

IVTrace: A Cost-Effective Vehicle Tracking System-A Prototype

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ABSTRACT

Recent technological developments allowed to envision the low-power and low-cost sensor devices (XBee) and Global Positioning System (GPS) with multi-mode (Wi-Fi/3G/) information & communication technologies (ICTs), a system on which is christened as IVTrace. Integrating these multi-mode and multi-level communication systems with distributed ambient sensory network location based service (LBS) is a challenging task, which could be a potential technology for monitoring various natural phenomena. This integrated system is introduced to provide and assist the travels, transports, and courier companies, and cars and bike users obtain the real-time dynamic location based vehicle tracking and travel route information with the time stamps. In addition, this proposed system also act as a GPS navigator. The IVTrace system prototype has been successfully experimented in the Indian Institute of Technology (IIT) Bombay campus, Mumbai, Maharashtra, India with IVTrace cloud service.

Keywords: *Wireless Sensor Network, Cloud Service, Distributing Sensing Devices, Vehicle Trace and GPS Navigator.*

1. INTRODUCTION

ICT is playing an important role in all walks of life in the knowledge society, including the development of satellite communication technology which is useful and easy to identify the vehicle locations. Vehicle tracking systems have brought this technology to the day-to-day life of the common man (Rose India) [22]. Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites (Garmin Ltd) [12].

Geographical ICT-Location based Services (LBS's) and Sensor Network (SN) is one of the important systems to solve a few dynamic open solutions in real-time manner. This integrated systems (ICT, SN and Geographical Information System) help to the travels, transports, and courier companies to track their service vehicles in dynamic real-time manner with open map systems i.e. Google map/Google Earth/ Nasa World Wind etc.,

Another importance of integrated ICT and SN system is data, and transmits sensed information to the interested hub routing/server/users. Basic features of sensor networks in (Mohamed et al.,) [16] are:

- Self-organizing capabilities
- Short/Long-range broadcast communication and multi-hub routing
- Dense deployment and co-operative effort of sensor nodes

- Frequently changing topology due to fading and node failures
- Limitations in energy, transmit power, memory and computing power

These characteristics, particularly the last three, make sensor networks different from other well-established communication wireless ad-hoc or mesh networks such as GSM (General Packet Radio Service) or WLAN (Wide Local Area Network), which are based on a fixed network infrastructure, unattended and self-organizing. These so-called wireless ad-hoc and sensor networks open a wide range of communication and applications in (Roger et al.,) [21]. The idea of mesh networking is not new but has been suggested for some time for wireless Intra/Internet access or voice communication in (Polycorn) [20]. However, combining small sensors, low-power computers and radios make for a new technological platform that has numerous important uses and applications. Although sensor networks are networks of computing devices, they are considerably different from traditional data networks. The first difference is that the sensor networks with severe energy, computation, storage and bandwidth constraints. The second difference is their overall usage scenario and the implications it brings to the traffic and interaction with the users. Typically, in traditional networks, users are connected to a node (or group of nodes) and require a service from another node. This two communication model describes the overwhelming majority of traditional network traffic. The network acts as a medium bringing the two parties together. The interaction model is also

straightforward. The user interacts directly with the user or service at the other end. Certain actions from the user will produce certain data transfers to and from the other end. Sensor networks, on the other hand, are less like networks (i.e. they loosely connect independent entities and more like distributed systems). SN nodes tightly collaborate to produce information-rich results. To achieve this efficiently, the nodes must form an application-specific distributed system are providing the solutions to the Travels, transports, and courier companies.

Muruganandham and Mukesh [15], cited, GPS tracking system developed that transmit vehicle's data in real-time via cellular or satellite networks to a remote computer or data center. Asim [4] cited the vehicle tracking system signifies the monitoring and management of vehicle, trucks, etc by using GPS system to get the current location, situation, hisotry and control them.

However, the biggest challenge in the transportation and travels are vehicle thieves, time delay by drivers/traffics etc. This will cause, lost a lot of money and reputation of the transport and travels. However, the transport travels and rental cars operators/owers tried to find the cost effective open source solution [17] to save the vehicle from above said troubles.

1.1 Wireless Sensor Network

WSN is an emerging technology, which has revolutionized the data collection in real time from the field (location), which will help to improve the decision-making process to a large extent and help user to draw contingent measures in real-time manner. IVTrace consist of XBee (modules series 2) WSN system ([catalinbujdei](#)) [11], for traffic management and real-time navigation information in IIT Bombay.

1.2 Geographical Information and Communication System

Geographical Information and Communication Technology (Geo-ICT) is an enabling technology, and is an integration of geospatial information and imaging technology with ICTs. GeoICT Lab, 2007 cited that, Geo-ICT is considered as a core technology in the 21st century that forms a basis for spatial decision making, geo-computation and location-based services (LBS). It contributes significantly to the emerging markets and applications, for example, E-Commerce, E-Governance, R-Governance, Spatial Data Infrastructure, Digital Earth, L-Commerce (Location based commerce), and M-commerce (mobile commerce), etc. Keeping in view the increasing demand of Geo-ICT applications in the precision agriculture, the Geo-ICT based location based sensory information is advisable for better decision making and data discovery.

2. OBJECTIVES

The vehicle tracking sytem presented in this paper as a open source and cost effective system that is designed to track and manage travels, transports, rental cars and courier companies needs timely real-time information/assistance to the clients and service vehicle GPS based tracking and navigation.

Geographical Information and Communication Technologies (Geo-ICT) (combination of GIS and ICT for location based services and geo-computations) and Sensor Network (SN). Realizing the potentiality, an attempt has made to interlink Geo-ICT and sensor network to develop a real time monitor (trace and navigation) and take necessary decision in delivery and deistigation informations. And mapping the vehicle traveled information in web-GIS system.

The existing GPS based tracking systems in India are not using cloud computing infrastructure and web portal for retrieving the data. The transmitting the data from GPS satellite received by specific access point and directly stored in the server. So utilization of server space is high. In developing countries like India, the vehicle tracking and navigation systems are still in emerging state and are too costly to implement in the real-time systems (travels and transporation level).

The main advantage of this developed web based tracking system allows user to log in and track the service/own vehicle in real-time manner and Navigation information (in the vehicle) obtain over the Google Earth/Google Maps etc. This systek allows users to locate their service/own vehicle in dynamic manner. Also, the user can obtian the past trace history of the vehicle which could be useful to map the vehicle traveld informtion in Geographical Information System (GIS) interface.

This paper illustrated the integration of multiple technologies to achieve a common goal. It is a case study of an example that shows how such technologies can be dynamically, cost-effectively and synergistically combined to address a real-time vehicle trace, navigation problems and route mapping WSN and Geo-ICT tools.

2.1 Existing/Related Systems

The existing GPS based tracking vehicle is quipped with only GPS antenna which is used to transfer the location signals to GPS satellite. The GPS satellite receives the signal and transmitting the corresponding access point and server. The access points are connected with access point server. The access points are connected with GSM model which is used to interface desktop to GPS data.

Aadhithya Systems [5] sells fishing vessel tracking systems (Marine Tracking) in India. Introduced India's first Fishing Vessel Monitoring Systems (Through Satellite) AVMS 800D+.

Aayur Technology Solution Fleet Management Solutions [6], the product range in Fleet management system includes real time tracking solutions for transport providers & consignment and tracking of employees & optimization of transportation in BPO Companies.

ABR Systems Private Ltd [1] is a leading provider of extremely powerful GPS Vehicle Tracking System & GPS enabled Mobile Phone, uses satellite & GPS technology to provide vehicles & Staffs' exact location and it's all other status reports . One can track 24 hours a day through any internet connection around the world

Accord Software & Systems, Inc [2] provides GPS solutions and product for automotive, mobile, defense and avionics domain. Has R&D center in India.

Accrete Infotech [3] is a leading company in India providing web based GPS tracking services for vehicles and other assets. The company is equipped with world class software having enhanced features of tracking reports, sms and email alerts, geozones, sensors etc. and providing solutions to individuals, travel agents, transporters, schools etc.

Bannari Infotech [7] provides location based services in India. Majorly focus on industries in India and Asia.

BonriX GPS tracking system [8] is a device that uses the Global Positioning System to determine the precise location of a vehicle, person, or other asset to which it is attached and to record the positioning of the asset at regular intervals. The recorded location data can be stored within the tracking unit, or it may be transmitted to a central location data base, or internet-connected computer, using a Cellular (GPRS), Radio, or Satellite modem embedded in the unit. This allows the asset's location to be displayed against a map backdrop either in real-time or when analysing the track later, using customized software.

Sonik GPS (Sonik GPS solutions) [23] provide GPS tracker system in three different levels. Such as GPS vehicle tracker for enable the owner or a third party to track vehicle's location, GPS bike tracer to trace the bike in google maps and GPS personal tracker to track users in any location through the GSM Mobile Phones.

iTrack (Internet Track) [14], provides a Fully Customized Fleet Management Application, designed to fit specific needs of various Organizations and Industries. Plan Alerts and Set Destination Route, get Customized Reports for any Specified Date and Time, Monitor and Track in Real-

Time through GIS map. With user Fleet in control, the increase in organizational efficiency and productivity is inevitable.

GPS India [13] cited GPS tracking/navigation services in India. These all services/unctionality/target area and methods are almost similar to one another. There are few differences in these systems like, additional facilities (traffic and voice direction) and help line services of service providers. The existing GPS tracking/navigation services in India: accuGPS, Accurate Maps , Acryon Engineering & Instruments , Active Fleets , Adhyan Techno Solutions Pvt. Ltd, Adsol , Advanced Micronic Devices Limited, AFTEK Limited, Agogue Solutions Private Limited , Airsys Safety Solutions (P) Ltd, Ajel Infotech Ltd, Alpha-Analytics, American Megatrends India Pvt Ltd, Anandtronics, Anode Informatics Pvt Ltd, Antler Technology Solutions Pvt Ltd, Applied Electro-Magnetics Pvt Ltd, ArcGeosystems, Archon India, Arya Omnitalk Wireless Solutions Private Limited, Ashok Leyland Limited, Asim Communications, M/S.ASSETtrackr Pvt. Ltd., ATIC Data Systems Private Limited, Atlanta Systems Pvt. Ltd, Atlantic Trading Company, Avancar Security & Access Services Pvt Ltd, Aventure Technologies, AVS Embedded Systems, Bharti Communications, BioEnable Technologies Private Limited, Bird Technologies Pvt.Ltd, [Business Solution](#), Callcomm, Center for Spatial Information Technology - CSIT , CERT InfoTrack CGIS, Chekhra, CISM Research Pvt. Ltd, Clay Telematics Pvt Ltd, Connekt technologies, ConnexTel Solutions, Convexicon, Delhi Integrated Multimodal Transit System Ltd, Dhanus, Digi m2m Solutions India Pvt Ltd, Digilog Systems, Digitrack, DIGIZONE, DoGo Vehicle Tracking System, DSM Soft (P) Limited, Duaworld Third Vision, e-con Systems India Pvt Ltd, Eagleeye India, effiKC, Ei Labs, Elanor Telematics, ELCOME Technologies Pvt Ltd, Elektronik Lab, Elogistics Pvt Ltd, Empezar Labs, Ennovasys, eTrans Solutions Private Limited, Fastrackerz, Feel Safe India Marketing Pvt. Ltd, Findnsecure, Focus Vtms, Focuz Technology Enabled Services, F-One Security Services, Freight Management System, Galaxy Geomatics Pvt Ltd, G4Globaltech, Galiakotwala Technologies Pvt. Ltd, Genesis Location Services Pvt. Ltd, Genium Soft Technoloigies, Geo Edge Private Limited, Geospa Technologies Pvt Ltd, Geotrackers Mobile Resource Management (P) Ltd, Global Trackers, GlobaleyesGPSTracking, Goodsmover Technologies, Groovy Earth, Gussmann Software Technologies Pvt. Ltd, Hans Techno Systems, Hashprompt Technologies Pvt. Ltd, Hawk View GPS Solutions, HCL Infosystems Ltd, Hetrogenous Inc, HeuroTracker, Hindustan Trackers, [Hi Tecpoint Techrnologies Pvt Ltd](#), Highbar Technologies, Holar System, i-Diagnosis Technologies, iBilt Technologies Ltd, Indtrack Solutions, INEN Solutions P Ltd, InfaGPS, Infinium Solutionz P Ltd, IntellyServe, Interchain Solution Private Limited, Interface Techno

Applications, Intergrated Digital Info Services Limited, Invendis Technologies, iRoute Technologies, Itemsofdesire, ITG Telematics Pvt. Ltd, iToolz Spatial Solutions, Itrack, iTriangle Infotech P Ltd, iWave Systems Technologies Pvt Ltd, J-Technologies India Pvt Ltd, J&T Enterprises, JMS Infotech, JS Securetech & Electronics, Jubilee Experts, JVM Networks (P) Ltd, Kannu Infotech, KEYSTONE Systems and Solutions, KGN Enterprise, Komal Business Machines, K S Technosoft Pvt Ltd (Tracking Genie), Kure Tech Systems, Landsmiths Projects Pvt Ltd, Locate N Track, LocationGuru Solutions Pvt. Ltd, M/S Tracking Solutions, Magnasoft NorthStar, MahaVentures, Mapmyindia Trackonline, [Maptell](#), Maven Systems Pvt. Ltd, Maxmobility Pvt. Ltd, Mechsoft Digital Technologies, Megasoft Systems, mForce Workforce Management Solutions, Microx Solutions, Milestone Multi Services, Multi-Speed Gears Pvt Ltd, NavAir, Nestwell Technologies, NexGen Tech, Next Gen Technologies, Niki Info Solutions, Nilson Technology, Nirman Eneterprise, Noble Integrated Solutions, Novire Technologies, Nucleus Microsystems, Nucleus Netsoft & GIS India Ltd, Oceantronix, OmaticsGPS, omnilink, Omniscient Electronics Pvt.Ltd, Openwire Solutions Inc, Peacock Enterprise, Peobrics Software Pvt.Ltd, Pink Power Technology, Pinnacle Teleservices PVT. LTD, Pioneer Wireless Solutions, Powertech Automation Solutions Pvt Ltd, Prabuddha Techno Ventures, Pranidhi Automation, Procall Pvt Ltd, Prometheus Infotech Pvt. Ltd, Pruthvi Co-Ordinates, Quantum Designs, Quintegra Solutions Ltd, Ratchet Info Tech, Raviraj Technologies, R B Tracking Solutions, Real track solution, Realtrack Infotek Pvt. Ltd, Rede Technologies (P) Limited, Rede Technologies Pvt Ltd, Reliable Securitas, Reliance Telematics, Remedy Software Systems Pvt. Ltd, Remote Data Exchange, Rilapp Network, Riverplate International, Roadmatics, Routeguru, Samtel Technologies Pvt. Ltd, SATCOP India, Satcome Zone, SatGuide, Sattvah Embedded Technologies (P) Ltd, SCMC Pvt. Ltd, Secure World, Senthil Navigations (P) Ltd, Sequare Solutions Pvt. Ltd, Sgs Weather & Environmental System Pvt. Ltd, ShadowOnline, Shareware Dreams, Shastra Softech, Shree Deepam Infotech Pvt.Ltd, Shresta eTechnologies Pvt Ltd, Silkroute Telematics Pvt.Ltd, Simoco Telecommunication (South Asia) Limited, SkyTrack, Smart Security Systems, Smart Signals Pvt. Ltd, Smart Track, Smr Solutions Pvt. Ltd, Softbit Technologies Pvt. Ltd, SoftKarma Telematics, Sosaley Technolgy, SPIN Technologies Pvt Ltd, Sreego Solutions, SSDL Marketing, Sstracking, Sugan Automatics Pvt Ltd, Sukrut Systems, Swastik Infotech, Symbioun Solutions Limited, TATA AutoComp Mobility Telematics Ltd, Techinnova Infosystems, Techlead Software Engineering, TechnoG Telematic Solutions, Techwiz Systems, TeeJet Technologies, ThinkClock, 3rd Eye Informatics, Totem International Ltd, Track Me, Trackon Telematics Pvt Ltd, Trackversa Mobile Solutions Pvt Ltd, Transworld

Compressor Technologies Ltd, TRAQR Technologies (P) Limited, Traxis India Pvt. Ltd, Trinity Comnet Pvt Ltd, Tulip Tele Infra Services, Uniglobe Enterprises. Upbeat Technologies, Ushus Technologies, UV Telematics, V Act Technologies, VardhmanSoft, Vechtrack, Vijayashree Computers, Vinayakgps, VISIONTEK. Linkwell Telesystems Pvt. Ltd, Worldwide Technologies, [XITIX](#), Zentek Electronics & Communication Pvt Ltd

Based on the above services approach/ methods/ systems/ works it found to be, none of them are cost effective and open source and open hardware system. Thus, in the present study, a real-time navigation and monitoring has been developed in a cost effect manner using open source tools/systems. i.e. XBee technology using for GPS data transmission, GIS for route mapping, web portal for viewing real-time navigation and cloud computing for dissemination of sensor network system with open hardware tools.

3. PROPOSED SYSTEM

The proposed system automatically gathered location information using sensors and transmitting through Xbee enabled devices and GPS used to locate the crrent location of the vehicle.

Most of the existing systems follow GPRS based GPS navigation and through data loggers, where as in GeoSense the data has been dynamically collected at every one minute interval and the collected data has been transmitted to the desired remote server (GeoSense server), which will store the data in the structured and usable (unit) format. This database is simultaneously available in the GeoSense database management system with cloud service. In addition, FieldServer in GeoSense system equipped with web camera, which will be helpful in monitoring the real-time/live pest/disease incidences/crop-quality/environmental conditions, where as in the existing system one has to physically take the picture, send to the remote expert by various communication modes and analyze the situation. The hand held devices such as Amprobe and weather tracker have been used to obtain the CO₂ and wind speed/velocity and humidity parameters respectively, in the existing systems, where as in GeoSense system these parameters, are collected through already embedded sensors.

3.1 IVTrace

GeoSense is an attempt towards developing a real-time DSS to assist the rural stakeholders for improving the rural livelihood, environmental sustenance/security and agriculture productivity. It is an integrated model with Geo-ICT and WSN for location based sensory information and modeling services for precision

agriculture with web-based GIS and short and long range communication/network systems.

3.1.1 Design of IVTrace

IVTrace is an XBee based self-organizing short range wireless sensor network communication system (Fig 1). It comprises several sensors to sense the vehicle speed, altitude and Geo-locations. IVTrace is a pre-defined close-loop system, which senses the data automatically at user-defined intervals. The interval (data collection timing) depends on the sampling requirement.

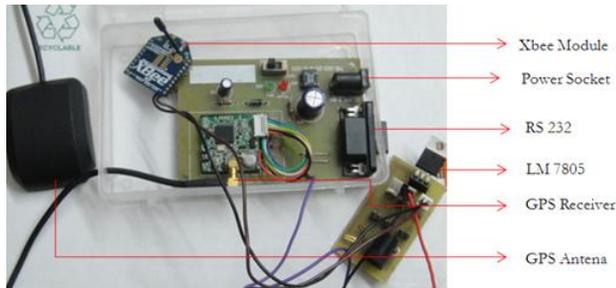


Fig 1. IVTrace and its Components

IVTrace comprises a three main components: (i) XBee module (2nd generation), (ii) signal processing/transmitting (two-tier hierarchical cluster topology) (iii) software development (algorithm process for raw sensory data conversion and user friendly GUI to view the sensory data in various formats such as excel, CSV, XML tables and graphs interactively.

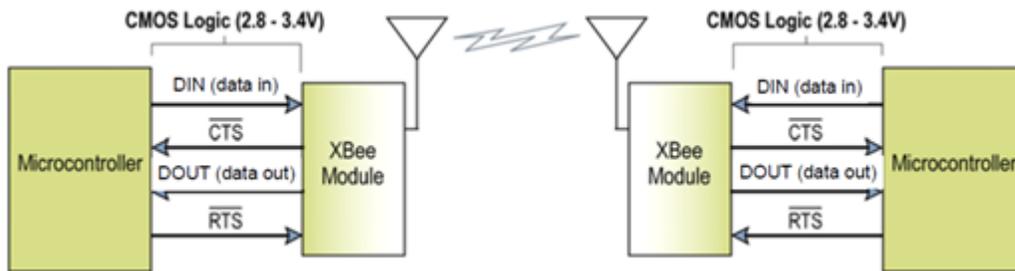


Fig 2. IVTrace Wireless Packets (Sending & Receiving) Flow Chart

IVTrace deployment consists of multiple nodes (client nodes) in the test site. If the client node broadcasts a packet then it becomes a clusterhead. All nodes that receives packet stop their timers and become a member (one of the client nodes) of the clusterhead depending on the strength of the received signal. The member sends a "member announce" packet to its clusterhead. The clusterhead collects data using time division multiple access (TDMA). During data transmission phase, every node is assigned a level based on its proximity to the base station, which is assigned level 0. After collecting

i. The XBee Series 2 OEM RF Modules were engineered to operate within the ZigBee protocol and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between remote devices. The modules operate within the industrial, scientific and medical (ISM) 2.4 GHz frequency band (XBee, 2012). The main advantage and key features of this system is high performance, low cost, low power, advanced networking & security and easy to use. Technically it performs Indoor/Urban: up to 133' (40 m), Outdoor line-of-sight: up to 400' (120 m), Transmit Power: 2 mW (+3 dBm), Receiver Sensitivity: -95 dBm RF Data Rate: 250,000 bps. TX Current: 40 mA (@3.3 V), RX Current: 40 mA (@3.3 V), Power-down Current: < 1 μA @ 25oC. No configuration necessary for out-of box RF communications AT and API Command Modes for configuring module parameters. Small form factor extensive command set Free X-CTU Software (Testing and configuration software) (XBee Series) [26].

ii. Signal processing/transmitting: In IVTrace, the communication module of the node consumes more power than any other part. XBee modules are utilizing ZigBee pro protocol i.e. communication (receiving and transmitting) program takes charge of receiving orders/data from sink node (data transmitting node) as well as sending its own data to other/sink nodes and then to consume mode (gateway). The design flow of the program is shown in Fig 2.

data from all its members, a clusterhead searches for the nearest lowest-level clusterhead. The clusterhead broadcasts a beacon containing its ID and level (IEEE 802.15.4), and all clusterheads in the lower level that receive this beacon acknowledge specifying their own ID and level. The clusterhead are transmit its data to the base station, it follow this process till the base station (stargate/gateway) receives all the data. This approach becomes particularly attractive in heterogeneous settings when the clusterhead nodes are more powerful in terms of computation/communication. The advantage of the

hierarchical clusterbased approach is that it naturally decomposes a large network into separate zones within which data processing and aggregation can be performed individually with single-hop communication. It has been configured with SQL database server to log the data from IVTrace cluster heads. It provides the data access capability to the server using Wi-Fi functionality with 1 to 1.6 km coverage range.

- iii. Open Source/Free Software’s and Languages Used: IVTrace has a dedicated server for storing, processing and publishing the data in the web environment by using X (any of four different operating systems); Apache, MySQL, PHP and Perl (XAMPP) tool (XAMPP) [27]. IVTrace web interfaces have been developed with HTML and PHP languages and PHPMyAdmin [19] acts in the back-end, which stores the collected GPS data in a structured format. The open source PHPMyAdmin database system could be helps the users to view/download the data in open source consortium (OSC) formats (Sudharsan et al.,) [25].
- iv. Signal processing/transmitting: FS can be deployed on the basis of simple WSN topology such as single-hop star network system. Embedded XBee module communicates directly to the relay/gateway then central/server FS. Wherever feasible, this approach can significantly simplify design as the networking concerns are reduced to a minimum. In larger areas, nodes that are distant from the gateway

will have poor-quality wireless links/pocket losses. Such cases hauler Wi-Fi router/relay helps to gain the maximum pockets and transfer the signals/data into long distances.

All collected GPS data, transfer (through Wi-Fi-ad-hoc facility) to the base station. In the server system has been utilized to store the GPS data as well to push the data into the internet clouds. In addition, it supports location based GPS web enablement. The advantage of agent system is its capacity to shows and operates by any browser running on the webserver without any operating system.

4. IVTRACE DEPLOYMENT AND UTILITY

4.1 Experimental Site

The field experiments are being carried out at Indian Institute of Technology (IIT) Bombay, India to study location based vehicle tracking and real-time navigation information. The test bed is situated at 17°19’ 00” Latitude and 78°23’00” Longitude and at an altitude of 543.3 meter mean sea level (MSL). Precise location information obtains from a Trimble GeoXT 2008 GPS for evaluation/accuracy assessment. The IVTrace has been deployed in the test bed to augment the IITB local transportation system (Fig 3) monitoring with proximal WSN systems and to develop a real-time decision support system along with location based sensory information service.

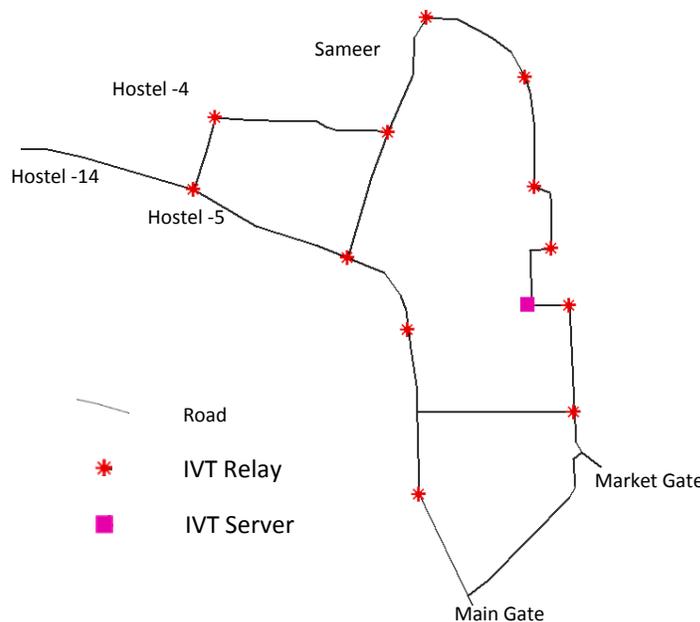


Fig 3. IVTrace Experimental site layout with IVT relay’s and Server

4.2 IVTrace Integrated Communication System

The integrated distributed wireless sensor network system (IVTrace) consisting of XBee module 2. This small to medium scale IVTrace network, for trace the IITB local transportation status and real-time navigation information, etc it includes 10 distributed sensing devices i.e. 4 setup tested with Bike, Car, Jeep and Tum-tum (IITB local bus), 6 relays are used to transfer the wireless packets to the

server. Broadband/3G networks were used for viewing GPS navigation/location map. The sensory data from the test site is transferred to the IVTrace server through a dedicated asymmetric digital subscriber line (ADSL). Figure 4 illustrates the overall architecture of IVTrace. The deployed IVTrace system provides a continuous and dynamic communication between source nodes to gateway (end node) without packet lost (communication signal).

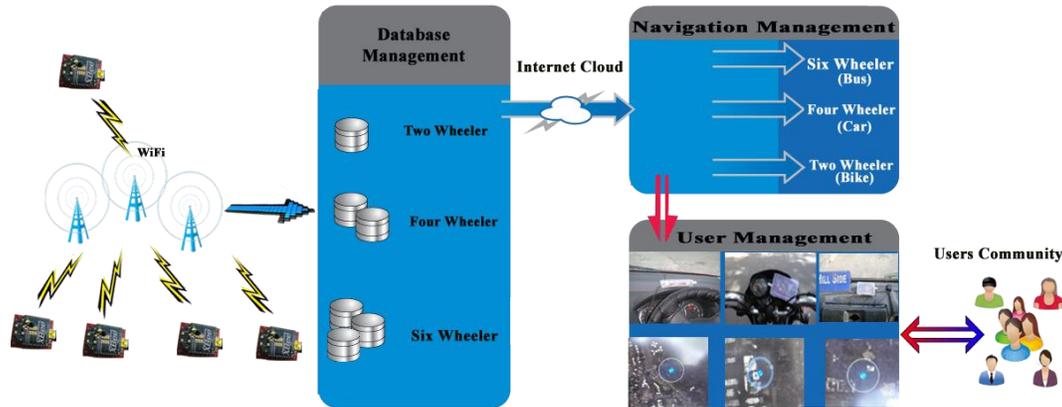


Fig 4. Integrated IVTrace Architecture

4.2.1 IVTrace Private Cloud Services

Cloud computing is a dynamically scalable and often a virtualized resource as a service over the internet cloud. The users need not necessarily to have knowledge of, expertise in, or control over the technology the clouds that support others. Sudharsan et al., [24] opined, the Internet is often represented as a cloud and the term “cloud computing” arises from that analogy. Cloud computing has the dynamic provision of IT capabilities (hardware, software, various services) from third party over a network. IVTrace distributed sensor network system has formed a new cloud, called IVTrace-cloud (Fig 5) by using Opera-Unite [18]. The IVTrace-cloud services include:

- (i) Infrastructure Cloud: The Inter connected (among the XBee 2 module) and inter-related to the distributed sensing system, which connected with Wi-Fi functionality, are part of this cloud service.
- (ii) Service Cloud: Provision of GPS data to the users with GPS real-time navigation information to the users.

- (iii) Application Cloud: IVTrace-cloud application cloud facilitates Google Earth/Google maps based real-time navigation information.

The main advantage of the IVTrace-cloud service is to provide dynamic real-time accessibility of data and navigation information to the IIT Bombay student, faculty and staff community for ubiquitous decision making in a real-time manner. Other advantages include the cost effectiveness and easy maintenance.

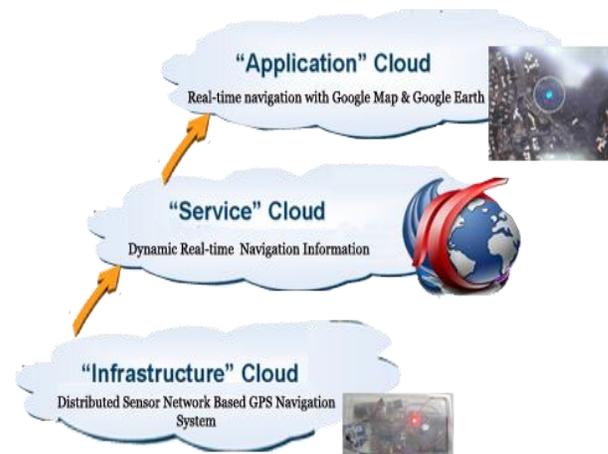


Fig 5. Cloud Services in IVTrace

4.3 IVTrace Database Management System

Database management application is common in nearly all walks of life. However, maintaining cost effective dynamic real-time vehicle based database management system is complex and challenging tasks. In this paper, main emphasis is given on the open source cost effective database management system using PHPMyAdmin to maintain the GPS location (latitude, longitude, altitude and vehicle speed). This database system would be useful to trace the vehicle monitor the path.

4.3.1 IVTrace Navigation/ Tracing System Accuracy Assessment with Trimble Geo-XT Handheld GPS

Before began field deployment the primary survey was performed throughout Trimble GeoTX-2008 (Trimble, 2012) Global Positioning System (GPS) equipment for accuracy assessment of developed navigation system. The Global Positioning System has developed into an efficient GIS data collection technology which allows for users to compile their own data sets directly from the field as part of 'location confirmation' called ground truth (Cunningham) [10]. Ground-truth surveys are essential components for the determination of accuracy assessment of locations (Congalton) [9].

This survey was performed in order to obtain accurate confluent locational point data for navigation included creation of training sites and for navigation; in addition, creating an independent data set reserved for accuracy assessment. The ground truth was also obtained on a confluent point basis; these include road intersections and landmark locations etc.

The field survey was carried out over a week period and total of 25 different locations were attempted. Before the trip was made, mission preplanning was conducted to ensure successful data collection. Specific factors where considered for data collection:

- i. Geographic distribution - an attempt to obtain point data evenly throughout the study area
- ii. Proximity routes - for travel logistics purposes

The GPS equipment utilized in the field survey was a Trimble GeoXT 2008 with data logger. Point data collection in the field was obtained by utilizing a bearing and distance measure. Total 280 data points were obtained from the field survey from which 58 ground truth points were used as ground truth for accuracy assessment.

The accuracy assessment of location predicted by IVTrace has been validated with Trimble Geo-XT handheld GPS (0.5-1 meter accuracy) (Trimble, 2012). The positioning s are almost similar. But in the sensory GPS reading seconds are given minor variations (about 1-3 meters). These variations changing depending on the number of satellites are available.

4.4 IVTrace Providing Solutions

IVTrace provides few navigation solutions in the cost effective manner to the following sectors:

- Goods Carrier Companies
- BPO
- Radio Taxis
- Milk Vans, Schools, Commercial Buses and City Transportation
- Car Rental and Leasing Companies
- Refrigerated Vehicles
- Oil Tankers
- Infrastructure and Construction Companies
- Company Owned Vehicles

5. SUMMARY AND CONCLUSIONS

An attempt has been made to integrate Geo-ICT with multi-range WSN based communication system, the model on which is christened as IVTrace (Internet based vehicle trace). The insights obtained integrating Geo-ICT and WSN indicated that the system performed in collecting and monitoring the data/phenomena precisely and communicate without any data/packets losses. This system is developed to provide a real-time vehicle location based cost effective tracking system. The main advantage of this system is, one no need to have any detected map server/map (for tracking), using open source map/system (ex. Google map/Google earth) one can monitor location of the vehicle in real-time manner. Location based data/information service is also provided to view the vehicles travelled path (routes) using open-source GIS tools (ex. DIVA, OpenJump, Grass, etc. This continuous high spatio-temporal resolution data information is possible through XBee relay (access points) with efficient energy (solar) utility. Steps are afoot towards interesting communication system to share the distributed sensory information and modeling services

is provided in social networking (Twitter) environment. These twitter-based services are given through private cloud service, called IVTrace cloud service using Opera-Unite found to be a cost-effective approach. Currently, the developed dynamic real-time vehicle tracking system is designed to cater the IIT Bombay students, visitors, employee and guest for local bus/van service information (vehicle location), which could be useful to monitor the vehicle location within the campus (IIT Bombay), which could form an intrusion approach in the present scenario.

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