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Intelligent Traffic Light System to Prioritized Emergency Purpose Vehicles Based on Wireless Sensor Network

E.Sireesha [1], D. Rakesh[2]

[1]PG Scholar, Electronics and Communication Engineering, Layola Institute of Management & Science, India
[2]Assistant Professor, Electronics and Communication Engineering, Layola Institute of Management & Science, India
eadarasireesha@gmail.com

Abstract: *Traffic congestion problem is a phenomena which contributed huge impact to the transportation system in country. This causes many problems especially when there are emergency cases at traffic light intersections which are always busy with many vehicles. A traffic light controller system is designed in order to solve these problems. This system was designed to be operated when it received signal from emergency vehicles based on radio frequency (RF) transmission and used the Programmable Integrated Circuit (PIC) 16F877A microcontroller to change the sequence back to the normal sequence before the emergency mode was triggered. This system will reduce accidents which often happen at the traffic light intersections because of other vehicle had to huddle for given a special route to emergency vehicle. As the result, this project successful analyzing and implementing the wireless communication; the radio frequency (RF) transmission in the traffic light control system for emergency vehicles. The prototype of this project is using the frequency of 434 MHz and function with the sequence mode of traffic light when emergency vehicles passing by an intersection and changing the sequence back to the normal sequence before the emergency mode was triggered. In future, this prototype system can be improved by controlling the real traffic situation, in fact improving present traffic light system technology.*

Keywords: *PIC 16F877A, Radio Frequency (RF), Sequence Control, Traffic Light*

1. INTRODUCTION

Many countries in the world are facing the problem at traffic light intersection that causes accident between emergency vehicle and other public vehicle. The traffic control system in Malaysia specifically has not been equipped with appropriate method when emergency case occurs. This will cause the emergency vehicles such as ambulances difficult to reach the destination on time because of the traffic congestion. Moreover, the situation is getting worse when emergency vehicles have to wait for other vehicles to give way at intersections with traffic lights. This causes a delay of time and may affect the emergency case. Besides, the collisions with other vehicles from other direction might occur at intersections when emergency vehicles had to override the red traffic lights. All these difficulties faced by emergency vehicles can be avoided using this traffic light control system based on radio frequency. Due to the problem, literature review for related issue prior to undertaking research project is decisive. The literature review will provide information on the technology available and methodologies used by other research counterparts around the world on this topic. The traffic light system designed by Levi L. Rose [1] used only for emergency vehicle. Sensor is used to transmit signal that has been installed in every emergency vehicle to the receiver which has been placed at every traffic light intersection.

When emergency vehicle reach at the traffic light intersection, the signal code will be sent information of frequency modulation to the receiver. The receiver demodulates the received code and the red traffic light will trigger at all the junctions. Thus, emergency vehicle will have special route from other vehicle to reach the destination. The traffic light system designed by M. R. Smith et al [2] provided early warning of the approaching an emergency vehicle to find a way out from traffic congestion and lead the emergency vehicle to the destination. The emergency vehicle also may take control of traffic light at an intersection. A transmitter placed on an emergency vehicle transmits a signal to the receivers positioned at the traffic lights whenever it is on emergency mode. The received signal is then processed by a master controller which in turn pre-empts the sequence of the traffic light

to control the traffic flow at the intersection which taken by the emergency vehicle. The master controller also provides an output which display signs to indicate that there is an emergency vehicle to the other road users from other direction at the traffic light intersection. Additionally, the display system indicates whether the emergency vehicle has passed through the intersection or not.

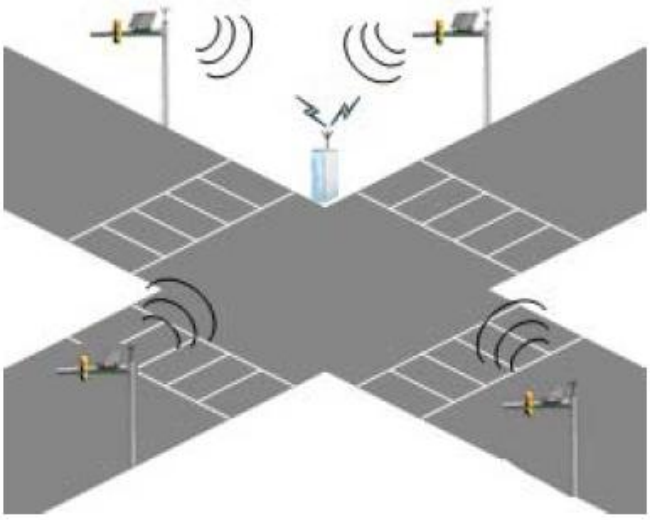


Fig1.*Wireless traffic signal control system*

The sound signal detection unit has at least one sound transducer for detecting sound signals and producing an electric current upon detection of a signal. A signal comparator is connected to the sound transducers for comparing the currents from the transducers to pre-programmed patterns. If there is matching pattern, a signal output encoder connected to the signal comparator constructs an encoded signal and transmits the encoded signal to a remotely located display unit through a transmitter. The display unit has a receiver for receiving the encoded signal and passing it to a signal comparator to compare the encoded signal to known patterns and activate at least one illumination device upon detection of a matched pattern.

2. HARDWARE DESIGN

2.1. System Design

The system is composed of host, controlled unit, power supply unit, communication unit. (Figure 2) High quality solar panel can supply clean power to system, power outages be void will by battery in bad weather. The control signal transmit by cc2530 model, S3C2440 is a low power, high performance 32-bit microcontroller, it capacity for complicated control signal processing work. When coordinate node lost signal form device node, the network could rebuilt by ZigBee protocol, keep the communication do not be interrupt.

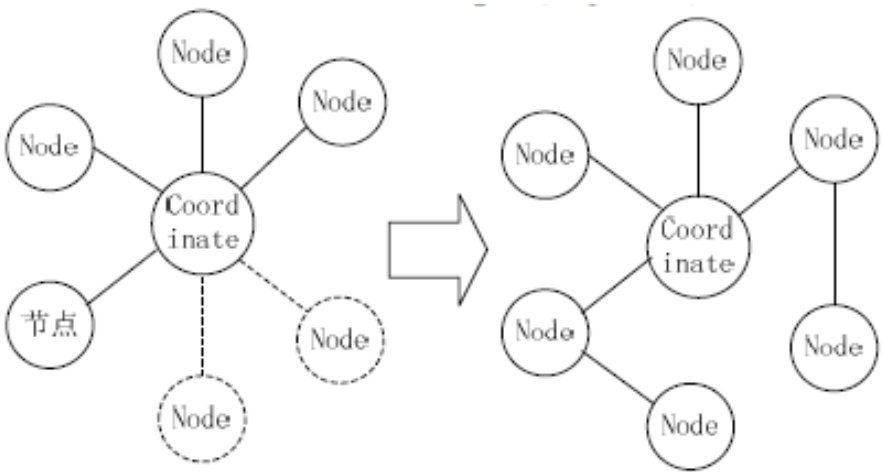


Fig2. *Network rebuilt*

2.2. Wireless Communication Model Design

The CC2530 is a true system-on-chip (SoC) solution for IEEE 802.15.4, ZigBee and RF4CE applications. It enables robust network nodes to be built with very low total bill-of-material costs. The CC2530 has various operating modes, making it highly suited for systems where ultralow power consumption is required. Short transition times between operating modes further ensure low energy consumption. A typical application circuit is shown in Figure 4.

Antenna is one of the most important parts in wireless model, it directly related to the distance and reliability. Whip antenna and PCB antenna are the most common applications, the whip antenna provides an excellent performance, but it's a higher price than PCB antenna. PCB antenna is a cheaper scheme when distance demand is not high, but the design of PCB antenna involves a lot of complex technical problems, so, in general, we use the official reference designs, it would save a lot of time and money.

3. PROGRAM DESIGN

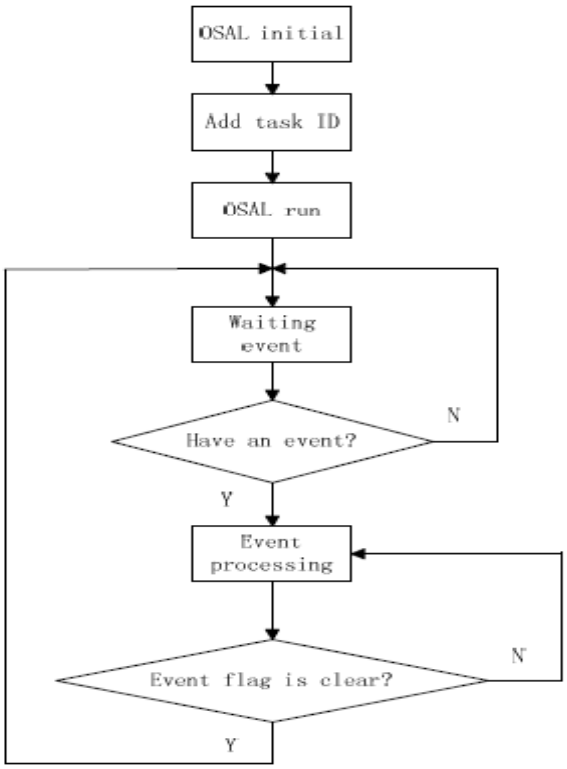
3.1. ZigBee Protocol Stack

The protocol stack is an implementation of computer networking protocol suite. The terms are of often used interchangeably. Strictly speaking, the suite is the definition of the protocols, and the stack is the software implementation of them. The design for the choice of protocol stack mainly concentrated in the TinyOS and Z-Stack.

TinyOS is a free and open source component-based operating system and platform targeting wireless sensor networks (WSNs). TinyOS is an embedded operating system written in the nesC programming language as a set of cooperating tasks and processes. It is intended to be incorporated into smartdust. TinyOS started as collaboration between the University of California, Berkeley in co-operation with Intel Research and Crossbow Technology, and has since grown to be an international consortium, the TinyOS Alliance. Z-Stack is TI's ZigBee compliant protocol stack for a growing portfolio of IEEE 802.15.4 products and platforms. Z-Stack is compliant with the ZigBee 2007 (ZigBee and ZigBee PRO) specification, supporting both ZigBee and ZigBee PRO feature sets on the CC2530 System-on-Chip. TinyOS has not release is CC2530 compatible version and it not get authentication from ZigBee Alliance. So, in this design, Z-stack is the chosen of the protocol stack.

3.2. OSAL(Operating System Abstraction Layer)

Fig 3.



The protocol stack task management thought OSAL in Z-Stack, task ID will add when OSAL initial, the low ID means high priority, so the user's task always highest ID. Every task ID include 16 events flag, it could trigger 16 events. When system running, OSAL will begin to cyclic query, if an event flag is not NULL, the program will call event processing function. The flowchart is shown in Figure 3.

3.3. Receive and Send Data Program

For the coordinate, the message of command used group broadcast mode to send, it include Group ID, Device ID and Command ID. When phase changed, coordinate would send a new command to device node.

For the device node, the same direction of nodes have same group ID, this can improve data transmission efficiency. When a message received by an Device node, firstly, the program would confirm the message send to this device, reading the equipment type information and the current equipment is consistent, if it not consistent, the message would be discard; if it consistent, processing the command, testing equipment operation is normal or not, if it not, enter the recovery processing, final the program will send a report to coordinate.

4. CONCLUSIONS

This paper proposes a wireless traffic signal control system, it not only low cost and reliable, but also easily upgrade. It could solve the inconvenience to upgrade and maintenance in road reconstruction project has a good application prospect and high market value.

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