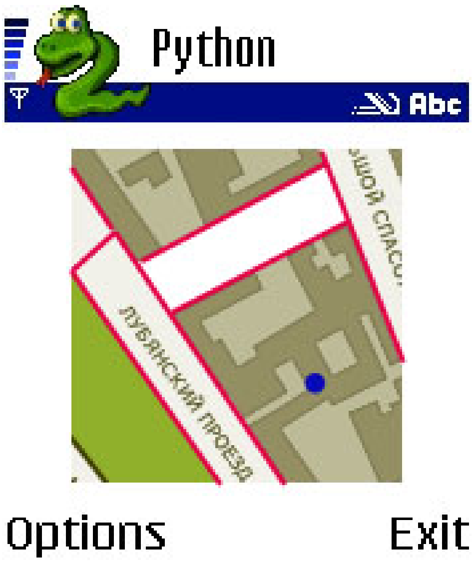

Figure 3.2: Road overlay

Our next concern is of course user interaction. We know for a fact that the map will occupy most of the screen. At the same time we need to keep it simple stupid, or failsafe. We choose to reserve some of the screen for buttons. We assume that the most important functions will be zoom (in and out) and refresh. We might add a pan-function later. With this in mind our screen now looks something like the picture below.

Of course this would not be enough to make a cell info based program work. Cell information is as we are aware of very inaccurate and will need constant updates to ever be able to use it. This brings us to the preferences panel. This panel would enable user interaction and optimize position.

3.4 Program design

The program design features technical solutions not directly concerning users. Seen from a programmers point of view this is where most of the project development is done. Deciding algorithms, input and output data and visualization methods are the key elements in any successful software project.

Figure 3.3: Buttons

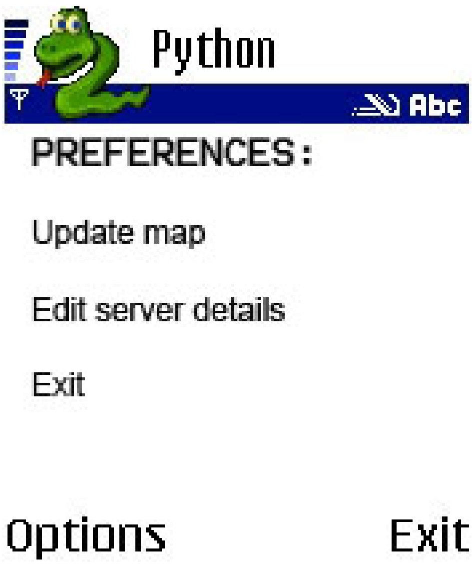

Figure 3.4: Preferences

Chapter 4

Discussion, Future Work and Conclusions

Wrap up (in separate sections, or integrated in one final section):

Discussion Explain in the discussion section of your document information presented in the results section, commenting on significant data and experience produced by the study.

Conclusions Include a conclusion as the final part of the body of your document. Because some readers of documents, particularly managers, will sometimes not read the entire document but, instead, focus on the conclusion, this part of the document should summarize all essential information necessary for your audience's purpose. In your conclusion:

- Relate your findings to the general problem and any specific objectives posed in your introduction.
- Summarize clearly what the report does and does not demonstrate.
- Include specific recommendations for action or for further research. Sometimes these recommendations will constitute a separate section of a document.

Recommendations Include appropriate and specific recommendations as part of your conclusion or, in feasibility and recommendation reports, as a separate section preceding the conclusion.

Many types of scientific and technical documents conclude by pointing to further action. Research reports often recommend further studies to confirm tentative explanations or to answer questions presented in the discussion section. Feasibility and recommendation reports always have one or more specific recommendations as the principal aim of the document.

Recommendations should always be specific and appropriate to the document's audience. Separate each specific recommendation. Often authors present recommendations in bulleted or numbered lists. Organize recommendations either in the order of importance or in the logical order of development.

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Bibliography

[1] PlaceLab, *Intel PlaceLab Research*. PlaceLab, 2005.

[2] ——, *Place Lab: Device Positioning Using Radio Beacons in the Wild.* In proceedings of Pervasive 2005, Munich, Germany, 2005.

[3] A. L. Yatin Chawathe and A. Balachandran, *Lighting the way with radio beacons: A global positioning system fron WiFi and other radio sources.* Intel Research, 2003.

[4] L. S. Hightower, Consolvo and Hughes, *Learning and Recognizing the Places We Go*. In Proceedings of Ubicomp 2005, Tokyo, Japan, 2005.

[5] MobiLife, *MobiLife and Context Watcher*. Johannes Koolwaaij, 2005.