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GPS Based Low Cost Intelligent Vehicle Tracking System (IVTS)

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Abstract. Intelligent Vehicle tracking systems (IVTS) are used for the purpose of tracking and navigation of vehicles. The paper describes the implementation of Global positioning systems (GPS) in IVTS systems. Further a critical GPS based low cost IVTS architecture has been described. The first part of the paper describes the need and the basic architecture of a general GPS based IVTS system. The three IVTS units (i.e. In-Vehicle unit, Communication link and Base station) are described individually. Further the paper describes how and why cost plays a major role in popularizing an IVTS system. The modification that should be carried out in the individual units to obtain a low cost GPS based IVTS system which suits the present dynamic urban environment are explained. The modifications carried out in IVTS units also help in finding a reliable and accurate planimetric solution in case of poor visibility of the GPS satellites, which usually is common in urban environment.
The GPS based low cost intelligent vehicle tracking system can be successfully designed and applied in the urban environment of a developing country like India. This if implemented in a well planned manner will bring significant revolutionary enhancement in the Indian transportation industry.

Keywords: IVTS, GPS, Tracking, Navigation

1. Introduction

Maps are older than alphabets. It is one of the most primitive natures of the human being to know their exact location on the surface of earth and at present Radio Navigation Systems (e.g NAVSTAR GPS (USA), GLONASS (Russia), GALELIO (European Community)) are the most efficient, accurate and reliable technology available to determine the precise position of any point on or above the surface of earth.

In the present fast moving urban life, transportation is among the most common and frequent needs. With the technological advancement in the transportation sciences the need of secure. dynamic and highly efficient system is felt. Use of radio navigation system best fit these entire high end requirements of transportation community (Kulkarni, 2001).

With the implementation of radio navigation system in vehicles they become capable of transmitting the information about their current geodetic position. Use of this information can be done in many systems like real time intelligent dynamic vehicle tracking and navigation system, mobile asset management system, fleet management system, travel time studies, traffic control etc.

In order to make any technology popular and bring it to masses cost plays the most crucial role. The paper describes a low cost intelligent vehicle tracking system based on NAVSTAR GPS, a radio navigation system by USA Department of Defense (DOD).

2. STANDARD INTELLIGENT VEHICLE TRACKING SYSTEM (IVTS)

An intelligent vehicle tracking system (IVTS) is generally used for tracking and navigation of vehicles. These tracking as well as navigation arc possible by using GPS in vehicles. Tacking provides a continuous

track of the vehicle whereas Navigation guides the user to the desired destination. The basic methodology remains same in both tracking and navigation (Padmanabhan, 2001). A standard IVTS is as shown in Fig.l.

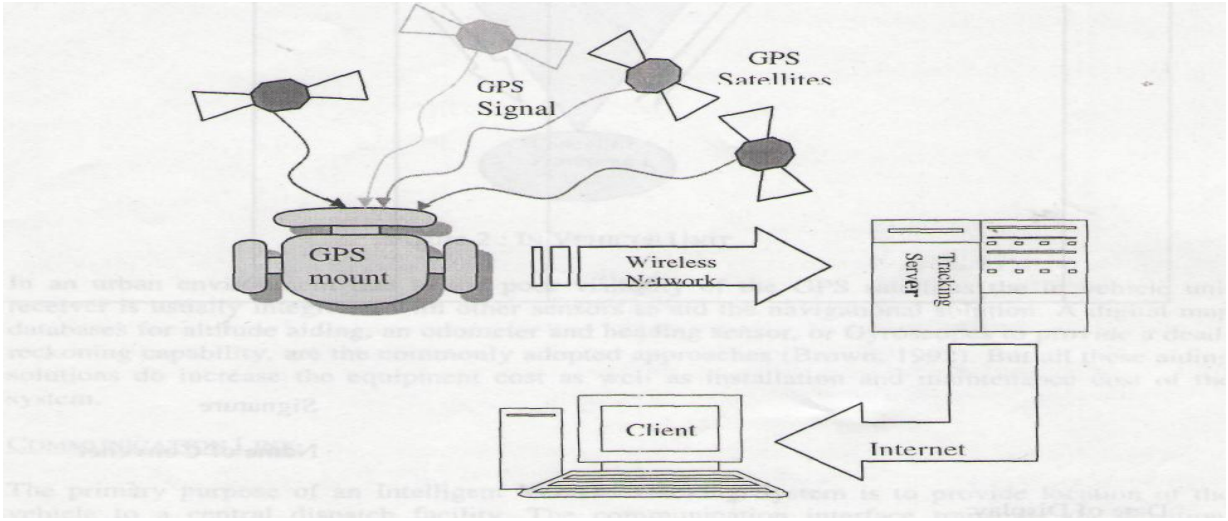

Figure 1: Standard IVTS Architecture

2.1. A standard IVTS basic modules:

2.1.1. In Vehicle Unit

The GPS unit placed in the vehicle receives signal from any four visible satellites among the constellation of satellites in the space. As shown in Fig.2 the GPS unit consists of a receiver, a controller/processing unit and a communication interface (Cellular Modem) (Kaplan, 1995).

Receiver captures signal from GPS satellites and send it to the controller unit. The controller unit processes the signal and calculates the Position, Velocity and exact Time (PVT) of the vehicle using passive trilateration[1] mechanism (http://www.trackmyvehicle.com). Signals arc tracked from four or more GPS satellites in order to resolve the 3-D position of the vehicle and to synchronize the receiver with GPS time.

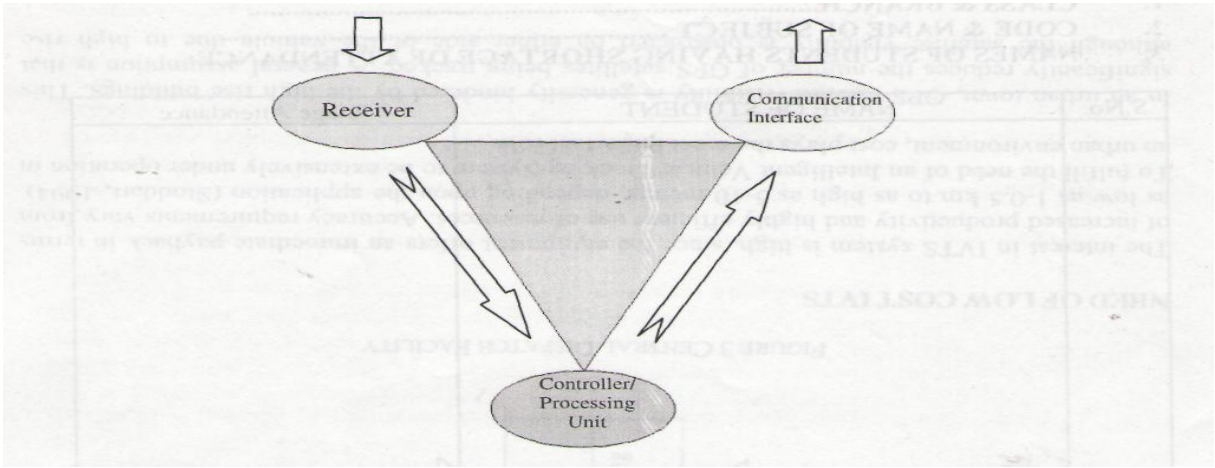

Figure 2: In Vehicle Unit

In an urban environment due to the poor visibility of the GPS satellites the in vehicle unit receiver is usually integrated with other sensors ID aid the navigational solution. A digital map databases for altitude aiding, an odometer and heading sensor, or Gyroscopes to provide a dead reckoning capability, are the commonly adopted approaches (Brown, 1992). But all these aiding solutions do increase the equipment cost as well as installation and maintenance cost of the system.

2.1.2. Communication Link

The primary purpose of an Intelligent Vehicle Tracking System is to provide location of the vehicle to a central dispatch facility. The communication interface transmits the Position, Velocity and Time information calculated by In Vehicle Unit, via wireless communication network to the tracking server at the base station

(http://www.trackmyvehicle.eoni) Communication systems that are commonly used for this purpose includes VHP, cellular radio and even satellite links. To make full use of the system, the communication link installed must be full duplex (i.e. both way transmission between in vehicle unit and the base station). This facilitates the display of vehicle location at tracking server as well as allowing the dispatch of routing information from the tracking server to the vehicle being tracked (Brown, 1992).

2.1.3. Bash Station

With the advent of sophisticated graphics and Geographical Information System (GLS), a host of information is available that can either be displayed at the base station or at client node (http://www.trackmyvehicle.com). As shown in Fig.3, the tracking server at the base station receives the PVT information of the vehicle. An application software is installed on the base station which displays the positional information of the vehicle in the form of a digital map. The client can log onto the tracking servers via web (internet) and access the desired locational information. These tracking servers are usually designed as very high end with the facilities of past information tracking, video display, entertainment system, network supporting etc.

GPS provides very accurate time information. So it also facilitates multiple vehicles tracking through time division multiple access (TDMA) communication protocol. Every vehicle communicates with the tracking server in a predefined time slot. This avoids collision and logging of radio signals in the communication channel (Padmanabhan, 2001).

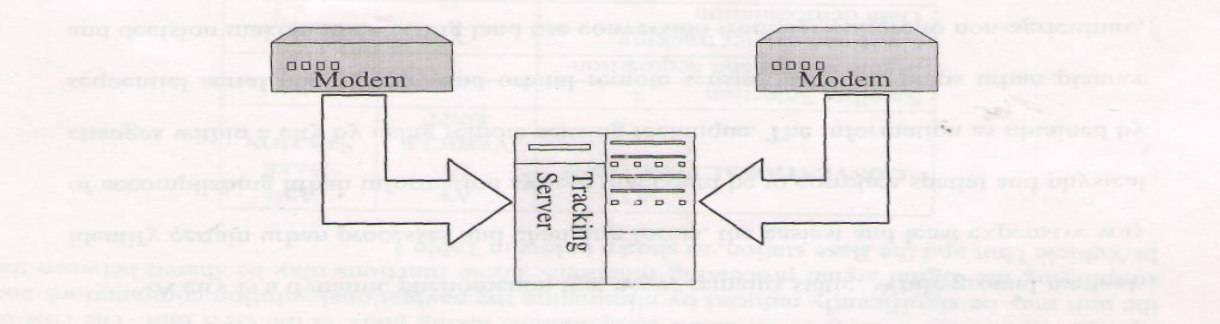

Figure 3 Central Dispatch Facility

2.2. NEED OF LOW COST IVTS

The interest in IVTS system is high, since the equipment offers an immediate payback in terms of increased productivity and highly efficient use of resources. Accuracy requirements vary from as low as 1-0.5 km to as high as 5-10 meters, depending upon the application (Stoddart, 1994). To fulfill the need of an Intelligent Vehicle Tracking System to be extensively under operation in an urban environment, cost plays the most important role.

In an urban town, GPS satellite visibility is generally hindered by the high rise buildings. Tins significantly reduces the number of GPS satellites being tracked. A general assumption is that although the satellite visibility is obstructed on either side of the vehicle due to high rise buildings but the field of view ahead and behind the direction of motion of vehicle is significantly better (Brown, 1992).

To solve the GPS satellite visibility problem, commonly we aid the GPS solution with data from In Vehicle Unit. This significantly increases the cost per vehicle of the sensor as the added equipment and installation expenses more than double the cost of the GPS receiver. Due to this reason there is a significant need of low cost intelligent vehicle tracking system which can easily be afforded by common mass in urban environment.

3. LOW COST IVTS DESIGN FOR URBAN ENVIRONMENT

The alternate low cost method for navigational solution under the condition of poor GPS satellite visibility may incorporates the following mentioned manipulations in the various IVTS system units.

In Vehicle Unit

The In Vehicle Unit incorporates the GPS unit consisting of a receiver, a controller/processing unit and a communication interface (Cellular Modem). To reduce the cost of GPS unit we should try to minimize the number of on board computations taking place at the GPS unit. The cost of the unit may be significantly reduced by eliminating the navigational solution computations and simplifying the digital signal processing functions. These functions may be shared between the In Vehicle Unit and the Base station, as shown below in Table 1.

Table 1: In Vehicle Unit and Base Station shared functions (Brown, 1992)

CONVENTIONAL FUNCTIONS	AT IN VEHICLE UNIT	AT BASE STATION
Satellite Selection		✓
Signal search and acquisition	✓	
Code and carrier tracking	✓	
Data demodulation		✓
Satellite position computation		✓
Atmospheric model computation		✓
Navigation solution		✓

Further the GPS sensor should be designed by using off-the-shelf components already manufactured in large quantities for other applications of communication market. The sensor may also be integrated into the vehicle communication link. Thus by sharing the common functions in the mobile communication radio and the GPS sensor further significant cost reduction can be achieved.

The simplicity of the design of the GPS sensor proposed allows mass production of the units while maintaining the quality which is an important consideration for the Intelligent Vehicle Tracking systems commercial market.

3.2. Communication Link

To reduce the cost of the communication in Intelligent Vehicle Tracking system it is very important to reduce the size of the data packet transmitted from In Vehicle Unit to the Base Station. This can be achieved by removing the fields which are not required in the navigational solution computation from the data packet being broadcasted (Brown, 1992). The reduction in the data packet size leads to increases in communication speed, improved multi-vehicle tracking, better utilization of the communication bandwidth and reduction in communication time. These all add to overall reduction in the communication cost of the IVTS system.

3.3. Base Station

In an urban environment, under the condition of poor satellite visibility an alternative approach may he adopted to find out the accurate and reliable navigational solution. An altitude and digital map aiding data for navigational solution computation is provided to the tracking server

In case three GPS satellites are visible, the Base Station can compute the navigation solution simply by looking up the vehicle altitude from the digital map. A more rigorous computational procedure can be followed in case only two GPS satellites are visible. The two GPS satellite measurements define the line of position on which the vehicle may be moving. The digital map data reduces the possible GPS solution to one of the points where the two satellite line of position and the city roads intersects. The set of possible location can further be refined by knowing the GPS satellite line of positions being tracked and by acquiring the information that which satellites are not being utilized due to shadowing from high rise buildings. Thus the problem narrows down to determining the route or the road on which the vehicle is traveling (Brown, 1992).

The possible offset can further be reduced by knowing the GPS receiver clock offset II previously three or more GPS satellites were tracked, this information can be used by the base station to compute the estimate

of the current sensor clock offset. This further limits the list of possible intersection points to points inside a radius.

The GPS sensor should always report four measurements to the base station. If at present four GPS satellites are not visible then the previous set of measurements made from the shadowed data should also be included. This approach allows the Base Station to derive a highly accurate position fix, even when only two GPS satellites are visible, by propagating the last fix made.

4. CONCLUSION

The Information Superhighway in India is dynamically heading towards a new dimension in Geometrics Industry. Geometrics is the synergy of geo related sciences, mainly including Surveying (Land/Geodetic), Photogrammetric, Remote Sensing, GPS, GIS. With advancement in Information Technology these sciences have emerged as real growth engine of the nation Economy.

Implementation of GPS in vehicles can certainly bring a revolutionary impact in transportation science in a developing country like India where there is an extremely high urban as well as rural vehicular transition every day. The low cost IVTS combined with available high performance processors can provide a highly accurate yet inexpensive vehicle tracking and navigation solution which is the need of the hour in fast moving urban cities of India. A rial ion wide integrated business plan for including automobile companies and GPS system providers is desired to bring this revolution.

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