Cost Effective GPS-GPRS Based Object Tracking System

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***Abstract*—This paper proposes and implements a low cost object tracking system using GPS and GPRS. The system allows a user to view the present and the past positions recorded of a target object on Google Map through the internet. The system reads the current position of the object using GPS, the data is sent via GPRS service from the GSM network towards a web server using the POST method of the HTTP protocol. The object's position data is then stored in the database for live and past tracking. A web application is developed using PHP, JavaScript, Ajax and MySQL with the Google Map embedded. The existing live tracking systems that are available now a days use SMS for the communication to the server which turned out to be expensive. (SMS are used for communication to device). We have used the GPRS service which made our system a low cost tracking solution for localizing an object position and status. This system is very useful for car theft situations (alarm alert, engine starting, localizing), for adolescent drivers being watched and monitored by parents (speed limit exceeding, leaving a specific area), as well as for human and pet tracking.**

***Index Terms*—GPS, GPRS, GSM, NMEA, IMEI, Google Map, Latitude, Longitude, Ajax, XML, HTTP, TCP, MySQL, Car tracking, Car monitoring.**

I. Introduction

A good number of tracking systems had so far been developed with a wide range of tracking facilities [1]–[6]. But the operation cost of most of these systems is higher which prevents from widespread use. On the other hand, the rate of car theft, asset theft, child kidnapping in many countries are increasing at a higher rate [7]. The objective of this research is to reduce the cost of the tracking system using the latest technologies and making it available to the common people.

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Automatic Vehicle Location (AVL) system was discussed in details by Al-Bayari and Sadoun that works under GIS environment [1]. However a complete FPGA implementation of the vehicle position tracking system using short message services (SMS) was reported by Hapsari [2]. Xiaobo Fan et.al. discussed the design and implementation of a mobile object management system that makes use of the existing GSM networks and its extension GPRS for data communication [3]. Hsiao and Chang developed analytical model to analyze the optimal location update strategy with the objective of minimum total cost [4]. Tamil et. al. did similar works compared with ours but used the SMS for the communication [5]. A more recent work by Nishikanta Pati on video surveillance and tracking of moving civilian vehicle added new dimension to the development of the tracking systems [6].

Our research has been focused on the reduction of overall cost of tracking and to do so we have used NAVSTAR-GPS, a satellite based service developed and provided by United States Department of Defense. Global Positioning System (GPS) is a 24-hour world wide service. It provides accurate, three-dimensional information of the location as well as precision velocities and timing services. It is accessible to an unlimited number of global military, civilian and commercial users [8]. The service is free of cost to everybody. Google Map is used for mapping the location. The tracking device

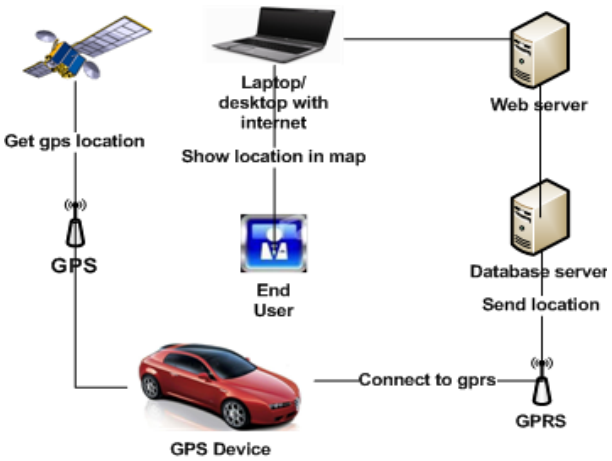

Fig. 1 The n-tier Tracking System Diagram

communicates with the server using General Packet Radio Service (GPRS). It is a low-cost wireless data communication system provided by cell phone operators. Cell phones are the booming technology reaching most parts

of the world and crossing the boundary between the developed and the developing world. For this reason, low cost GSM/GPRS is one of the best possible communication media for the present and the future.

II. System Overview

The system has two parts – the tracking device and the database server as shown in Figure 1 below. The device is attached with the moving object and gets the position from GPS satellite in real-time. It then sends the position information with the International Mobile Equipment Identity (IMEI) number as its own identity to the server. The data is
checked for validity and the valid data is saved into the database. When a user wants to track the device, s/he logs into the service provider's website and gets the live position of the device on Google Map. A custom report is also generated which includes a detailed description of the vehicles status. Users can also see the previous positions of the device.

III. Hardware Specification

We need a module which is compatible with 850MHZ/900MHz/1800MHz/190OMhz frequencies of cellular networks. Telit GM862-GPS GPS/GPRS is the module we have selected for this system shown in Fig 2. This device is capable of working in any GSM network around the world. It has a python interpreter with 3MB Non-volatile

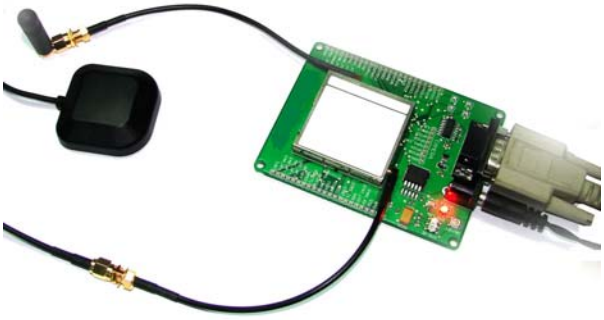

Fig. 2 GPS-GPRS module with EVK and antennas

memory and a 1.5 MB volatile memory integrated inside the module [9]. No external controller is required. It has a 20 channel high sensitive GPS receiver and built-in SIM card holder. This makes the system compact and power efficient. To build a complete working system using this module, only the power source and the antenna is required. It also supports complete standard AT command set plus custom AT command set for GPS.

Figure 3 shows the work flow of the hardware. After turning on the device, it automatically initializes the network. Then it gets the GPS data in NMEA 0183 format and adds it with its own unique IMEI number [10], [11]. It then tries to connect to GPRS. If it fails due to GPRS unavailability then it logs the data in the non-volatile memory and waits for a certain fixed time period. After that it tries to connect to the GPRS again. After establishing the GPRS connection it tries to connect to the service provider's server using the HTTP protocol. After successful connection, the GPS data with IMEI number is sent to the server as a string. Then after a certain time period it checks the availability of GPRS and connects to the HTTP server. The current location of the device is sent. In this way the device communicates with the server and sends the location.

IV. Software Specification

To view the current position of the device a web-based application has been developed. Using this Web application an end user will be able to view the live position of the device and also the past position by selecting a specific date and time interval.

To develop this software PHP5, JavaScript and Ajax scripting language was used. MySQL database server is used for storing data because of its high-performance query engine, tremendously fast data insert capability, and strong support for specialized web functions like fast full text searches [12]. A case study shows that it could process an average of 3000 queries per second [13].

A PHP file named dgl.php is responsible for accepting data which is sent by the device via GPRS using POST method of the HTTP protocol. This data consists of IMEI number of the

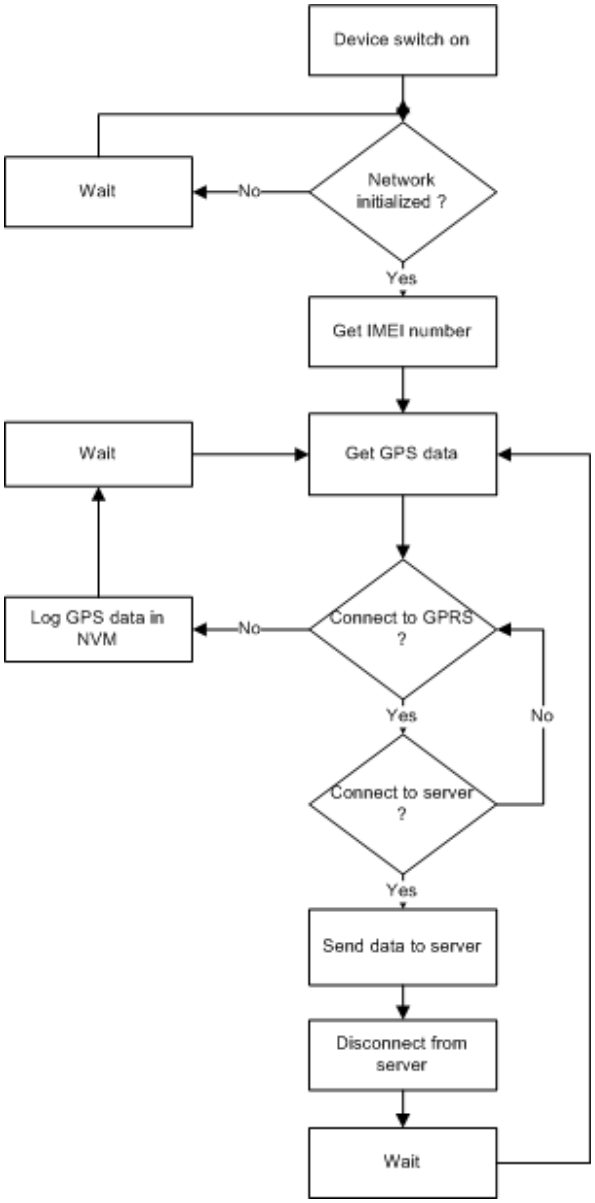

Fig. 3 Hardware flowchart of the system

device, Latitude, Longitude, UTC, Date, Speed and number of satellite. IMEI number is used to authenticate the device. Fig. 4 shows the server side flow diagram.

A. NMEA Conversion

This following NMEA protocol is received using GPS device.

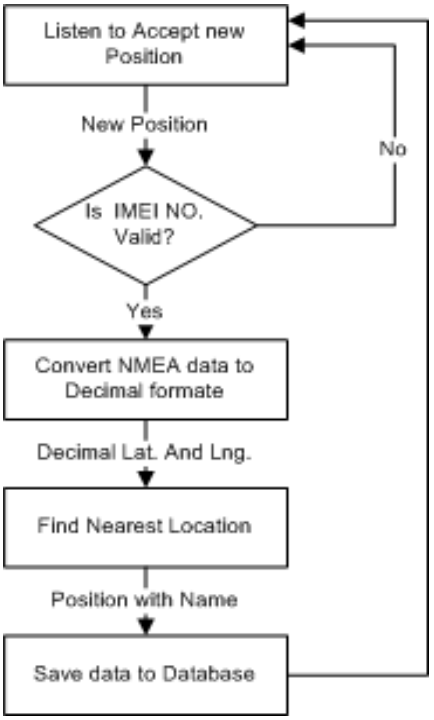

Fig. 4 Server side flow diagram

$GPSACP:160223.999,2345.3522N,09022.0288E,2.4,33.9,3,51.30,1.62,0.87,090408,06

After accepting the IMEI and NMEA data from the device by the web server, a method is used for tokenizing all the particular data. This is done after verifying the IMEI number of the device that the NMEA formatted data converted to the decimal format. After converting NMEA formatted data to decimal Latitude and longitude, it changes as following:

2345.3522N = 23.755895

09022.0288E = 90.367205

B. Finding Nearest Location

The Spherical law of cosines is used to find out the name of the device's location. This formula is used generally for computing great-circle distances between two pairs of coordinates on a sphere.

Spherical law of cosines [14]:

d=R*acos(cos(lat1).cos(lat2).cos(lng2−lng1)+sin(lat1).sin(lat2))

Here, d is the distance between two coordinates (lat1,lng2) and (lat2, lng2).

First of all, a geocode table is implemented which has four attributes as given in Table 1.

Table 1 Geocode Table

ID	Name	Latitude	Longitude
1	Banani	23.3456554	90.9825973
2	Gulshan-1	23.3456546	90.9825934
3	Gulshan-2	23.3456590	90.9825926
4	Mohakhali	23.3456525	90.9825979

After receiving a new position, dgl.php the nearest location name of the newly received position is found. This is done by running the Spherical law of cosines in sql query as below:

"**SELECT** name, (3959 * acos(cos(radians('lat1')) * cos(radians(lat2)) * cos(radians(lng2)– radians('lng1')) + sin(radians('lat1')) * sin(radians(lat2)))) AS distance
FROM geocode
HAVING distance < 5
ORDER BY distance LIMIT 0 , 1"

This query returns the name of the location which has the shortest distance with the new position.

C. Live Tracking:

Live tracking is the major part of this web application. This enables a user to view the live position of the device on the map. Google Map Satellite version is used to locate the position.

After Logging in, a user will automatically be redirected to live_track.php page. In this page AJAX (Asynchronous JavaScript and XML) function is used to fetch the new position from the server. This is done at fixed intervals in order to update it on the map without reloading the whole page repeatedly. The Fig. 5 shows the how AJAX works between user and server side.

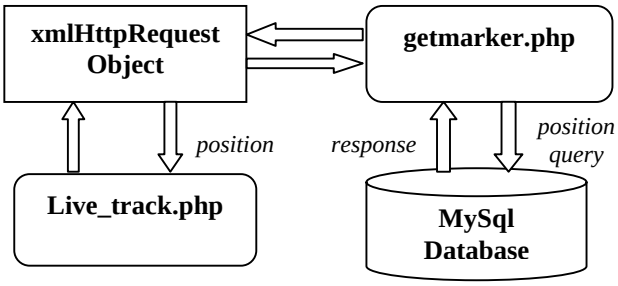

Fig. 5 Live Tracking Flow Diagram using Ajax

Ajax is asynchronous, in that extra data is requested from the server and loaded in the background without interfering with the display and behavior of the existing page. Data is retrieved using the XMLHttpRequest object that is available to scripting languages running in modern browsers, or, alternatively, through the use of Remote Scripting in browsers that do not support XMLHttpRequest [15].

D. Tracking History from the System

User can check the history of tracking after logging into the system. The 'history.php' page will allow viewing the past positions of the device by selecting a fixed date and time interval.

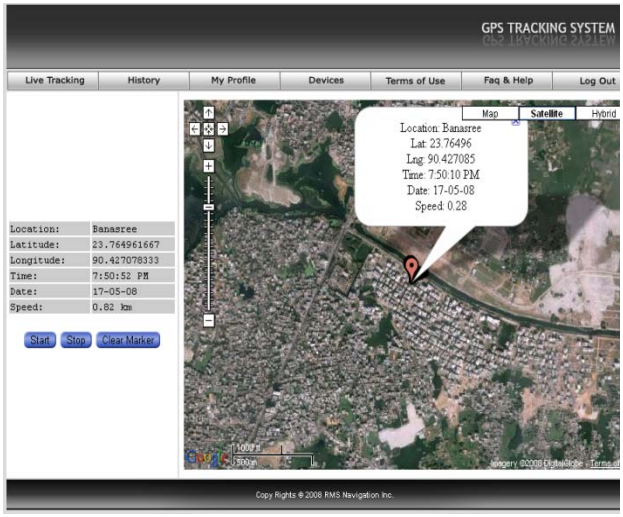

Fig. 6 Snapshot of the webpage which shows the live position of the tracking device by using Google map

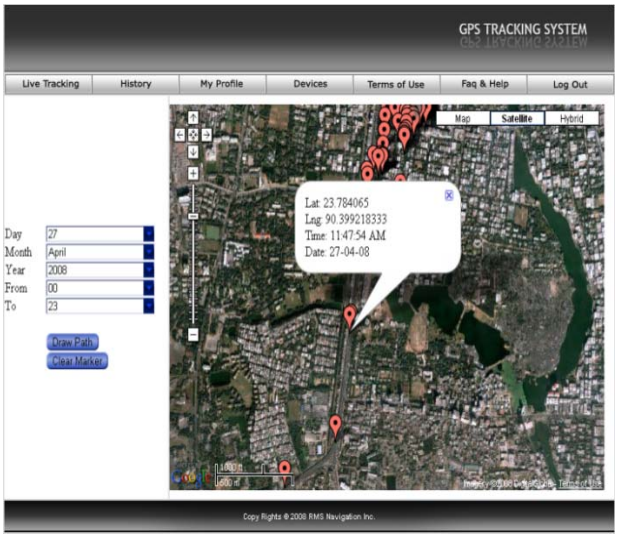

Fig. 7 Snapshot of the webpage which shows the history (previous recorded positions) of the tracking system. Bubble indicates the position and time of tracking device.

In the database, the positional information along with current date and time is stored. This information is used to search for the location of the device using the specified date and time.

V. Discussion on Low Cost Solution

Efforts have been taken to reduce the total cost of the system including device and services. The device cost is reduced by using a single module solution. By using free Google map API and HTTP protocol the service cost has been reduced dramatically. Starting from small business to large enterprise, the device and service cost can be affordable. They can also set up their own customized web-based remote monitoring system easily.

GPRS was used for data transfer instead of SMS. Several SMS based vehicle tracking systems are available in the local market which sends SMS with current position data when a request is made by SMS. This SMS based tracking system is neither efficient nor cost effective. In most countries the cost of GPRS is cheaper than SMS by a factor of 20 to 100. (SMS costs about 0.5-1.0 Taka/SMS whereas GPRS costs about 0.02 Taka/KB [16].)

To reduce the total system cost, a single GSM/GPRS/GPS module was used instead of separate devices. It requires only external power and an antenna for GPS and GSM. Beside the cost, this approach saves extra PCB space of the system. On the other hand, it is integrated with high level python language interpreter. This makes it easy to program, update and optimize the system and additionally save the external controller. Moreover, it saves development time and cost compared to programming and interfacing external controller.

The service cost was reduced by integrating free Google map into the service provider's site using the Google map API and customizing the service. Countries where there is a lack of proper GIS based map, it would be time consuming and extremely expensive to develop a map solution. A small company can start providing such tracking service quickly in an affordable price by using Google map. Moreover, they can take advantage of the advanced features of the Google map by integrating their own customized services.

Using the HTTP protocol also reduces cost to send data from the tracking device to the server. Most of the GPRS/GPS based tracking devices available in the market use TCP or UDP protocol to connect with the server and send data. A dedicated server with a static IP is required. This is more expensive compared to that of shared web hosting. Opening several ports for TCP or UDP incoming connection makes the server vulnerable. On the other hand, this tracking device uses HTTP protocol to communicate with the server. It uses the POST method which is safer in data communication. Since it does not require any extra port other than the HTTP port (port 80) for incoming connection, it is more secured. Small companies can easily set up and provide their own services in a shared web hosting.

VI. Conclusion

This paper presents a low cost tracking system using GPS and GPRS of GSM network, suitable for wide range of applications all over the world. The combination of the GPS and GPRS provides continuous and real time tracking. The cost is much lower compared to SMS based tracking systems. Free Google map and the use of HTTP protocol as data sending method reduces the monthly bundle cost for the individual user and also for the small business owner. It is expected that the full implementation of the proposed system would ultimately replace the traditional and costly SMS based tracking systems.

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