A mobile ZigBee module in a traffic control system

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Time is of the essence when ambulances are utilized to save people's lives, but when an ambulance needs to pass through a junction, its speed often must be reduced due to traffic. This complicates situations when the patient in the ambulance needs urgent treatment that can be administered only at a hospital. Due to the unavailability of advanced medical procedures in an ambulance, there is the possibility for patients to suffer a loss of life.

In Karnataka, India, the government has introduced a service for ambulances called *108*. This 108 service is used to admit patients to the nearest hospital. For example, in Bangalore, India, this service is being used, but everything gets thrown for a loop whenever an ambulance gets stuck in traffic. It may take hours to clear the traffic and, in the meantime, the patient's situation may become critical.

Traffic control is a challenging issue in the urban cities of India, as is the case in much of the rest of the world. ZigBee technology is a wireless standard designed to operate low-power wireless sensor networks, and it can aid emergency vehicles in dealing with traffic congestion.

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The proliferation of vehicles

Urbanization is a global phenomenon, and its effect is more pronounced in developing countries like India. In these countries, there is a drastic improvement in industrialization. Due to an increase in industrialization, the usage of vehicles has been proliferating, and motor vehicle fatalities in accidents has been increasing. This is also the case in developed countries but with the number of fatalities somewhat less due to modern infrastructure. In developing nations, due to a lack of infrastructure, motor vehicle fatalities are comparatively higher. Globally, road accidents claim lives of 1.24 million people per year with as high as 50 million people injured. The statistics show that countries have various numbers of fatalities and accidents. In India, statistics show that fatalities and accidents have been increasing.

"Bus priority control system based on wireless sensor network (WSN) and Zigbee" (Wu et al., 2006) provides an

Digital Object Identifier 10.1109/MPOT.2014.2341331
Date of publication: 8 January 2016

overview of how buses are routed along roadways with all of the necessary information to control traffic congestion. Here, a bus priority control system is implemented with the help of wireless sensor nodes and a ZigBee module, which are fixed at the roadside.

Buses are also equipped with on-board wireless infrared (IR) sensors that interact with the sensors fixed on the roadside. The sensor nodes at the road intersection provide information regarding traffic congestion to the sink node, which is connected to the control center. "Intelligent traffic light system to prioritized emergency purpose vehicles based on wireless sensor networks" (Goel et al., 2012) describes two types of fixed-in-nature wireless sensor nodes—*intrusive* type is underground and *nonintrusive* type is on the ground. The intrusive type sensor works as a metal detector. "An Efficient Freeway Traffic Information Monitoring Systems Based on Wireless Sensor Networks and Floating Vehicles" (Yu and Guo, 2010) talks about the implementation of three-tier-architecture, where the bottom tier focuses on the roadside sensors installed on the road and floating-vehicles nodes. Here, floating-vehicle nodes collect information regarding traffic from all of the roadside nodes.

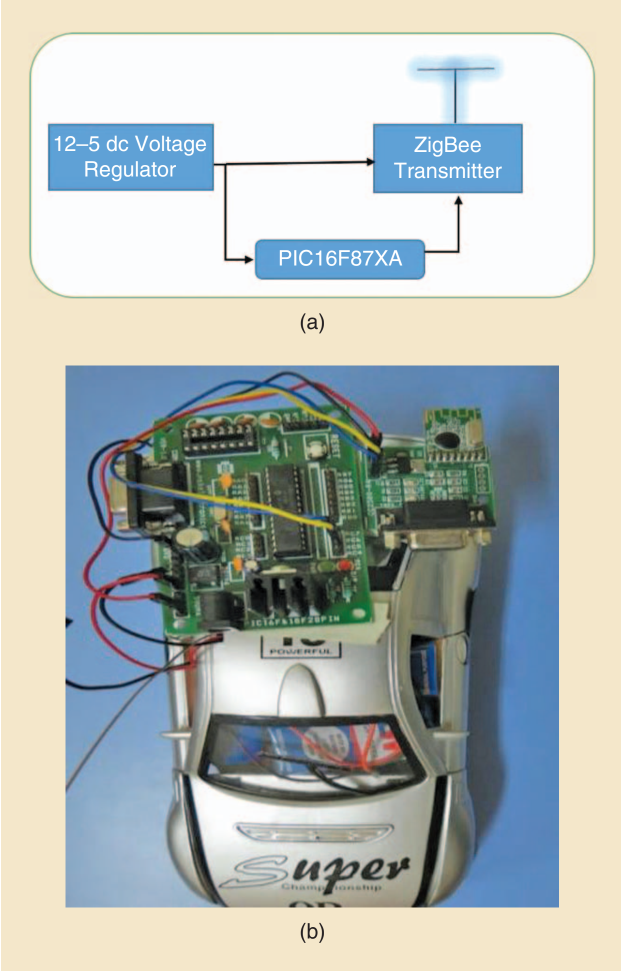

FIG1 The proposed module architecture at ambulance. (a) A block diagram of the trasmitter. (b) The transmitter working model.

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The middle tier involves the exit and entrance sink nodes, where floating-vehicle nodes collect information and pass it along to the freeway traffic control center. In the top-tier, an overall analysis is completed on the collected information. "Priority based traffic lights controller using wireless sensor networks" introduces an intelligent traffic controller system for vehicle detection and dynamic traffic signal time management. It also proposes numerous interactions with multiple intersections of a traffic system.

"Smart Traffic Light Control and Congestion Avoidance System During Emergencies Using Arduino and Zigbee 802.15.4" (Maqbool et al., 2013) proposes a smart traffic light control system and congestion-avoidance system during emergencies. The proposed work is divided into two parts: a smart traffic light control (STLC) system and a smart congestion avoidance (SCA) system. STLC controls the traffic light at the road intersection and prioritizes emergency vehicles such as ambulances, fire brigades, and other rescue vehicles. Here, an IR proximity source continuously sends IR rays to IR sensor nodes that are deployed at the roadside. IR-sensor-output is connected to Arduino, and Arduino is connected to Xbee. As Xbee receives the signal, it communicates with a directional radio-frequency (RF) antenna system at the traffic lights.

Current problems

Whenever fatalities or accidents occur due to any kind of transport problem or natural calamities, the most convenient way to carry the victims to nearby hospitals is through an ambulance. Some of the traffic control system models are fixed in nature. If the sensors have to be fixed on the roadside, it increase the cost of implementation. As in "Bus priority control system based on wireless sensor network (WSN) and Zigbee," the bus is equipped with an on-board node that sends information regarding the traffic conditions along its entire route, including to the roadside fixed-sensor nodes and the intersection nodes. This means that all of the nodes must be working all of the time. Even though the ZigBee model comes with the advantage of using low power, it is underutilized. As in "Intelligent Traffic Light System to Prioritized Emergency Purpose Vehicles Based on Wireless Sensor Networks," fixing sensors at almost all points on one side of the road and then collecting data and processing it according to the mentioned algorithm consumes a lot of time and resources.

In "An Efficient Freeway Traffic Information Monitoring Systems Based on Wireless Sensor Networks and Floating Vehicles," there are wireless sensor nodes that are fixed on road, which can sense the alarm produced by the emergency vehicle and communicate among the fixed sensor nodes. The nodes work together to clear traffic to give way to the emergency vehicles.

The proposed model

It can be concluded that almost all fixed roadside sensors face problems. To overcome this, we propose the mobile ZigBee module in a traffic control system, which gives way for the ambulance at traffic junctions without any problems. In this article, there are mainly two parts. The first part describes the ZigBee transmitter that is placed in the ambulance, and the second part details the ZigBee receiver implemented at the traffic pole. In the first part of the proposed model, the ZigBee transmitter is switched on only by the driver, in case of emergencies. There are situations where the ambulance is not carrying patients who are in need of urgent treatment, and the traffic need not be controlled using the ZigBee module. As a result, the system is implemented such that only the driver can turn it on.

When the ZigBee transmitter is switched on, it begins sending signals to the nearest receivers, which are in the range of 100–200 m. Whenever the ambulance comes in range, the signal is automatically turned to green so that vehicles that are ahead of the ambulance can pass through the signal, giving way to the ambulance. Soon after the ambulance passes through the traffic junction, the signal is turned back to its previous state. Figure 1 shows the architecture of the proposed model in an ambulance.

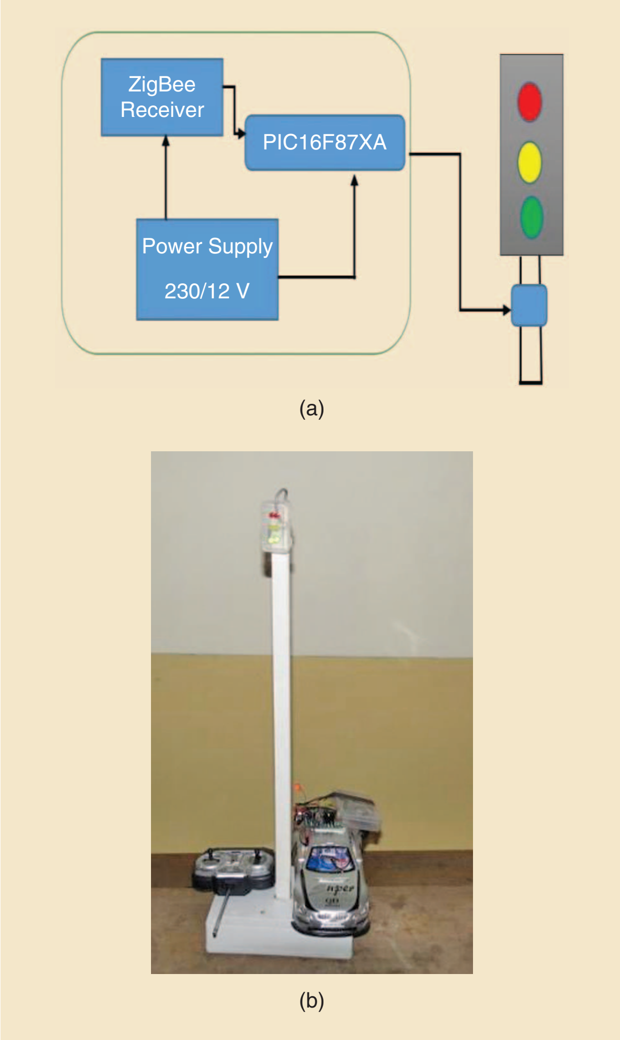

FIG2 The proposed module architecture at a traffic pole. (a) A block diagram of the receiver. (b) A working model image of a receiver.

Globally, road accidents claim lives of 1.24 million people per year with as high as 50 million people injured.

In the second part of the proposed model, the ZigBee receiver receives a signal from a transmitter, processes it, and converts the traffic signal to green so that the ambulance can pass. The traffic signal will be green as long as the ambulance passes by that traffic pole. Here, care is taken not to make the public wait for extended periods of time due to interruptions caused by the ambulance interruption passing through the signal. This is accomplished by reverting the signal duration to the previous state from where it was interrupted. The components used in the experiment are a CC2500RF module, microchip PIC16F877A. The CC2500 RF module, which is a transreceiver that provides a way to use RF communication at the industrial, scientific, and medical band of 2.4 GHz. It can be used to transmit and receive data at 9,600 baud rates from any standard complementary metal-oxide semiconductor (CMOS)/transistor–transistor logic (TTL) source. This module is a direct replacement for serial communications and does not require any extra hardware and coding. It works in half-duplex mode and provides communication in both directions but only one direction at a time. Its operation range is 30 m, and the input voltage needed for operation is 5 V dc. It works with the RS 232 interface and the TTL interface.

A working model

The transmitter that is placed in the ambulance continuously transmits the signal. The transmitted signal contains a security code and unique identification number, which are stored in the microcontroller (PIC16f877a). In Fig. 1, it has a power supply, a microcontroller, and ZigBee. A 12–5 V regulator is used to

FIG3 The proposed model images of the transmitter and the receiver. (a) Red light, (b) yellow light, and (c) green light. (d) A detailed image of the receiver. (e) The transmitter. (f) A working model.

With the proposed model, we made sure that the ambulance has passed through the traffic junction without having to wait on its way to the hospital.

energize the microcontroller and ZigBee within the rated supply. The microcontroller sends commands as well as data to the ZigBee via serial communication. The model built for testing purpose has a range of 10 m.

The signal is continuously transmitting whenever an ambulance is approaching any of the signal junctions. The receiver model receives these signals and compares it to the already stored data. If it finds that it is an emergency vehicle, it turns on green lamp signal to clear traffic and give way to the ambulance.

The receiver is designed and programmed in such way that it continuously receives the signal and compares it to a database that is periodically updated for the purpose of detecting new vehicles. Whenever the ambulance approaches a traffic junction, a signal is sent to the main signal controller (Fig. 2 shows the receiver). Here, the power supply is taken directly from 230 V ac supply. So, we are using a 230–12 V transformer, and it is converted to 5 V using an electronic voltage regulator to energize the receiver.

The proposed model is tested with the following configurations: 10 s for a red light and 2 s for a yellow light. We selected a short range (10 m) for testing our prototype. First, we turned on the devices on the receiver side, and it started running according to the above-mentioned time delay for every signal indication. At the receiver end, when the ambulance enters the range, the receiver only acknowledges signals if they contain the correct security code and registered serial number. In our case, we loaded the serial number to the receiver database so that the signal light switched to green.

During testing, the ambulance was made to wait near the receiver for a duration of 1 min so that vehicles ahead of the ambulance could pass through the traffic junction. The green light continued until the ambulance was out of range. During normal operation, it maintains the same sequence as in Fig. 3(a)–(c). Figure 3(d)–(f) shows the working model.

Conclusion and enhancements

With the proposed model, we made sure that the ambulance has passed through the traffic junction without having to wait on its way to the hospital. This is done by turning the traffic signal to green. The system then turns the signal back to its previous state so that it does not cause traffic chaos.

This proposed model is an efficient and a cost-effective solution for the problems faced by ambulances due to traffic jams at junctions. For an enhancement, we can install a global positioning system to monitor ambulance routes to find the shortest route to the nearest hospital.

Read more about it

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Digital Object Identifier 10.1109/MPOT.2015.2512319