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Automatic Control of Railway Gates and Destination Notification System using Internet of Things (IoT)

Chandrappa S[a], Dharmanna Lamani, Shubhada Vital Poojary[b], Meghana N U[a]

[a]*Department of Computer Science and Engineering, SDMIT, Ujire, Karnataka, India*
[b]*Department of Information Science and Engineering, SDMIT, Ujire, Karnataka, India*

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Abstract

The Internet of Things (IoT) is a network of interconnected devices which are outfitted with sensors and Radio-Frequency Identification (RFID) devices. These devices are uniquely addressable and use standard communication protocols like Transmission Control Protocol (TCP), User Datagram Protocol (UDP) and Internet Control Message Protocol (ICMP) in a networking environment. Here devices are communicating with each other without human interaction. The objective of this work is to provide an Automatic Railway Gate Controller, which operates the railway gates without gatekeeper which makes it useful for operation at level crossings. This controller deals with the reduction of time of which the gate is being kept closed and provide the safety to the road users by reducing the accidents that usually occur due to carelessness of road users and the gatekeepers. In addition to this, one more additional module is implemented for the passenger's convenience. Here, passenger needs to register their phone number via website to get destination arrival notification. This system is cost effective, real time and automatic.

Index Terms: Internet of Things (IoT), Sensors, Raspberry Pi, Railway Gate and SMS.

1. Introduction

The railway system in India and other countries is the most commonly used transportation mode and it is also a one of the low cost transportation mode. At present, country like India is having world's largest railway network in the world. There are thousands of rails running on track every day. In railway system, it is impossible to stop some of the critical situations or emergencies which are arising during the running of train. Every year, more than 40,000 people are dieing in the railway crossing accident. Current devices present at

* Corresponding author. Tel.: +919743220034; fax: 8256237271
E-mail address chandrucs21@gmail.com

railway crossing are not safe, manually operating and difficulty to prevent accidents because railway crossing system using in many countries is not advanced.

Therefore Train accidents having serious repercussion in terms of death of human life, injury, damage to railway property. These train accidents are mainly because of the fire in trains and Collisions of trains at railway crossings. A level crossing or railway crossing is an intersection of a road and a railway line. It requires human co-ordination to open or close the gates, lack of this leads to accidents, which leads to loss of human life, injury and loss of properties. In order to avoid the human mistakes that could occur during the operation of gates, a new automatic railway gates control system using IoT is developed. The Internet of Things (IoT) is a world-wide network of interconnected objects which are outfitted with sensors, actuators and RFID devices. Present days, IoT is used in all most all areas such Agriculture, industry, business, environmental parameter monitoring [7] and also used in medical field to detect diseases like glaucoma [8] and monitoring health parameters of the patient.

The proposed system attempts to develop a system which automates the gate operations. It uses Infrared obstacle detection sensors to detect the arrival and departure of trains at the railway level crossing and a stepper motor to control the opening and closing of gate. Two IR sensors are used to detect the arrival of the train and another two IR sensors are used to detect the departure of the train. The first IR sensor is placed at 7km away from cross section and second IR sensor is placed at 6km away from cross section. If train is detected at first IR sensor location and second IR sensor location respectively with in predefined time interval then only gates are closed at cross section. If one senor is active and another one is inactive, in that case gates are not closing. That means object detected by the sensor is not train. This concept is applied both left sensors and right sensors. Hence depending on the activation of the corresponding sensors, the closing and opening of the gates are performed. In the proposed system, one side prototype was developed. Same technique can be used for another side.

In addition to opening and closing of the gate an additional module for the passenger's convenience is developed. In this module, passenger can register, specify destination station name, train RFID (unique Id assigned for each train) and date of journey via web application to get destination arrival notification message. To send the message to passengers an online portal way2sms is used. When the train is detected by the RFID reader, which is placed at 7kms away from the railway station, automatically system will send the message to passengers registered phone number regarding to the reaching of destination station.

2. Related Work

Xishi et al [1]., explained about the advanced train safety system. In this paper authors de- fines that in the process of developing ATSS, a fault tolerance method was applied for both the hardware and the software components. The railway gate automation system was successively implemented in Korea. The implementation of the system in Korea effectively reduced the accident rate at the level cross and the magnetic sensors were used in rail- way gate automation system. Magnetic sensors were placed in underground to detect the movement of trains. But this system is not cost effective and not providing destination notification facility to passengers.

Acy et al [2]., this paper deals with the topic of much contemporary relevance. In this paper authors proposed a unique and economical method for improving the safety at railway level crossings. The proposed method works on microcontroller. The system uses ATmega 16A microcontroller, IR sensors for monitoring the arrival and departure of the train and the gate is operated accordingly. But this system is not providing destination notification facility to passengers.

Ahmed et al [3]., developed the system for automatic control of railway gates at level crossings. The proposed system has been developed by using 8052 microcontroller. Main objective of this work is to avoid railway accidents occurring at level crossings. Train arriving to- wards the gate was detected by means of two sensors placed on either side of the gate. The sensor along the train direction named as fore- side sensor and the other as after side sensor. When foreside sensor sense train, the sensor is activated and the sensed signal was

sent to the microcontroller 8052. Later, gate is closed by the microcontroller automatically and gate stays closed until the train crosses the gate and reaches after side sensor. When the side sensors sense the train, the sensors are activated and the signal about the departure is sent to the microcontroller. The microcontroller runs the motor in opposite direction and gate opens.

Hnin et al [4]., proposed the advanced system for automatic railway gate operations. The proposed system consisting PIC 16F877A microcontroller, IR sensors, buzzer, light indicator, DC motor and LCD display components. LCD display displays the railway gate open or close section. The buzzer and light signal warns about the arrival of train. IR sensors sense the arrival and leaving of train. These sensors are placed at both sides of gate. This system also uses the DC motor to open and close the gates automatically. DC motor rotates both in clockwise and anticlockwise direction.

Chellaswamy et al [5]., explained about control ling railway gates using detectors, GPS and GSM. Authors discussed about level crossing controller utilizing GPS and GSM. In this work authors is combines the use of GPS (Global Positioning System) tracking system and GSM (Global System for Mobile communication) modem to accomplish an efficient gate closing at the level crossings. Detectors are used to sense the arrival and departure of the train and also forward this information to the subsequent crossings. The system has been implemented and the results of this proposed system showed that it has high speed, accurate, robust and flexible.

Karthik et al [6]., presented the system which attempts to control the opening and closing of gates automatically at a railway level crossings. In most of the countries where the gates are operated by the gate keeper at level crossing, the gates remain closed for long durations which will cause dense vehicle traffic at near the gates due to the late arrival of train. The authors were used IR obstacle detection sensors to detect the arrival and leaving of trains at the railway level crossing. Here authors were used Arduino board to control the opening or closing of gates.

2.1. Problem Statement and Objectives

The following are the drawbacks of the existing system:

1. Most of authors used the Microcontroller to develop the system. But Microcontrollers have more complex architecture than microprocessors.
2. Due to the complexity of the circuit board and architecture, system development time increases.
3. Costly, not providing destination notification facility and difficult to develop.
4. The Arduino Board is a delicate device so it has to be handled carefully.

To overcome from the above mentioned draw- backs, we proposed a new system for the automatic control of railway gates and destination notification using raspberry pi 2 and RFID reader. Pi consisting high speed 900 MHz quad-core ARM Cortex A7 (ARMv7 instruction set) processor and it is less cost. RFID reader is used for destination notification. This is an efficient and cost effective system com- pared to the earlier system since it uses an in- built microprocessor.

The proposed system performs following two tasks.

1. Automatic closing and opening of railway gate at the level crossings without gate- keeper.
2. Automatic sending of message to the registered passengers mobile numbers about reaching of their destination station.

3. System Design And Analysis

The maximum speed at which passenger or goods trains can moves in India is approximately 91km/hr. and

the minimum speed of train is approximately 59 km/hr. Hence the ideal place at which IR sensors could be placed to detect the arrival of the train is 6km and 7kms from the level crossing and ideal distance for IR sensors to detect the departure of the train is 2km and 3km. thus the gate will not be closed for more than 10 minutes.

The proposed system uses 4 IR sensors for detecting the train, LEDs for controlling the traffic, RFID reader for sending notification or alert message and Servo motor for opening and closing gate. These devices are connected to raspberry pi board as shown in the figure 1. Pi control and operate all these devices according to program written in the pi. Once the RFID reader read the ID of train, information related to train means date, time, train RFID number are send to central server through internet. Central server receive the information from pi, immediately it will fetch all phone numbers registered to train based on RFID number and send the notification message to all phone numbers.

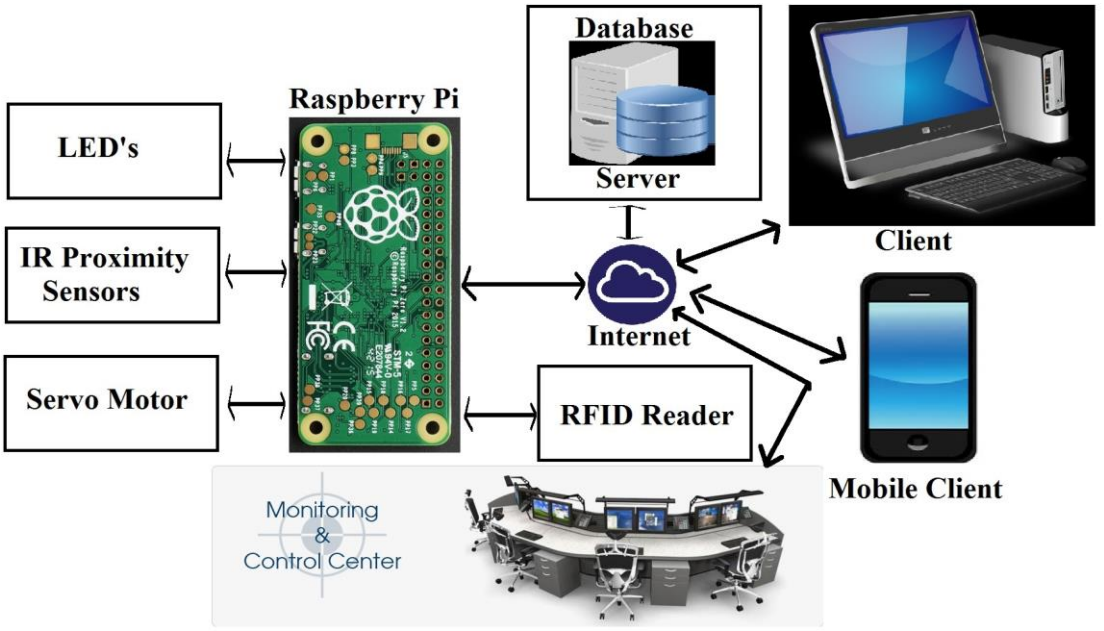

Fig.1. General Architecture of Proposed System

An IR proximity sensor is a sensor which detects the presence of train/object without any physical contact. An IR proximity sensor emits an electromagnetic field or a beam of electro- magnetic radiation and looks for changes in the field based on changes/no changes it will return the signal. The proposed system makes use of 4 IR sensors- 2 left and 2 right sensors. Left sensors are to detect the arrival of the train. One is located at 10kms away from station or cross section and another IR sensor is located at 7kms away from station or cross section. Difference distance between these two sensors is 3kms. In same way Right sensors are used to detect the departure of the train.

A light-emitting diode (LED) is a two-lead semiconductor light source. It is a pn junction diode, which emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence. The proposed system consists of 2 LEDs- red and yellow. When the train arrives red LED will glow and when the train departures yellow LED will glow.

A servomotor is a rotary actuator and it is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is some signal, either analogue or digital,

representing the position commanded for the output shaft. The proposed system uses servo motor for controlling the gate operations (opening and closing). The Raspberry Pi is small sized single-board computer. All Raspberry Pis included the same Video Core IV GPU and either a single- core ARMv6-compatible CPU or an ARMv7- compatible quad-core one. Pis also included the 1 GB of RAM or a Micro SDHC one for boot media. In this work Raspberry Pi 2 model is used. The IR sensors, LEDs, servo motor and RFID reader are connected to Rasp- berry Pi as shown in the figure 1. Python programming language is used to connect various sensors, LEDs, servo motor and RFID reader. PHP and html languages are used for Graphical User Interface. For information storage and retrieval, MySql is used.

Figure 2 shows the Data flow diagram for gate operations and working of LEDs. When the train is detected by the right sensors, the motor closes the gate and red LED will glow. In the same way, the left sensors will senses the departure of the train and motor will opens the gate and yellow LED glows.

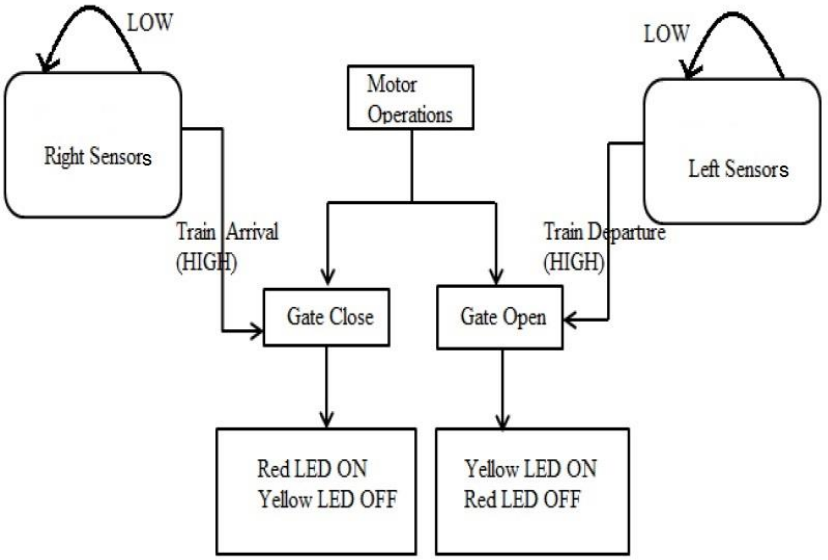

Fig.2. Data Flow Diagram for Gate Operations and LEDs Operations

Figure 3 shows the Data flow diagram for destination satiation notification. RFID reader is placed few kilo meters away from the station. Initially, the details of journey entered by the passenger are stored in the database. When the train is detected by RFID reader, the server fetches the all phone numbers registered to the upcoming station then server will send the destination alert message to retrieved phone numbers.

The Algorithm for opening and closing of the gate is as follows.

Step 1: Start.
Step 2: Turn on all IR sensors and yellow LEDs.
Step 3: Continuously check the status of right IR sensors.
Step 4: If both right IR sensors are active [arrival of train] go to Step 5 otherwise go to Step 3.
Step 5: Activate the motor, which closes the gate, turn on Red LED [stop indication for vehicles] and turn off yellow LEDs.
Step 6: Continuously check the status of left IR sensors.
Step 7: If both left IR sensors are active [departure of train] go to Step 8 otherwise go to Step 6.
Step 8: Send the signal to motor for opening the gate. Motor opens the gate then Pi turns off Red LED and turn on yellow LEDs [go indication for vehicles]. Go to Step 3.

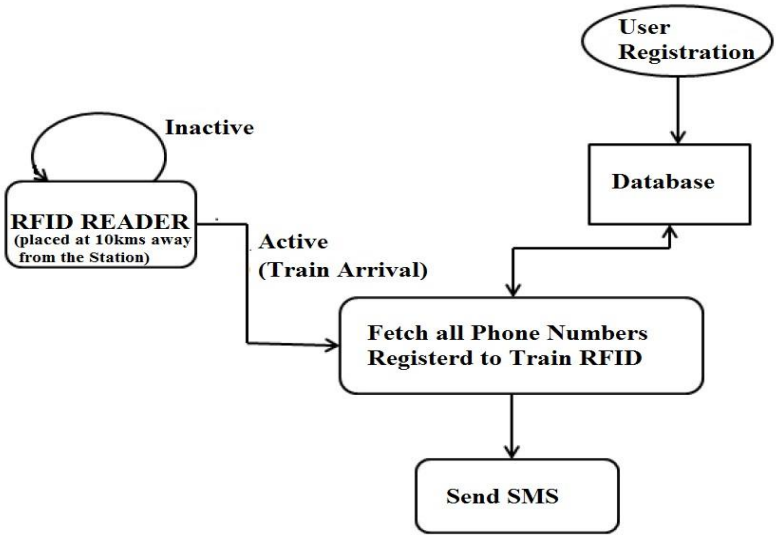

Fig.3. Data Flow Diagram for Destination Notification

The Algorithm for registration is described in the following steps.

Step 1: Start.
Step 2: Passengers have to register their phone number along with name, email id and pass word through web application only once. If every time passenger wants travel, a same email id and password can be used for registration to destination alert system. If the registration is successful go to Step 3 other- wise display the error message and go to Step 1.
Step 3: Login with email id/phone number and password.
Step 4: If all the credentials what they have provided while logging in are matches with the information they have provided while registering then go to Step 5, Otherwise display error message and go to Step 3.
Step 5: Take source station, destination station, date of journey and Train RFID number to send alert message and store the information in database.
Step 6: Stop.

The Algorithm for sending the destination station alert message is as follows.

Step 1: Start.
Step 2: Initialize RFID reader [RFID tag is attached with the train].
Step 3: When a train approaches the RFID reader, it will read the id of tag and send to central server via raspberry pi.
Step 4: Central server fetch the all phone numbers registered to this train based on RFID number and date of journey. Send the alert message to all phone numbers.
Step 5: End.

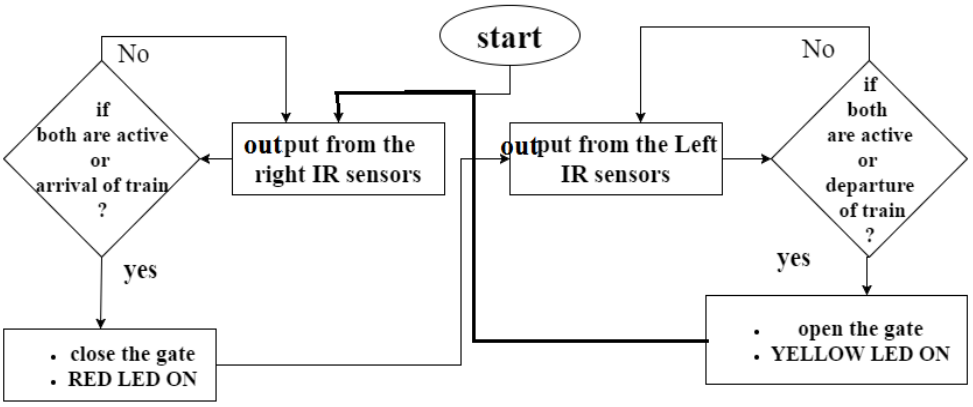

Fig.4. Flowchart for Opening and Closing the Gate

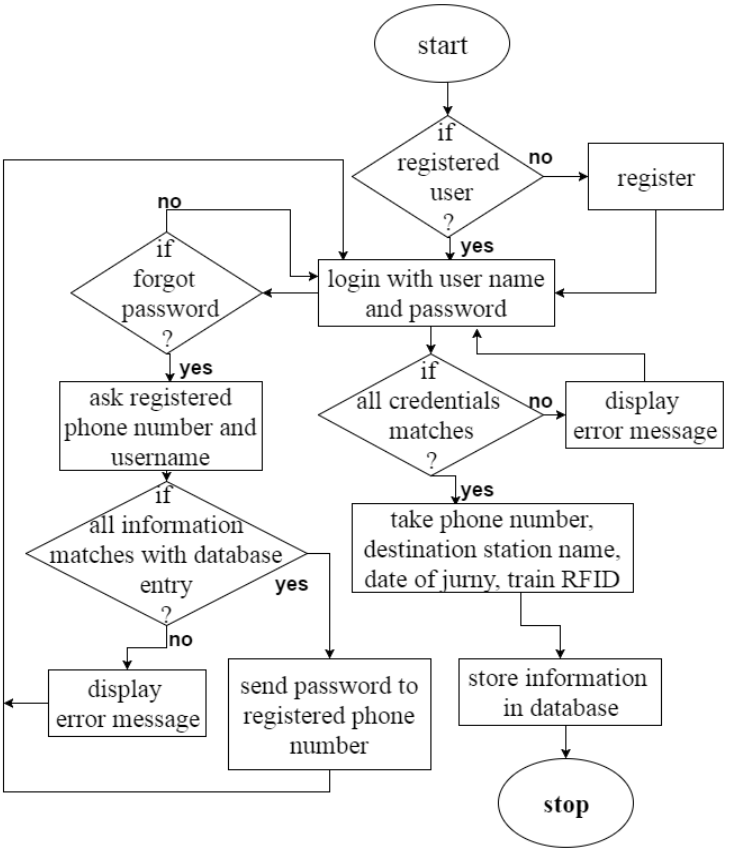

Fig.5. Flowchart for SMS Notification Registration

4. Result and Analysis

Figure 6 shows the developed model, model including the raspberry pi, railway station, RFID reader, railway

track, three mobiles, left sensors, right sensors, LEDs, level crossing and gate controller. The pi device controls and co- ordinates all these devices. All devices are connected to Pi device GPIO pins and Pi is connected to central system or server through LAN.

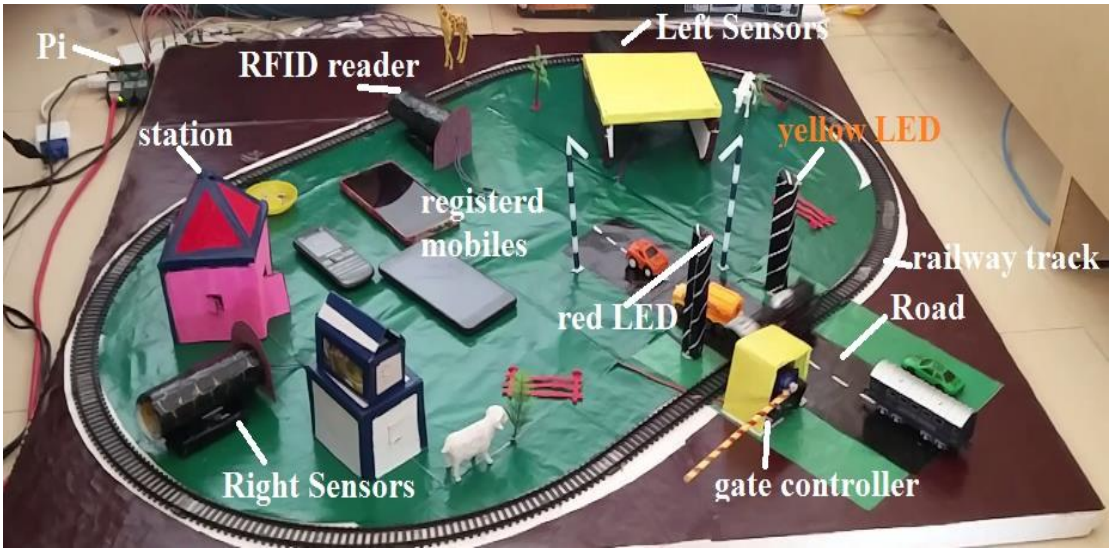

Fig.6. Prototype of Proposed Model

Fig.7. a) Train Approaching the Gate [Gate Closed and RED LED Was ON]. B) Train Leaving the Gate [Train Crossed the Gate, Gate Opened and Yellow LED Was ON]

In normal state [no train], YELLOW LED is blinking, right and left sensors are in inactive state and RED LED is in OFF state. When train is detected by the right sensors [both are active], right sensors will send the active information to pi then pi will send the gate closing information to gate controller, OFF signal to YELLOW LED and ON signal to RED LED. After receiving the signal from pi, gate controller will close the gate, RED LED is turned ON and YELLOW LED is turned OFF as shown in the figure 7.a.

When train is detected by the left sensors [both are active], right sensors will send the active information to pi then pi will send the gate opening information to gate controller, OFF signal to RED LED and ON signal to YEL- LOW LED. After receiving the signal from pi, gate controller will open the gate, YELLOW LED is turned ON and RED LED is turned OFF as shown in the figure 7.b.

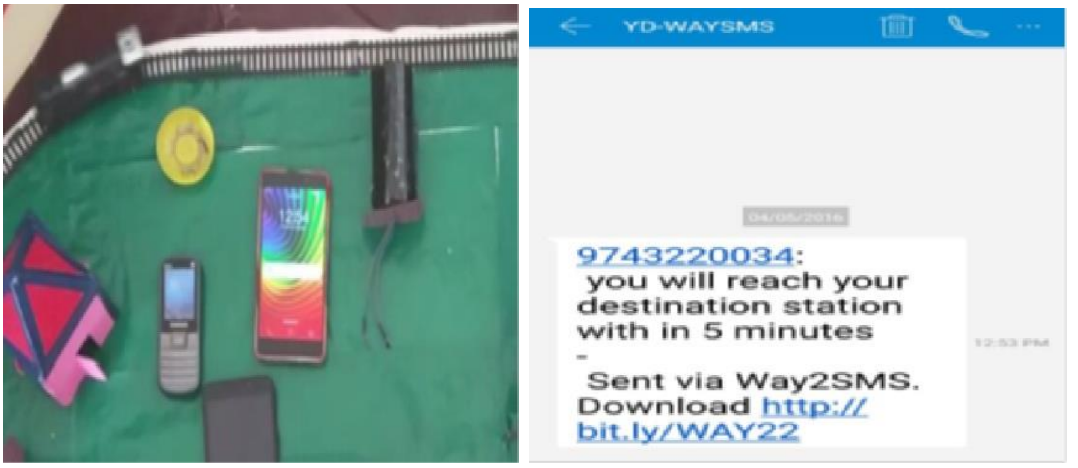

Fig.8. a) Train Approaching the Station [Two Registered Mobiles, Display on, Received the Alert Message and Another Mobile, Display Off, Is Not a Registered Mobile.]. b) Alert Message Format

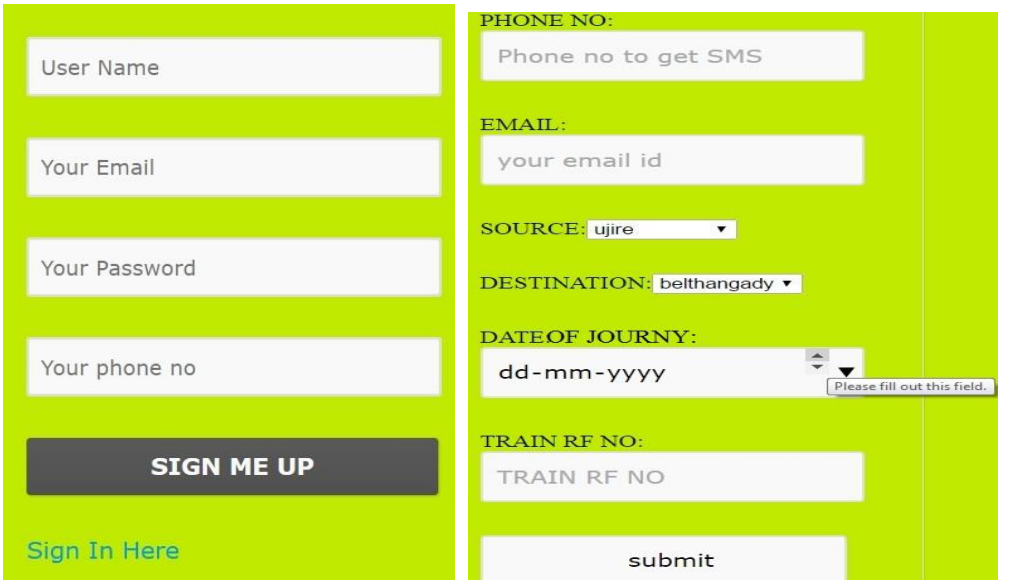

Fig.9.a) Passenger Registration Web Page b) Destination Station Alert Message Registration Form

When train is detected by the RFID reader, it will send the train RFID to pi then pi will send the train RFID to central server. Immediately server will fetch the all phone numbers registered to this RFID based on current date then server will send the alert SMS to all registered phone numbers as shown in figure 8.a.

Figure 8.b shows the alert message format, way2SMS gate is used to send the messages to registered

passengers. Central server fetch the registered phone numbers from the database when train is detected by the RFID reader then it will send message text and registered phone numbers to Way2SMS web server. Later, the Way2SMS web server will send message text "you will reach your destination station within 5 minutes" to all registered phone numbers.

Figure 9.a shows passenger registration web page. Here passenger needs to provide name, email id, password, and phone number. Pro- vided information is stored in the central server database.

Figure 9.b shows the registration form to get alert message. Here passengers needs to provide phone number to get alert message, email id, source station, destination station, date of journey and train RF numbers. All information is stored in the database of central server. Train RF number is provided to passages in tickets

5. Conclusion

Automatic gate control system using IoT is an effective and advanced method to reduce the occurrence of railway accidents. This system provides the lot of benefits to the road users and railway management. The system is completely automated. So this system can be used in remote places and villages where no station master or line man is present. IR sensors are placed at two sides of gate. These sensors are used to detect the arrival and departure of the train. This system uses the stepper motor to open and close the gates automatically. Most of the passengers will not be aware of their destination station. So the proposed system called as Destination alert system offers the user to get the notification about the destination station before few kilo meters away from the station. Finally, we conclude that proposed system is reliable, high performance and low cost compared to existing systems.

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Authors' Profiles

Chandrappa S was born in Channagiri city, India. He obtained his Bachelor of Engineering in Computer science and Engineering from SJM Institute of technology, affiliated college of VTU, in 2006 and M.Tech degree in Computer Science and Engineering from NMAM Institute of technology, Nitte, Karnataka, India. Since 2011, He is working as Assistant Professor in Computer science and Engineering Department at SDM Institute of technology, Ujire, Karnataka. He has published around 6 papers in reputed Journals and Conferences. His research interests include Networking, internet of things (IoT) and Medical Image Processing.

Dharmanna Lamani is currently HOD of information science and engineering, SDM Institute of technology, Ujire, Karnataka. He obtained M.Tech degree from VTU, Belagavi. He was awarded Ph.D. in computer science and engineering from VTU, Belagavi. His research interest includes Medical Image Processing, Embedded System design, Pattern Recognition and Computer Networking. He has published around 15 papers in reputed Journals and Conferences.

Shubhada Vital Poojary is currently working as assistant professor in information science and engineering department, SDM Institute of technology, Ujire, Karnataka. She obtained M.Tech degree from VTU, Belagavi. Her research interest includes Image Processing and Computer Net- working.

Meghana N U was born in karnataka state, India. She received B.E degree in Computer science and Engineering from SDM Institute of technology, affiliated college of VTU, Ujire, Karnataka, India in 2016. Her research interests include internet of things, network security and Networking.

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