RAPID FIRE INTIMATION SYSTEM FOR RAILWAYS USING ZIGBEE WIRELESS SENSOR NETWORK

Ramprasath P S, Sairam K, Sivaraman N, Prof. D. Shanthi Chelliah

***Abstract*— Many attempts have been made to minimise the fatal fire accidents in Indian Railways. However, minimising the delay in communicating the near-by fire station has been a challenging task. In this paper, an alternative solution to this delay is overcome using embedded system technology powered by zigbee network, sensors, and enhanced vehicle tracking. To reduce the time consumption and to overcome the need of knowing the nearby fire station with respect to the train's location, our paper proposes rapid system for Railway fire alerts. In case of a fire accident, the wireless sensors mounted on the compartment will detect the fire and with the use of Zigbee network the microcontroller is interrupted through node to node communication. The microcontroller that is interfaced with the GPS gets the current location of the train and with the use of pre-fed database it sends the train number, compartment, time, position, and speed to the nearest fire station and hospitals that is determined using the Haversine formula. The controller also sends an emergency signal and the alert message to the engine driver in order to stop the train and to confirm the fire accident. After confirmation, the fire and medical service facility starts for the rescue mission. By this way the delay in reaction time to railway fire accident can be effectively minimised.**

***Index Terms*— Ionization and Photoelectric sensors, GPS, GSM, Zigbee Wireless Sensor Network.**

I. INTRODUCTION

In the past few years, railway accidents in India have been occurring frequently. India being ranked as the fourth largest railways in the world lacks safety when it comes to fire accidents. Hundreds of passengers get killed or injured due to lack of proper fire extinguishing and evacuation system in the coaches. The recent proposal of providing fire extinguishers in each compartments are one way to minimise the deaths. According to the statistics, a large number of fatal incidents occur mostly on night or during early mornings when the passengers are unaware of the fire brewing up. in addition to this, havoc caused by the accident and manual intimation to co-passengers decreases the probability of voluntary requisition by passengers for rescue services. So, there is a high demand for automated fire detecting system which will not only alert the concerned authority but also inform the nearby fire control station and medical services. Our paper proposes a methodology which ensures the reduction of delay in time in informing the fire stations and hospitals. This also removes the inconvenience of knowing the fire stations and hospitals near the train's current position which also may be unknown.

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II. TECHNOLOGIES USED

A. Global System for Mobile Communication (GSM)

Global system for mobile communication was developed as a standardized group to create a mobile cellular radio system operating at 900MHz in Europe. Now it is a globally accepted standard for all digital cellular communication. It is one type of modem that operates with the help of a network provider using a integrated circuit embedded on a plastic card called Subscriber Identity Module (SIM).

The 2G signals are modulated and demodulated using a SIMCOM SIM300 GSM Modem. It can be operated at 3 different frequencies. Default frequencies are EGSM 900MHz and DCS 1800MHz. The module needs only TTL interface which allows us to serially interface with a microcontroller. By using AT commands, operations like sending SMS, making and receiving calls are done. SIM300 allows and adjustable serial baud rate from 1200 to 115200 bps. It has a low power consumption of 0.25A for normal functions and 0.9A during transmission and has a operating voltage of 7-15V.

B. Global Positioning System (GPS)

Global Positioning System (GPS) is worldwide known device for transportation, navigation and vehicle position tracking. When connected with GSM, the position of the device can be determined instantaneously. The Global Positioning System (GPS) uses satellite for detection of location and position. It uses satellites that have unobstructed line of sight with respect to the position. The system provides critical capabilities to military, civil and commercial users around the world. It is maintained by the United States government and is freely accessible to anyone with a GPS receiver.

Due to advancements in technology and demand in society, positioning using GPS has become more accurate. Contemporaneously with GPS, the Russian Global Navigation Satellite System (GLONASS) was developed, but suffered from incomplete coverage. Combining both GPS and GLONASS satellite constellation enabled better

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performance in even obstructed areas. This high precision technology in positioning of the GPS module is required for tracking the train all through its journey. The hardware interfaces for GPS units are designed to meet NMEA requirements which provide Time, Date, Position and Speed in the form of RMC sentence. A typical example for an RMC sentence is shown below:

$GPRMC,153618,A,6655.018,N,23654.007,E,122.8,079.5,280314,101.2,W*6B

RMC	Recommended Minimum sentence C
153618	Fix taken at 15:36:18 UTC
A	Status A=active or V=Void.
6655.018, N	Latitude 66 deg 55.018'N
2365.007,E	Longitude 23 deg 65.007' E
122.8	Speed over the ground in knots
079.5	Track angle in degrees True
280314	Date – 28th of March 2014
101.2,W	Magnetic Variation
*6B	The checksum data, always begins with *

Table I GPS Notations

C. ZIGBEE

A wireless sensor network is a collection of nodes. A wireless sensor network is much needed in order to reduce power consumption, cost, and maintenance. This enables the use different types of sensors interfaced to a single system and usage of unlicensed radio bands. This can be achieved by implementing IEEE 802.15.4 ZIGBEE. Here, each sensor interfaced with the system acts as a node. Each sensor nodes senses, process the information and then communicates [1]. It senses the environmental phenomena and generates sensor readings that are delivered, typically through multi-hop paths to a specific node (called the sink) for collection.

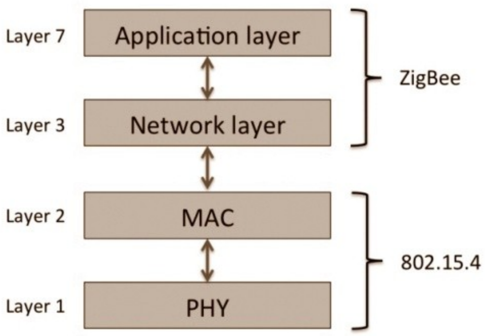

Fig. 1 Layers of ZIGBEE

ZIGBEE network has the characteristics of the physical and MAC layers for Low-Rate Wireless Personal Area Networks (LR-WPAN). Zigbee has defined rate of 250Kbps best for periodic, intermittent and single signal transmission from a sensor. The layered architecture of the network node comprises of Physical layer (PHY) and Medium Access Control (MAC) sub layer [3].

The MAC sub layer is interfaced with the Logical Link Control sub layer and other upper layers such as Networking layer and Application layer. One of the physical layer services is the Physical Data Service which enables the transmission and reception of PHY Protocol Data Units (PPDU) across the Physical Radio Channel (PRC).

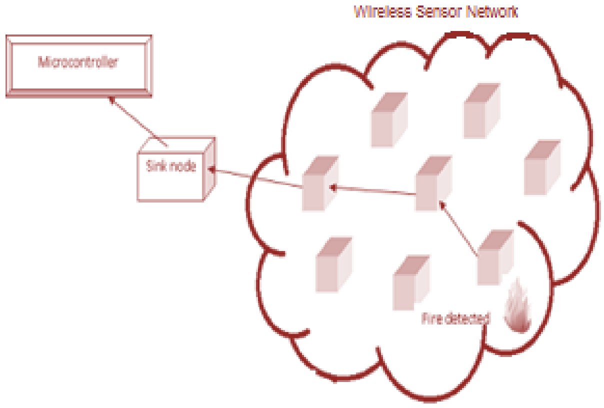

Fig. 2 Data propagation from slave to master node

In order to connect the sensors with the ZIGBEE network, a wireless connection module is required. This enables assignment of PAN ID Address to each of the sensor present in the network. Thus the compartment in which fire is detected is known by the microcontroller.

D. Sensor

When it comes to sensor nodal network, the challenging task is to reduce the number of false alarms as the number of sensors is very large. Hence there is need to implement usage of high precision sensors. This can be achieved by combining the conventional smoke sensors such as ionization and photoelectric sensors [2]. Ionization sensors are more sensitive to flaming fires whereas photoelectric sensors responses to fires that have long period smoldering.

Ionization smoke sensors as shown in Fig.3, consists of a small amount of radioactive material in between a pair of electrically charged plates. The radioactive material ionizes the air between the plates and causes current to flow between them. When smoke enters the chamber, flow of ions gets disturbed. This reduces the flow of current which senses the fire.

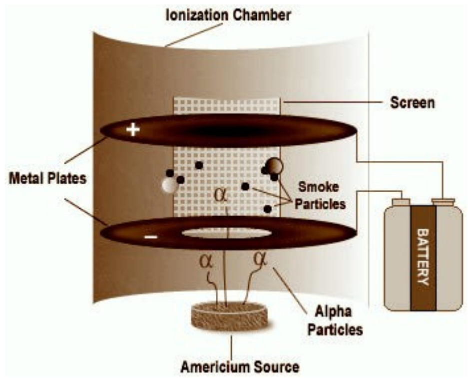

Fig. 3 Chamber of Ionization Smoke Sensor

Photoelectric sensors consist of a light source, sensing chamber, and a light sensor. Initially, the light is focussed onto the sensing chamber at an angle away from the light sensor as shown in Fig.4. Smoke particles enter the chamber and reflect the light onto the light sensor. This change helps in detecting the fire.

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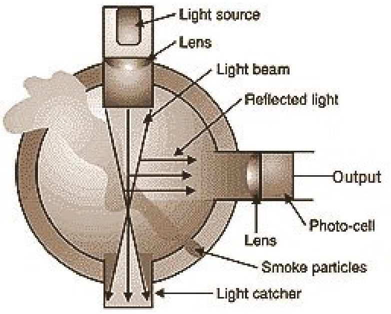

Fig. 4 Photoelectric Smoke Sensor

E. Microcontroller

The system requires high performance with extended peripheral ports. PIC24 type microcontroller satisfies these requirements. With minimum voltage requirement (2.0V to 3.6V), it process 16 million instructions per second. It provides highly integrated peripherals for motor control, graphic displays and UART. It has one 8bit file select register. It features automotive support qualified for AEC-Q100. It has very high temperature resistance (up to 150°C) which is one of the primary requirements of the proposed system. In order to interface peripherals such as GPS, GSM and ZIGBEE, an external IC MAX232 which is a dual driver and receiver is used. It converts the RX, TX, CTS and RTS signals into signals which are suitable for microcontroller to access.

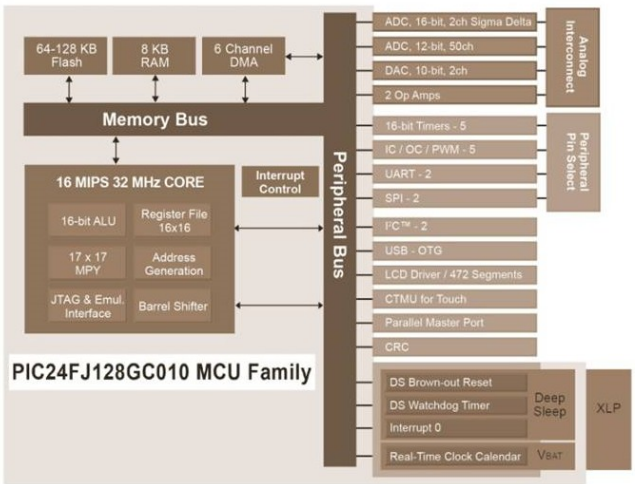

Fig. 5 Architecture of PIC24F Microcontroller

III. System Implementation

A. Block Diagram

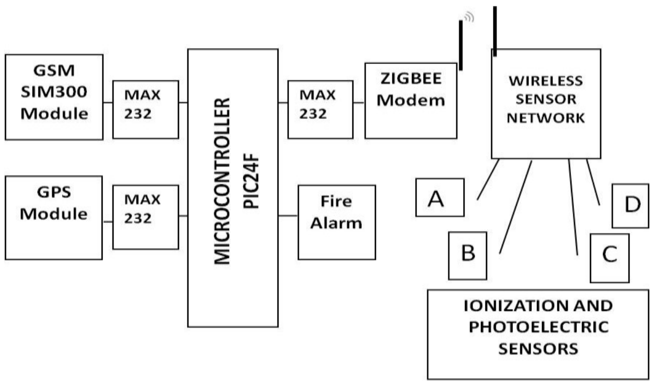

Fig. 6 Simplified Block Diagram

B. Flow Chart

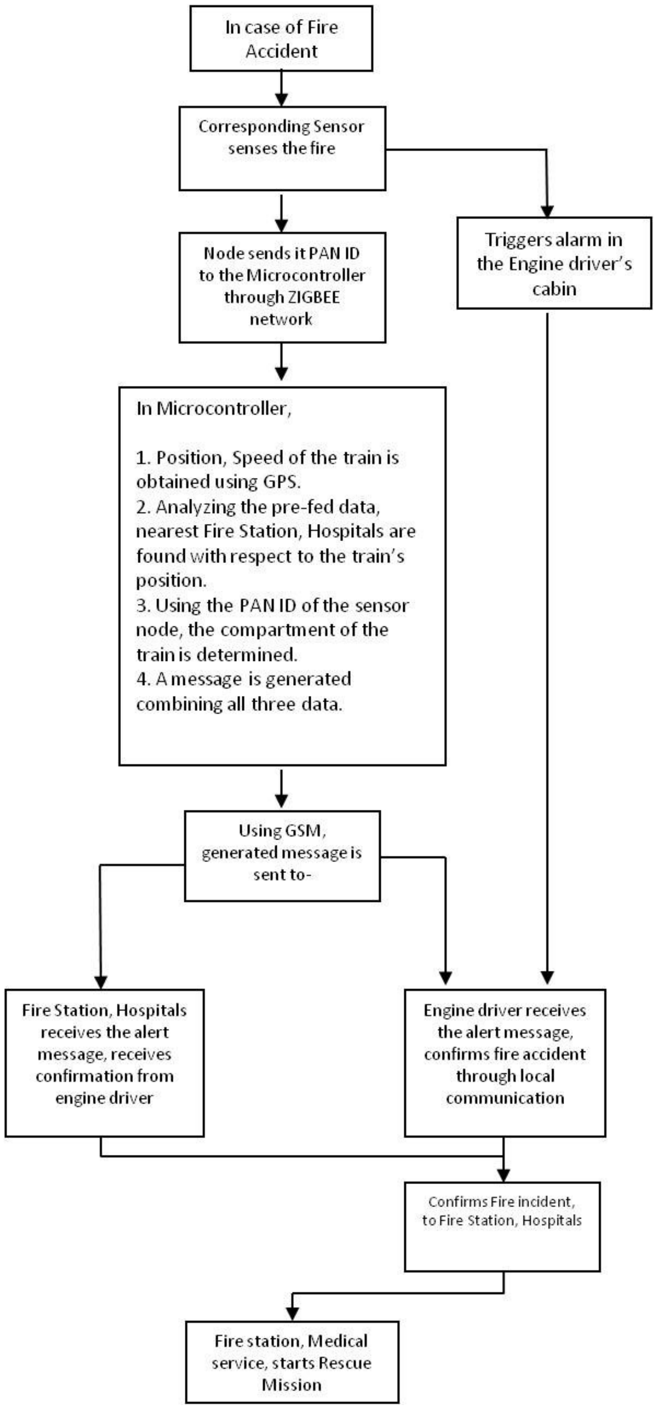

Fig. 7 Flow Chart

IV. Methodology

In case of fire accident, one of the ionization and photoelectric sensors which is present in the compartment senses the fire. Using other nodes, the signal is sent to the ZIGBEE modem which is interfaced with the microcontroller. This triggers the fire alarm present in the engine driver's cabin asking to stop the train. Once the microcontroller is interrupted, using the PAN ID of ZIGBEE module, the compartment under fire is determined. From the GPS the time, position and speed of the train are obtained by the microcontroller [3]. The pre-fed data about the location of Fire station and hospitals are compared with the train's current location and the nearest services are found with its

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contact details. Now, the microcontroller combines all data into a single message as shown in the Fig. 8 below:

Train number: XXXX
Compartment: XX
Train Location:
$GPRMC,153618,A,6655.018,N,23654.007,E,
122.8,079.5,280314,101.2,W*6B
Nearest Fire Station: XYZ, Phone number
Nearest Medical Service: ABC, Phone number

Fig. 8 Sample Alert Message

Using GSM, this message is sent to fire Station and Medical service as well as the engine driver. On confirming the fire through local communication, the driver informs the fire station once again. This reduces unnecessary panic during false alarms which are inevitable. The fire station and medical services on receiving the confirmation start for the rescue mission.

V. CONCLUSION

Thus this system primarily helps in reduction of time delay in informing the fire stations during fire accidents in trains. This time reduced, is highly crucial in reducing the fatality of the accident. Also, it helps the fire fighters and doctors to determine the exact location of the train as well as the compartment which is in fire. It will provide them with extra time and help them in planning the rescue mission meticulously. Since, the driver is alarmed at the very moment of the accident, spreading of fire to the rear compartments can also be avoided by stopping the train. By the implementation of this system in railways, the loss of lives as well as the property can be effectively minimized to a large extent in all respects.

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