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Satellite Based Train Monitoring System

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***Abstract*—Transportation is a large and important part of the economy of a country, train is one of the main transportation systems of Bangladesh. Therefore, we should have a good and strong monitoring system that can locate a train at every instant. This paper has proposed the implementation of a global positioning system (GPS) based train monitoring system that could locate a train at every instant. Here a GPS–GPRS module transmits the location information to a web server. Every track in the system will be assigned a unique number. Now this track position of the train is also transmitted with this location information via an onboard computer placed on the train. This computer continuously updates the track position when the train is moving. This information is stored in the web server. When a client user requests for a particular train status, a web application shows the status in Google map. This implementation can effectively reduce train accidents in Bangladesh.**

***Index Terms*— global positioning system (GPS), tracking, monitoring system, web server, Google map.**

I. Introduction

TRAIN is one of the main and biggest transportation systems in Bangladesh. It contributes a lot in the economy of this country. Everyday thousands of people travel in train to different destinations. For good customer services, it is their responsibility to have a good management system. Therefore, it is necessary for them to have a clear idea about the actual position, speed and time to reach destination of a particular train at every instant. However, train-monitoring system of Bangladesh [1] does not posses such system that could give them the actual information like the position, speed and distance of a train from a particular station at every instant. The existing conventional monitoring system most of the time rely on the oral communication through telephonic and telegraphic conversations. There is large scope for miscommunication. This miscommunication may lead to wrong allocation of the track for trains, which ultimately leads to the train collision in our railway system. When train crosses a station and sets for next station the rail truck between the two stations is locked and no other train are permitted to enter in that locked section. A station can only senses a train within its 1200 ft. range. When a train crosses this limit, a station can only tell the train is somewhere between the two station but cannot tell in which particular position and at what speed the train is heading to the next station.

In this paper, the main objective is to implement a system with GPS-GSM/GPRS (General Packet Radio Service) [3] device which is kept at the train and forwarded its position to the controller via GPRS/GSM network. This provides the control rooms with the information like as position, speed and distance from particular station which are required for proper controlling of trains.

II. GPS (Global Positioning System)

The Global Positioning System gives accurate position and velocity information anywhere in the world. The Global Positioning System (GPS) [3] is a satellite-based navigation system made up of a network of 24 satellites placed into orbit. A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D movement.

With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude). Once the user's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination etc. [2]. There are three unknown position coordinates (x, y, z). Therefore, three equations from three satellites are required to solve for the three unknown coordinates. Here, (Ux, Uy, Uz) represents the GPS position. A fourth unknown is the error in the receiver's clock, which affects accuracy of the time difference measurement. To eliminate the clock bias error (Cb), a fourth satellite is needed to produce the fourth equation necessary to solve four unknown parameters using simultaneous equations. The solutions to the simultaneous equations for determining latitude and longitude are given in figure 1. The accuracy of a position determined with GPS depends on the type of receiver. Most of the existing hand held GPS units are of about 8-10 meter accuracy. For obtaining higher accuracy DGPS (Differential Global Positioning System) may be used.

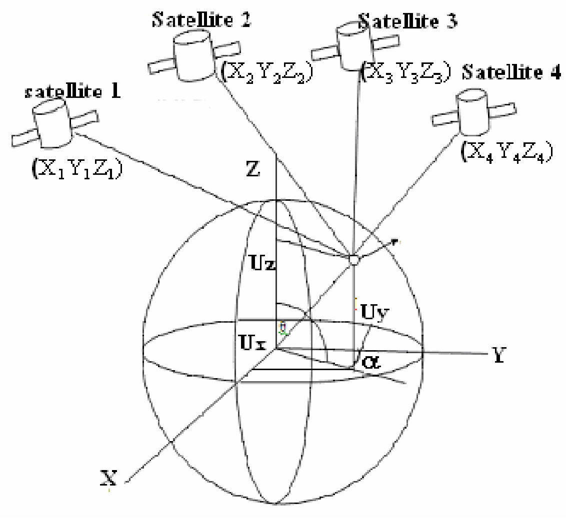

Fig. 1. GPS satellite position calculations [3].

$$(X_1 - U_X)^2 + (Y_1 - U_Y)^2 + (Z_1 - U_Z)^2 = (r_1 - C_b)^2 \quad (1)$$

$$(X_2 - U_X)^2 + (Y_2 - U_Y)^2 + (Z_2 - U_Z)^2 = (r_2 - C_b)^2 \quad (2)$$

$$(X_3 - U_X)^2 + (Y_3 - U_Y)^2 + (Z_3 - U_Z)^2 = (r_3 - C_b)^2 \quad (3)$$

$$(X_4 - U_X)^2 + (Y_4 - U_Y)^2 + (Z_4 - U_Z)^2 = (r_4 - C_b)^2 \quad (4)$$

$$\text{User's latitude} = \theta = \cos^{-1}\frac{\sqrt{U_X^2 + U_Y^2}}{|U|} \quad (5)$$

$$\text{User's longitude} = \alpha = \tan^{-1}\frac{U_X}{U_Y} \quad (6)$$

III. System Overview

In this system, the GPS-GSM/GPRS [3] module collects the position information of a train at every instant and passes this information to a web-server shown in figure 2 and in figure 3. As data being passed to the web server containing a real IP address and now listen to a specific port assigned for it. A database created at the server end stores these data. The database now contains all the necessary information that it needs to update the position of any particular train. A web page continuously communicates with the host server as requested. This web page contains a detailed map of a location. Here Google map is used to show the updates of location. As new data being inserted into the database, it updates the location information containing speed, distance from a particular station etc. of the train at the client end in this Google map.

The man machine interface can also become a useful tool for preciously locating a train in a track. Every track available in our current railway system is assigned to a specific code number. This code number can individually represent the track position of a train. An operator in the train continuously updates the track number in the computer which is connected with the GPS-GPRS module. The data served by GPS and the onboard computer is accumulated by the server and the server is able to give accurate position with track number and makes the decision when and in which track the train should arrive at the next crossing. The central control room now has the total overview of every single train running all over the Bangladesh with their instant status.

IV. Hardware Specification

Here, figure 4 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 (National Marine Electronics Association) [4] format and adds it with its own unique IMEI (International Mobile Equipment Identity) number. 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

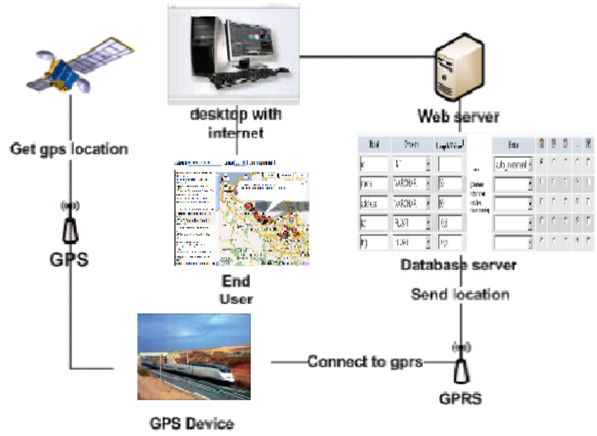

Fig. 2: Flow Diagram of GPS based train monitoring system.

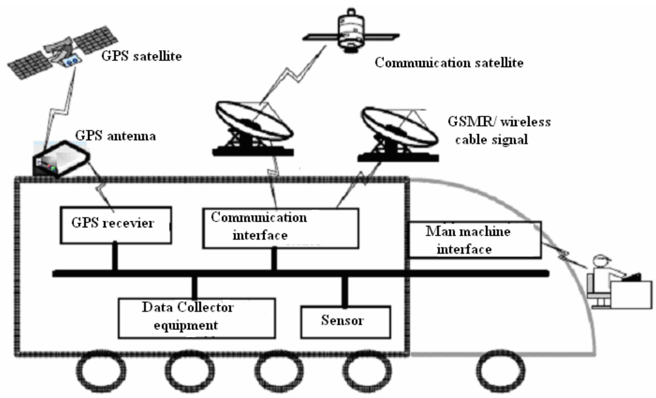

Fig. 3. Block Diagram of GPS based train monitoring system.

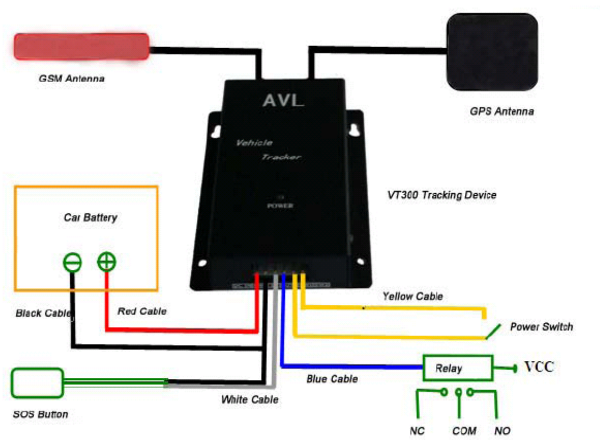

Fig. 4. AVL VT300 GPS-GPRS Module.

again. After establishing the GPRS connection it tries to connect to the service provider's server using the HTTP (Hypertext Transfer Protocol) protocol. After successful connection, the GPS device sends the data with id number.

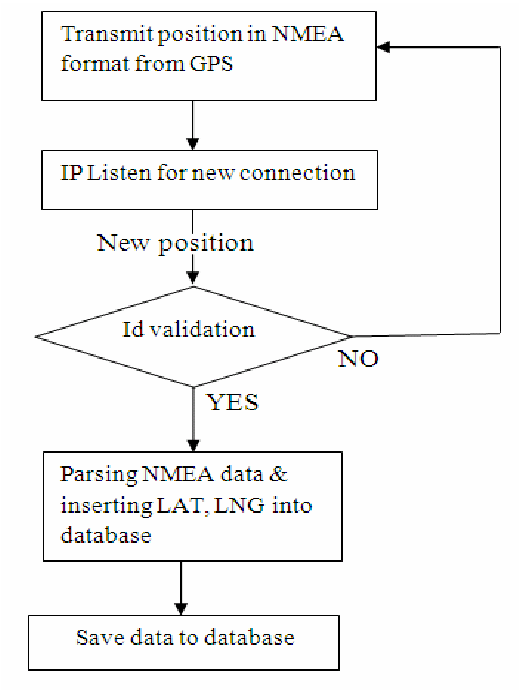

Fig. 5. Server side flow diagram.

V. Software Specification

To view the current position of the train a web-based application has been developed. Using this web application an end user is able to view the live position of the train and also the distance from a particular station in a Google Map. To implement this project PHP5 (Hypertext Preprocessor), HTML (Hyper Text Markup Language) [5-6] and Ajax (Asynchronous Java script) scripting language was used. MySQL, [7] 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.

A TCP/IP (Transmission Control Protocol/ Internet Protocol) listener is responsible for accepting NMEA [4] data which is sent by the device via GPRS to a specific Port of the desired IP address. This data consists of the id number of the device. Each device can be assigned to a unique id no. The sever side flow diagram is shown in figure 5. Figure 5 explains that when a GPS is set to work, it transmits its position in NMEA format to the server station. After listening the IP for new connection, it responds. Then new position is transmitted to the server in NMEA format. NMEA data consists of GPS identification no. If module id is verified, then data is transmitted. Now, server parses the NMEA data and extracts Latitude and Longitude and saves them to the database.

Ajax is asynchronous, to which extra data is requested from the server and loaded in the background without interfering the display and behaviour of the existing page. Data is retrieved using the XML (Extensible Markup Language) Http (Hypertext Transfer Protocol) request object that is available to scripting languages running in modern browsers, or, alternatively, through the use of

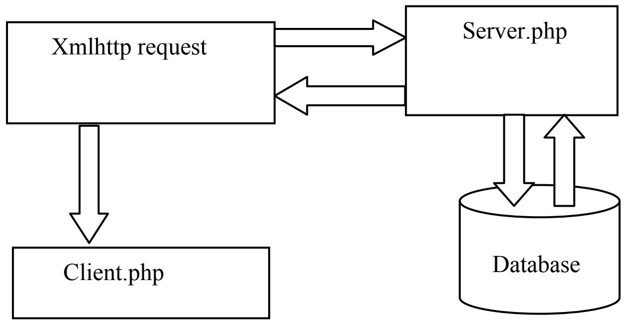

Fig. 6. Client-Server interaction.

Remote Scripting in browsers that do not support XML Http Request. Server Database stores all the position information. As illustrated in figure 6, when a client asks the position of a train an xmlhttp request is generated and is transferred to the server. Then the server queries database for extracting the latest position information. Finally, the server sends this information to the client end and shows the updates in Google map.

VI. Important Attributes

This system is very cost effective. GPRS was used for data transfer instead of SMS (Short Message Service). Several SMS based vehicle tracking [8] 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). This system firstly reduces the manpower required and secondly reduces train accident, one train accident leads to loss of huge money, which can be saved and be used by government for modernization of railways and also late running of trains can be prevented to large extend. In the present railway system, it is not possible to locate and monitor the status of all trains on a single moment. But, now in the implemented satellite based train monitoring system, it is possible to locate every locomotive and show the positions of these locomotives on a single monitor within an instant. As the control room has the full access in the system, the controller now has a clear understanding about the current situation of the system in a moment. Besides, as this system works along with the onboard computer held on the locomotive, the operator now also have clear view about its own position and the track on which it is moving. As a result, if another train comes on the same track it can easily generate a SOS signal to the trains moving on the same track. Thus the head to head collision can now be effectively minimized and a lot of lives and resources can be saved.This system can also be implemented for vehicle tracking. It 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.

This experiment has done in Chittagong University of Engineering and Technology (CUET) campus. Figure 7 shows different points as the system moved through CUET campus. Here the centre circle is considered as reference point and all other distances are measured from this reference position. The distance in figure 7 is shown inside the bracket and the speed is shown under each position

VII. CONCLUSION

Railway has long been considered as the safest transportation media. To improve the efficiency of the transportation systems, it is necessary to investigate the accidents and find out the essential methodologies for optimum management of information and resources available in railway rescue operations. The statistics shows that a huge number of accidents occurred due to human errors. Therefore, having a systematic way for railway operation management and reduction of human intervention, controlling activities, performances etc. may play a significant role to diminish the number and impact of accidents. Moreover, Reliable, accurate, precise, up-to-date and structured geospatial data is the key for decision making. Therefore, this system is very essential for the Bangladesh railway because it could bring an abrupt change to the existing train monitoring system.

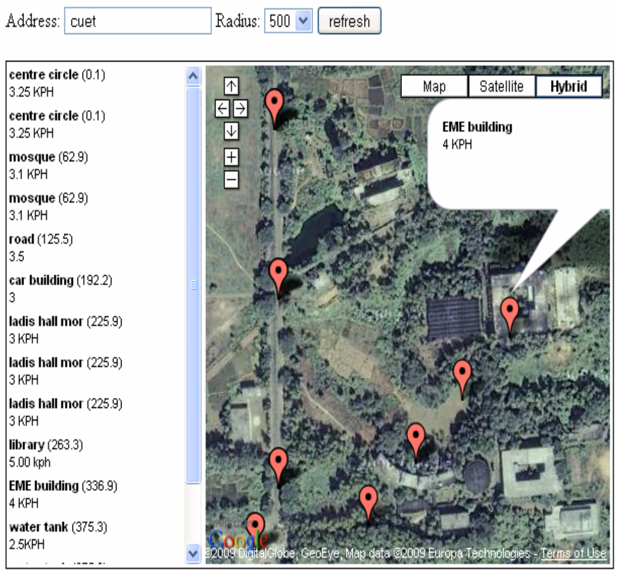

Fig. 7. Position updating in Google Map from client end.

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