Analysis and Development of a Wireless Traffic Light for Pedestrian Crossing

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Abstract— This document discussing Traffic signals for pedestrian crossing are crucial in ensuring safety for the public, especially in urban streets. A pedestrian crossing requires a control unit connected through underground cables between traffic and a pedestrian signalling device. Due to the infrastructure and maintenance cost of a conventional pedestrian crossing is high, alternative techniques to improvise the system is required by the municipal. The wireless traffic light for pedestrian crossing can reduce the costly infrastructure needed in future implementation as this involves no cutting of roads and underground cables. Hence the reduces maintenance cost. A reliable and stable wireless connection between traffic signalling poles is a mandatory feature in ensuring timely signals. A mesh network of wirelessly connected devices to a traffic controller can provide different traffic sequences by demand as a conventional pedestrian crossing light. The proposed wireless traffic light for pedestrian crossing can vary as per traffic conditions and by user demand.

Keywords— Wireless Traffic Light, LoRa (Long Range Communication), Pedestrian Traffic Light, Wireless Technology, LoRa Dragino

1. Introduction

The traffic light is a system that monitoring vehicle and pedestrian traffic. The pedestrian traffic light is a device for controlling pedestrians. If the button is pressed, the traffic light will show red color and let the pedestrian crossing the road. They must be programmed to adapt to outside environments to interact and transfer the signal between them in any environment [1]. For this to be completed, the traffic signal model necessities regulator gadgets to react to the environment. Such as ultrasonic, ultrasound, Programmable Logic Control (PLC), and many more microcontroller technology can be used.

Wireless Traffic Light for Pedestrian Crossing is a system that combined software and hardware project. This project system will use a wireless technique, which is Long Range Communication (LoRa). LoRa is a spread spectrum modulation method got from chirp spread spectrum (CSS) Technology. LoRa is a Wireless Technology created to empower low data rate communication over a long-range by sensors and actuators for Machine to Machine (M2M) and Internet of Things (IoT) applications. A bidirectional communication technique is a use in communicating the signal, starting with one traffic signal next [2].

In this project, LoRa will be transmitted the signal to the other LoRa system of devices to interface and communicate with the two traffic lights. At that point, the traffic signal model will work as the traffic signal's present function and it is utilizing the wireless technology method [3]. The proposed system would remain the current traffic light system and functionality, but there is no wire used for connecting the traffic lights in this project. In this project, the software is Arduino IDE, and this software is used as a computer code compiler. There are two devices included in this project. LoRa Sensor Node and LoRa Gateway. The sensor node powered up by a battery and made up of the Arduino UNO, Lora Module, and Push Button, as shown in Figure 1.

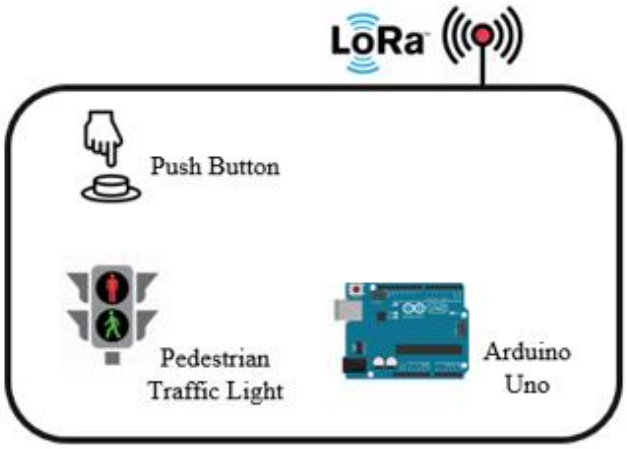

Figure 1: Sensor Node

The gateway used is Dragino LoRa LG01P and will be located at the data centre, as shown in Figure 2. In this project, the LoRa gateway is important because the transmitted data must be received in the same transceiver language. The information is translated and sent to the cloud using an ethernet cable or Wireless Fidelity (Wi-Fi) connection. The data is then decrypted using an ethernet cable or Wi-Fi link and sent to the cloud.

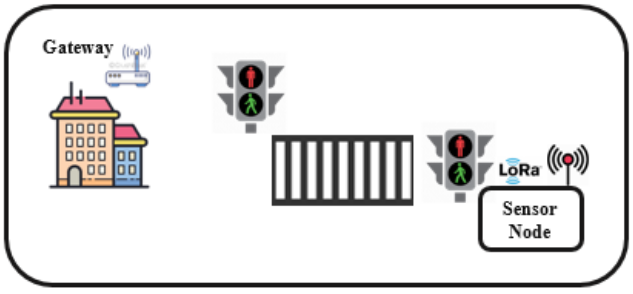

Figure 2: Sensor Node and Gateway Located

2. Wireless Technology

Wireless Technology hugely affects our lives by encouraging pervasive processing [4]. It offers imperative assistance, to give some examples, for smart homes, savvy urban communities, smart grids, and the Internet of Things. This makes mobility possible for audio, video, and data traffic. The need for thousands of cables was removed by interconnecting several separate, most often tiny devices. However, as opposed to the corresponding wired channel, far more distortions and environmental disturbances are faced due to the existence of wireless communications. These disruptions are due to heat, pollution, and physical barriers in the transmission path, such as houses, cars, trees, and mountains [5].

The Wi-Fi Alliance has envisaged Wireless Fidelity (Wi-Fi) as a single, internationally accepted standard for high-speed local area wireless networking. Based on IEEE 802.11 standards [6], the term Wi-Fi hand out Wireless Local Area Network (WLAN) technology [7]. Wi-Fi is access or edge-network technologies. This suggests that they offer the last-kilometre wireline network options. Both depend on comparable organization associations and transmission support infrastructure past the last kilometre [8].

ZigBee is an extremely well-known industry wireless mesh networking standard for interfacing sensors, instrumentation, and control frameworks. For example, the correspondence in a Wireless Personal Area Network (WPAN) has been known as the "Internet of things (IoT)". This device is also an open device, a worldwide, packet-based protocol intended to give a simple to utilize design for secure, reliable, Low Power Wireless Networks. ZigBee and IEEE 802.15.4 are low data rate wireless networking standards guidelines that can dispose of the expensive and harm inclined wiring in industrial control applications [9].

Long-Range Communication (LoRa) is the actual layer or modulation layer used to establish the long-range communication link. LoRa extremely productive adjustment for accomplishing low power because many legacy wireless systems use Frequency Shifting Keying (FSK) modulation as the physical layer [10]. LoRa processing gain is presented in the RF channel by duplicating the information signal with a spreading code or chip arrangement. By increasing the chip rate, we increment the frequency part of the complete sign spectrum. As such, the absolute sign's energy is presently spread over a more extensive range of frequencies, permitting the receiver to recognize a sign with a lower signal-to-noise ratio (SNR) [11] .

3. Comparison Between Wireless Technologies

The most serious elements to be examined under coexistence Bluetooth Low Energy (BLE), Wi-Fi, Lora, and ZigBee devices are included. The specifications, as shown in Table 1, interpret from different wireless technologies [12].

TABLE I. SPECIFICATION OF DIFFERENT WIRELESS TECHNOLOGIES

Technology	Standard	Frequency	Range	Typical Transfer Radio
ZigBee	IEEE 208.15.4	2.4 GHz	10 meters - 100 meters	250 kbps
LoRaWAN	LoRaWAN	433 MHz,688 MHz, and 915 MHz	2 KM -15 KM	300 bps – 50 kbps
Wireless Fidelity (WiFi)	802.11n	2.4 GHz and 5 GHz	50 meters	150 Mbps – 200 Mbps
Bluetooth Low Energy (BLE)	IEEE 802.15.1	2.4 GHz (ISM)	50 meters – 150 meters (Smart/LE)	1 Mbps (Smart/LE)

According to the wireless technology, the network size for Zigbee approximately up to 65,000 nodes. Bluetooth is eight nodes per network, while Wi-Fi approximately 8000 nodes network size. The most bigger network size is the LoRa gateway has a very high capacity and capability to receive a message from a very high volume of End Node [13]. This illustration of network size comparison shown in Figure 3.

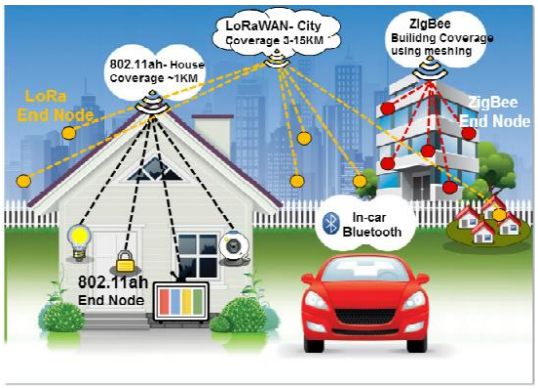

Figure 3: The Influence Wireless Technologies Range

The power consumption of some wireless communication technologies addressed in this study in the range coverage range, as may be seen in Figure 4.

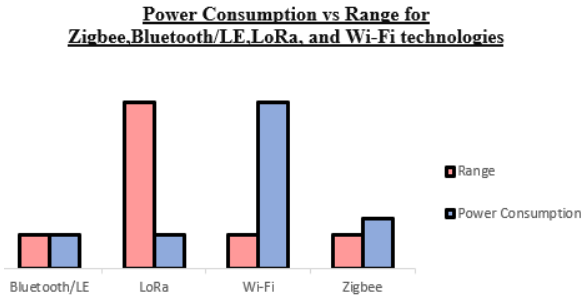

Figure 4: Power Consumption vs. Range for Bluetooth/LE, LoRaWan, and Wi-Fi technologies

It presents that LoRa covers the largest range with less power consumption, in comparison with Bluetooth/LE, Wi-Fi networks [14]. Wi-Fi and Bluetooth achieve very high data rates, but the energy consumption is comparatively high and the range very short. All users of smartphones are only too well aware of this hunger for energy. The base stations of the major telecommunications providers offer high data rates and relatively long ranges, but a large amount of energy must be available for this. This is why the power supply is always a very important planning factor in such installations [15].

4. Hardware

The hardware development of this project consists of the process of constructing the sensor node and gateway. It includes circuit designing, circuit testing, circuit troubleshooting, and PCB development. Several software was used during this development to allow the controller to operate and communicate as intended. In this project, there are some hardware components used. The hardware component used is two pieces Arduino controller, two pieces LoRa Shield, LoRa Gateway, Push Button, Red Light, Amber Light, and Green Light.

4.1. LoRa

SX127x LoRa Shield, as appeared in Figure 5, will be highlighting with an Arduino Shield. This innovation depends on the Open-source library. This Shield permits the to send information and arrive at exceptionally long ranges at low data rates. It gives super long reach spread spectrum communication and high obstruction invulnerability while limiting energy usage.

Figure 5: SX127x LoRa Shield

4.2. LoRa Dragino LG01-P Gateway

In this project, the gateway used is Dragino LG01-P. As shown in Figure 6, in Malaysia, the suitable frequency is 915MHz restriction as stated by the Malaysian Communication and Multimedia Commission (MCMC). The LG01 is an open-source single channel LoRa Gateway. It lets connect LoRa wireless network to an IP network base on Wi-Fi, Ethernet, 3G, or 4G cell. LG01 runs on an open-source implanted Linux framework. It has a USB port and has full Ethernet and 802.11 b/g/n Wi-Fi abilities. The USB port can be utilized to associate cell modules, so LG01 is entirely adaptable to connect LoRa Network to various types of network to fit necessity.

Figure 6: Dragino LG01-P

In this project, all the values regarding LoRa Dragino LG01-P Gateway are set by referring LoRa Dragino LG01-P Gateway specification, as shown in Table 2.

TABLE II. LORA DRAGINO LG01-P GATEWAY SPECIFICATION

Frequency Range	i. Band 1 (HF): 862~1020 Mhz ii. Band 2 (LF): 410~528 Mhz
Link Budget	168 dB maximum
RF Output	+20 dBm – 100mW
Efficiency PA	+14 dBm
Programmable Bit Rate	Up to 300 kbps
Sensitivity	Down to -148 dBm
Modulation	FSK, GFSK, MSK, LoRa TM and OOK
Dynamic Range RSSI	127 dBm
Tx Power	i. 11n transmitter power: mcs7/15:11db mcs : 17dB ii. 11b transmitter power: 18 dB iii. 11g transmitter 54M transmitter power: 12 dB iv. 11g 6M transmitter power: 18 dB
WiFi Sensitivity	i. 11g 54M: -71 dB ii. 11n 20M: -67 dB

4.3. Arduino Uno

In this project, Arduino UNO, as shown in Figure 7, is used to communicate with the LoRa module, which transmits data input from the user and sends it to the LoRa module then

connects to another LoRa module and operate the wireless traffic light for pedestrian crossing.

Figure 7: Arduino UNO R3

5. Software

In this project, the operation of the control system is programmed by using the Arduino IDE Software. In order to build the perfect coding for this project, the first thing that needs to do is the construction of the project flowchart.

5.1. Project Flowchart

Project Flowcharts, as shown in Figure 8, are often used to describe in detail algorithms that will be carried out by a computer. When a computer carries out an algorithm, the computer is said to execute the algorithm. Execution is also sometimes referred to as running.

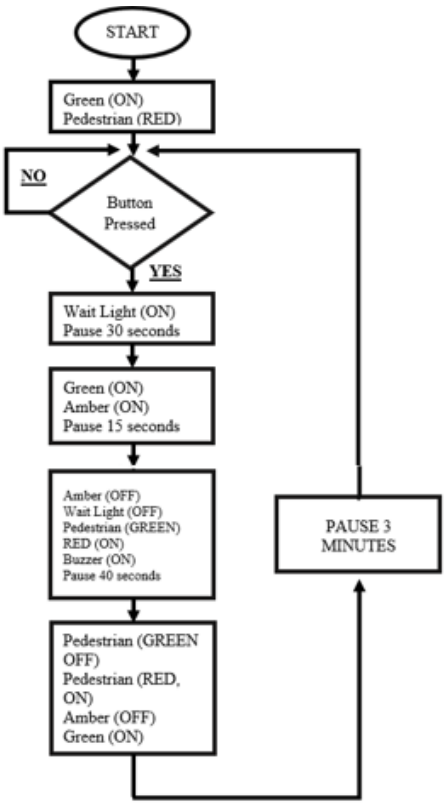

Figure 8: Project Flowchart

5.2. Project Coding

In order to connect both the sensor node and gateway to operate, it is very important to have a program code as shown in Figure 9 and Figure 10 to give instruction that needs to be run. The software used for program development is Arduino IDE 1.8.7. The coding Arduino is called a sketch, and it is uploaded to the Arduino UNO R3.

SendData

```
#include <SPI.h>
#include <RH_RF95.h>

RH_RF95 rf95;

void setup()
{
  Serial.begin(9600);
  while (!Serial) ;
  if (!rf95.init())
    Serial.println("init failed");
}

void loop()
{
  Serial.println("Sending to rf95_server");
  uint8_t data[] = "Hello I'm from lora!";
  rf95.send(data, sizeof(data));

  rf95.waitPacketSent();
  // Now wait for a reply
  uint8_t buf[RH_RF95_MAX_MESSAGE_LEN];
  uint8_t len = sizeof(buf);
```

Figure 9: Sending Data

ReceivedData §

```
#include <SPI.h>
#include <RH_RF95.h>

RH_RF95 rf95;
int led = 13;

void setup()
{
  pinMode(led, OUTPUT);
  Serial.begin(9600);
  while (!Serial) ;
  if (!rf95.init())
    Serial.println("init failed");
}

void loop()
{
  if (rf95.available())
  {
    // Should be a message for us now
    uint8_t buf[RH_RF95_MAX_MESSAGE_LEN];
    uint8_t len = sizeof(buf);
```

Figure 10: Receiving Data

6. Conclusion

The traffic light for pedestrian crossing is a very important role in our life because it intended to increase pedestrian safety and facilitate the flow of vehicular traffic. They are absolutely vital in maintaining order in the streets and protecting both drivers and pedestrian on the road. Nowadays, the usage of wireless device is always demanded by the user because it can be reduce cost of cable rates for connecting between two points thus simplifies the device. With LoRa Technology, Long Range of communication can be produced with lower power consumption as compared to the other communicating technologies. In addition, this project is applicable anywhere since there is no use of external power supply, only using a lithium battery where it can last up to three years. Instead of using a solar panel, this battery also helps to reduce the cost.

This project, analysis and development of a wireless traffic light for pedestrian crossing will results in greater effectiveness it is because this project enhance machine to machine (M2M) communication. Staying in contact with the database would ensure complete disclosure of the physical equipment. It needs little or no human interference because of the wireless system, and it is capable of functioning almost on its own. As the system operates on minimum energy, this system makes it more environmentally friendly.

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