DGPS IN MOBILE PHONES – PERSPECTIVES, TECHNOLOGY, LIMITATIONS

Witold Rohm[1]

Abstract

The article addresses the issue of DGPS application in mobile phones. In introduction the review of presently active services of reference networks in Poland is given. Second section discuss state of the art in positioning using mobile phones, here also the concept of DGPS is presented. The following section shows the software's algorithm with separation into NMEA decoder part, NtripClient software, and DGPS solution description. The software should be ready to release in the middle of 2011. It should allow shorten time to first fix especially in the urban canyons, and which is the most important feature, upgrade the position accuracy to 1 meter.

Keywords

Differential GPS, mobile phones, Ground Based Augmentation System

1 INTRODUCTION

Currently, there are several manufacturers of mobile phones, which includes on boards GPS chipsets. The market leaders (Nokia, Samsung, iPhone, Blackberry), even in the middle shelf products provide GPS functionality. This paper is focused on Nokia phones due to their low complexity, decent costs, and availability on polish market. Differential GPS or Differential GNSS in case of usage of more than one navigation satellite system, is the present of land surveying where required accuracy is on the level of 0.05 meter. It is possible to achieve such high level of integrity due to the real time transfer of corrected observations from the base receiver to the rover receiver. Currently in Poland, and neighborhood countries there are 120 GNSS stations [2] working in the frame of the ASG-EUPOS network, providing different services to the end users (NAWGEO, KODGIS, NAWGIS). Depending on the available observations on the reference station and rover receiver there are different type of corrected observations and variable level of accuracy [2]:

- GNSS L1/L2 phase measurements highest present accuracy 0.05 meter (NAWGEO),
- GNSS code measurements, with corrections tailored to the user position, accuracy 0.25 meter (KODGIS),
- GNSS code measurements, accuracy 1.00 meter (NAWGIS).

While the first service constitutes 98% [2] of the payload of the ASG-EUPOS network the last two are not exploited so far. In the author's opinion it is due to lack of advertisement of the system in the other applications and also lack of the appropriate software for mobile platforms. This paper addresses the problem of developing such software for mobile platforms focusing on Nokia phones with Symbian, and using for transferring corrections Networked Transport of RTCM via Internet Protocol (Ntrip) version 2.0 [2] and for collecting observations National Marine Electronics Association 0183 (NMEA) protocol.

2 DGPS AND PRESENT STATE OF THE ART IN THE NAVIGATION IN MOBILE PHONES

In the mobile market (Nokia also) currently there are number of phones with GPS chip (one GNSS only) with 12 channels and code measurements, providing on the output the NMEA message written into *.NME file. When it becomes more and more popular, the manufacturers of the mobile phones and GPS chipsets add additional functionality like [2] receiving SBAS (EGNOS), Assisted GPS (AGPS) and hybrid navigation (using WiFi Access Points and GSM network positions).

Basic Single Point Positioning is based on two information: the coordinates of the satellites, pseudoranges, using these two software estimates 3 coordinates of the receiver (*XYZ*), receiver clock error (*dt*), thus there are need for at least four visible satellites. The accuracy of such solution is limited to 10 – 15 meters, the time to get solution might be as long as 12,5 minutes (if the almanac data are out of date), and the horizontal obstacles are present.

Allowing receiving the Satellite Based Augmentation System corrections (EGNOS or WAAS), on the same frequency as the almanac data. In such messages there is ionosphere model transmitted, this model is used instead of standard Klobuchar model. It improves the accuracy of the solution by a factor of two/three so now the accuracy of the solution might be 2-3 meters. The main disadvantage is that the geostationary satellites in Europe are located in South and on the very low elevation angle ~20^0. Thus, most of the time, especially in the cities, the SBAS systems are useless.

Assisted GPS is a way to speed up the initialization process (receiving signal and almanac data from at least 4 satellites). It needs an internet connection to the server which, provides first estimates of the users position (based on the

[1] Witold Rohm, MSc, Wroclaw University of Environmental and Life Sciences, Faculty Of Environmental Engineering And Geodesy, Institute of Geodesy and Geionformatics, Grunwaldzka 53. witold.rohm@up.wroc.pl

cellular tower position and signal strength), and may also provides with missing observations in case of urban canyons, or in some modes even calculates the position of the user. The main advantage is the shorter Time To First Fix (TTFF), and possible navigation in urban canyons.

Hybrid navigation uses any other possible location service provided by the cellular phone network, WiFi network, or Inertial Navigation System.

Up till now none of the mass market manufacturer of the mobile devices have provided the Differential GPS solution for navigation. Differential GPS based on code measurements (***Fig. 1***) offers the positioning precision on the order of 1 m (NAWGIS) or 0.25m (KODGIS) and faster initialization process (TTFF).

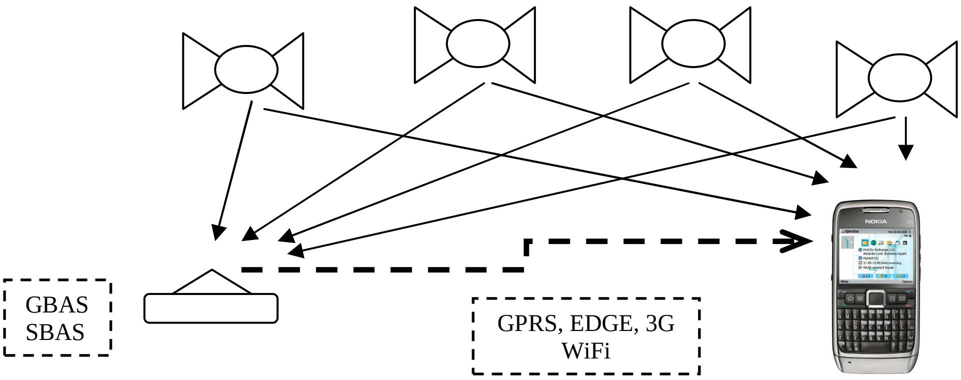

Fig. 1 *The DGPS concept*

This paper discuss the possibilities to implement DGPS software for Nokia mobile phones with Symbian operating system. In each DGPS system there are four interoperating elements needed:

- set of pseudoranges (to GPS satellites) for GPS mobile receiver
- set of pseudoranges (to GPS satellites) for GPS Ground Based Augmentation System, (or Satellite Based Augmentation System)
- data link between reference network GBAS (or SBAS) and mobile phone (via GPRS, EDGE, 3G or WiFi)
- software able to utilize corrections coming from GBAS or SBAS system

3 DGPS SOFTWARE

The software described in this paper is separated into 3 main blocks (***Fig. 2***):

- NMEA file, located on the mobile phone, decoder which in turns should give the set of SPP solutions, pseudoranges, and possibly ephemeris as observed by the mobile receiver
- NtripClient software which is able to connect to the NtripCaster port to receive pseudorange corrections, pseudorange correction rates, and optionally satellite ephemeris.
- DGPS software which will be responsible for calculation of the GPS satellites orbits, DGPS solution, and coding solution into new *.NME file.

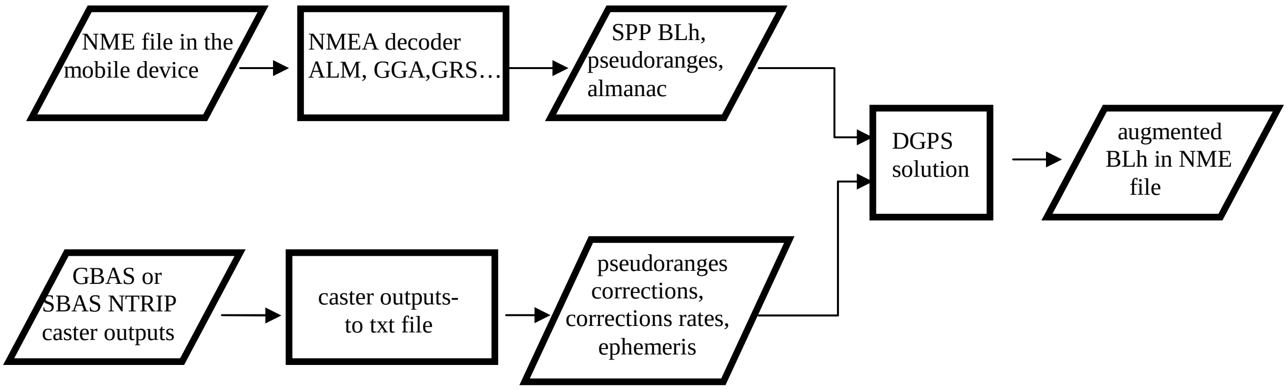

Fig. 2 *The DGPS flowchart*

3.1 NMEA decoder

The mobiles described here are most of the time equipped with a SiRF GPS chip which transmits the observations in the NMEA format into the ASCII file. The file contains continuously appended NMEA message. Here we are planning to use following messages:

- ALM – almanac data providing input for orbit arcs calculations,
- GGA – fix information basic information concerning Lat/Lon,
- GRS – GPS Range Residuals with respect to obtained solution,
- GSV – Detailed Satellite data the present visibility of satellites.

File after update by the GPS chip should be opened, then with the aid of pattern recognition function most recent information should be located and stored into separate file or into the memory.

3.2 NtripClient software

According to the Ntrip specification (RTCM) version 2.0, the Ntrip system consist of [2]:

- NtripSources, which generate data streams at a specified location,
- NtripServers, which transfer the data streams from a source to the caster,
- NtripCaster the major system component,
- NtripClient which access data stream of desired source at the NtripCaster.

The first three are provided and maintained by the management of the ASG-EUPOS and working in the real-time, transferring into the NtripCaster port 2101 the RTCM messages over HTTP protocol. As stated before the messages composition differs from service to service. Currently there are number of casters in Europe (EUREF-IP, SAPOS, CZEPOS...). The tasks for the NtripsClient software is to:

- retrieve from the NtripCaster sourcetable with all available mountpoints,
- request from the NtripCaster GNSS data from chosen mountpoint, here also authorization is being processed,
- send information in case of communication loss,
- write the requested information into a file or buffer.

The requested information consist of: pseudoranges corrections, pseudoranges correction rates, ephemeris if properiaty message used.

3.3 DGPS solution

The present pre realization stage of the project assumes usage of the classic iterative method to solve for position of the receiver. The method is separated into several steps:

- Calculation of the position of the satellites in the Earth Centered Earth Fixed based on the 3 angles rotation,
- Correction of pseudoranges with RTCM derived corrections,
- Based on the linearization of the equation for at least 4 pseudoranges ρ between satellite ^{S} and receiver $_R$ [2]:

$$\rho_R^S = \sqrt[2]{(X^s - X_0)^2 + (Y^s - Y_0)^2 + (Z^s - Z_0)^2} + cdt \tag{1}$$

derive the system of linear equations:

$$\hat{dx} = \left[A^T A\right]^{-1} A^T L \tag{2}$$

where $\hat{dx}$ is a corrections to approximate position of the receiver, and matrix A is a design matrix of the form:

$$A = \begin{bmatrix} \frac{-X^{S1}-X_P}{\rho_P^{S1}} & \frac{-Y^{S1}-Y_P}{\rho_P^{S1}} & \frac{-Z^{S1}-Z_P}{\rho_P^{S1}} & 1 \\ \frac{-X^{S2}-X_P}{\rho_P^{S2}} & \frac{-Y^{S2}-Y_P}{\rho_P^{S2}} & \frac{-Z^{S2}-Z_P}{\rho_P^{S2}} & 1 \\ \frac{-X^{S3}-X_P}{\rho_P^{S3}} & \frac{-Y^{S3}-Y_P}{\rho_P^{S3}} & \frac{-Z^{S3}-Z_P}{\rho_P^{S3}} & 1 \\ \frac{-X^{S4}-X_P}{\rho_P^{S4}} & \frac{-Y^{S4}-Y_P}{\rho_P^{S4}} & \frac{-Z^{S4}-Z_P}{\rho_P^{S4}} & 1 \\ \vdots & \vdots & \vdots & \vdots \\ \frac{-X^{Sn}-X_P}{\rho_P^{Sn}} & \frac{-Y^{Sn}-Y_P}{\rho_P^{Sn}} & \frac{-Z^{Sn}-Z_P}{\rho_P^{Sn}} & 1 \end{bmatrix},$$

(3)

and *L* is a vector containing the differences between pseudoranges from measurements ρ_R^S and based on coordinates of satellites and the iteratively obtained coordinates of the receiver P_R^S. The vector L is of the form:

$$L = \rho_P^S - P_P^S,$$

(4)

- The missing weighting matrix might be considered in the future development stage of the project,
- Transformation XYZ ->BLh,
- Also there is possibility to further improve the solution based on troposphere corrections.

All functions will be written in C++ and tested on accessible Nokia phones.

4 SUMMARY

Due to the increasing market for mobile phones positioning, there is a need to develop the services to upgrade time and precision of the first fix of the mobile receiver to one meter. The article shows the concept of increasing of accuracy of mobile phones positioning by using internet data link to the pseudorange correction data provider. Here the software is separated into three parts: NMEA decoder part, NtripClient software, DGPS solution. NMEA decoder part transfers the measurements (pseudoranges residuals, almanac, coordinates), to the required form/file, while NtripClient connects to the port on NtripCaster to download pseudorange corrections data, and eventually also ephemeris to speed up the fix time. DGPS solution is planned to be delivered as simple as possible to speed up the processing, further improvements are considered. The application should be operational in 6 months and available from OVI store.

Literature

[1] JARVINEN J., DESALAS J., LAMANCE J., Assisted GPS: *A Low-Infrastructure Approach*, GPS World, March 1, 2002

[2] ORUBA A., LEOŃCZYK M., RYCZYWOLSKI M., WAJDA S., *ASG-EUPOS po roku*, Geodeta - magazyn geoinformacyjny, Geodeta Sp. z o. o., nr 4/2009 (167), pp. 10-14.

[3] RTCM Standard 10403.1 for Differential GNSS (Global Navigation Satellite Systems) Services - Version 3, October 27 (2006)

[4] STRANG G., BORRE K., *Linear algebra, geodesy, and GPS*, Wellesley-Cambridge Press, 1997

Reviewer

Jan Kaplon, Wroclaw University of Environmental and Life Sciences, Faculty Of Environmental Engineering And Geodesy, Institute of Geodesy and Geionformatics, assistant professor, Grunwaldzka 53 50-357 Wroclaw, +48 71 3205682 jan.kaplon@up.wroc.pl