COMPARISON OF GSM AND GPS TECHNOLOGIES FOR TRACKING PEOPLE

Antonín SIROTEK[1], Jan HART[1]

[1]Department of Technological Equipment of Buildings, Faculty of Engineering, Czech University of Life Sciences Prague

Abstract
This article deals with the comparison of a technologies for tracking people. People can be tracked using GSM and GPS. These methods have different properties and are suitable for different applications. For this reason, GPS and GSM receivers have been tested. People were tracked for a period of 90 days. People did not change their behaviour in any way. The accuracy and reliability of these methods was monitored. This makes it possible to determine which method is more suitable for tracking people.

Key words: *GPS; GNS; tracking.*

INTRODUCTION

Thanks to modern technologies it is possible to not only determine your location but also to track other people or other things. Tracking people use emergency services, firefighters, police in search of missing persons and employers to control their employees. The first way is to track via a mobile network. Mobile network is a telecommunication network designed for telephone calls, data transfer and other services. The network consists of mobile devices, Base Transceiver Station (BTS), Serving Mobile Location Center (SMLC), Gateway Mobile Location Center (GMLC). These networks work most often at frequencies from 300MHz to 3GHz (*Eberspächer, et al., 2009*). Mobile phone users are well-traceable, which they may not be aware of. Tracing of a mobile device in the mobile network is necessary function based on the principle of operation. The mobile device still checks its position and connection to the transmitter BTS. Tracking is not possible in the area outside the BTS range (*Qayyum, et al., 2013*). Another option is using GNSS (Global Navigation Satellite System) localization. GNSS enables global satellite positioning. The current positioning systems in use are the American GPS (Global Positioning System), Russian GLONASS, European Galileo and the Chinese BeiDou. GNSS consists of a universe segment, user segment and control segment. A-GPS (Assisted GPS) has been used in our research. It is known that GPS positioning with code measurements for the civil sector has an accuracy of 5 to 15 m under ideal conditions (*Bona, 2000*). Smartphones typically have an accuracy of 5 meters in ideal conditions (*Diggelen, Enge, 2015*). Positioning using the mobile network has an accuracy of hundreds of meters. The most important thing here is the density of BTS transmitters (*Kos, et al., 2006*). However, it is necessary to test the accuracy and reliability of positioning in real conditions. The aim of this study is to determine which method is the most suitable for tracking people and what characteristics is has.

MATERIALS AND METHODS

It was tested tracking via mobile network, GPS and equipment using both methods. Equipment used methods E-OTD (The Enhanced Observed Time Difference method) in GSM and GPRS mobile networks and OTDOA (Observed Time Difference Of Arrival) method in UMTS networks for tracking in mobile networks. E-OTD method is a terminal based method. The mobile device includes clocks, which are synchronized by the network. The mobile device calculates the delay of the signal emitted from BTS. The result is the Real Time Difference (RTD). Value between two BTS is Geometry Time Difference (GTD). Intersections of GTD values indicate the most likely occurrence of mobile devices (*Dzulkifli, et al., 2017*). OTDOA method works on the same principle as the E-OTD method. The accuracy of localization by mobile networks depends on the density of BTS (*Orlich, 2006*). For the GSM method, we assume less accuracy and greater reliability.
Another method that was tested for determining the position was GPS. The receivers use code measurement methods. The code measurement principle uses the distance between the receiver and the transmitter to determine the position. The distance codes are the marks that determine the time when the satellite signal was broadcast. The receiver detects the broadcast time and code reception time. From the detected difference, the distance between the satellite and the receiver is determined. It is possible to

calculate the position from the signal of four satellites. This method is used in most ordinary GPS receivers (*Bensky, 2006*). In addition, A-GPS has been used for faster positioning. GBAS (Ground Based Augmentation Systems) and SBAS (Satellite Based Augmentation Systems) were not used. For GPS, we assume greater accuracy and low reliability.
Equipments displayed median position error. It is an estimate of accuracy in meters. The magnitude of the medium positional error is affected by the constellation of transmitters, number of transmitters used and the strength of the received signal. That is why, the accuracy of localization depends on the environment in which the receiver is located (*Ge, et al. 2017*). The navigation equipment used was PRA type LX series 1. Equipment includes GMS module and A-GPS receiver. It has a CPU Kirin 655 Octa-Core, 3 GB RAM, a triple virtual antenna, a battery with a capacity of 3000 mAh, for long life and works on the Android 7.0 platform.

Five people were tracked for 90 days. People were tracked using three devices. The first device uses the GSM method, the second GPS and the third device use GPS and GSM simultaneously. All three methods were measured at the same time. The tracking method was set on the device. The results were stored in the equipment memory. Measurements took place in Central Bohemia Region in Czech Republic in the territory with coordinates 50 ° 3′0 ″ N, 14 ° 42′36 ″ E. The measurement took place on weekdays in 2018.

RESULTS AND DISCUSSION

Five people have been monitored for 90 days in three ways of tracking. The tracking results using various methods are shown in Tab. 1., 2. and 3.

Tab. 1 Tracking via GSM and GPS

	m
Best accuracy	4.00
Worst accuracy	100.00
Modus	21.00
Median	21.00
Average accuracy	30.41

Tab. 2 Tracking via GSM

	m
Best accuracy	50.00
Worst accuracy	863.00
Modus	150.00
Median	170.00
Average accuracy	200.00

Tab. 3 Tracking via A-GPS

	m
Best accuracy	4.00
Worst accuracy	98.00
Modus	10.00
Median	38.00
Average accuracy	40.00

The devices worked 24 hours a day and recorded their position every hour. It was not always possible to determine the location. The Tab. 4 shows the number of measured values. If we compare how many times, we could not determine the location for each method, we can judge the reliability of the methods.

Tab. 4 Number of measured values

Method	n
GPS + GSM	10 152
GSM	10 044
GPS	7 020

The reliability of the individual methods is shown in Tab. 5.

Tab. 5 Reliability of the methods

Method	Reliability (%)
GPS + GSM	94
GSM	93
GPS	65

GPS accuracy is 5 to 15 m with conventional devices using the code measurements. The devices reach this accuracy with an excellent view of the sky (*Bhatta, 2011*). But tracked people spend most of their time in buildings or vehicles, where there is poor, or no sky view and GPS signal is weak. As a result, localization accuracy has deteriorated to 40 m. GPS tracking reliability was 65%. *Fischer et al., (2018)* reported a small error rate of 8.2%, because his measurement took place outside buildings. Therefore GPS-only tracking is not appropriate for search for people. This method is useful for cases, where we assume that people will be in an environment with a good view of the sky, for example, measuring sports performance, was described by *Scott et al., (2016)*. It is enough to monitor people's behaviour and health, reported by *Brusilovskiy et al., (2016)*. The average accuracy deteriorated to 200 m when localized via GSM. Reliability increased to 93%. It does not matter if the receiver moves inside or outside the building. Localization is possible everywhere there is a mobile network signal. GSM tracking is a reliable and less accurate method, which responds to our expectations. When using GPS and GMS localization simultaneously, we got surprisingly good results. It achieves the best accuracy and reliability. This method seems ideal for tracking people.

CONCLUSIONS

Tracking via GPS is suitable for applications where is not important reliability, but accuracy. Reliability of 65% does not seem to be enough for searching for people. Reliability is major when searching for persons. Of course, we can assume that tracked people will not be in an environment with a good view of the sky. Tracking via GSM is a reliable method, but worse accuracy in hundreds of meters makes it harder to find people. The device uses localization via GSM and GPS together achieved 93% of high reliability and good accuracy of 30.41 meters. This method seems to be best for tracking people.

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Corresponding author:
Ing. Antonín Sirotek, Department of Technological Equipment of Buildings, Faculty of Engineering, Czech University of Life Sciences Prague, Kamýcká 129, Praha 6, Prague, 16521, Czech Republic, phone: +420 721 354 426, e-mail: siroteka@tf.czu.cz