Real Time Based Navigation and Prevention System

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Abstract: Lakhs of people are availing Train transport services daily in India. Presently in Sub-Urban Train Services in Chennai, the passengers are able to get announced of the name of the arriving Stations, in advance. This service is being provided by using traditional Track Circuit, which updates train position on a map every time it crosses a station on its way. This system does not provide Real Time tracking, as the stations are at least 1 Km apart in urban areas and 10 to 20 Km in other areas. Most of the Train accidents such as collision with stationed racks, mishaps at unmanned level crossings are due to human errors, over-speeding problems, signaling problems etc., Terrorists’ attack, fire breakout in one bogie etc., are unnoticed by the passengers in the other bogies as well as Drivers or Guard of the same train, since there is no intra-train communication methodology adopted so far. In order to solve these problems we propose the Real Time Based Navigation and Prevention System. This system will run the Train autonomously without any human operators. The system can start the train, run at a predetermined speed and it can stop at the scheduled station automatically.

Keywords: Real Time Based Navigation and Prevention System, Centralised Server, Train location, Explosives, Fire outbreak, panic situation

1. Introduction

In the present scenario, proclamations of approaching station are provided by the railway users so that it might be very helpful to know the timing of the train which will be arrived. For that purpose, they use traditional track circuits, which is able to make aware of the time at which the train crosses the station. Due to the large distance of 1 Km to 20 Km from one station to another, traditional track circuits is not suitable for a real-time tracking method as location of the train not known until it reaches the next station somewhat nearer which may be 5 to 20 minutes distance away. Human can lead more mistakes, which may cause the train accidents. Statistical analysis tells that every year finish up with atleast 2 or 3 major train accidents which is due to human carelessness. Some of the train accidents caused due to human carelessness are Train to train collisions, over speeding trains and signalling errors, which leads to lot of deaths in the train track. Most of the train accidents causes due to signal operator, i.e., carelessness of the signal operators not properly provide the signals to the train.

Another issue is to need of safety and security of passengers within trains. Now a day, many terrorist organizations place the bomb and heavy explosives in the train or in the railway station for the purpose of revenging the country. To avoid these types of revenging, securities are tightened at the railway stations. But still it will happen because of lack in communication about these type of activities. Also, there is a possibility of fire eruption which is originated in one section which will quickly spread to other part of the trains which results in loss of plenty of lives. This will also happen due to the lack of communication about these types of fire breakout to the driver so that the driver used to stop the train and make the passenger from remaining part will run out from the train. Lot of lives will also lost in the crossing of tracks without noticing an approaching train. This type of mishap happens in the unmanned railway crossings. There is no way to prevent this in any existing technology. But during an emergency situation, there is no alerting process for onboard passengers. There is agrowing trend of habit of using rail traffic due to the low cost and faster travelling. Also night time travel is preferred by the rail user. To eliminate human errors during night times, human driverless train operations, i.e., automated driving is necessary. One of the solutions of this situation is to use the Real Time Based Navigation and Prevention System (RTB-NAPS).

2. System Model

RTB-NAPS is used to operate the train automatically without any intervention of human operators. Central railway servers are being used to monitor and control all the trains. This may used to avoid all accidents occurred due to the operator’s carelessness and lack of communication. The Train Engine unit consists of an onboard Global Positioning System module and a Global System for Mobile Communication module. These two modules are used to update the various parameters, such as location of the train, speed, direction related information, to the Railway Server unit (once in 30 sec). Programmed Micro Controller is used to start the train engine from a Station, passes the train through the route provided by railways, and stop the train at the scheduled Station, based on its GPS based location. The railway server is used to collects all the information, which is sent by the GSM Module. The information collected by the railway is used to calculate the optimum speed of travel for the train and sends this information from server unit to the train. The train control system is used to adjust the speed automatically based on the information given from the server unit.

It is used to help the passenger to know the location of the train, speed and direction from anywhere in India through the mobile phone of the railway user. It also contains Metal and Fire Sensor in every coach for detecting the explosives and fire accident likely to occur. It provides interconnection of all the train compartments with embedded network which is used for the purpose of safety and security of passengers from any unexpected accidents occur within trains such as bomb blasts and fire outbreaks. It also havethe audio speakers which is used to inform the
passengers about the approaching station and also to provide any alert messages during a crisis situation. If any railway user used to query about the location of the train, they just give the SMS from the mobile phone. After received by the Server from the user mobile, server sends the acknowledgement reply in which location of the train is to be mentioned.

3. Hardware’s of the RTB-NAPS

In Real Time Based Navigation and Prevention System, 32 bit ARM Cortex M3 Microcontroller is used to model the Train Engines and Compartments. The advantages of Cortex-M3 Microcontroller over the previous version controller are that it provides branch speculation in pipelining.

![Train Engine Circuit](figure1.png)

The sleep mode and non maskable interrupt are present in this version. Remaining advantages are shown in table 1.

Table 1: Cortex-M3 Vs. Other Micro-controller

<table>
<thead>
<tr>
<th>ASPECTS</th>
<th>ARM7TDMI-S</th>
<th>Cortex-M3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture</td>
<td>V4T</td>
<td>V7M</td>
</tr>
<tr>
<td>ISA Support</td>
<td>Thumb/ARM</td>
<td>Thumb/Thumb-2</td>
</tr>
<tr>
<td>Pipeline</td>
<td>3-Stage</td>
<td>3-Stage+ Branch Speculation</td>
</tr>
<tr>
<td>Interrupts</td>
<td>FIQ/IRQ</td>
<td>1-240 Phy Interrupts 1-255 Priorities</td>
</tr>
<tr>
<td>Interrupt Latency</td>
<td>24-42 Cycles (Depends onLSM)</td>
<td>12 Cycles (6 when Tail Chaining)</td>
</tr>
<tr>
<td>NMI</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Sleep Modes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>PU</td>
<td>No</td>
<td>8 region MPU</td>
</tr>
<tr>
<td>Configurable</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>DMIPS/MHz</td>
<td>0.74 Thumb/0.93ARM</td>
<td>1.25 Thumb-2</td>
</tr>
</tbody>
</table>

Other than this ARM Cortex M3, Train Compartment Model consists of CAN Transceiver, Micro SD Card, MP3 Decoder, Emergency Switch, Quad Motor Driver, Motor, Temperature Sensor, 3-Axis MEMS Compass. The Circuit Diagram of the Control Circuit of Train Engine Unit is depicted here.

4. Technologies incorporated in RTB-NAPS

This section describes the various technologies incorporated in RTB-NAPS such as GPS, GSM, and Sensors etc.

4.1 Global Positioning System (GPS)

The Global Positioning System (GPS) is a system which is used to show the location of the train which is based on a group of about 24 satellites which has been orbiting the earth at the height of approximately 11,000 miles. Department of Defense (DOD), United States are developing this GPS system for the purpose of military locating utility. But GPS is not only used in military application, it can also be used in non-military mapping applications. To avoid the problems associated with land based systems, GPS satellites are orbited high enough. It can provide accurate positioning 24 hours a day, anywhere in the world. Positions of the train are
determined from GPS satellite signals, which will produce accuracies in the range of 50 to 100 meters. Differential correction technique is used to provide the users to get positions of the train accurately to within 5 meters or less.

GPS is used to provide any location on the earth with a unique address. GPS informs the address to the user’s mobile phone (say XYZ). GPS satellites are located at the height of 11,000 miles from the earth. The DOD is used to predict the paths of the satellites versus time with greater exactness. Furthermore, by means of huge land based radar system, the satellites can be periodically adjusted. Therefore, we know about the information of the orbits, and the locations of the satellites. So the GPS receivers contain this type of orbit information for all of the GPS satellites, called as the almanac.

GPS is used to determine the distance between a GPS satellite and a GPS receiver by measuring the amount of time to take the radio signal, i.e., the GPS signal, to pass through from the satellite to the receiver.

Speed of the Radio waves is equal to the speed of light, which is equal to 186,000 miles per second. So, we know the amount of time to travel the signal from the satellite to the receiver. Therefore, the distance from the satellite to the receiver (distance = speed x time) can be easily determined. If the exact time when the signal was transmitted and the exact time when it was received are known, the signal’s travel time can be determined. In order to do this, accurate clocks are used in the satellites and the receivers. These clocks are synchronized so that they generate the same code at exactly the same time.

The code received from the satellite and receivers are to be compared. By comparing these two codes, the time difference between satellite time and receiver time to generate the code can be easily determined. This interval of time is referred to as the travel time of the code. Multiplying this travel time (must be expressed in seconds) by 186,000 miles per second, which will give rise to the distance from the receiver position to the satellite in miles. GPS receiver in the Train Engine unit is used to detect the location once in 3 sec and also updates this information to the Central Railway Server. This information is used by the server for the purpose of calculating the speed of the train and to control the train by giving commands to boost/diminish the speed of the train.

4.2 Global System for Mobile Communications (GSM)

A GSM network consists of various functional entities, which is defined by functions and interfaces. The various functional entities in the GSM network are Mobile Station (MS), the Base Station Subsystem (BSS), the Network Switching Subsystem (NSS), and the Operation Support Subsystem (OSS). Usually the mobile phone or handset, which is used by every user can be used a mobile station. This mobile phone can be called as mobile station in the 2G systems like GSM, but in the 3G systems, we can call the mobile station (MS) user equipment (UE). The mobile station in the GSM consists of various components such as Mobile Terminal (MT), Terminal Equipment (TE), Terminal Adapter (TA), and Subscriber Identity Module (SIM).

The next component of the GSM is the Network switching subsystem (NSS). Its main function is used to do the various switching functions in the GSM network. Also it is used to administrate the connections between mobile phones and the Public Switched Telephone Network (PSTN).
the GSM transceiver and Base Stations available along the railway track are communicated in which base stations are placed once in 3 to 5 Km based on the nature of the location.

The uplink is defined as the data transport from Mobile Station to Base Station Subsystems whereas Downlink is defined as data transport from Base Station Subsystems to Mobile Stations. Interaction between Base Station Subsystems and Network Switching Subsystems is provided by using Optical Fiber Communication, in which data’s are travel through the cable in the form of light, by the Railways throughout its network due to the high speed of communication. The data transportation between the GSM Module and the Railway Central Server is also recognized through the Base Station System through the Optical Fibre medium due to the high speed. Since the GSM Module is used to provide the interaction with the Base Station through Uplink/Downlink Frequencies, mobility of the Train is ensured without any difficulty. At the same time, the transport of data between the BSS and the Server is created through the Optical Fiber Communication so that there is no delay in the both-way communication ensuring the safe, secure and autonomous travel of the train.

4.4 Temperature Sensor (LM35)

The Temperature Sensor is used to sense the abnormal Temperature variation occur in the Train Compartment/ Engine which will be send as the analog output. This sensor is used in this project for detecting any fire accident occurs at any compartment of the train. Here the temperature sensor used is a LM35, which will produce the temperature in the form of analog value. But microcontroller cannot capable of reading the analog values. So the analog signal is converted into a digital signal by using Analog to Digital Converter and then the converted digital signals are sent to the Microcontroller. This temperature variation is used to understand about the fire break-out in the compartment and starts the announcement system in all the compartments, bring the Train to a halt and sends message to the Server about the nature of the situation and GPS based location of the train. The announcement system is provided to engine driver, to stop the train, and the passengers who travelling in other compartment, to run out from the train.

4.5 Digital MEMS Magnetometer

MEMS Magnetometer is used to measure the variation in the magnetic field around the train. It is very helpful in detecting any kind of bomb in the compartment. The signal is received through I2C by the Microcontroller on detection of bomb. This information send to microcontroller through I2C bus is used to understand the bomb in the compartment and starts the announcement system in all the compartments, make the train to stop automatically and sends message to the Server about the nature of the situation and GPS based location of the train.

4.6 Emergency Switch

Emergency Switch is also provided in the entire compartment. If any railway user faces critical situation on-board the train, the particular user may press the emergency switch. This signal is then sensed by the microcontroller and is used to activates the Emergency related announcement throughout the train, bring the Train to a stop condition and sends message to the Server about the Emergency situation and GPS based location of the train. This activity supersedes any command from the Central Railway Server to increase/ Decrease the speed of the train.

4.7 Control Area Network

A high speed highly noise tolerant protocol is used to meet the requirement of the information exchange between the train Compartment and the Train Engine at real-time without any data loss.

5. Performance Comparisons

The performance of the RTB-NAPS is far better than that of the Communication-Based Train Control Systems with Coordinated Multipoint Transmission and Reception (CBTC). This is due to the fact that CBTC System is sustains
a Communication delay of 2s in case of Command to reach from Central Railway Server to the Train, where as in the case of RTB-NAPS, since it incorporates SONAR, any kind of obstacle is detected within a time gap of 100 ns. Hence the remedial action such as halting of Train or reducing the speed of the train etc., are taken locally at the Train Engine itself. Hence its performance is far better than that of CBTC System.

6. Conclusion

Thus Real Time Based Navigation and Prevention System can ensure a safe and secured train travel for the passengers autonomously, without a Driver. Implementing this System in Indian Railway System will open a arena where Night Train Services can be increased without disturbing the Human Drivers. New Train Routes can be introduced, without the Human Drivers.

References