A-GPS (Assisted GPS), is this the system we need for indoor location & navigation?

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Abstract

For a long time the GSM and GPS world has been living side by side. There have been some half hearted attempts to invoke the GPS unit into GSM units but performance and usability has suffered. The A-GPS approach is interesting and we wanted to verify general performance for fleet application and alarm/emergency situations.

The result is now promising but still more to enhancements are anticipated. We achieved near acceptable availability (~70%) under indoor conditions. Accuracy was as anticipated (50-100 meter) as we are using reflected signals. Time to first fix is in general good in outdoor conditions but too long for indoor conditions (45-60 seconds). We would like manufactures to put some more effort to get better performance in the future as test with Nordnav high sensitivity measurement system proves that conditions indoor are at a level where better performance should be possible.

Keywords: A-GPS, Assisted GPS

1. Introduction

TeliaSonera, which is Sweden's largest mobile operator, see an increased demand for location based services, such as fleet management, asset tracking, and emergency services, which have new requirements on the positioning method used. The GPS receiver has been very suitable for navigational needs, but it is less suitable for the new type of services described above, due to long startup times, signal strength requirements and lack of communication channels.

Positioning in the mobile phone network, on the other hand, is very fast, has better signal strength availability and a two way communication channel, but lack the precision provided by the GPS system.

2. Purpose "Analyze customer value"

The purpose of this is to evaluate the **customer value** added by A-GPS. This should be done through an investigation of the accuracy and response times with commercially available products (phones with A-GPS support such as Motorola A1000, A835, HP6515 etc.) and non commercial SUPL products from several vendors.

3. Background

3.1 Cell phones with GPS

There have already been phones with GPS receivers available on the market for some time. Among some users, these receivers have been much appreciated, but the success on the mass market has so far been limited. From the mobile operator's point of view, a problem has been that to make services that use GPS positioning available, there is a great need of a standard for requesting position information from the device. In the early GPS devices, non standardized SMS communication has been used to request position information. **This makes integration with current positioning services hard** and consequently it has not been performed to any great extent.

3.2 Principals of the A-GPS system

The ideas of an assisted, or aided, GPS was formulated by Sennot and Taylor (1981). They introduced the theory that if a receiver is provided with the information needed to estimate the Doppler frequency before acquiring a signal, the Doppler dimension of the search space is reduced and, hence, the acquisition time is shortened. This principle has been extended to include all ephemeris and almanac data as well as approximate receiver position. By supplying the receiver with the full contents of the GPS navigation message, the need for decoding the data stream is eliminated. (Bryant, 2005).

The important characteristics with A-GPS are:

- Increased performance (time to first fix etc)
- ***A standardized protocol to send back the position through the GMS network***

4. Approach

4.1 A-GPS

The approach used to find A-GPS customer value is field testing, implying that publicly available A-GPS receivers are tested in the real mobile network in some predefined typical user conditions.

For TeliaSonera, results from field testing in their our own mobile network is very important, since this is the only way to observe the real performance of A-GPS and evaluating the customer value.

A theoretical study was performed (here omitted) to be able to relate the field testing results to theory and conclude if the results correspond to those to be expected from a theoretical point of view.

4.2 Message call flow

The A-GPS messaging structure is specified by OMA. Worth noting is that the SUPL INIT message is sent through a WAP-push message using SMS as a bearer.

All assistance data is contained in the RRLP message included in SUPL POS. RRLP is specified by 3GPP for control plane A-GPS (3GPP, 2005b), but as seen here the same message is used, but contained in a SUPL message in the user plane (OMA, 2005b). **This gives a standardized process to send positions through the net!!**

4.3 A-GPS in theory

The advantages achieved by supplying satellite data through the mobile network, instead of in the satellite data stream, are all related to the acquisition process. The most obvious advantage is, not having to wait 30 seconds until recent ephemeris data have been decoded from the data stream. A less obvious one is that having this information in advance gives a choice of increased speed or sensitivity when searching for satellite signals. (Abraham & van Diggelen, 2001)

4.4 A-GPS in practice

In this project, TeliaSonera is interested to see the real performance when implemented in real GSM and WCDMA networks and with real user equipment. Ackermann (2006) points out that there are some issues with repeatability and control over the test environment in field testing, since A-GPS performance will change with the location of satellites as well as weather conditions. In this study, the most important objective is finding an indication of the real performance in a live network. This means that the repeatability and control problems have to be accepted and accounted for when interpreting the results.

TeliaSonera have, in earlier studies, used field testing as a method and found very important results not published in results from laboratory studies.

Network initiated

TeliaSonera is mainly interested in the performance of network initiated positioning request, since most of TeliaSoneras current LBS services are accessible through WAP, SMS or through a web browser. In these cases, the positioning request is network initiated even if the service request can be initiated via the user equipment. The network initiated performance is also a very useful indicator of the performance of positioning requests initiated in the user equipment. The reason for this is that the user equipment performs the same operation in both cases, but in the network initiated case, it has to wait for an initiation message to arrive before the positioning request is handled.

Cold start/Hot start

The definition of cold start and hot start used in this report is knowledge of coarse position and up to date ephemeris when the GPS receiver is started.

The acquisition performance of an ordinary GPS receiver differs greatly between cold start and hot start. The usage pattern of most LBS services does not imply that the user requests a position with less than a four hour interval and thus do not have up to date ephemeredes. Because of this, the case of cold start performance is of interest for TeliaSonera. As with network initiated requests, cold start performance will never be better than hot start. It is therefore, a performance indicator of a worst case scenario.

To test the cold start performance, all compatible terminals must have the capability of resetting all available satellite information. Whether this option is made available for the user or not is not specified. (3GPP, 2005d)

In the terminals that are used for this project there is a software application installed, where this option is available as an “Always Cold Start” option, for evaluation purposes. All the tests are done with this option activated.

4.5 Measurements indoor, not only signal strength

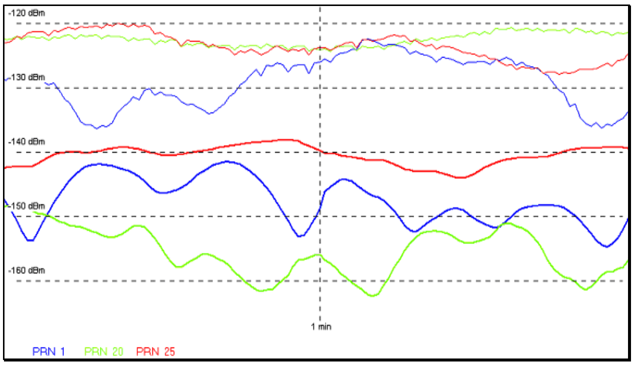

Figure 1. GPS indoor signal strengths measurements

The pictures above shows the signal strengths found inside the office building where the testing are performed. The strongest signals are outdoor signals that each corresponds to an indoor signal which is shown with the same color. From this figure it is found that difference between the outdoor and indoor signals are about 10-40 dB.

Inside an office building, the signal environment will be characterized by lots of multipath signals that is reflected by walls and furniture. The figures below exemplify three different cases of mutlipath. The horizontal direction represents time and the vertical can be interpreted as received signal strength.

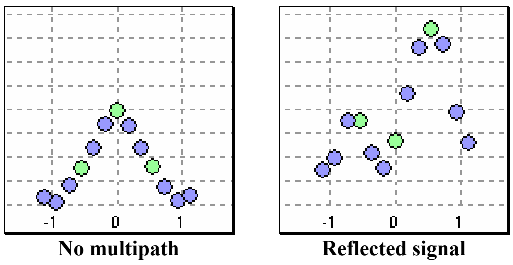

Figure 2. No multipath (typical outdoor) and reflected signal (indoor/urban canyons)

No multipath shows a signal without reflections. This kind of signal is desired for accurate positioning results, but is rarely found in urban areas.

Reflected signal shows two signal components. The component that arrives first has travelled the shortest way, but is attenuated by passing through walls and furniture. A reflected signal, with a slightly longer way travelled, has higher signal strength. In this case, the latter is reflected on a nearby house and received through a window.

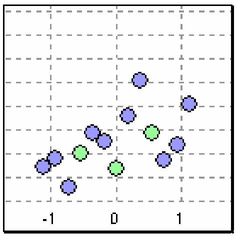

Figure 3. GPS indoor signal with heavy multipath

This shows a signal that has been reflected multiple times and finding the true signal is very hard. This kind of signals is often found under indoor conditions.

5. Result and analysis

5.1 Open sky conditions

In open sky conditions, the signal strength is expected to be about -130dBm. Under these conditions an unassisted GPS receiver works very well, but the assistance data should decrease the acquisition time noticeably.

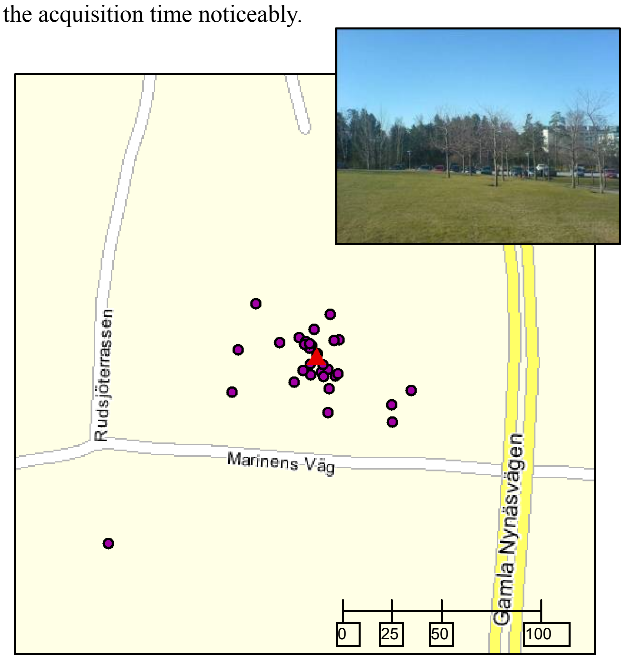

Figure 4. Positioning responses in open sky conditions

Response time	Min: 13 s	Max: 41 s
Accuracy	Min: 1 m	Max: 139 m
Total tests	24	
Success rate	100%	

Table 1. Summary of results in open sky conditions

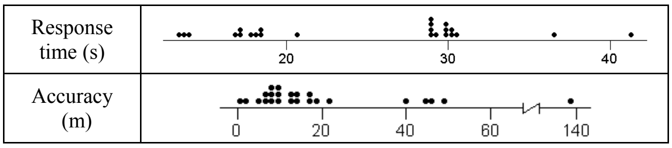

Table 2. Dot plots of response time and accuracy in open sky conditions summary of results

5.2 Indoor conditions (10 meters from window)

Under indoor conditions, the signal strength is far below those found outside. The measurements show that the signal strengths found were from -140 dBm down to -160 dBm and lower. It is also a heavy multipath and fading environment. At such conditions, a traditional GPS receiver would not be able to track any satellites. A high sensitivity receiver might be able track satellites, but acquiring them without up to date ephemeredes and coarse position would not be done within a reasonable time frame.

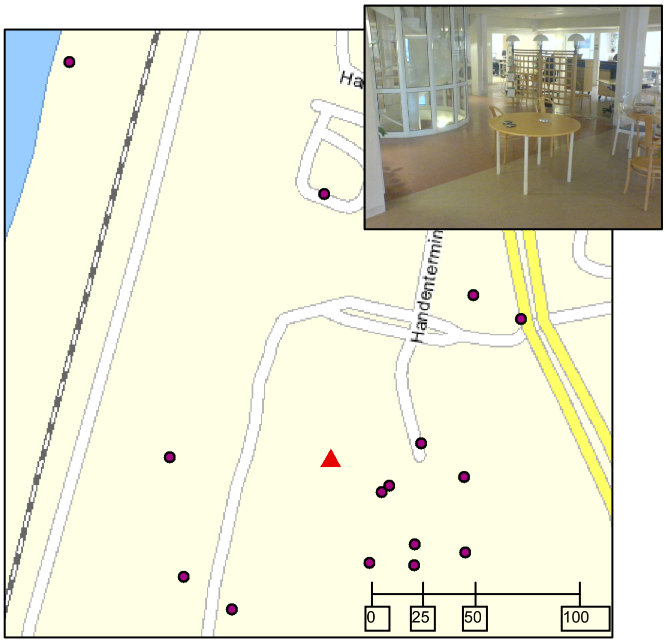

Figure 5. Positioning results from an indoor environment

Response time	Min: 29 s	Max: 66 s
Accuracy	Min: 29 m	Max: 224 m
Total tests	24	
Success rate	71%	

Table 3. Summary of results in indoor conditions

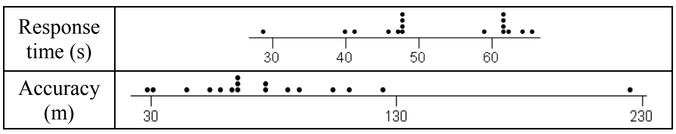

Table 4. Dot plots of response time and accuracy in indoor conditions

6. Conclusion

The customer value added by A-GPS has to be seen from two perspectives depending on the positioning system currently used. The current GPS users will see a decreased startup time, decreased power consumption, decreased demand for signal strength, access to positioning and communication in one device as well as the possibility of network initiated positioning requests and the use of GSM/WCDMA positioning as a fallback. The current user of GSM/WCDMA positioning will see the possibility to get more accurate positioning results, positioning in roaming networks and continuous tracking capabilities as well as standardized personal integrity management.

From this, it is clear that A-GPS has the potential to give a great customer value, but start up times and accuracies found in this tests show that the quality of the user plane A-GPS implementations available today limits the customer value in applications that have high demands on reliability. An example of such a service is emergency services, where both response time and accuracy is essential. This issue is further discussed by Borrughs & Gum (2006).

Acknowledgement

The background work has been done by the Thesis student Oskar Grönqvist. His eager and enthusiastic work has inspired us all.

Reference

Here are the samples of references.

1. O. Grönqvist, "Field test of A-GPS on the SUPL platform and evaluation of hosted mapping services at TeliaSonera". 2006-06-08