UACEE International Journal of Advances in Computer Networks and its Security – IJCNS
Volume 3 : Issue 2 [ISSN 2250 – 3757]
Publication Date : 05 June 2013

Automated Railways Collision Avoidance System Using Wireless Networks

Amit Bir Singh Chadha[1], Abhishek Goyal[2], Davisha Verma [3] , Meenakshi Sood[4]
[1,2,3,4] Department of Electronics and Communication Engineering,
Jaypee University Of Information Technology, Waknaghat
Solan, H.P, India
amitbir.singh@gmail.com, abhishek.goyal28@gmail.com, davisha.7apr@gmail.com, meenakshi.sood@juit.ac.in

***Abstract*— This paper concentrates on predicting and removing the major cause of railway accidents, that is, head-on collisions on the same track. For this purpose we are using advanced technology to identify train positions, detect collision as well as the points where collisions may occur. The primary goal of this paper is to provide an anti-collision safety device for vehicles travelling on tracks, even without any driving personnel, that is to say, a device which itself can estimate risks and react in consequence. This ensures that if any collision is likely to occur, then this system will help to avoid collisions by giving an alarm in time and actuating emergency brakes if required. The goal of this work is to design and implement a cost effective and intelligent full-fledged microcontroller and wireless based Train Anti Collision System to successfully prevent the train collisions. It aims at efficiently integrating into the existing signaling system implemented in Indian Railways and avoiding accidents due to head-on collisions. For automated set-up, the advanced wireless technologies, GPRS and ZigBee are used. A ZigBee master-slave network is setup, which is interfaced with GPS to receive location-related data and then transmit it to different nodes**.

***Keywords-* GSM (Global System for Mobile Communication), GPRS (General Packet Radio Services), GPS (Global Positioning System), ZigBee, CAS (Collision Avoidance System).**

I. INTRODUCTION

Indian Railways is an Indian state-owned enterprise, owned and operated by the Government of India through the Ministry of Railways. It is one of the world's largest railway networks comprising 115,000 km (71,000 mi) of track over a route of 65,000 km (40,000 mi) and 7,500 stations. Indian Railways carries about 7,500 million passengers annually and 2.8 million tons of freight daily, making safe transportation the key objective. Train accidents occur normally due to safety violations resulting from 'human errors or limitations' and 'equipment failures' loosing precious lives. The Ministry of Railways (Railway Board), Government of India has recognized the need for research and efficient development of an efficient Train Anti-Collision system [1].

Presently, emergency may be passed through traditional tele-communication devices. In the traditional communication method, human error or carelessness may lead to severe disasters. IR sensors have limitations in due to the geographic nature of the tracks. Konkan railways have proposed and implemented an Anti-Collision System [2].

However, a severe bug was detected on testing, in which the system causes running trains to halt abruptly for no apparent reason. The system did not take any active inputs from the existing Railway signaling system, and also lacked two way communication capability between the trains and the control centers or stations, hence was later decommissioned.

Railways has been unable to develop a robust and reliable anti-collision device to prevent train mishaps despite carrying out field trials for over a decade, the Comptroller and Auditor General has observed in its latest report[3]. The device's field trials are being carried out since 2000-01 and site acceptance tests and modifications are being done since November, 2006 in the 1,736 km-long Katihar-Guwahati-Ledo/Dibrugarh section of Northeast Frontier Railway at a cost of Rs 158.67 crore. This paper is organized as follows: Section 2 gives an insight into the main modules used, Section 3 details about the proposed architecture and the design flow for implementation and Section 4 gives the results.

II. WIRELESS NETWORKS

A. ZigBee

ZigBee wireless mesh technology has been developed to address sensor and control applications with its promise of robust and reliable, self-configuring and self-healing networks that provide a simple, cost-effective and battery-efficient approach to adding wireless to any application, mobile, fixed or portable.

The IEEE standard 802.15.4 specifies the RF link parameters, including modulation type, coding, spreading, symbol/bit rate, and channelization (Table I.) Currently, the standard identifies 27 channels spread across three different frequency bands. The modulation mode used by 802.15.4 is phase-shift key (PSK) based, chosen because of its strong ability to be recovered even in very low signal to interference environments.

TABLE I.

	Frequency Band (MHz)		
	868.3	902-928	2400-2483.5
# of Channels	1	10	16
Bandwidth (kHz)	600	2000	5000
Data Rate (kbps)	20	40	250
Symbol Rate (ksps)	20	40	62.5

UACEE
Globalize The Research
Localize The World

ZigBee networking is natively mesh-based. The ZigBee networking specification provides networking mechanisms that allow a developer to create star, tree and mesh network topologies, depending on network requirements. Once formed, a wireless network is subject to interference, propagation changes, continued growth, unintended usage and security issues. There are two physical and three logical types of devices specified in 802.15.4 (Figure1). The two physical types are the Full Function Device (FFD) and the Reduced Function Device (RFD) and logical devices are the Coordinator, Router, and End Device [4]. An End Device is the end of routing environment for the network, the Router and the Coordinator are potentially identical devices, and differ in function only based upon the network's initial power-up sequence.

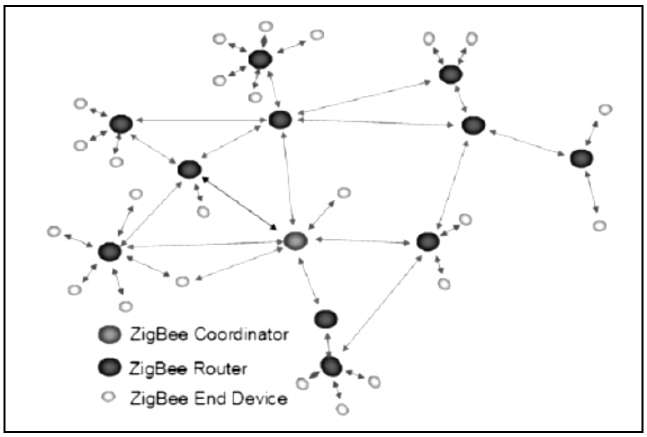

Figure1. ZigBee/802.15.4 Mesh Network and Device Types

B. GPRS (General Packet Radio Service)

GPRS is a technology where mobile phone users can transfer data using "packets" of information rather than conventional "circuit switched" communications. GPRS is an upgrade to the existing network that sits alongside the GSM network. GPRS network architecture mainly consists of the support nodes (Figure 2): Serving GPRS Support Node (SGSN), which takes care of routing, handover and IP address assignment and the Gateway GPRS Support Node (GGSN), which is basically a gateway, router and firewall rolled into one, GGSN is the "last port of call" in the GPRS network before a connection between an ISP or corporate network's router occurs.[5] The connection between the two GPRS Support Nodes is made with a protocol called GPRS Tunneling Protocol (GTP). GTP sits on top of TCP/IP and is also responsible for the collection of mediation and billing information. In practice the two GSN devices may be a single unit.

The SGSN works out which BSC to "route" a connection through. If the user moves into a segment of the network that is managed by a different SGSN it will perform a handoff of to the new SGSN, this is done extremely quickly and generally the user will not notice this has happened. Any packets that are lost during this process are retransmitted. The SGSN converts mobile data into IP and is connected to the GGSN via a tunnelling protocol.

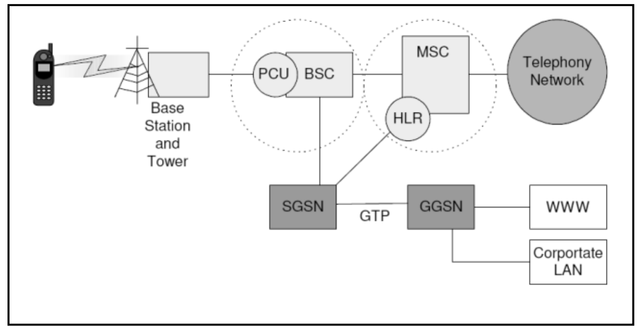

Figure2. GPRS Network Architecture

C. GPS (Global Positioning System)

The GPS is a space-based satellite navigation system that provides location and time information in all weather, anywhere on or near the Earth, where there is an unobstructed line of sight to four or more GPS satellites. A GPS receiver calculates its position by precisely timing the signals sent by GPS satellites high above the Earth. Each satellite continually transmits messages that include the time the message was transmitted along with the satellite position at the time of message transmission [6].

The receiver uses the messages it receives to determine the transit time of each message and computes the distance to each satellite using the speed of light. Each of these distances and satellites' locations define a sphere. The receiver is on the surface of each of these spheres when the distances and the satellites' locations are correct. These distances and satellites' locations are used to compute the location of the receiver using the navigation equations.

III. PROPOSED ARCHITECTURE

The aim of this endeavor is to design a collision avoidance system for railways that predicts and avoids collision without requiring human intervention and for this we have proposed architecture for the Collision Avoidance System (CAS) which assumes that the locomotives have some random locations on a single line between two destinations.

As depicted in Figure 3, each locomotive has CAS installed on board. The CAS of each locomotive is transferring location related data along with its loco ID to the other locomotives. This information is being transferred through GPRS communication. The loco ID is the Loco number which is pre-fed into the memory of the system through a Human Machine Interface. The location related data is taken from the GPS receiver which is a part of the system.

As per the design flow shown in Figure 4, each locomotive after receiving the information from the others, decodes the information packet to get the position related data of the transmitting locomotive and its loco ID after

UACEE
Globalize The Research
Localize The World

which it calculates its distance from the two transmitting locomotives by using its own location information derived from the GPS receiver communicating with it and takes action as per the conditions enumerated in the flowchart. In this way, each of the locomotives at any point of time knows its own location as well as the location of the other locomotives in terms of distance between them. The main objectives include interfacing GPS with GPRS for a communication system, interfacing a ZigBee receiver with braking system in locomotives and developing a Human Machine Interface.

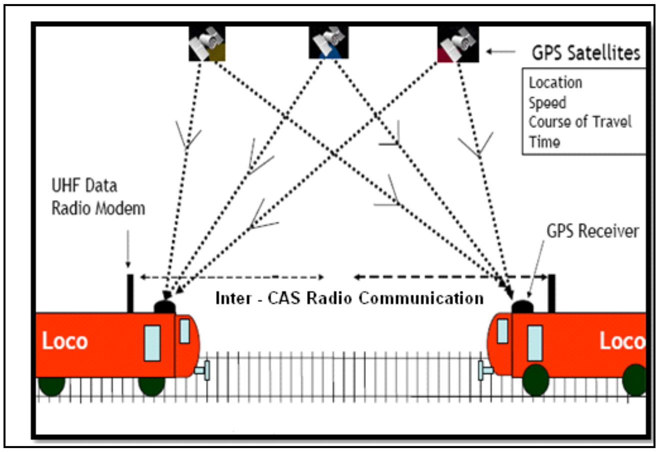

Figure3. Basic Operation of CAS

The standard GPGGA (Global Positioning System Fix Data) GPS [7] message given by (1) is decoded to determine the location information of the locomotives.

*GPGGA,hhmmss.ss,llll.ll,a,yyyyy.yy,a,x,xx,x.x,x.x,M,x.x,M,x.x,xxxx *hh* (1)

The distance between two points on the earth's surface can be calculated by using its latitude and longitude coordinates. The concept we use to find out a distance between two points is similar to that used to calculate a perimeter between two points on a sphere.

The Great circle distance formula [7] is used to calculate exact distance between points precisely given by (2).

$$DISTANCE = 69.1*(180/\pi)\cos^{-1}[\sin(LAT_1)*\sin(LAT_2)+Cos(LAT_1)*\cos(LAT_2)*\cos(LONG_2-LONG_1)] \quad (2)$$

where

DISTANCE is the distance(miles) between the first and the second point.
LAT_1 is the latitude of the first point in degrees,
$LONG_1$ is longitude of the first point in degrees,
LAT_2 is latitude of the second point in degrees, and
$LONG_2$ longitude of the second point in degrees.

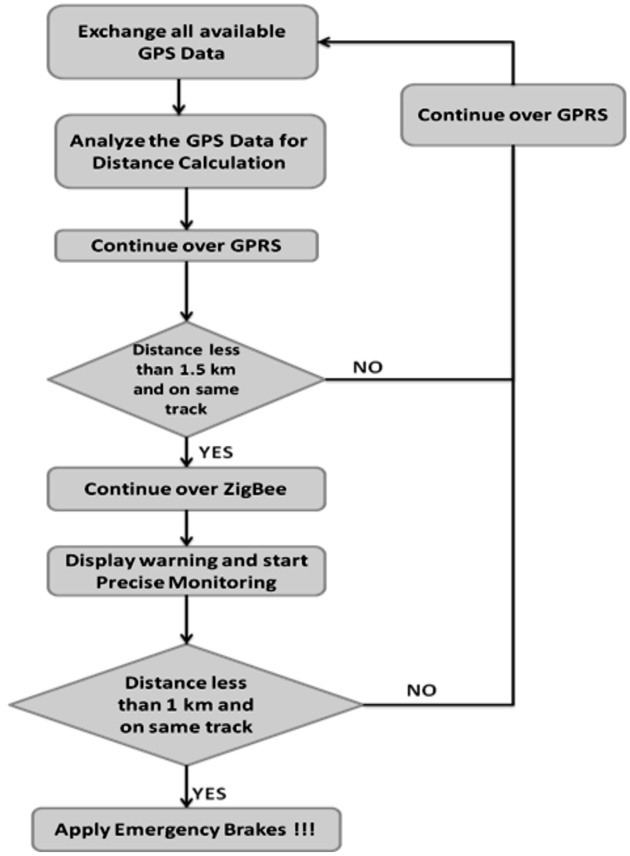

Figure4. Design Flow of CAS

IV. RESULTS

In our proposed collision avoidance system, as soon as the two trains with Zigbee routers installed on them would come within each other's radio range, they would start exchanging their GPS coordinates, loco ID and track ID. If the track IDs is same then the distance between them would be calculated and for decreasing distance a warning would be issued to the drivers aboard to apply the emergency brakes and if the driver fails to take any action, then an emergency braking system would be applied by releasing a relay in the loco engine. A safe distance of 1 Km has been taken for safe braking between the trains in case of an impending collision [6]. Based on studies by Indian Railways, it has been observed that even for two trains travelling at 120kmph, the safe distance after automatic braking under normal conditions has been estimated to be 920m.

GPRS network would be used for more precise monitoring than the GSM network. Using GPRS the loco ID of each train would be broadcasting its information in packets to other trains in its vicinity. The information packet would contain the train's GPS coordinates, loco ID, track ID, time, speed and course of travel which is decoded as shown in Fig 5. The CAS would compare the track IDs of the train and if they are same, the distance between them would be calculated. According to the distance between the trains and their respective speeds, a warning would be issued to the

UACEE
Globalize The Research
Localize The World

drivers on board. If the distance between the trains reduces to 1.5 km the communication between them would take place with the help of Zigbee routers installed on them.

A ZigBee Master-Slave Network is created so that when the number of nodes has to be increased, it can be modified accordingly. The ZigBee modules keep transmitting data packets to the other nodes so that their location coordinates can be monitored constantly. A standard GSM module will be used for communication over GPRS. Moreover, a specialized form of the human machine interface will be used with only necessary functions for the systems being installed in locomotives so as to make them robust. A basic GPS receiver chip using 12V DC supply from Omniscient Electronics along with an omni-directional antenna is employed. Once the Module is connected using Serial-to-USB port converter 1110, a hyper terminal has to be set up on the computer for further communication.

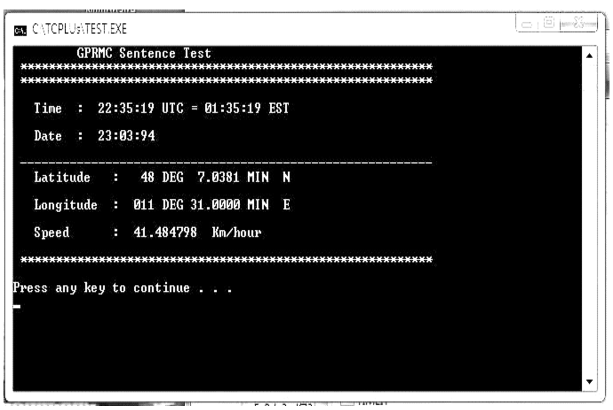

Figure5. GPS Coordinates Decoded Output

V. Conclusion

The above proposed system has been implemented with success to a large extent by using various modules for the networking operation. The ZigBee network is found to be cost-efficient and enables precise monitoring of the locomotives. The actuation mechanism for the brakes poses a design problem which may be solved on actual implementation in real locomotives. The signal flow has been found to be theoretically free from the previous faults in earlier attempts at such a system. Moreover, GPRS connectivity for normal monitoring provides an efficient means of tracking as Indian Railways already has a lease from Bharti Airtel for communications and also has an existing dedicated network by the name of RailTel.

The ideas presented in this paper propose a system that has the potential to drastically reduce the number of train accidents by removing the major cause of these accidents. It is unique in that it uses better and more efficient technology to track train movements and at the same time is cost-efficient. Moreover, the automation brought in leaves little room for error and the system can be easily incorporated into the existing Railway Network. The Indian Railways already has its own communication system in place and has the resources required for incorporation of our system into this network. Presently, there is a need being felt for such a system and once implemented after initial testing, this ystem would prove to be a major safety feature in the Indian Railways.

References

[1] A.P,Saritha, S,K.M.Martin, Madhukumar.S, “Simulation of Zigbee based TACS for collision detection and avoidance for railway traffic.,” in International conference on Advanced Computing & Communication Technologies for high performance application, paper ID 51, pp.22-26, June 2012.

[2] Bhatt, Ajaykumar A, “An Anti-Collision Device (ACD) Network - A Train Collision Prevention System (TCPS)” in International Railway Safety Conference (IRSC) - Goa (India), October 2007.

[3] CAG Report, 2012.

[4] Ramya, C.M., Shanmugaraj, M.,and Prabakaran, R., “Study on ZigBee technology” in International Conference on Electronics Computer Technology (ICECT), 2011, 8-10 April 2011.

[5] Cai. Jian, and Goodman, David J. ,” General packet radio service in GSM” Communications Magazine, IEEE, vol. 35 (10), pp. 122 – 131, Oct 1997.

[6] Global Positioning System, Standard Positioning Service, 1995.

[7] GEO Data Users Guide Book.