IMPLEMENTING INTELLIGENT TRAFFIC CONTROL SYSTEM FOR CONGESTION CONTROL AND AMBULANCE CLEARANCE IN METRO CITYES

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ABSTRACT
In order to pass emergency vehicles without incident, this study proposes an intelligent traffic management system. It is difficult to remove or destroy the unique radio frequency identification (RFID) tag that is attached to every single vehicle and is strategically positioned. To read the RFID tags affixed to the car, we utilise an RFID reader, NSK EDK-125-TTL, and PIC16F877A system-on-chip. It keeps track of the number of cars that go along a certain road during a given period of time. Additionally, it establishes network congestion and, therefore, the length of the green light for that route. If the RFID tag is from a stolen car, a message is delivered to the police control centre via GSM SIM300.
Additionally, an ambulance will signal the traffic controller at the intersection to switch on the green light as it approaches the intersection. The ambulance and traffic controller may communicate wirelessly with one another because to this module's utilisation of ZigBee modules on the CC2500 and the PIC16F877A system-on-chip. The prototype was put to the test in our wireless communication lab using a variety of input combinations, and the experimental outcomes were as anticipated.
ZigBee, CC2500, GSM, SIM300, PIC16F877A, ambulance vehicle, stolen vehicle, traffic intersection, congestion control—these are only a few of the index terms.

I. INTRODUCTION

INDIA is the second most populous Country in the World and is a fast growing economy. It is seeing terrible road congestion problems in its cities. Infrastructure growth is slow as compared to the growth in number of vehicles, due to space and cost constraints [1]. Also, Indian traffic is nonlane based and chaotic. It needs a traffic control solutions, which are different from the developed Countries. Intelligent management of traffic flows can reduce the negative impact of congestion. In recent years, wireless networks are widely used in the road transport as they provide more cost effective options [2]. Technologies like ZigBee, RFID and GSM can be used in traffic control to provide cost effective solutions. RFID is a wireless technology that uses radio frequency electromagnetic energy to carry information between the RFID tag and RFID reader. Some RFID systems will only work within the range inches or centimeters, while others may work for Manuscript received July 14, 2014; revised September 20, 2014; accepted September 20, 2014. Date of publication October 27, 2014; date of current version November 26, 2014. The associate editor coordinating the review of this paper and approving it for publication was Prof. Subhas C. Mukhopadhyay.

The authors are with the B.M.S. College of Engineering, Bangalore 560019, India (e-mail: rajeshwaris_here@yahoo.co.in; santhoshshebbar@gmail.com; varaprasad5555555@yahoo.co.in). Color versions of one or more of the figures in this paper are available online at http://ieeexplore.ieee.org. Digital Object Identifier 10.1109/JSEN.2014.2360288 100 meters (300 feet) or more. A GSM modem is a specialized type of modem, which accepts a SIM card and operates over a subscription to a mobile operator, just like a mobile phone.

AT commands are used to control modems. These commands come from Hayes commands that were used by the Hayes smart modems. The ZigBee operates at low-power and can be used at all the levels of work configurations to perform predefined tasks. It operates in ISM bands (868 MHz in Europe, 915 MHz in USA and Australia, 2.4 GHz in rest of the world). Data transmission rates vary from 20 Kilobits/second in the 868 MHz frequency band to 250 Kilobits/second in the 2.4 GHz frequency band [3], [4]. The ZigBee uses 11 channels in case of 868/915 MHz radio frequency and 16 channels in case of 2.4 GHz radio frequency. It also uses 2 channel configurations, CSMA/CA and slotted CSMA/CA [5].

The whole paper is grouped into 5 parts. Sections II talks

about the literature survey. Section III discusses about the current problems that exist in making way to an ambulance and other vehicles. It also talks of how the proposed model will overcome the problems faced in developing Countries as well as developed countries. Section IV gives the implementation details of the proposed model. Section V presents the enhancement of this work.

II. LITERATURE SURVEY

Traffic congestion is a major problem in cities of developing Countries like India. Growth in urban population and the middle-class segment contribute significantly to the rising number of vehicles in the cities [6]. Congestion on roads eventually results in slow moving traffic, which increases the time of travel, thus stands-out as one of the major issues in metropolitan cities. In [7], green wave system was discussed, which was used to provide clearance to any emergency vehicle by turning all the red lights to green on the path of the emergency vehicle, hence providing a complete green wave to the desired vehicle. A 'green wave' is the synchronization of the green phase of traffic signals. With a 'green wave' setup, a vehicle passing through a green signal will continue to receive green signals as it travels down the road. In addition to the green wave path, the system will track a stolen vehicle when it passes through a traffic light. Advantage of the system is that GPS inside the vehicle does not require additional power. The biggest disadvantage of green waves is that, when the wave is disturbed, the disturbance can cause traffic problems that can be exacerbated by the synchronization

Fig. 1. Traffic in Bangalore city.

In such cases, the queue of vehicles in a green wave grows in size until it becomes too large and some of the vehicles cannot reach the green lights in time and must stop. This is called over-saturation [12], [13].

In [8], the use of RFID traffic control to avoid problems that usually arise with standard traffic control systems, especially those related to image processing and beam interruption techniques are discussed. This RFID technique deals with multivehicle, multilane, multi road junction areas. It provides an efficient time management scheme, in which, a dynamic time schedule is worked out in real time for the passage of each traffic column. The real-time operation of the system emulates the judgment of a traffic policeman on duty. The number of vehicles in each column and the routing are proprieties, upon which the calculations and the judgments are done. The disadvantage of this work is that it does not discuss what methods are used for communication between the emergency vehicle and the traffic signal controller. In [9], it proposed a RFID and GPS based automatic lane clearance system for ambulance. The focus of this work is to reduce the delay in arrival of the ambulance to the hospital by automatically clearing the lane, in which, ambulance is travelling, before it reaches the traffic signal. This can be achieved by turning the traffic signal, in the path of the ambulance, to green when the ambulance is at a certain distance from the traffic junction.

The use of RFID distinguishes between the emergency and non-emergency cases, thus preventing unnecessary traffic congestion. The communication between the ambulance and traffic signal post is done through the transceivers and GPS. The system is fully automated and requires no human intervention at the traffic junctions. The disadvantage of this system is it needs all the information about the starting point, end point of the travel. It may not work, if the ambulance needs to take another route for some reasons or if the starting point is not known in advance. Traffic is a critical issue of transportation system in most of all the cities of Countries. This is especially true for Countries like India and China, where the population is increasing at higher rate as show in figure 1. For example, Bangalore city, has witnessed a phenomenal growth in vehicle population in recent years. As a result, many of the arterial roads and intersections are operating over the capacity (i.e., v/c is more than 1) and average journey speeds on some of the key roads in the central areas are lower than 10 Km/h at the peak hour. In [10], some of the main challenges are management of more than 36,00,000 vehicles, annual growth of 7–10% in traffic, roads operating at higher capacity ranging from 1 to 4, travel speed less than 10 Km/h at some central areas in peak hours, insufficient or no parking space for vehicles, limited number of

policemen. In [11], currently a video traffic surveillance and monitoring system commissioned in Bangalore city. It involves a manual analysis of data by the traffic management team to determine the traffic light duration in each of the junction. It will communicate the same to the local police officers for the necessary actions.

III. PROPOSED MODEL

From the current problem section, it can be seen that, existing technologies are insufficient to handle the problems of congestion control, emergency vehicle clearance, stolen vehicle detection, etc. To solve these problems, we propose to implement our Intelligent Traffic Control System. It mainly consists of three parts. First part contains automatic signal control system. Here, each vehicle is equipped with an RFID tag. When it comes in the range of RFID reader, it will send the signal to the RFID reader. The RFID reader will track how many vehicles have passed through for a specific period and determines the congestion volume. Accordingly, it sets the green light duration for that path. Second part is for the emergency vehicle clearance. Here, each emergency vehicle contains ZigBee transmitter module and the ZigBee receiver will be implemented at the traffic junction. The buzzer will be switched ON when the vehicle is used for emergency purpose. This will send the signal through the ZigBee transmitter to the ZigBee receiver. It will make the traffic light to change to green. Once the ambulance passes through, the receiver no longer receives the ZigBee signal and the traffic light is turned to red. The third part is responsible for stolen vehicle detection.

Here, when the RFID reader reads the RFID tag, it compares it to the list of stolen RFIDs. If a match is found, it sends SMS to the police control room and changes the traffic light to red, so that the vehicle is made to stop in the traffic junction and local police can take appropriate action. List of components used in the experiment are CC2500RF module, Microchip PIC16F877A, RFID Reader–125KHz–TTL and SIM300 GSM module. Figure 2 shows the pin diagrams (or pictures) of components used.

A. ZigBee Module CC2500

The CC2500 is a RF module and has transreceiver, which provides an easy way to use RF communication at 2.4 GHz. Every CC2500 is equipped with the microcontroller (PIC 16F877A), which contains Unique Identification Number (UIN). This UIN is based on the registration number of the vehicle. One of the most important features is serial communication without any extra hardware and no extra coding. Hence, it is a transreceiver as it provides communication in both directions, but only one direction. The microcontroller and CC2500 always communicate with the

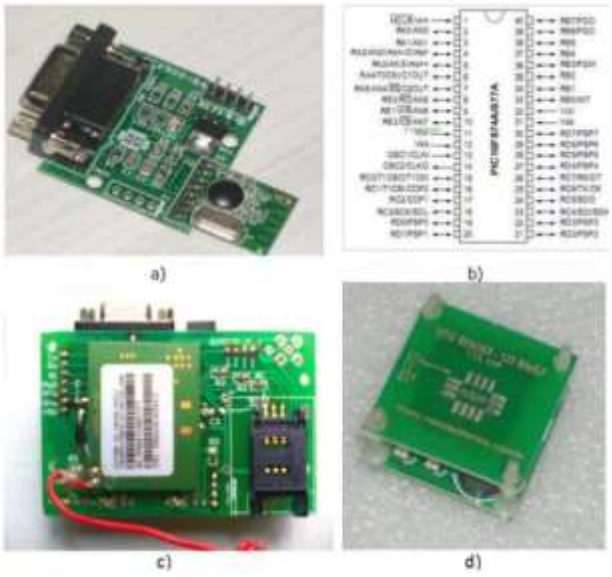

Fig. 2. PIN diagrams of different components used in our prototype. (a) ZigBee module CC2500. (b) Pin diagram of PIC16F877A. (c) GSM Module SIM300. (d) RFID reader–125 kHz–TTL. microcontroller via serial communication.

Rx pin of CC2500 is connected to Tx (RC6) of microcontroller and Tx pin of CXC2500 is connected to Rx pin of microcontroller (RC7).Other two pins are used to energize transreceiver. It is used to transmit and receive the data at 9600 baud rate. Figure 4.1.a shows the image of transreceiver. Here, we uses CC2500 ZigBee module and it has transmission range of 20 meters.

B. Microcontroller (PIC16F877A)

Peripheral Interface Control (PIC) 16F series has a lot of advantages as compared to other series. It executes each instruction in less than 200 nanoseconds. It has 40 pins and has 8K program memory and 368 byte data memory. It is easy to store and send UINs. At the junction, it is easy to store large number of emergency vehicles. Before switching to green, it should satisfy all the conditions. Simple interrupt option gives the advantage like jump from one loop to another loop. It is easy to switch any time. It consumes less power and operates by vehicle

battery itself without any extra hardware. Figure 2.b shows the PIN Diagram of PIC16F877A.

C. GSM Module SIM 300

Here, a GSM modem is connected with the microcontroller. This allows the computer to use the GSM modem to communicate over the mobile network. These GSM modems are most frequently used to provide mobile Internet connectivity, many of them can also be used for sending and receiving SMS and MMS messages. GSM modem must support an "extended AT command set" for sending/receiving SMS messages. GSM modems are a cost effective solution for receiving SMS messages, because the sender is paying for the message delivery. SIM 300 is designed for global market and it is a tri-band GSM engine. It works on frequencies EGSM 900 MHz, DCS 1800 MHz and PCS 1900 MHz. SIM300 features GPRS multi-slot class 10/ class 8 (optional) and supports the GPRS coding schemes. This GSM modem is a highly flexible plug and play quad band GSM modem, interface to RS232, it supports features like voice, data, SMS, GPRS and integrated TCP/IP stack. It is controlled via AT commands (GSM 07.07,07.05 and enhanced AT commands). It uses AC – DC power adaptor with following ratings DC Voltage: 12V/1A.

D. RFID Reader–125 kHz–TTL

Radio Frequency Identification (RFID) is an IT system that transmits signals without the presence of physical gadgets in wireless communication. It is categorized under automatic identification technology, which is well established protocol. The working of an RFID system is very simple. The system utilizes tags that are attached to various components to be tracked. The tags store data and information concerning the details of the product of things to be traced. The reader reads the radio frequency and identifies the tags. The antenna provides the means for the integrated circuit to transmit its information to the reader. There are two types of RFID categories, active and passive tags. The tags that do not utilize power are referred to as passive and they are driven by an antenna that enables the tag to receive electromagnetic waves from a reader. On the contrary, active tags rely on power and they have inbuilt power sources that enable it to send and receive signals from RFID reader. RFID range depends on transmit power, receive sensitivity and efficiency, antenna, frequency, tag orientations, surroundings. Typically, the RFID range is from a few centimeters to over hundred meters. RFID reader uses frequency 125 KHz with a range of 10 cm.

IV. WORKING MODEL

In this model, there are mainly 3 modules as follows.

A. Automatic Signal Control System

In this module, for experiment purpose, we have used passive RFID tags and RFID reader with frequency 125 KHz. RFID tag, when vehicle comes in the range of the receiver will transmit the unique RFID to the reader. The microcontroller connected to the RFID reader will count the RFID tags read in 2 minute duration. For testing purpose, if the count is more than 10, the green light duration is set to 30 seconds, if count is between 5 and 9, the green light duration is set to 20 seconds. If the count is less than 5, the green light duration is set to 10 seconds. The red light duration will be for 10 seconds and orange light duration will be for 2 seconds. Figure 3 implementation for automatic signal control and stolen vehicle detection system.

B. Stolen Vehicle Detection System

In this module, for testing purpose, we compare the unique RFID tag read by the RFID reader to the stolen RFIDs stored in the system. If a match is found, then the traffic signal is immediately turned to red for a duration of 30 seconds.

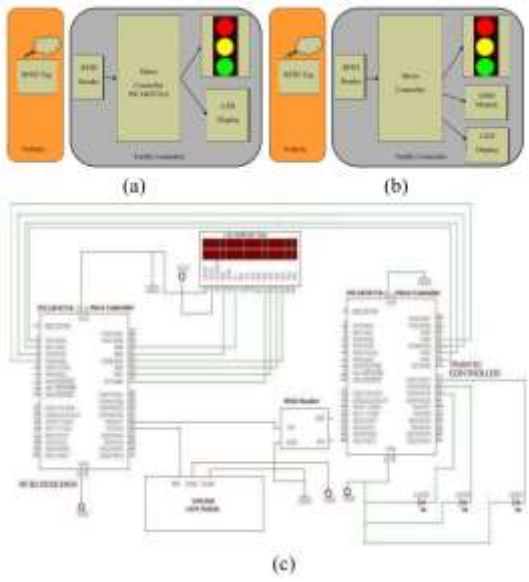

Fig. 3. Implementation for automatic signal control and stolen vehicle detection system. (a) Block diagram for automatic signal control system. (b) Block diagram for stolen vehicle detection. (c) PIN Diagram for automatic signal control and stolen vehicle detection system.

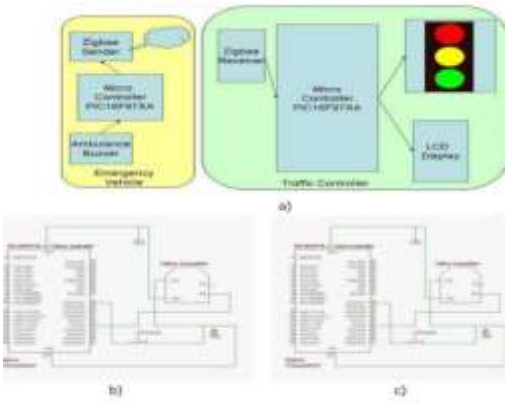

Fig. 4. Implementation for ambulance. (a) Block diagram for emergency vehicle clearance. (b) PIN Diagram for ZigBee transmitter. (c) PIN Diagram for ZigBee receiver.

Also an SMS is sent specifying the RFID number by using SIM300 GSM module. The LCD display will indicate that stolen vehicle is present as shown in Figure 3.

C. Emergency Vehicle Clearance System

In this module, there are 2 parts, first part which is ZigBee transmitter is placed in the emergency vehicle. When the

Fig. 5. Proposed model images transmitter and receiver. (a) Pole status at different condition. (b) Transmitter (ZigBee). (c) LCD display at receiver. (d) Detailed image of receiver. (e) When stolen vehicle is detected. (f) Working model.

switch is pressed, it will transmit the signal. The signal contains unique id and security code. The transmitter contains PIC16F877A microcontroller and ZigBee module. The microcontroller sends the commands and data to the ZigBee via serial communication. Second part is the receiver, which is placed at traffic pole. It also contains PIC16F877A microcontroller and ZigBee module. The receiver compares the security code received to the security code present in its database. If it matches, then it will turn the green light on. For testing purpose, we used short range RFID reader in our prototype. First, the receiver part is turned on. The red and green signal will be on for 10 seconds duration and orange light will be on for 2 seconds duration one after the other. Secondly, we bring the RFID of stolen vehicle into the range of RFID reader. Then the signal will turn to red for duration of 30 seconds and a SMS is received. Thirdly, we bring 12 RFIDs into the range of RFID reader, and then the green light duration will change to 30 seconds. Fourthly, we bring an emergency vehicle carrying ZigBee transmitter into the range of ZigBee receiver, and then the traffic light will change to green till the receiver receives the ZigBee signal as shown in Figure 4. Figure 5 shows the images of different components and highlighted features of the proposed work. Figure 5.a shows the signal pole installed in junction. In the default condition, red and green light will set for 10 seconds. The time period will be varied according to the traffic conditions, stolen vehicle, and emergency vehicle. Figure 5.b shows the transmitter part is placed in the ambulance. It transmits ZigBee signal continuously. Figure 5.c shows the LCD display status at different conditions (in that figure one is normal conjunction image (traffic signal running as per the default time period) and another one is LCD display status, when an ambulance coming near to junction. Figure 5.d shows the actual connections of different components like RFID, GSM, ZigBee, interfacing different microcontrollers. Figure 5.e shows the status updated at the time of stolen vehicle is found. The stolen vehicle RFID number should be updated in the database. If stolen vehicle is found, then it will immediately turn on red light in the signal. It sends immediately a message to authorized person. Figure 5.f shows the working model of the proposed work.

V. CONCLUSION

The traffic policeman's human labour is reduced with automated traffic light regulation depending on the volume of traffic along the route. Because the whole system is automated, very little human interaction is needed. When a stolen car is detected, the light immediately changes to red, allowing the police officer who is on duty at the intersection to take the necessary action. Additionally, SMS will be delivered so that they may be ready to stop the stolen car at the following intersections. Emergency vehicles, such as ambulances and fire engines, must arrive at their locations as soon as possible. Numerous people's lives might be at jeopardy if they are stuck in traffic for an extended period of time. As long as the emergency vehicle is waiting at the traffic intersection, the traffic light changes to green after it has been given clearance. Only after the emergency vehicle has passed through does the light change to red. The prototype may be improved further by being tested with extended range RFID scanners. In order to pinpoint the precise position of the stolen car, GPS may also be added to the stolen vehicle detection module. As of right now, our technology is only taking into account one road at the traffic intersection. By expanding it to every road in a multi-road junction, it may be made better.

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