Design and Implementation of Web-Based GPS-GPRS Vehicle Tracking System

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***Abstract*— In this paper, an integrated cost effective web-based GPS-GPRS vehicle tracking system was designed and implemented. The system enables enterprises owners to view the present and past positions recorded of the target vehicle on Google Map through purpose designed web site. The current position of the vehicle was acquired by GPS device which is integrated in the target vehicle and the location coordinates are sent through GPRS service provided by the GSM network. The GPS data are sent using Get method of HTTP protocol, the data at server side are stored in a database tables and can be retrieved as request for position browsing on map. A web application is developed using PHP, JavaScript, Ajax, XML, and MySQL with embedded Google Map to retrieve and display on track details.**

***Keywords*—GPS, GPRS, Vehicle Tracking.**

I. INTRODUCTION

The GPS-GPRS-based tracking system is a system that makes use of the Global Positioning System GPS to determine the precise location of a vehicle to which the device is attached. When a large number of objects or vehicles were spread all over the ground, the owner of corporation needs to keep track for fuel saving, security purposes…etc. A tracking system is required to determine the location of any object at any given time and the distance travelled. Also, the need for a tracking system in users vehicle is used to prevent any kind of theft since police can use tracking reports to locate a stolen vehicle location. GPRS and GPS based tracking system will provide effective, real time vehicle location report. A GPS-GPRS based tracking system gives all the specifications about the location of a vehicle. The system utilizes geographic position and time information from the Global Positioning Satellites [1-2].

The system uses an On-Vehicle Module consists of GPS receiver and GSM modem, the device resides in the vehicle to be tracked. In order to track the movement of the vehicle Google Maps used for mapping the location. The GSM modem fetches the GPS location and sends it to the server using GPRS.

Extensive research work had been carried in the field of object based system ranging from GSM based location determination [3] to GPS based location determination [4]. The integration of GPS and GSM was first established using SMS as a method of transmitting GPS coordinates. The inclusion of GPRS technology to transmit location coordinates to a remote server facilitates the tracking of object remotely using any computer connected to the web.

II. GLOBAL POSITIONNING SYSTEM

The GPS is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to three or more GPS satellites.

GPS technology can be described in terms of three segments:

1. Space Segment: Consists of twenty-four satellites orbiting 11,000 nautical miles above the earth.
2. Control Segment: Consists of 5 ground stations around the globe that manage the operational health of the satellites by transmitting orbital corrections and clock updates.
3. User Segment: Consists of various types of GPS receivers that can vary in complexity and sophistication.

GPS receivers are able to identify their location when three GPS satellites triangulate and measure the distance to the receiver and compare the measurements. A fourth satellite measures the time to the receiver. The information from all four satellites is compiled to determine the location. The sophistication of a GPS receiver impacts the reliability and accuracy of the GPS data received [4]

III. GENRAL PACKET RADIO SERVICES

General Packet Radio Service GPRS is a packet switched service based on Global System for Mobile Communications GSM, an extensively deployed voice technology. GPRS is a 2.5 G cellular network. It provides affordable and fast internet connections to service users. Billing is based on the amount of data transferred rather than on the connection time. This is achieved by allocating resources radio channels to users only when they need to send data. GPRS may offer data rates up to 171.2 kbps [5-6]. GPRS utilizes most nodes in an existing GSM network; two additional nodes are introduced in the GSM network to support GPRS Serving GPRS Support node SGSN and Gateway GPRS Support Node GGSN, these two nodes constitute the core network of a GPRS sub-network and they are connected through an IP based GPRS backbone network.

IV. WEB BASED VEHICLE TRACKING SYSTEM

The web based tracking system is a system designed using a combination of several modern information and communications technologies. The system comprises of vehicle-mounted tracking devices, a central server system and a web-based application. Through the system, users will have the facility of monitoring the location graphically and other relevant information of vehicle. This system is designed to serve enterprises with an unlimited number of vehicles and complex usage requirements. The web based system enables user to browse location track on map through developed web application embed Google Map and interact with database server for vehicles track details. Using the web based system enables users with different operating system platforms to easily reach the demanded details by the existence of internet access. Figure 1 shows an overview of a stypical web based vehicle tracking system.

The location is acquisitioned from satellite using GPS receiver location coordination sent through GPRS, the GSM network will pass the information to the destination server as HTTP packet. And through the internet the clients can browse track on electronic map using purpose designed web application on website.

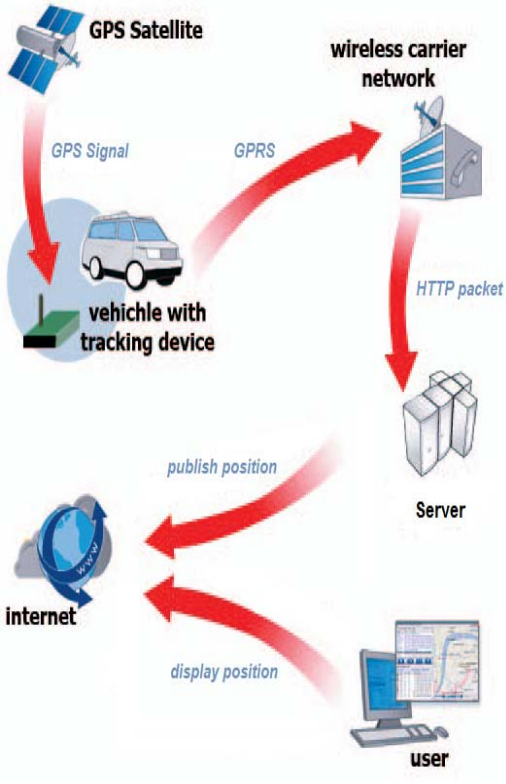

Figure 1 Web Based Vehicle Tracking System Overview

V. SYSTEM COMPONENTS

The overall system functionality outcomes from interaction between the system components which are:

1. Quad-band SIM908 GSM-GPS module
2. Web application and purpose designed database
3. Desktop application

VI. GSM/GPS MODULE

Quad-Band SIM908 module is used which combines GPS technology for satellite navigation with worldwide known technology GSM. This module is configured to connect to navigation satellite and gets GPS location at predetermined intervals and sends this information to web application through GPRS service provided by GSM.

The GSM/GPRS engine works on frequencies GSM 850MHz; EGSM 900MHz, DCS 1800MHz and PCS 1900MHz. SIM908 supports the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4. The GPS solution offers best- in-class acquisition and tracing sensitivity, Time-To-First-Fix TTFF and accuracy. With a tiny configuration of 30*30*3.2mm, the device can meet almost all the space requirements in user applications and is designed with power saving technique so that the current consumption is as low as 1.0mA in sleep mode. Figure 2 shows SIM908 GSM/GPS module board where main components are indicated [7].

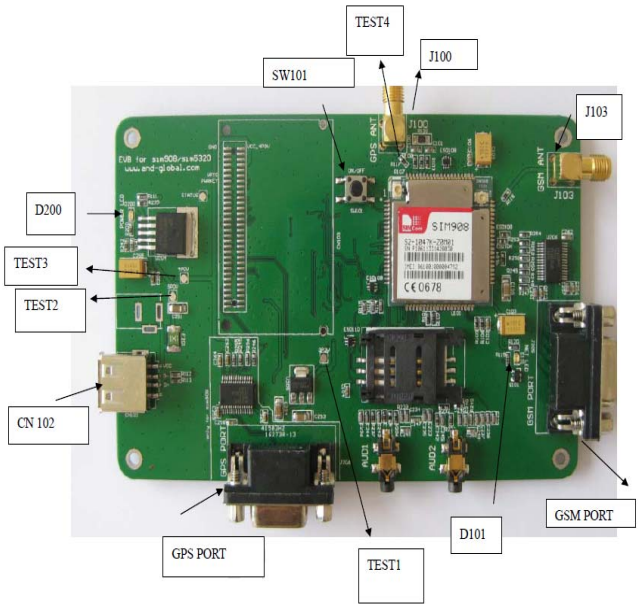

Figure 2 SIM908 GSM/GPS Module Board

VII. WEB DESIGN

The overall functionality and usage eased using various web application development languages where the interaction between several purposes designed applications resulted in complete integrated system enables the users to reach and benefit of the system. The overall design goals of the web application can be summarized in the following:

1. Define and manage all client accounts information by system administrator.
2. Define, manage and browse all agents accounts information and tracking data by clients.
3. Receive and identify tracking information from each device unit.
4. Store tracking information received from tracking device to the related agent in the database.
5. Display track locations on electronic map through using several browsing types.

6. Generate reports of agents movements showing agent information and tracking details.

Web pages formatted using HTML elements. Appearances and text layout formatted using. HTML embeds scripts such as JavaScript and PHP which performs functions and adds effects on the behaviour of HTML pages. JavaScript performs all background operations and functions such as login checking, data validation, and paging function; also JavaScript embeds Google Map API on the web site using key and Google maps class provided by Google where vehicle locations coordination are presented. Administration of accounts implemented using PHP functions; PHP commands can be embedded directly into HTML source document rather than calling external file to process data. The administration functions include adding, editing, deleting, browsing clients and agents accounts, and formatting those accounts into tables. PHP used at the server side to store the received GPS data in forms which is easier to examine and check relevant parts of received data. Detailed reports of agents track also generated using PHP function where the relevant data are presented into table contains agent basic information and detailed track including exact time and location coordination.

VIII. DATABASE DESIGN

The database responsible for storing all system information including user login credentials, clients information, agent information, and tracking data. Databases also enforce data integrity by ensuring that data is collected and presented using a consistent format. For the system to be usable, it must retrieve data efficiently. The need for efficiency has led to use complex data structures to represent data in the database. The database architecture consists of the following layers:

1. Presentation layer: This is the topmost level of application. The presentation layer displays information related services. The presentation layer communicates with other tiers by outputting results to the browser/client tier and all other tiers in the network.
2. Business Logic Layer, Data Access Layer (or middle layer): The logical layer is pulled out from the presentation layer and, as its own layer; it controls an application's functionality by performing detailed processing. Another in-between layer added to make benefit of the reusable set of functions performing database operations, this is the DB Worker Layer.
3. Data layer: This layer consists of database servers. Here the information is stored and retrieved. This keeps data neutral and independent from application servers or business logic. Giving data its own tier also improves scalability and performance.

Figure 3 present the database architecture indicating to all database layers.

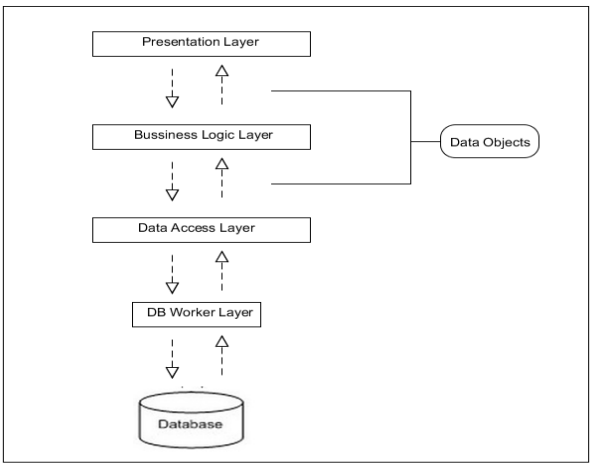

Figure 3 Database Architecture Layers

IX. DATA BASE ENTITY-RELATIONAL MODEL

The entity-relationship E-R data model uses a collection of basic objects, called entities, and relationships among these objects. System database consists of three tables which are accounts table which holds all the important account information including credentials and contact details. agentinfo table holds extra information related to agent account. track table holds the tracking information that is received from GPS modules and reference to agents which the track data belongs.

accounts table has Type column which identifies account type of user which is administrator, client, or agent. track table has a foreign key relationship to accounts table to link each agent account to the track data in track table. agentinfo table has a foreign key relationship to accounts table to link each agent account to the client account responsible for defining the agent.

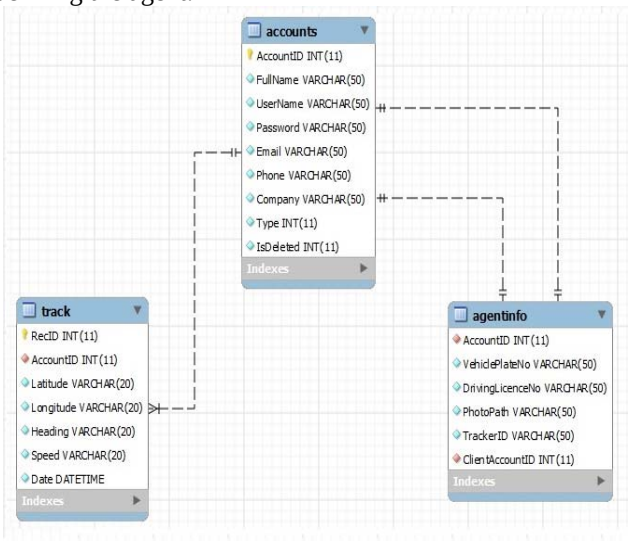

Figure 4 Entity-Relationship Database

Figure 4 shows a diagram of Entity-Relationship database. As in the diagram, agentinfo table has two foreign key relationships to AccountID in accounts table, where AccountID and ClientAccountID in agentinfo table are both foreign keys to AccountID in accounts table; the first

relationship is to identify extra agent information ownership, and the second identify to which client this agent belongs. For track table one foreign key relationship used identify the ownership of track data to agents.

X. INTERACTION BETWEEN APPLICATION LAYER AND DATABASE

All user interactions designed to be through presentation layer, were information related accounts administration and tracking on map displayed in forms of HTML web pages. Figure 5 shows the interaction between application layer and database.

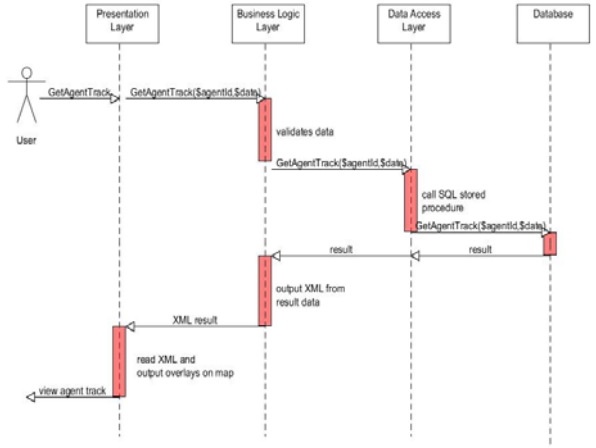

Figure 5 Interaction Between Application Layer and Database

XI. DESKTOP SIMULATION APPLICATION

A software application interacts with integrated GSM/GPS module through serial interface. The simulation application sends a set of AT commands to operate GSM/GPS device, set the device mode, and to inquiry GPS receiver for location coordinate, the receiver determine location coordinates using the received GPS signal from satellite. The application listen to the received data which are sent to the application server along with device identification information through GPRS service provided by GSM module to a specified IP address, the application specify the protocol to be used in transmitting data and method.

XII. DATA GATHERING, TRANSMITTING, AND RECEVING

Initially, the SIM908 module is initialized to start gathering GPS data from the satellite; device initiation is done using AT commands and includes GPS and GSM module; to turn on the GPS, first it is powered on and put in reset mode then in the worm mode where the module become ready for receiving coordinates from satellite. The GPRS is next turned on; the process includes GPRS power on, setting APN of service provider, initiating HTTP protocol, and setting protocol method (Get method). Device initialization process may take up to 1 minute to worm up and calculate the accurate position. Figure 6 shows SIM908 module initialization process, the process starts with powering the module and setting the reset mode, the worm up may take a minute, and then GPRS is configured with the GSM network APN and HTTP protocol initialized.

```
start
SYSTEM : port opened
AT+CGPSPWR=1

OK

AT+CGPSRST=1

OK

AT+CGPSOUT=255

OK

SYSTEM : GPS ON
AT+SAPBR=3,1,"CONTYPE","GPRS"

OK

AT+SAPBR=3,1,"APN","net.asiacell.com"

OK

AT+SAPBR=1,1

OK

AT+HTTPINIT

OK

AT+HTTPPARA="CID",1

OK

SYSTEM : GPRS ON
AT+CGPSINF=0

0,0.000000,0.000000,0.000000,20130825162118.000,0,3,0.000000,0.000000
OK

AT+CGPSINF=0

0,0.000000,0.000000,0.000000,20130831184906.405,0,9,0.000000,0.000000
OK
```

Figure 6 SIM908 Initialization

Then the device is queried for GPS coordinates, the satellite will respond with string of data including latitude and longitude coordinates, heading, speed, and time. The received data are trimmed and details separated; the set of data plus the device id are sent through GPRS to the path defined in the URL using HTTP Get method. Figure 7 shows the process of GPS data gathering and parsing and then sending data to the defined URL.

```
AT+HTTPACTION=0

OK

+HTTPACTION:0,604,0

AT+CGPSINF=0

0,4419.800759,3318.093940,35.132473,20131116185157.000,110,11,0.000000,199.085
7
OK

AT+HTTPPARA="URL","www.gpstracker-iq.com/input.php?data=33.30156,44.330012,201
11-16_18:51:57,0.0,Agent1"

OK

AT+HTTPACTION=0

OK

+HTTPACTION:0,604,0

AT+CGPSINF=0

0,4419.800759,3318.093940,35.132473,20131116185207.000,110,11,0.000000,199.085
7
OK

AT+HTTPPARA="URL","www.gpstracker-iq.com/input.php?data=33.30156,44.330012,201
11-16_18:52:07,0.0,Agent1"

OK

AT+HTTPACTION=0

OK
```

Figure 7 GPS Data Reception and Transmission

The GSM network was assumed to be highly reliable and availability assumed to be very high since it means revenue

to the provider. In case of network un-availability, the acquisitioned GPS coordinates and other data such as time and speed are stored temporarily until the network returns back to service then the stored coordinates are sent with their time stamp and speed.

XIII. TRACK BRWOSING

A tracking page implemented for the purpose of track browsing; this page consists of an embedded Google Map in the body, two drop-down lists for agent selection and route type, Show track details, and calendar. Through this page, clients and agents can view track on map by selecting agent, route type, and date, however, for agents only route type drop-down list is used since the agent is identified. Figure 8 shows tracking page.

The map cantered at Baghdad city centre for default case, however, for a specific agent the map initially centred at vehicle position and keeps updated at the specified intervals. Google Maps provide zoom and moving tools which ease zooming in and out and navigation on map.

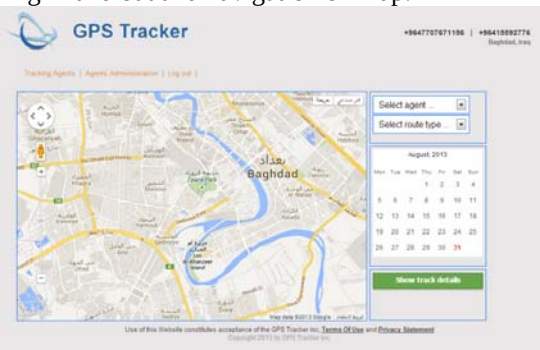

Figure 8 Tracking Page

By selecting agent, route type, and date the vehicle location will be displayed on map. For static tracking, all location in track table which match the selected agent and date will be added on the map indicated by green markers and polygons connecting markers from start point to the last point. google.maps class defines the vehicle location using LatLng variable and map options. mapping_vehicles function using the selected agent, route type, and date will call agentXMLTrack PHP function which will return XML marker rows of Latitude, Longitude, Heading, Date, and Speed. Depending on route type selected, if static or simulated route type is selected then all track data for the specified agent and date are retrieved, but for real time only the track data with max RecID are retrieved. For static routing all the retrieved data are added on the map. For simulated, the retrieved markers are added one-by-one by duration on 2 seconds with polygons connecting the markers.

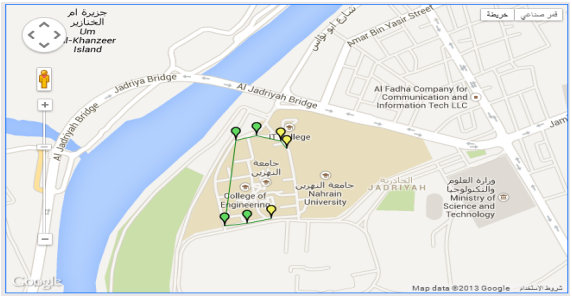

Figure 9 Static Route Tracking

In real-time tracking only last location is queried from database and presented on map. In real-time tracking, the database is queried every 10 seconds for new data and the page refreshed with the new data.

Figure 10 show the mapping process flowchart the three displaying methods (static, simulated, realtime) are presented.

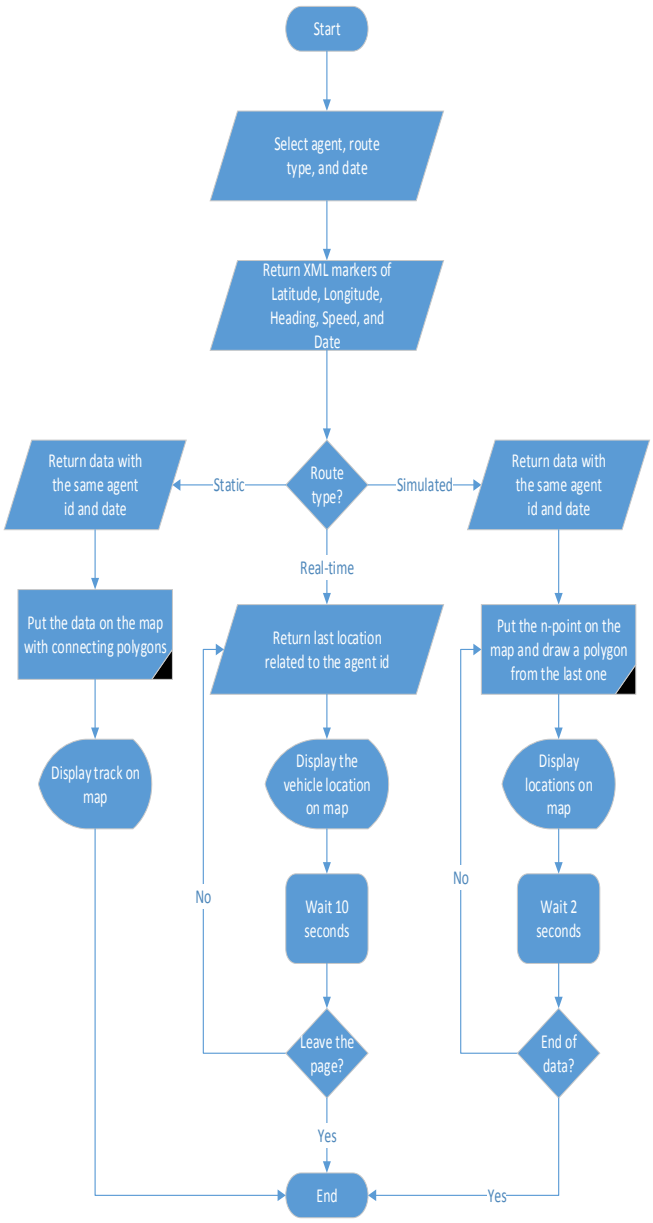

FIGURE 10 MAPPING PROCESS FLOWCHART

XIV. CONCLUSIONS

The integration of GPS with GPRS provides continuous and real-time tracking. Transmission cost extremely reduced by using GPRS service instead of SMS. Google Map free service and the use of HTTP protocol as a data sending method reduces the monthly cost for an individual user or an enterprise. The proposed system was designed to be expandable with unlimited number of users and support independent different type of authorization.

The Designed system displays locations of the tracked vehicle with an error between 2.5 and 50 meter in real-time on the map. Accuracy of the system is highly dependent on the GPS device and the coordinates received from GPS satellite while reliability and usability depend on the reliability of the mobile communications network. The system is very effective in areas where there is wide mobile network coverage; ease of use is another factor, the client application is a PC-based web browser, mobile browser or other PDAs browser which enables user to log check track where and when ever internet access is available. The web designed to be user friendly, interactive, secure, and reliable.

Normalized database tables used results in reduction in cost as the redundancy is avoided as much as possible. Repetition when occurs exhausts the server and database engines by checking similar data exist in a number of different tables. Using the standardized set procedures and distributing database functionality into set of stored procedures reduces the needed code amount and syntax lines of code used.

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