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Wireless Traffic Management System for Emergency Vehicles

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***Abstract*:- India has the second largest population in the world. It is a fast growing nation. However, the emergency response is not up to par with global standards. In medicine, the 'golden hour' refers to the hour following a traumatic injury during which if prompt medical attention is given to a patient, the likelihood of prevention of death is highest. This in turn means that an ambulance must be able to get to its destinations as quickly as possible. Traffic flow management is a major obstacle in today's developed urban cities. In the ever-changing nature of traffic flow, it is imperative to provide priority to ambulance.**

In this paper, firstly the Indian ambulance scenario is briefly discussed. The primary objective was to develop an embedded electronic system that can significantly mitigate the problem of ambulances getting stuck at traffic lights. With this project, we have tried to improve the response time of ambulance in urban area.

Keywords:- *Wireless, ZigBee, Nuvoton NUC140, Traffic Management, Ambulance*

I LITERATURE REVIEW

The initial motivation of the project came from discussions with people living in metro cities; particularly Bangalore. It was a general opinion that although the traffic management infrastructure is in place, the driving habits exhibited by most drivers is that they do not give the right of way to ambulances. Another important aspect is that ambulances have to pass through a lot of traffic light junctions to get the destination. This causes major delays. A compounding factor is the traffic density, mainly during rush hours. [1]

By consulting news resources, it was found that the prescribed response time of an ambulance is 8-10 minutes for urban areas. However, the average response time in India is 13-18 minutes. [2]

Pertaining to emergency services in India, GVK EMRI (Emergency Management and Research Institute) is a pioneer. It works in 16 states within the country through a public-private-partnership (PPP) with the state governments. In interviews with Times of India, Mr. Raju of GVK EMRI said that the mindset of other road users is responsible for ambulance delays. In another report, Mr. Subodh Satyawadi who is the chief executing officer at GVK EMRI, stated that the company is working on a technology that will turn traffic signals green to clear the way for an ambulance during peak hours.[3]

A monthly call analysis of the Centralized Ambulance and Trauma Service (CATS) during the period of June 2009 to May 2010 by AIIMS showed that in New Delhi, the ambulance response times are suffering. During the period, 70,768 calls were received but only 51,124 could be serviced. 28% of the calls were unattended due to unavailability of ambulances. Those which were serviced took longer than the prescribed response time of 8 minutes. [2]

According to WHO (World Health Organization), there must be one ambulance per 100,000 people. In India, there is one ambulance per 144,763. [4] In view of the above facts, we started to develop the idea on how to decrease the response time. According to the studies by researchers from various prominent institutes [6][7][8], the common idea was to wire-lessly track the vehicle and use some form of vehicle-to-infrastructure communication to selectively operate the traffic lights. GPS technology is the most common way to track vehicles.

However, in some cases, the error produced in the tracking can create problems. [5] Therefore, we decided to create a system based on ZigBee [9]. Another consideration was the detection of lane from where the ambulance is approaching and where it wishes to go. Given the fact that ZigBee does not create directional beams, we implemented a self-developed algorithm to identify the correct lane. Choice of the microcontroller was a matter of availability. For the prototype, we decided to use the Nuvoton NUC140. [10] [11]

II BLOCK DIAGRAM

The system contains of two basic blocks: one controller located in the ambulance and other located on the traffic light system.

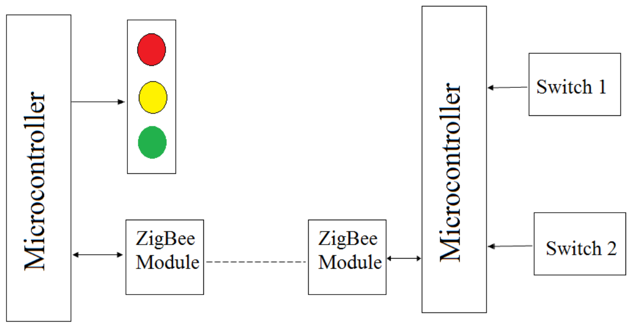

Figure 1 Block Diagram of the system

The ambulance block consists of a microcontroller interfaced with a ZigBee module and a pair of switches. The driver uses the switches to send the signals to the traffic light controller. The ambulance-to-traffic light communication is done with the use of the ZigBee modules interfaced to the microcontroller.

The traffic light block consists of a microcontroller interfaced with the traffic light array and a ZigBee module. When the module receives a message from its network, it initiates the UART transmission to the controller and the controller responds to the input message by producing the suitable response sequence.

III FLOW CHART

The device in normal operational mode operates the normal traffic sequence in the lanes by the use of the GPIO ports. The lane traffic sequences are controlled by a timer and the pre-defined sequence executes in a continuous loop.

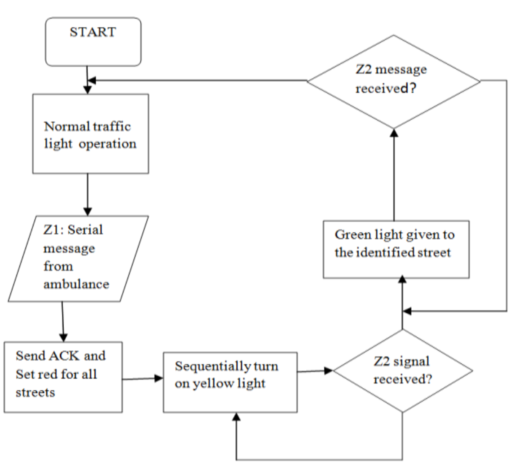

Figure 2 Flow Chart

On receiving a serial signal from the ambulance module, the traffic light module responds. The microcontroller responds to the incoming UART signature message. On identifying the trigger message from an emergency vehicle, the controller initiates a red signal to all the streets and sequentially produces red-yellow combination on each of the lanes, one at a time. When the ambulance responds with the second confirmation message, the lane under consideration at that instant is given green signal. The status of signal is maintained until the vehicle goes out of the coverage and the system resumes normal mode of operation afterwards.

IV DETAILS OF EXPERIMENTATIONS, ANALYSIS, MODELING

A. Hardware

1) ZigBee:- Now-a-days for the home automation systems researchers are giving more attention towards low-power RF radios. The most common technologies which are used to implement these systems are Z-wave, Insteon, Wavenis, Bluetooth, Wi-Fi and ZigBee[9]. ZigBee has been selected for the implementation because of its features. ZigBee can provide a good range for communication as compared to other technologies when the data needs to be transmitted at a data rate of few Kb/s. ZigBee is having following features

Table 1 features of zigbee

Parameter	**Value**
Range	10 - 100 Meters
Extensions	Automatic
Power Supply	Years
Complicity	20 kbps 40 kbps 250 kbps
Frequency Range	868 MHz, 916 MHz, 2.4 GHz
Network Nodes	65535
Linking time	30 ms
Cost of terminal unit	Low
Security	128 bit AES
Integration levels and reliability	High
Prime Cost	Low

2) XBee:- XBee Series 2 has improved power output and data protocols. Complex mesh networks can be created using series 2 modules. A very reliable and simple communication can be established this way. It can be easily established between microcontrollers, computers, and other systems with a serial port. XBee Series 2 supports point to point and multi-point networks.

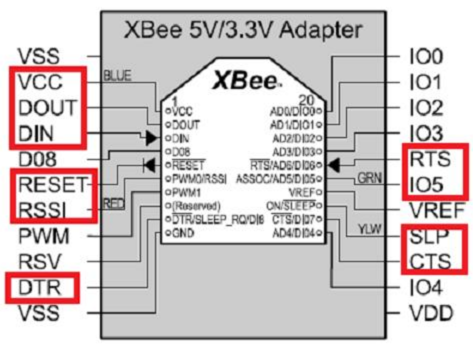

Figure 3 Pin diagram of XBee

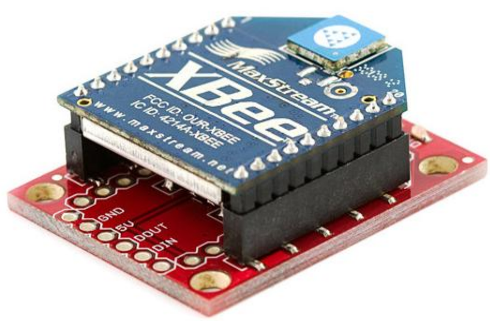

Figure 4 XBee Module with adapters

3) Nuvoton NUC140:- The NuMicro™ NUC140 Nuvoton development board is an ARM Cortex M0 based microcontroller board which gives an easy access to the 32-bit microcontroller based development [10]. The board is provided with a lot of communication interfaces so that it can meet the requirements for industrial applications such as sensor and control applications. Its cost is same as that of the 8-bit microcontroller.

The board comes with a highly reliable connectivity line with support for full speed USB 2.0 along with other communication protocol support such as CAN, I2C, SPI, RS232 UART etc. The board comes with a wide variety of peripherals to suite various applications. They include timers, RTC and Watchdog for timing applications. ADC, UART, GPIO, and comparator are available for external interfacing.

B. Software

1) Keil :- The new Keil µVision4 IDE is intended to improve engineer's profitability, empowering quicker, more productive system advancement. µVision4 presents an adaptable window administration framework, empowering the user to move and customize singular windows to any place on the visual surface including backing for multiple monitors. Numerous new features have been added to µVision4 and those are multiple monitor, system viewer, debug-restore views, multi-project workspace, source and disassembly linking, memory window freeze, device simulation, support for hardware debug adapters.

2) X-CTU:- X-CTU is freely available by Digi which is the manufacturer of XBee. X-CTU is used to configure, manage and test XBee modules and networks. XBees are easily configurable. XBee modules need to configured for three most important settings and those are Personal Area network (PAN ID), My Address (source address), and the destination address. Most of the XBee modules operate on the 2.4GHz band using IEEE 802.15.4 protocol. The PAN ID can be any value between 0 to 0xFFFF. The XBee modules can communicate with each other only if they have the same PAN ID. Each XBee is having a unique address knows as My Address. The destination address is the address of the XBee with which communication needs to performed.

V RANGE TEST

The ZigBee modules were tested in open-air environment to check and confirm the range of communication.
Methodology –
X-CTU has an in-built range testing tool. There were two kinds of tests performed.

i. Stationary test –

In this test, the ZigBee modules were kept at a measured distance from each other. 10 packets were sent and the number of packets received was observed. The test was performed at 100, 150 and more than 150 meters.

ii. Mobile test –

In this test, the ZigBee modules were relatively in motion. One ZigBee was stationary while other was moved. 35 packets were sent and the number of packets received was observed. The test was performed twice: once by moving the ZigBee modules away and secondly towards each other.
The following results were obtained –

1. Between 0 to 100 meters –

In this range, the success rate was 100%

2. Between 100 to 150 meters –

In this range, the success rate was 60% (average).

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3. Over 150 meters –

The success rate dropped significantly and quickly to 2% (average).

Table 2 range test observations

Sl. No.	Distance	Success %
1.	0-100mts	100%
2.	100-150mts	60%
3.	>150m	2%

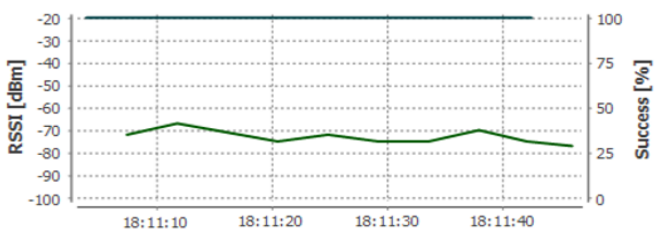

Figure 5 at 100 meters

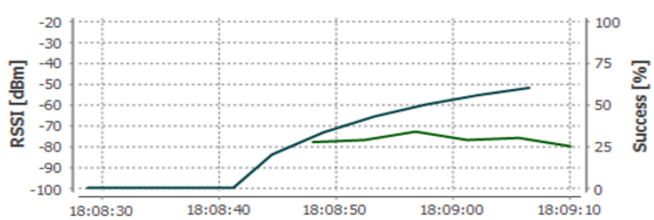

Figure 6 at 150 meters

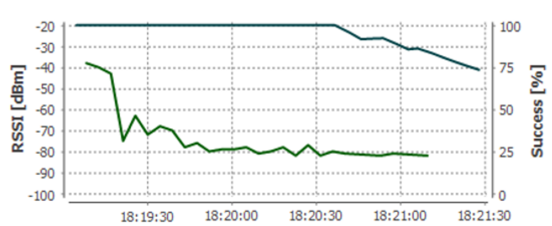

Figure 7 moving away

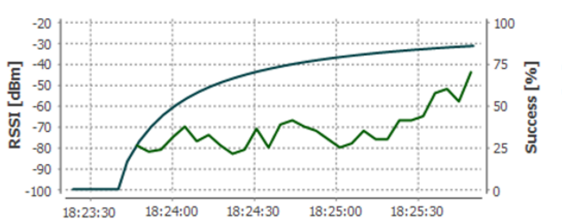

Figure 8 moving towards

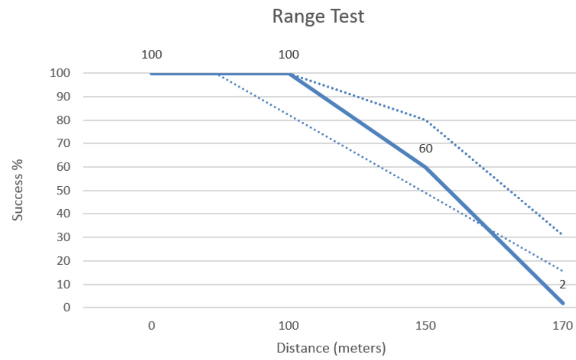

Figure 9 Range Test Cumulative Result

In the final plot, the dotted lines represent the two period moving average. These lines show the average expectation of success for intermediate values in the graph.

With this test, we are able to conclude that the ZigBee modules can communicate with 100% success at the range of 100 meters or below. This range should be sufficient for the ambulance.

VI RESULT AND FUTURE SCOPE

The aim of the project was to achieve the reduction in response time for an ambulance by reducing the waiting time at traffic signals. In the project, the system was developed with use of ZigBee. In the event that the ambulance gets a stuck in a traffic rush created by a red signal, it can request for the green signal so that the time lost in waiting for the green can be avoided. Thus the problem of prolonged waiting is resolved by the use of this embedded system.

The system is simple in design and can be applied to the existing infrastructure at a low cost while proving to be effective in practice. It is easy to operate and robust in design.

There are some possible improvements to the system. Firstly, in order to make system more reliable and secure, the communication between the modules can be encrypted. Secondly, a driver identification system can also be incorporated so that only an authorized user can activate the system. Thirdly, the system can be made cloud-powered to achieve better accuracy and maintain a running-record of ambulance paths. With this, the reliability can be increased further.

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