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GPS Based Train Tracking System: Utilizing Mobile Networks to Support Public Transportation

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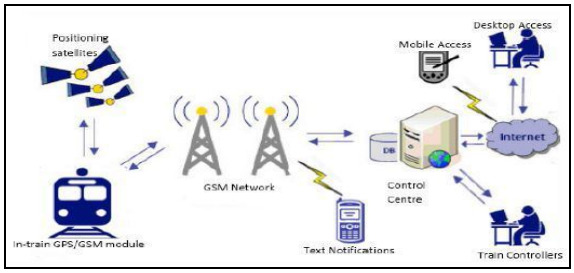
Abstract:
The paper presents a solution implementing for SCR Vijayawada, to provide an intelligent train tracking and management system to improve the existing railway transport service. The solution is based on the powerful combination of GSM, GPS and software. The inbuilt GPS module identifies the train location with a high accuracy and transfers the information to the central system via GSM. The availability of this information allows the train controller to take accurate decisions as for the train location. Location data can be further processed to provide visual positioning using maps granting a wholesome view on train location. Additionally, the location information can be used to facilitate accurate scheduling with regard to train arrival and departure on each station.

I. Introduction

Rapid growth in the field of Communication Technology is a worldwide phenomenon experienced today. Governments worldwide have also recognized the high potential in communication sector and using it as a core instrument to facilitate government processes**.** Railway services in India are rendered by the Indian railways department, which is owned by the public sector of the country. The government is seeking methods to improve the efficiency of this service with the main objective of providing a better service to the train commuters (passengers). The current switch based train-tracking system used by SCR (South Central Railway) supports the train controllers to manage the train operation by providing the train's location. The train safety has been an issue with the increasing number of incidents such as deaths and injury. These can be avoided if there is a mechanism to track the train location and warn the locomotive drivers about possible safety issues. Additionally, the passengers also face difficulties due to frequent train delays, as the administration is unable to provide accurate schedules based on train's location.



The solution is GPS based train tracking system, which provides accurate and timely information to the controller. The in-built GPS module identifies the train location with a highest accuracy and transfers the information to the central system via some communication interface (GSM or Zigbee). The availability of this information allows the train controller to take accurate decisions as for the train location. Location data can be further processed to provide visual positioning using maps to facilitate accurate scheduling with regards to train arrival and departure on each station.

2. Present Working Scenario of SCR

Indian Railways are one of the biggest transportation networks in the world providing lakhs of job. Being biggest sector there are some key problems which are to be rectified in order to ensure the complete safety of passengers. Such problems are flaws in tracks and collisions of trains.

Whenever a particular train arrives at a station, the information should be sent to that specific station control room & to headquarters. Usually Station master will pass this information to the control room through landline communication .i.e. information is passed manually. The control of the train is under the station Master. But this manual operation strictly depends on keen observation of station master & the proper communication through landline. Otherwise train collisions and accidents may happen. In addition if a train was stuck at any of the stations in a section, this information cannot be obtained immediately.

With the growing of high speed railway traffic and to reduce practical human errors, there is a need to develop an ***automatic train tracking system***. This enables to identify the exact location of trains at any time. This system automatically passes the information to the station control room. The information to the headquarters is passed through railnet. This application will surely help in creation of efficient, punctual and safe transportation service. This is also useful to avoid land line communication errors.

3 Difficulties in Present Process

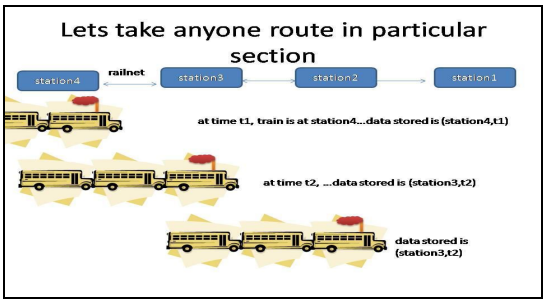
The provision of safe and reliable services is a fundamental requirement of the railway as thousands rely on this service as their prime mode of transportation. The Railway department of India carries about millions of passengers per annum and the safety of such service can never be taken. Passengers are entitled to expect to travel in safety throughout their journey and the government should be committed to protect the passengers and employers form any safety issue that might rise during journey. Effective safety planning requires a detailed understanding of key risk areas; this allows resources and effort to be concentrated where they will have greatest impact.

The main safety issues are in the form of accidents that mostly involve third parties other than the passengers and theemployers. Most of the infrastructure issues are associated with signaling and accident. This can be addressed by developing a communication channel between the train and control center. The control center should be able to identify the train's location to recognize possible safety threats; such as collisions. The control centers should also be able to notify thelocomotive drivers of the security threat. This will allow the drivers to avoid or at least minimize the harmful issues. Newsystem-management technology combined with accurate knowledge of train position will give the opportunity to present drivers aimed at maintaining the flow of traffic by regulating trains to await paths. Human intervention at control centers can lead to accidents due to human error or negligence.

This problem can only be solved via an automated system, which will handle these tasks and would consequently avoid human errors.

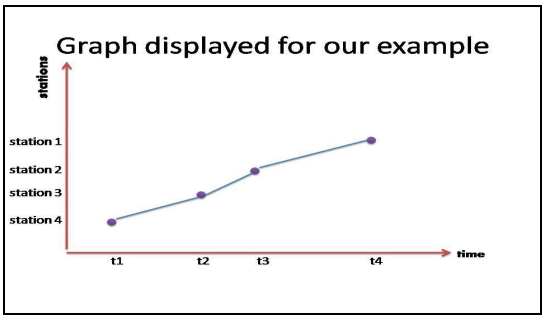
4. Proposed Working Principle

We strongly believe that the latest communication technologies can provide an effective and feasible solution for the requirement of a reliable and accurate train tracking system to improve the efficiency and productivity of Indian railways. The solution we propose encompasses a powerful combination of GSM(or Zigbee or GPRS), GPS technologies and software to provide an intelligent train tracking and management system to improve the existing railway transport service. The following figure is architecture for this tracking system. The fundamental process in our system is obtaining train location using GPS technology and transmitting the data to local station. Data received at local station is transferred to main station via railnet for further data processing and controlling. Real-time positioning information received by the server is made meaningful and extremely useful for end user. End user can better organize and utilize information from a graphicsl view point. The train locator unit planted in train is designed and implemented, considering the cost factor, size of the module, durability and low power consumption. The GPS receiver of the unit is capable of identifying the latitudinal and longitudinal position of specific train by receiving information from GPS satellites. The position data is periodically sent to microcontroller that data compared with the data already present in microcontroller, when it matches with particular L/L ratio, then it sends the active signal to corresponding local station. There the local station stores the data along with its time. Further data is transferred to main station (BZD) viarailnet.



The central control system present in Mainstation includes a server for handling and processing all the position information received from the train locators via the GSM network. The server automatically updates the database with latest position of each train. The server carries out information processing and analyzing in order to cater different requirements of the users of our system. Our main objective is to be instrumental in improving the efficiency and effectiveness of Indian Railway services by fulfilling the fundamental

requirements of reliable and real time information of train positioning for monitoring and administration purposes by the railway department.

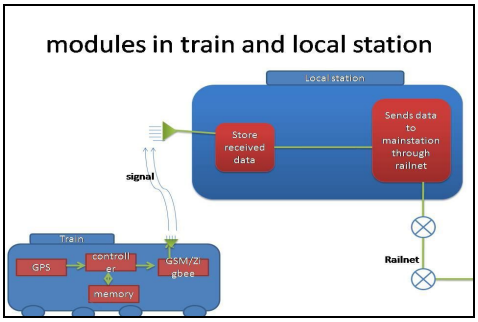


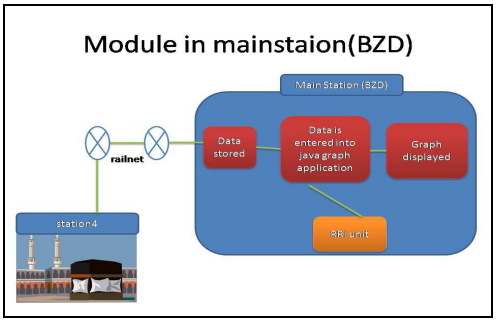
After getting location, time data from each station to central station, there it stores the data into database. From there it sends to graphical interface for better understanding and for better control. RRI (Route Relay Interlocking) unit will control the relays present in main station depending this graphical view of data.

5. Hardware and Software Requirements

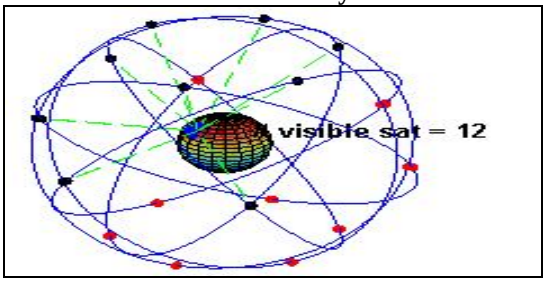
Our tracking system consists of the following modules

- GPS (Global Positioning System)
- Communication media between train and local station
  GSM (Global System for Mobile Communication)
  Zigbee Rx/Tx
- Railnet between local station and main station (BZD)
- Data base system for visual graph of train locations





Global Position System



There are three parts to a GPS system: a constellation of between 24 and 32 solar-powered satellites orbiting the earth in orbits at an altitude of approximately 20000 kilometers, a master control station and four controland monitoring stations (on Hawaii, Ascension Islands, Diego Garcia and Kawajale) and GPS receivers such as the one in a car.

Each of the satellites is in an orbit that allows a receiver to detect at least four of the operational satellites. The satellites send out microwave signals to a receiver where the built-in computer uses these signals to work out your precise distance from each of the four satellites and then triangulates your exact position on the planet to the nearest few meters based on these distances.

In fact, signals from just three satellites are needed to carry out this trilateration process; the calculation of your position onearth based on your distance from three satellites. The signal from the fourth satellite is redundant and is used to confirm the results of the initial calculation. If the position calculated from distances to satellites “A-B-C” do not match the calculation based on “A-B-D” then other combinations are tested until a consistent result is obtained.

The process of measuring the distance from satellite to GPSreceiver is based on timed signals. For example, at 16h45m precisely, the satellite may begin broadcasting its signal. The GPS receiver will also begin running the same random sequence at 16h45m local time, but does not broadcast the sequence. When the receiver picks up the signal from the different satellites, there will be a time lag, because the microwaves take a fraction of a second to travel from the satellite to the receiver. The time lag is easily converted into distance to each satellite. The slight difference between signals from each satellite is then used to calculate the receiver's position.

5.1. What Does The Signal Consist Of?

GPS satellites transmit two radio signals. These are designated as L1 and L2. A Civilian GPS uses the L1 signal frequency (1575.42 MHz) in the UHF band. The signals travel by line of sight, meaning they will pass through clouds, glass, plastic etc. but will not travel through solid objects such as buildings and mountains.

The GPS signal contains three different bits of information — a pseudo random code, almanacdata and ephemeris data.

- The **pseudo random code** is simply an I.D. code that identifies which satellite is transmitting information. You can often view this number on your GPS unit's satellite information page, the number attached to each signal bar identifies which satellites it's receiving a signal from.
- **Almanac data** is data that describes the orbital courses of the satellites. Every satellite will broadcast almanac data for EVERY satellite. Your GPS receiver uses this data to determine which satellites it expects to see in the local sky. It can then determine which satellites it should track. With Almanac data the receiver can concentrate on those satellites it can see and forget about those that would be over the horizon and out of view. Almanac data is not precise and can be valid for many months.
- **Ephemeris data** is data that tells the GPS receiver where each GPS satellite should be at any time throughout the day. Each satellite will broadcast its OWN ephemeris data showing the orbital information for that satellite only. Because ephemeris data is very precise orbital and clock correction data necessary for precise positioning, its validity is much shorter. It is broadcast in three six second blocks repeated every 30 seconds. The data is considered valid for up to 4 hours but different manufacturers consider it valid for different periods with some treating it as stale after only 2 hours.

6. Advantages

The train control and management process includes management of heavy traffic of passenger and freight trains, which operates in complex running patters on the railway network. The train controller needs to ensure that passenger trains are adhering to the schedules as well as to find efficient routes for unscheduled freights trains. Recording the train locations, arrival/departure time is a tedious task for the train controllers and would be time consuming if done manually. The accuracy of this information is very important to ensure smooth functioning of the railway service as well as to optimize resources planning. Following is a list of facilitiesthat can be offered by our system to automate the train control and management process.

- Automatic record keeping of train operations and events
- Functionality to generate time-station(distance)graph for trains which can be used to control andplan train movements.
- Facility to playback the progress of each train andevents for review purposes.
- Automated schedule regulation
- Forecasting functionality of train arrival-departureat different stations.
- Automatic detection of over speeding, train delaysetc.
- Facility to send alerts/warnings to particular traindrivers on possible collisions through system.

7. Future Implementation

Till now we are giving information only at end station,thatis the train after leaving the station and before reaching next station premises we don’t know that train status, we can’t give details about crossings, and velocity of train, we can give all these details, we can track the train instantaneously at any time, so estimated elapsed time to reach the destination will know around 2% tolerance.

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