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Performance Improvement of GPS based Vehicle Tracking System using DGPS and Mobile Wi-Max

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***Abstract*— This paper gives case study of Vehicle Tracking System using GPS technology. The system presently available uses GSM technology for transmitting the information like Longitude, Latitude, Altitude and Speed through SMS /GPRS. It is having several limitations because of dependency on GSM service provider. The practical observations made on VTS are discussed here. Probable modifications in the present systems are suggested with addition of mobile Wi-Max and DGPS (Differential Global Positioning System). With DGPS, accuracy of positions will be around 1 to 3 meters and Wi-Max gives more bandwidth/ data rate of 3 Mbps or more, enabling transmission of video files. The system accuracy will be improved and the system is expected to function more efficiently and effectively. The modified VTS system may be effectively used for applications like Theft Tracking System, Electronic Parking system and curbing the crime along with its intended applications of positioning and navigation.**

***Keywords*— Differential Global Positioning System (DGPS), General packet radio service (GPRS), Worldwide Interoperability for Microwave Access (Wi-MAX), Vehicle Tracking System (VTS).**

I. INTRODUCTION

The GPS based Vehicle Tracking System uses GPS and GSM technologies for localization and positioning of the vehicle. It sends the data string of following information through GPRS / to the designated IP address of the server at control station. [1]

- Latitude
- Longitude
- Vehicle ID
- Speed of the vehicle
- Distance travelled
- Direction of the vehicle
- Date and Time

The data received by data server at designated IP address is stored and processed by using dot net based data base programming. This data received is linked with either local map or Google map for localization of vehicle on map.

II. TECHNICAL DESCRIPTION OF VTS

The Vehicle Tracking system consists of GPS Module, GSM with GPRS and Micro controller. The GPS Module receives the information from the GPS satellites and generates a 64Kbps data string. This data string is given to the Micro controller which acts as an interface between the GPS module and the GSM. It then sends this conditioned data string to the GSM. This data string can be forwarded either by using SMS or by GPRS to control station. If data stream is forwarded by SMS, it is received by remote GSM and data is possessed further by Microcontroller and finally given to PC or Laptop with local / Google Maps for display. In case of GPRS, this data string is encrypted and forwarded to designated static IP address of Web / Data server at control station. [1] This data is displayed on Website with local and Google /Satellite Maps.

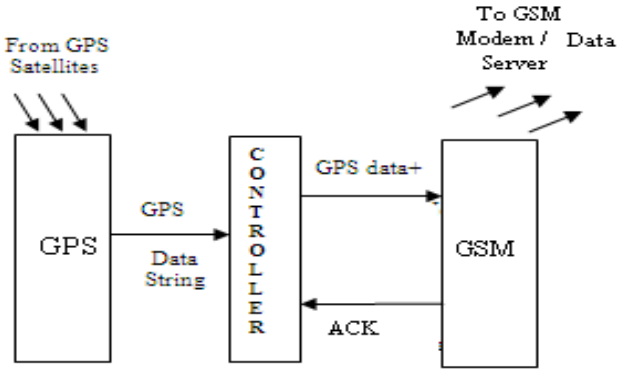

Figure 1: VTS Unit onboard Vehicle

The information about vehicle can be checked on website anywhere by entering suitable login and password. The VTS unit is required to be configured for IP address and Port address of remote server, type of protocol with server (TCP/IP or UDP), Access Point Name(APN), User Name and Password for GPRS communication with server. The GPS parameters are also required to be set for Time, Date, Speed options, number of satellites, Vehicle ID, etc. [1] The storage space required at data server is typically about 10 Mb per one user per one month. The backup of data is taken every week for each user. Also the information about the vehicle like: type, registration number, licence plate number, manufacturer, organization name and information about driver is stored at the website. Dashboard display on the website shows live status of vehicle indicating location by nearest landmark, speed, time, date, etc. [2]

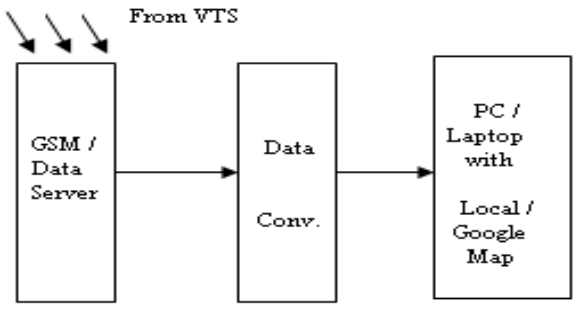

Figure 2: VTS Data Reception at Control station / Data Server

III. REPORTS GENERATED IN VTS

The reports are generated related to information of VTS [2].

A. Stoppage Analysis:-

Stoppage analysis gives idea about the stop time of vehicle for a particular trip. By selecting start date and end date and start time and end time, we can get the details like average speed, maximum speed, and total distance travelled throughout the trip.

B. Speed and Risk management:-

Detailed speed and risk management reports are available, including detailed information about the moments before a crash. Generating pop up alerts saves the laborious task of continuously monitoring the tracking events for any violation. Excessive speed alert is sent when the maximum speed is exceeded for a period designated by the user, for an interval of few seconds to few minutes. Over speed reports can be used to track the drivers for running the vehicle with more than designated speed. The fastest speed of the track is also displayed with a graph of time verses speed.

C. Viewing Trips:-

Detailed information can be reviewed on local map / Google map including present and past track of Vehicle.

D. Daily Report:-

It contains information about the vehicle for entire day. It shows the average and maximum speed obtained by the vehicle with distance travelled in a day.

E. Monthly Reports:-

Monthly summary contains information about the vehicle for entire month. It will show the average / maximum speed obtained by the vehicle with distance travelled for each day in a month and total time taken for the trip.

F. Miscellaneous Facilities:-

The facility for Geofence for marking the predetermined routes / tracks can be used by the subscribers. The two way voice communication can be established in case of emergency conditions. The SMS of predetermined message can be forwarded to specific mobile number either in case of emergency or as when required by the user in a vehicle.

IV. PRACTICAL OBSERVATIONS ABOUT VTS

The limitation of conventional GSM based VTS system performance is dependent on GSM service provider. The data rate of the present GSM system using GPRS is limited to 144Kbps and up to 384Kbps with EDGE. The practical data rate achieved many times is around 100 Kbps, checked at data server. The update for data about location and other parameters is every 10 seconds. Hence position is updated by every 10 seconds. For a stationary vehicle this update of 10 seconds is not a problem. However, if vehicle is moving with a speed of 60 Kmph, position for every 10 second is indicated for a distance of 166.66 meter. Hence for a moving vehicle, position can be indicted at minimum distance of 166.66 meter. If speed of Vehicle is still more, then this minimum distance will also increase. This is a limitation of present system. The waypoints for less than this minimum distance are not indicated on local/Google maps. Hence accurate position of vehicle at one particular time cannot be displayed on the map. Practically, VTS system has options of data updates for every 10, 15, 20, 30 seconds, 1, 2 and 5 minutes. However, it is observed that for selection of 10 to 20 seconds options, few readings of positions are not received and displayed. The other limitation is about accuracy of GPS for positioning information. The GPS for civilian application uses Standard Positioning Services (SPS). The accuracy presently observed practically is around 10 meters. The accuracy may degrade sometimes up to 100 meters (2D RMS) because of US DoD imposed Selectivity Availability Programme (SA).[3,4,7] Hence position indicated by GPS can be actually away by around 10 to 15 meters. [5, 6]

V. MODIFICATIONS SUGGESTED IN PRESENT VTS WITH DGPS AND MOBILE WI-MAX

The limitation of limited data rate / Bandwidth can be overcome by using 3G (Wi-Max) Technology. The data rates practically available in the order of 3 Mbps to 7Mbps. With this data rate, it may be possible to update the data for positions of the vehicle by every second or even less than a second. Hence it may be technically possible to record waypoints at a distance around one to three meters for moving vehicle. Also live video taken from CCD Camera / Camcorder onboard the vehicle can be forwarded by system to control station. The video frequencies DC to 5 MHz can be digitized and compressed with advanced MPEG techniques. With this, it may possible to see live video clips received from vehicle at control station. Also it is recommended to use Differential Global Positioning System (DGPS) to improve accuracy of positions around 3 meters. [3, 5] The figure 3 shows the proposed modified Vehicle tracking System with DGPS and Mobile Wi-Max. The GPRS system can be still used as a backup to Wi-Max, wherever there is no availability of 3G (Wi-Max) in some of the areas. With 3G, more capacity of data space will be needed at data server. The Bluetooth adapter / RFID is recommended for electronic parking applications.

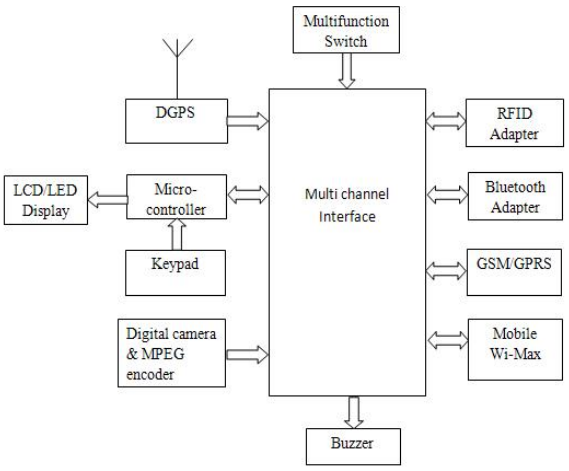

Figure 3: Proposed modified VTS with DGPS and Mobile Wi-Max

VI. DGPS (DIFFERENTIAL GPS)

DGPS uses position corrections to attain greater accuracy. It is done by the using a reference station. The reference station (or base station) may be a ground based station whose position is a known point. Differential GPS involves the co-operation of two receivers, one that is stationary another that is moving around making position measurements. The stationary receiver at reference station is the key. It ties all the satellites measurement into a solid local reference. The difference between the known position and the required position of the reference unit is the positioning error given as ΔX, ΔY ΔZ. The measurement correction are transmitted via either data communication link by using VHF/ GSM/GPRS or voice communication, to the moving receivers as deviation or offset. This offset is to be added to the measurements derived by the moving receivers from the GPS signals received directly from the satellites. With DGPS the accuracy of position with GPS improves from 10 meters to 3-5 to meters. [3, 5] The control station of Vehicle Tracking system will be sending reference positions periodically to vehicles for computation of errors. These readings will be added or subtracted from the current readings taken by the GPS of vehicle. The corrected readings of positions will be transmitted by VTS to the Control Station for further display on local / Google maps. This will give more accurate location on the map. Detailed DGPS method of operation can be summarized shortly. The effects of the ionosphere are directly responsible for inaccuracy. DGPS, a technology is now available that can compensate for most of the errors.[5] Compensation takes place in three phases, determining the correction values at the reference station, relaying the correction values from the reference station to the GPS user, and correcting the pseudo-range measured by the GPS user. Figure 4 shows principle of operation for working of DGPS technique. [5]

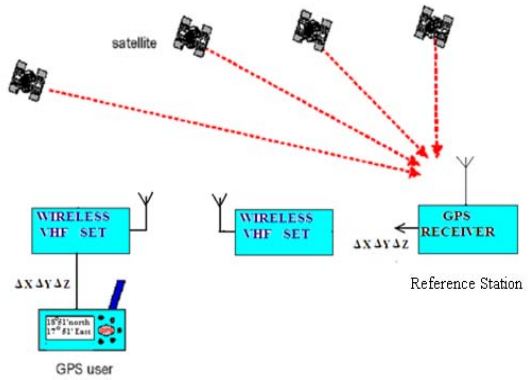

Figure 4: Principle of operation for DGPS

This strategy of DGPS works for around 50 Km to 75Km, as there is a condition that reference and remote station should pick up the same set of satellites for calculating the positions. For distance more than 75 Km, new satellites will be rising across the horizon and technique will not be effective for providing good accuracy for GPS readings. [7] DGPS overcome the errors caused by Selective Availability Programme and improves accuracy up to 3 meters. [7]

VII. MOBILE WI-MAX

Wi-MAX, the Worldwide Interoperability for Microwave Access, is a telecommunications technology aimed at providing wireless data over long distances in a variety of ways, from point-to-point links to full mobile cellular type access. It is based on the IEEE 802.16 standard, which is also called Wireless MAN. Wi-MAX allows a user, for example, to browse the Internet on a laptop computer without physically connecting the laptop to a router, hub or switch via an Ethernet cable. Wi-MAX is a standards-based broadband technology as an alternative to cable and DSL. Wi-MAX has some similarities to DSL in this respect, where one can either have high bandwidth or long reach, but not both simultaneously. WiMAX systems are composed of subscriber stations, base stations, interconnecting switches, and databases. [8] Wi-MAX system can reach distances of up to 50 km for fixed point to point operation. The radio channel bandwidth of a Wi-MAX system can be very wide (e.g. greater than 20 MHz) and the radio access technology uses dynamically assigned burst transmission. This allows Wi-MAX systems to provide data transmission rates that can exceed 120 Mbps. [9] Mobile Wi-Max is the use of wireless technology to provide voice, data or video service to locations that may change over time .[10]

A Features and Benefits for Wi-Max [11, 12]

1) Range- Wi-MAX can operate up to 50 km under line of sight (LOS) and up to 8 km under non-line of sight (NLOS) conditions
2) Speed- 70 Megabits per second Frequency bands- 2to11GHz and 10 to 66GHz (licensed and unlicensed bands respectively) It Allows service providers to deliver high throughput broadband based services like VoIP, high-speed Internet and Video.
3) Scalability- The Wi-MAX system can be expanded through the addition of radio channels, transmitter sites and smart antenna systems giving it virtually unlimited scalability.
4) Quality of Service- Wi-MAX systems can be configured to offer services that have different types of quality of service (QoS) levels. It permits system operators to provide priority services to high-value customers and best effort services to less demanding consumers.
5) An Alternative to Cable - By using a Wi-MAX system, companies/residents no longer have to rip up buildings or streets or lay down expensive cables.
6) High Bandwidth- Wi-MAX can provide shared data rates of up to 70 Mb/s. this is enough bandwidth to support more than 60 businesses at once with T1-type connectivity. It can also support over a thousand homes at 1 Mb/s DSL-level connectivity Also, there will be a reduction in latency for all Wi-MAX communications.

B Wi-Max Standards

TABLE I: Wi-MAX Standards [11]

Characteristics	Fixed Wi-Max	Mobile Wi-Max
Industry Standard	802.16-2004	802.16e-2005
Modulation	OFDM	OFDMA
Duplexing	TDD, FDD	TDD, FDD Optional
Handoffs	No	Yes
Types of Service Providers	DSL, Cable Modem and Competitive Access Providers (CAPs)	Mobile Operators, DSL, cable Modems, Wireless and wired ISPs
Subscriber Unit	High Performance Outdoor and Indoor CPE	Low cost Consumer Electrical CPE and embedded Modules
Preferred Frequency Bands	2.5GHz, 3.4to3.6GHz., 5.8GHz	2.3-2.4GHz, 2.5-2.7GHz, 3.3-3.4GHz, 3.4-3.8GHz
Data rates	Up to 50Mbps	Up to 50 Mbps

VIII. APPLICATIONS OF PROPOSED MODIFIED VTS

A Theft Tracking System:-

With minor modifications with LED license plate it can be used as a Theft Tracking System. The VTS suggested can obviate the possibility of vehicle thefts and make the tracing of stolen vehicles easier and more efficient. The LED license plate mounted at the back of the vehicle is more than just a fancy piece of technology. The vehicle license number, which will be unique for each vehicle displayed on the LED License plate. Hence, if for whatever reason, an individual wants to change the license plate number, he will have to change the number in the memory of the micro controller. It is said that non-professionals carry out most of the vehicle thefts. The mere possibility of tampering with the microcontroller will abate the alacrity of these "non-professionals". If the LED is disconnected, then a warning message will be transmitted along with the data string and vehicle license number via SMS to the control station, Suppose, an individual is able to change license number present in the micro controller, this new license number will be transmitted along with the GPS data string. All the received data will be stored in a database in the Control Station. Thus, each time the data will be received, the license plate number in the current iteration will the compared with that of the previous iteration. If there is any discrepancy, then a warning signal will be initiated in the control station.

Certainly it is not claimed here that the system will reduce the theft cases to zero, but it will reduce the theft cases definitely.

B Curbing Other Crimes like Terrorist attacks and providing Quick First – Aid to Victim:-

There are a number of vehicle hijackings. So, how this system is going to stop these? The system won't entirely stop these, but will definitely help to reduce the same. For this, two switch buttons would be provided, one near the driver's seat, and one at the back. When either of these switch buttons is hit, an SOS message will be transmitted to the Control Station. When SOS message is received in the Control Station, the number and location of the vehicle may be forwarded to the nearest police station. A police team can then be dispatched to the place, and the necessary action can then be taken and first – aid can be administered. This can also be used in case of accidents. During emergencies fast voice communication between driver and control room is possible.

C Electronic Parking:-

The Bluetooth Adapter/RFID is used with the system. Each major parking lot will be provided with a computer and Bluetooth Adapter/RFID. Whenever any vehicle enters the parking lot, the license number, date and the time of entry will be logged into the system. The license number of the vehicle will be searched in the database. If there has been a previous data entry of the vehicle as an "entry" then this entry will be treated as "exit". Otherwise, it will be treated as an "entry".

D Military Applications:-

Ruggedised version of GPS VTS system can be used for tracking the movement of positioning friendly units for Army, search and rescue operations (SAR), for quick navigations of Navy ships. Special EMI/EMC and Environmental tests are required to be conducted on VTS and ruggedisation methodologies are required to be implemented to make system compatible with MIL-STD-461E EMI/EMC standard and MIL-810 Environmental standard. [13]

E Other important applications:

- Oil tankers transport.
- Public and private buses.
- Police vehicles.
- Call center vehicles for tracking the movements of pick up cars.
- In logistics for keeping track of the shipment.
- For mapping purposes, i.e. to make precise road maps of a city or town.

F Future Scope

With these additional modifications, the scope of system can be tremendously increased. The future applications of this system are numerous and are only limited by ones imagination.

- Guiding Systems for Automated Robotic Cars.
- Guiding Systems for Unmanned Arial Vehicles.
- Proximity warning Systems.

IX. CONCLUSION

The case study of GPS based VTS System clearly indicates several limitations. These limitations can be overcome to some extent by addition of DGPS and Mobile Wi-Max. With differential GPS, the accuracy of the position will be improved within 2 to 3 meters practically. With addition of Mobile Wi-Max technology we can get high bandwidth (data rates from 3 Mbps to 50Mbps) through which we may be able to send the live videos from inside and outside the vehicle. The data update rate for position may by every one second or even less. Quick

information to control room, in case of breakdown/accident is possible. Effective control over the drivers, check on over-speeding can be achieved. As the system is fully automatic, automation of fleet operations minimizes human intervention which results in better services. This system also prevents the alteration in the license plate of the vehicle. With modifications discussed, system definitely will improve its performance and utility as compared to present VTS system. The ruggedised (MIL grade) version of this system can be used for Military applications.

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