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EMPIRICAL STUDY OF GLOBAL POSITIONING SYSTEM ANALYZING ISSUES AND CHALLENGES

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ABSTRACT

This is a research paper on The steady This paper discusses the topic of the "last 100 meters connectivity" in systems where small devices (such as various sensors) are connected to services on a wide-area Internet network. Subject matters covered are the requirements on the "last 100 meters connectivity" vision as well as what wireless technologies would be suitable for future Internet of Things (IoT) use cases. This paper also presents the background to why u-blox envisions the "last 100 meters connectivity" is an important factor in the area of IoT and u-blox' view on the impact of IoT in general. As both mobile service providers and GPS device manufacturers struggle to find new profitable services to offer their customers, the convergence of GSM and GPS technologies is starting to bear fruit. By equipping global positioning terminals with a parallel wireless back-channel, a whole new realm of application possibilities emerge that would have been impossible with either technology alone. This whitepaper describes some recent deployments of converged wireless/GPS applications, and gives a hint as to what exciting possibilities lie in the near future.

Keywords: GPS (Global Positioning System), IoT (Internet of Things) SA (Selective Availability)

I. INTRODUCTION

(GPS) technology is a great boon to anyone who has the need to navigate either great or small distances. The Global Positioning System (GPS) is a burgeoning technology, which provides unequalled accuracy and flexibility of positioning for navigation, surveying and GIS data capture. This wonderful navigation technology was actually first available for government use back in the late 1970s.

The Global Positioning System (GPS) is a radio based **navigation system** that gives three dimensional coverage of the Earth, 24 hours a day in any weather conditions throughout the world. The technology seems to be beneficiary to the GPS user community in terms of obtaining accurate data upto about 100 meters for navigation, metre-level for mapping, and down to millimetre level for geodetic positioning. The GPS technology has tremendous amount of applications in Geographical Information System (GIS) data collection, surveying, and mapping.

The first GPS satellite was launched by the U.S. Air Force in early 1978. There are now at least 24 satellites orbiting the earth at an altitude of about 11,000 nautical miles. The high altitude insures that the satellite orbits are stable, precise and predictable, and that the satellites' motion through space is not affected by atmospheric drag. These 24 satellites make up a full GPS constellation. The satellites orbit the Earth every 12 hours at approximately 12,000 miles above the Earth. There are four satellites in each of 6 orbital planes. Each plane is inclined 55 degrees relative to the equator, which means that satellites cross the equator tilted at a 55 degree angle. The system is designed to maintain full operational capability even if two of the 24 satellites fail.

The GPS system consists of three segments: 1) The space segment: the GPS satellites themselves, 2) The control system, operated by the U.S. military, and 3) The user segment, which includes both military and civilian users and their GPS equipment.

The GPS system is passive, meaning that the satellites continuously transmit information towards the Earth. If someone has a GPS receiver they can receive the signal at no cost. The information is transmitted on two frequencies: L1 (1575.42 MHz), and L2 (1227.60 MHz). These frequencies are called carrier waves because they are used primarily to carry information to **GPS receivers**. The more information a receiver measures the more expensive the unit, and the more functions it will perform with greater accuracy.

When one receiver is tracking satellites and obtaining position data, the information received has traveled over 12,000 miles and has been distorted by numerous atmospheric factors. This results in accuracy of about 25 meters. Moreover, the department of Defense (the agency running the GPS) degrades receiver accuracy by telling the satellites to transmit slightly inaccurate information. This intentional distortion of the signal is called **Selective Availability** (SA). With SA turned on and one receiver is used, the greatest accuracy a user can expect is 100 meters.

To improve the accuracy of GPS, differential, or Relative Positioning can be employed. If two or more receivers are used to track the same satellites, and one is in a known position, many of the errors of SA can be reduced, and in some cases eliminated. Differential data can be accomplished using common code or carrier data (L1 or L2). The most accurate systems use differential data from a GPS **base station** that continually tracks twelve satellites and transmits the differential data to remote units using a radio link. With these systems centimeter accuracy and real-time navigation is possible.

All of these features make it a very desirable and useful technology for a mirid of activities including Search and Rescue, Aviation and Nautical navigation, hiking, hunting, camping, fishing, and many more. All of these various GPS users have unique needs which require different levels of understanding and skill in using this technology.

The Russian government has developed a system, similar to GPS, called GLONASS. The first GLONASS satellite launch was in October 1982. The full constellation consists of 24 satellites in 3 orbit planes, which have a 64.8 degree inclination to the earth's equator. The GLONASS system now consists of 12 healthy satellites. GLONASS uses the same code for each satellite and many frequencies, whereas GPS which uses two frequencies and a different code for each satellite.

Galileo is Europe's contribution to the next generation Global Navigation Satellite System (GNSS). Unlike GPS, which is funded by the public sector and operated by the U.S. Air Force, Galileo will be a civil-controlled system that draws on both public and private sectors for funding.

The service will be free at the point of use, but a range of chargeable services with additional features will also be offered. These additional features would include improved reception, accuracy and availability. Design of the Galileo system is being finalized and the delivery of initial services is targeted for 2008.

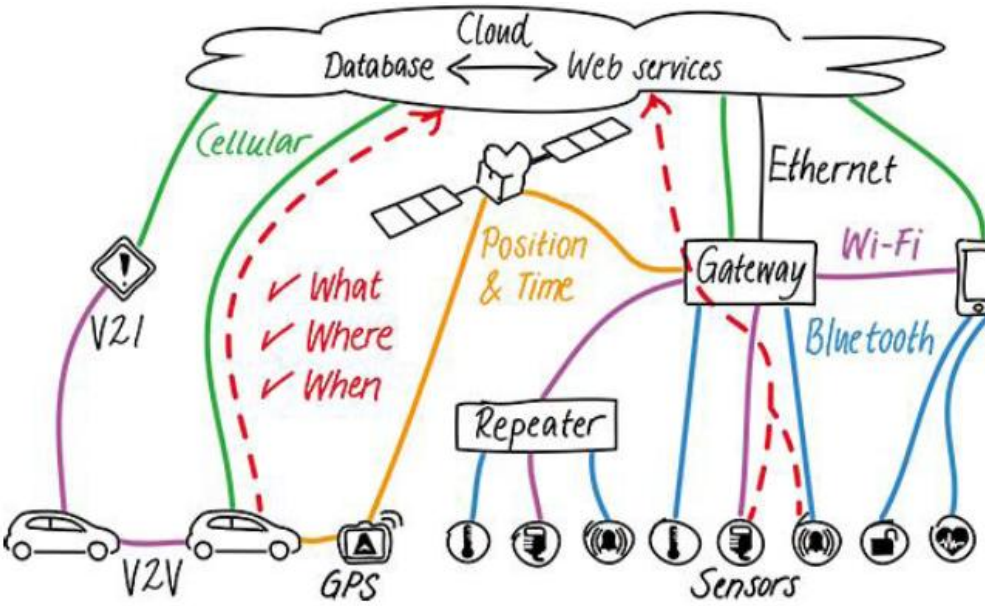

Figure 1 GPS Architecture with Application

II. BASIC CONCEPT OF GPS

By positioning we understand the determination of stationary or moving objects. These can be determined as follows:

1. In relation to a well-defined coordinate system, usually by three coordinate values and
2. In relation to other point, taking one point as the origin of a local coordinate system.

The first mode of positioning is known as point positioning, the second as relative positioning. If the object to be positioned is stationary, we term it as static positioning. When the object is moving, we call it kinematic positioning. Usually, the static positioning is used in surveying and the kinematic position in navigation.

2.1 GPS - Components and Basic Facts

The GPS uses satellites and computers to compute positions anywhere on earth. The GPS is based on satellite ranging. That means the position on the earth is determined by measuring the distance from a group of satellites in space. The basic principles behind GPS are really simple, even though the system employs some of the most high-tech equipment ever developed. In order to understand GPS basics, the system can be categorized into

FIVE logical Steps

- Triangulation from the satellite is the basis of the system.
- Totriangulate, the GPS measures the distance using the travel time of the radio message.
- To measure travel time, the GPS need a very accurate clock.
- Once the distance to a satellite is known, then we need to know where the satellite is in space.
- Asthe GPS signal travels through the ionosphere and the earth's atmosphere, the signal is delayed.
- To compute a positions in three dimensions. We need to have four satellite measurements. The GPS uses a trigonometric approach to calculate the positions, The GPS satellites are so high up that their orbits are very predictable and each of the satellites is equipped with a very accurate atomic clock.

2.2 The Control Segment

The Control Segment consists of five monitoring stations (Colorado Springs, Ascesion Island, Diego Garcia, Hawaii, and Kwajalein Island). Three of the stations (Ascension, Diego Garcia, and Kwajalein) serve as uplink installations, capable of transmitting data to the satellites, including new ephemerides (satellite positions as a function of time), clock corrections, and other broadcast message data, while Colorado Springs serves as the master control station. The Control Segment is the sole responsibility of the DoD who undertakes construction, launching, maintenance, and virtually constant performance monitoring of the GPS satellites.

The DOD monitoring stations track all GPS signals for use in controlling the satellites and predicting their orbits. Meteorological data also are collected at the monitoring stations, permitting the most accurate evaluation of tropospheric delays of GPS signals. Satellite tracking data from the monitoring stations are transmitted to the master control station for processing. This processing involves the computation of satellite ephemerides and satellite clock corrections. The master station controls orbital corrections, when any satellite strays too far from its assigned position, and necessary repositioning to compensate for unhealthy (not fully functioning) satellites.

2.3 The Space Segment

The Space Segment consists of the Constellation of NAVASTAR earth orbiting satellites. The current Defense Department plan calls for a full constellation of 24 Block II satellites (21 operational and 3 in-orbit spares). Each satellite contains four precise atomic clocks (Rubidium and Cesium standards) and has a microprocessor on board for limited self-monitoring and data processing.

- **Satellite orbits.**

There are four satellites in each of 6 orbital planes. Each plane is inclined 55 degrees relative to the equator, which means that satellites cross the equator tilted at a 55 degree angle. The system is designed to maintain full operational capability even if two of the 24 satellites fail. They orbit at altitudes of about 12000, miles each, with orbital periods of 12 sidereal hours (i.e., determined by or from the stars), or approximately one half of the earth's periods, approximately 12 hours of 3-D position fixes. The satellites are equipped with thrusters which can be used to maintain or modify their orbits. The next block of satellites is called Block IIR, and they will provide improved reliability and have a capacity of ranging between satellites, which will increase the orbital accuracy.

- **Satellite Signals**

GPS satellites continuously broadcast satellite position and timing data via radio signals on two frequencies: L1 (1575.42 MHz), and L 2 (1227.60 MHz). These frequencies are called carrier waves because they are used primarily to carry information to GPS receivers. The radio signals travel at the speed of light (186,000 miles per second) and take approximately 6/100ths of a second to reach the earth.

The satellite signals require a direct line to GPS receivers and cannot penetrate water, soil, walls or other obstacles. For example, heavy forest canopy causes interference, making it difficult, if not impossible, to compute positions. In canyons (and "urban canyons" in cities) GPS signals are blocked by mountain ranges or buildings. If you place your hand over a GPS receiver antenna, it will stop computing positions.

Two kinds of code are broadcast on the L1 frequency (C/A code and P code). C/A (Coarse Acquisition) code is available to civilian GPS users and provides Standard Positioning Service (SPS). Using the Standard Positioning Service one can achieve 15 meter horizontal accuracy 95% of the time.

This means that 95% of the time, the coordinates you read from your GPS receiver display will be within 15 meters of your true position on the earth. P (Precise) code is broadcast on both the L1 and L2 frequencies. P code, used for the Precise Positioning Service (PPS) is available only to the military. Using P code on both frequencies, a military receiver can achieve better accuracy than civilian receivers. Additional techniques can increase the accuracy of both C/A code and P code GPS receivers.

2.3 The User Segment

The user segment is a total user and supplier community, both civilian and military. The User Segment consists of all earth-based GPS receivers. Receivers vary greatly in size and complexity, though the basic design is rather simple. The typical receiver is composed of an antenna and preamplifier, radio signal microprocessor, control and display device, data recording unit, and power supply.

The GPS receiver decodes the timing signals from the 'visible' satellites (four or more) and, having calculated their distances, computes its own latitude, longitude, elevation, and time. This is a continuous process and generally the position is updated on a second-by-second basis, output to the receiver display device and, if the receiver display device and, if the receiver provides data capture capabilities, stored by the receiver-logging unit.

III. FACTORS THAT AFFECT GPS

There are a number of potential error sources that affect either the GPS signal directly or your ability to produce optimal results:

- **Number of satellites - minimum number required**:

You must track at least four common satellites - the same four satellites - at both the reference receiver and rover for either DGPS or RTK solutions. Also to achieve centimeter -level accuracy, remember you must have a fifth satellite for on-the fly RTK initialization. This extra satellite adds a check on the internal calculation. Any additional satellites beyond five provide even more checks, which is always useful.

- **Multipath- reflection of GPS signals near the antennae:**

Multipath is simply reflection of signals similar to the phenomenon of ghosting on our television screen. GPS signals may be reflected by surfaces near the antennae, causing error in the travel time and therefore error in the GPS positions.

- **Ionosphere- change in the travel time of the signal:**

Before GPS signals reach your antenna on the earth, they pass through a zone of charged particles called the ionosphere, which changes the speed of the signal. If your reference and rover receivers are relatively close together, the effect of ionosphere tends to be minimal. And if you are working with the lower range of GPS precisions, the ionosphere is not a major consideration. However if your rover is working too far from the reference station, you may experience problems, particularly with initializing your RTK fixed solution.

 Troposphere - change in the travel time of the signal: Troposphere is essentially the weather zone of our atmosphere, and droplets of water vapors in it can affect the speed of the signals. The vertical component of your GPS answer (your elevation) is particularly sensitive to the troposphere.

 Satellite Geometry - general distribution of the satellites: Satellite Geometry or the distribution of satellites in the sky effects the computation of your position. This is often referred to as Position Dilution of Precision (PDOP). PDOP is expressed as a number, where lower numbers are preferable to higher numbers. The best results are obtained when PDOP is less than about 7.PDOP is determined by your geographic location, the time of day you are working, and any site obstruction, which might block satellites. You can use planning software to help you determine when you'll have the most satellites in a particular area.

When satellites are spread out, PDOP is Low (good).

When satellites are closer together, PDOP is High (weak).

 Satellite Health - Availability of Signal: While the satellite system is robust and dependable, it is possible for the satellites to occasionally be unhealthy. A satellite broadcasts its health status, based on information from the U.S. Department of Defense. Your receivers have safeguards to protect against using data from unhealthy satellites.

 Signal Strength - Quality of Signal : The strength of the satellite signal depends on obstructions and the elevation of the satellites above the horizon. To the extent it is possible, obstructions between your GPS antennae and the sky should be avoided. Also watch out for satellites which are close to the horizon, because the signals are weaker.

 Distance from the Reference Receiver : The effective range of a rover from a reference station depends primarily on the type of accuracy you are trying to achieve. For the highest real time accuracy (RTK fixed), rovers should be within about 10-15 Km (about 6-9 miles) of the reference station. As the range exceeds this recommended limit, you may fail to initialize and be restricted to RTK float solutions (decimeter accuracy).

 Radio Frequency (RF) Interference: RF interference may sometimes be a problem both for your GPS reception and your radio system. Some sources of RF interference include:

 Radio towers

 Transmitters

 Satellite dishes

 Generators

One should be particularly careful of sources which transmit either near the GPS frequencies (1227 and 1575 MHz) or near harmonics (multiples) of these frequencies. One should also be aware of the RF generated by his own machines.

 Loss of Radio Transmission from Base:

If, for any reason, there is an interruption in the radio link between a reference receiver and a rover, then your rover is left with an autonomous position. It is very important to set up a network of radios and repeaters, which can provide the uninterrupted radio link needed for the best GPS results.

Table 1: Possible Sources of GPS Error and their general impact on positioning accuracy.

Error source	Potential error	Typical error
Ionosphere	5.0 meters	0.4 meters
Troposphere	0.5 meters	0.2 meters
Ephemeris data	2.5 meters	0 meters
Satellite clock drift	1.5 meters	0 meters
Multipath	0.6 meters	0.6 meters
Measurement noise	0.3 meters	0.3 meters
Total	~ 15 meters	~ 10 meters

IV. GPS APPLICATIONS

Global Positioning Systems is in fact is available to users at any position worldwide at any time. With a fully operational GPS system, it can be generated to a large community of likely to grow as there are multiple applications, ranging from surveying, mapping, and navigation to GIS data capture.

There are countless GPS applications, a few important ones are covered in the following passage.

- **Surveying and Mapping**

The high precisions of GPS carrier phase measurements, together with appropriate adjustment algorithms, provide an adequate tool for a variety of tasks for surveying and mapping. Using DGPS methods, accurate and timely mapping of almost anything can be carried out. The GPS is used to map cut blocks, road alignments, and environmental hazards such as landslides, forest fires, and oil spills. Applications, such as cadastral mapping, needing a high degree of accuracy also can be carried out using high grade GPS receivers. Continuous kinematic techniques can be used for topographic surveys and accurate linear mapping.

- **Navigation**

Navigation using GPS can save countless hours in the field. Any feature, even if it is under water, can be located up to one hundred meters simply by scaling coordinates from a map, entering waypoints, and going directly to the site. Examples include road intersections, corner posts, plot canters, accident sites, geological formations, and so on. GPS navigation in helicopters, in vehicles, or in a ship can provide an easy means of navigation with substantial savings.

- **Remote Sensing and GIS**

It is also possible to integrate GPS positioning into remote-sensing methods such as photogrammetry and aerial scanning, magnetometry, and video technology. Using DGPS or kinematic techniques, depending upon the accuracy required, real time or post-processing will provide positions for the sensor which can be projected to the ground, instead of having ground control projected to an image. GPS are becoming very effective tools for GIS data capture. The GIS user community benefits from the use of GPS for location data capture in various GIS applications. The GPS can easily be linked to a laptop computer in the field, and, with appropriate software, users can also have all their data on a common base with every little distortion. Thus GPS can help in several aspects of construction of accurate and timely GIS databases.

- **Geodesy**

Geodetic mapping and other control surveys can be carried out effectively using high-grade GPs equipment. Especially when helicopters were used or when the line of sight is not possible, GPS can set new standards of accuracy and productivity.

- **Military**

The GPS was primarily developed for real time military positioning. Military applications include airborne, marine, and navigation.

V. CONCLUSION

Barring significant new complications due to S/A (Selective Availability) from DOD, the GPS industry is likely to continue to develop in the civilian community. There are currently more than 50 manufacturers of GPS receivers, with the trend continuing to be towards smaller, less expensive, and more easily operated devices.

While highly accurate, portable (hand-held) receivers are already available, current speculation envisions inexpensive and equally accurate 'wristwatch locators' and navigational guidance systems for automobiles. However, there is one future trend that will be very relevant to the GIS user community, namely, community base stations and regional receive networks, as GPS management and technological innovations that will make GPS surveying easier and more accurate.

Also **INDIA** in the future will do use this technology, not only in the field of Defense, but also in civilian community as this is not a scientific luxury but is the need of future.

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