Global Positioning System

Rupish Arora[1], Asmita Gautam[2], Shilpa Sahni[3]

[1] Assistant Prof. , Department of Computer Science & Engineering, M.B.S College, University of Jammu, India
[2] Student, Department of Computer Science & Engineering, M.B.S College, University of Jammu, India
[3] Student, Department of Computer Science & Engineering, M.B.S College, University of Jammu, India

Abstract *— A system that supports the activity of moving to a place or finding a place is a navigation system. Global Positioning System (GPS) is the popular term for navigation system. GPS is a satellite system whose basic aim is to find the current location and provide directions to other locations. This paper gives an overview of GPS, its basic concepts, GPS receiver and its working. The basic concepts include trilateration and system segmentation. A simple GPS receiver requires only a screen and a compass. Now GPS is not only limited to a single country but has become a global phenomenon.*

Keywords *— Navigation, GPS, Trilateration, System segmentation, Location*

I. INTRODUCTION

A navigation system consolidates hardware and software related to sensors (position and orientation), computing and communication. The navigation system guides movement of mobile objects. The system can either be land based or space based. The history of navigation systems can be traced back to the earliest of times when navigation was restricted to follow landmarks or memorize a particular route. Historical records show some of the early navigation devices such as the magnetic compass and odometer. The introduction of modern navigation devices were introduced in early 20th century. These devices are automated and intelligent enough to determine the location, display it and update it as well.

The Global Positioning System is a satellite based navigation system that provides rapid, cost effective and accurate navigation. The prime advantage of GPS is that it can locate anyone on anytime whether on land, sea or air.

GPS has become the part of our life through the efforts of American Military. In 1950, the US Navy started using artificial satellites to study navigation. TRANSIT was the very first aid in this programme and was able to locate accurately the receivers spread over an area of 160 meters. The system failed to provide accurate information for ships located at ports or shallow water. In 1967, TIMATION I satellite was launched for moving receivers and was more accurate than the former satellite system. The popularity of the concept made the aviation industry interested to invest in this project and to improve it for locating faster moving objects. The current high speed navigation is based on NAVSTAR (Navigation Satellite Timing and Ranging). NAVSTAR was an initial project of United States Department of Defence in the year 1973. NAVSTAR proved to be an excellent replacement as it was used in handling a variety of projects. It is extremely reliable as it is able to provide information in all weather conditions and can survive in any condition. It was designed to provide no receiving functions so that their competitors could not detect signals transmitted by the US military. With time passing by this technology became available to larger masses.

The satellites used in this system offer 24 hour-a-day coverage through which both two and three dimensional positioning is possible anywhere on earth.

GPS offers two levels of services:-

- SPS (Standard Positioning Services) which is used by civilians worldwide and the service is free of cost.
- PPS (Precise Positioning Service) accessible to military with higher level of encryption.

II. BASIC CONCEPTS

Trilateration

Trilateration is one of the important concepts to understand the working of GPS. This concept involves three satellites that provide details on location and the speed with which the object is moving relative to three satellites. It can be thought in a way as pin pointing a location on a map while being aware of the exact distance from three different places. Basically these satellites can be imagined to be extending acorn to cover an object's location. While reaching close to the earth the cones from circles that intersect each other and the intersection point is the position of object.

To elaborate information from a single satellite identifies a large area of the earth. Adding information from second satellite limits down the position to an area where two circles imbricate. Then again getting data from third satellite will provide a highly precise position. The more the number of satellites used to analyse a particular position, more accurately that position will be determined.

Fig 1: Basic Concepts of Trilateration

System Segmentation

Currently GPS contains three main segments namely-

- ***Space Segment:*** - It consists of 24 satellites and four out of total number of satellites are maintained in each of six orbits, giving a total system of 24 satellites. Every single satellite in an orbit is at altitude of 11,000 nautical miles and it takes about 12 hours for a satellite to move around the orbit one time. The six orbits are inclined at an angle of 55 degree. This was done so that the polar regions of the earth could also be covered. These satellites work on solar energy. These satellites orbit the earth twice a day to transmit precise and accurate time and position. Along with the 24 satellites five spare satellites are available to resolve any catastrophic situation. There are four atomic locks on each satellite.
- ***Control Segment:*** - This segment contains five base stations situated worldwide. These stations automatically monitor the satellites so that they work correctly. The paths of the satellites are monitored by US air force. The stations are situated in Hawaii, Kwajalein, Ascension Island, Diego Garcia and Colorado springs. These stations remain in contact with GPS satellites so that they can update information and organise and coordinate the atomic locks on board.
- ***User Segment:*** - This part consists of receivers which can be placed in handheld machine. Each receiver contains an antenna that is a coordinated with the satellite frequency, receiver processors and a stable clock. Depending on the application using the GPS technology it may also include a display so that the information can be provided to the user of that application. The receivers have an ephemeris that is registered into a computer or any other device and it keeps track where the satellites are at a particular position. To summarize the receivers detect, decode and process all the signals that it receives from satellites at a particular time. Since, there is no direct communication between a user and a satellite, a number of users can benefit from the satellites at the same time.

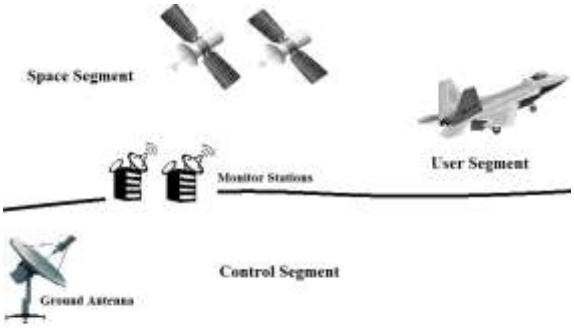

Fig 2: Relationship between Three Segments

III. INTRODUCTION TO GPS RECEIVERS

GPS devices look different and have different software's. An important difference that prevails among these receivers is the number of satellites to which they can communicate concurrently. The modern day receiver has the ability to communicate with 14-20 satellites simultaneously. A receiver can be characterized as 12 channel. This means that the receiver has the ability to communicate 12 satellites.

In every GPS device there is some sort of a display screen. Depending on the device user might be able to view only a single page, termed as the default page or he may view several pages depending upon the versatility of the device. The default screen incorporates various elements which are:-

- The concentric circles representing horizon
- Bottom of the screen exhibiting the strength of the signal
- Dots illustrating the satellites

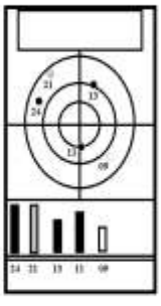

Fig 3: Basic GPS Screen Layout

For data to be preserved the GPS receiver are equipped with database. There are mainly two types of data that a receiver will record:-

- The basic data that GPS will inscribe in terms of distance moved is known as track points.
- The data which is stored according to the user's preference is known as way point.

Essential part of the GPS receiver is the compass. Most receivers prefer digital compass over the magnetic compass since, the digital compass is cheaper. The compass will only work when the device is in motion.

IV. WORKING OF GPS

The aim of the GPS device is to locate the position of an object. Thus, the basic principle on which the GPS technology works is based on the estimation of distance between each satellite and the user. This is termed as satellite ranging. For this the satellite sends out a low powder radio signal to the receiver. The receiver determines the time taken by the signal to traverse from the satellite to the receiver. Now the receiver will determine the distance using the formula:-

$$D = c \times (t_f - t_i)$$

Where D = distance between the satellite and the receiver,
c = speed of light
t_f = time at which the signal reaches the receiver
t_i = time at which the signal originates from the satellite

To elucidate the above process let us assume that at a particular time the satellite sends out a complex but random signal. The receiver will also run the same pattern. There will be a certain time lag between the reception of the signal and playing of the signal.

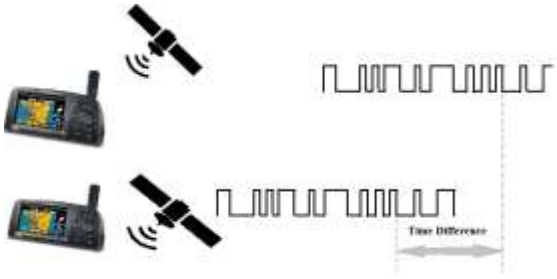

Fig 4: Indifference of Time

Since there is an indifference of time, both receiver and satellite need to be synchronized. Atomic clocks are the best option but a bit expensive too. So there is no doubt that the atomic clocks can be used in satellites but not in the receivers. A practical solution is to use quartz clock instead of atomic clocks for the receiver. To summarize the receiver needs input from three or more satellites to adjust its own inaccuracy.

For determining a two dimensional position i.e. latitude and longitude there is a requirement of three satellites and for a three dimensional position i/e/ latitude, longitude and altitude there is a requirement of four satellites.

Input from one satellite deduces that the GPS receiver device is at a uniform distance from the satellite, thus making a sphere with radius (say r) equal to the distance between the satellite and the GPS receiver (D) i.e.,

$$r = D$$

This is shown in the following figure.

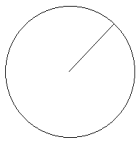

Fig 5: Single Satellite

Now input from two satellites will deduce that two spheres intersect each other forming a line and the receiver might be anywhere in that area of line as shown in the following figures.

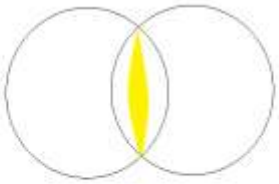

Fig 6: Two Satellites

Again input from three satellites will result the device to be on any of the two locations formed by the intersection of plane and a circle. One of these locations will be a point on the earth and that will give the final position of the GPS receiver device, the other point will be not considered. Only one of the two points will be present on the surface of earth at a particular time. This is shown in the following figure.

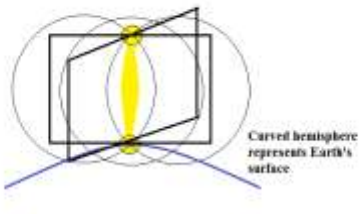

Fig 7: Three Satellites

To summarize more the number of inputs from the satellites more accurate and precise will be the reading of a GPS receiver device.

V. FUTURE SCOPE

GPS today is sophisticated, versatile, accurate and precise, all thanks to the interest shown in the progress of the technology. Initially only US had taken the initiative and are controlling the existing network of satellites i.e., NAVSTAR, but with the range of services GPS is providing, many other countries have also take up the initiative. The other popular Global Navigation Satellite includes GLONASS, Galileo, Compass and many more. The most popular regional satellite navigation system is being developed by India and will be controlled by the Indian Space Research Organisation (ISRO) and is named IRSS (Indian Regional Navigation Satellite System). An ongoing research at Stanford is trying to use signals from multiple satellite systems (US GPS, Russian GLONASS, Chinese BeiDou, Japan Quasi-Zenith, EU's Galileo and India IRNSS) to form a multi constellation Global Navigation Satellite System. To study marine animals and protect aquatic life GPS tags are being developed to know the real time location of marine animals. Also a lot of research is going on in making a software receiver rather than using a hardwired receiver. It will be more flexible and will be designed so that it can be reconfigured quickly.

VI. CONCLUSIONS

As the number of satellites will be increased in the future it will help GPS track more accurate and precise location. This will not only help in making the current database more accurate but will also help in increasing the database so that remote locations can be found. Also the success rate of regional GPS services will be more accurate as compared to the global ones. GPS is not exclusive any more. Experts, developers and global investors behind mega social platforms are introducing features to keep up with the ever changing GPS technology.

REFERENCES

[1] A. Damani , H. Shah, K. Shah and M. Vala, "Global Positioning System for Objet Tracking," International Journal of Computer Applications, vol. 109, pp. 40-45, Jan. 2015.

[2] J. Wolf, S. Hallmark, M. Oliveira, R. Guensler and W. Sarasua, "Accuracy Issues with Route Choice Data Collection by Using Global Positioning System," Transportation Research Record Journal, pp. 66-74.

[3] S. Pooja, "Vehicle Tracking System Using GPS," International Journal of Science and Research, vol. 2, pp. 128-130, Sept. 2013.

[4] Obuhuma, J. I., Moturi, C. A., "Use of GPS With Road Mapping For Traffic Analysis," International Journal of Scientific and Technology Research, vol. 1, pp. 120-128, Nov. 2012

[5] S. Darekar, A. Chikane, R. Diwate, A. Deshmukh and Prof. A. Shinde, "Tracking System Using GPS and GSM: Practical Approach," International Journal of Scientific and Engineering Research, vol. 3, pp. 1-4, May 2012.

[6] S. Menaga, S.S. Anusha, S.B. Shankari and M.D. Bharathi, "Real Time Web Based Tracking System Using GSM and GPS Technology," International Journal on Applications in Engineering and Technology, vol. 1, pp. 23-27, Feb. 2015.

[7] M. Mohammadi, E. Molaei and A. Naserasadi, "A Survey on Location based Services and Positioning Techniques," International Journal of Computer Applications, vol. 24, pp. 1-5, June 2011.

[8] S. Lee, G. Tewolde and J. Kwon, "Design and Implementation of Vehicle Tracking System Using GPS/GSM/GPRS Technology and Smart Phone Applications," IEEE World Forum on Internet of Things, pp. 353-358, March 2014.

[9] Ashwini B M and Dr. Usha J, "Location Based Services – Positionig Techniques and its Applications," International Journal of Application or Innovation in Engineering and Management, vol. 3, pp. 176-183, Jan. 2014

[10] S.S. Babu, Y. Vijayalakshmi, Dr. A.R. Murthy and Prof. J.R. Kala, "Improving Performance and Privacy in Location Based Service Applications Using GPS," IOSR Journal of Computer Engineering, pp. 28-31, 2016

[11] R. Jegadeeswari and S. Parameswaran, "Location-Based Services Using Autonomous GPS," International Journal for Research in Applied Science and Engineering Technology, Issue 3, pp. 84-92, Nov. 2014.

[12] R. Ramani, S. Valarmathy, Dr. N.S. Vanitha, S. Selvaraju, M. Thiruppathi and R. Thangam, "Vehicle Tracking and Blocking System Based on GSM and GPS," International Journal of Intelligent Systems and Applications, vol. 5, pp. 86-93, Aug. 2013.

[13] Muthumurugesan D, Nalini S and Vinodini R, "Smart Way to Track the Location in Android Operating System," IOSR Journal of Computer Engineering, vol. 12, pp. 27-32, Jul. – Aug. 2013

[14] M. Singhal and A. Shukla, "Implementation of Location based Services in Android using GPS and Web Services," International Journal of Computer Science Issues, vol. 9, pp. 237-242, Jan. 2012.

[15] M. Mukhtar, "GPS Based Advanced Vehicle Tracking and Vehicle Control System," International Journal of Intelligent Systems and Applications, vol. 7, pp. 1-12, Feb. 2015.

[16] S. Kotte and H.B. Yanamadala, "Advanced Vehicle Tracking System on Google Earth using GPS and GSM," International Journal of Computer Trends and Technology, vol. 6, pp 130-133, Dec 2013

[17] E. Gupta, "Global Positioning System using Dijkstra's Algorithm Traffic Planning System," International Journal of Computer Trends and Technology, vol35, pp 231-235, May 2016