Li-Fi

Table of Contents

Executive Summary

In today's world, wi-fi has become my part of our daily lives. With the combination of mobile devices, wi-fi has allowed us to stay in connection with anyone, anywhere, at any time. However, the radio frequency that wi-fi produces has the potential to cause problems to various equipment, hence limiting the service's at certain area maybe not at our daily lives, but at places where it would make our lives easier if we would have access to it. In this project, we've chosen the scenario where wi-fi is currently either not available, extremely slow, or charged at a very high rate when we are boarding commercial flights.

Light fidelity (li-fi), a product which transmit data using simple LED lights can be found easily around us. Li-fi uses Visible Light Communication (VLC) and functions very much like our everyday wi-fi: running wireless communication between devices, but with the potential to run much faster than wi-fi. In this project, we've made a simple demo to carry out simple data transmission across two computers, to understand the basic concept and equipment required to allow the two computers to communicate.

Looking at the hybrid layering network model, we've learned that li-fi has little to no difference when comparing the application and TCP/IP layer that of wi-fi. The physical and data link layers, however, proves to be quite different from wi-fi. The prototype we've built in the project shows that the physical layer of wi-fi was replaced with a simple LED light bulb and a photoresistor, while the data link layer was replaced by an Arduino board.

Core Concept:

- **Background:** In today's modern world, Wi-Fi has become part of our daily lives. With the combination of mobile devices and network, Wi-Fi has allowed us to stay in connection with anyone, anywhere, and at any time. However, the radio frequency that Wi-Fi operates on the radio spectrum has the potential to cause problems to various equipment, hence limiting the service in areas such as airplanes. LiFi is a potential solution to this problem, since light does not interfere with radio waves. For the purposes of our network project, we will be be explaining the core concepts of Li-Fi, and relating its application to the commercial airplane industry, a well-known scenario to where end-users are asked to turn off personal radio device.

- **Objective**: There are frequent occurrences across the world where WiFi is either not available, extremely slow, or charged at a very high rate when consumers traverse on commercial airplanes. In this project we wish to demonstrate an alternative to the Wi-Fi that generates wireless Internet to users but none of the problem-causing radio frequency.

- **Expected Benefits:**This project itself is to provide our colleagues with knowledge to an alternative to Wi-Fi, where users can actually gain internet access at places where the Internet is not allowed. In addition, Li-Fi also allows users to transfer data much faster than our ordinary WiFi, with better security, and potentially a lower cost.

- **Light Fidelity (Li-Fi):** Introduced to the world by Professor Harald Haas from University of Edinburgh in 2011 Ted Talk, Li-Fi is a wireless communication technology that works similarly to our everyday WiFi, but uses a different way to transmit data. As opposed to using antenna to transmit radio frequency as a mean of achieving wireless connection, the main item required for Li-Fi to work is a LED light bulb that can be found easily around us to transmit data over the Visible Light Spectrum (VLS). Using the research from US FCC, we can see that we are limited by the capacity of which radio frequency of WiFi works in, but VLS itself is bigger than the entire radio frequency spectrum. In addition, for having the fastest travelling speed known to mankind, transmitting data using VLS spectrum light proves to be much faster than any of our current internet that transmits through the radio spectrum. Due to the fact that Li-Fi transmit data using only simple LED light bulbs, its cost has the potential to be much cheaper as compared to our current Wi-Fi.

To begin with, we can attach LED light bulbs to any devices that can be used to transmit data, and with the correct coding, we can transmit data by controlling the rate of which the LED light bulbs blink, even at the rate that is too fast for human eyes to observe. Although the light produced cannot penetrate through walls, a direct line of sight between sender and receiver is not required as data can still be transmitted when the light bounces off walls which would work slower, but just as fine. In addition, we do not need to worry about constantly having a bright blinking light right next to our devices, the LED lights can be dimmed down to the spectrum not visible to our naked human eyes. Atmospheric light is also not a problem to Li-Fi wireless connection, as the receiving end of the connection only detects the blinks of the sender's LED light.

5 Layer Hybrid Networking Model

The main difference between Li-Fi and WiFi Hybrid model in this project would be at the physical and data link layer. The physical layer of Li-Fi is replaced with LED light bulb, Arduino Boards (microcontroller), photoresistor and cables to connect the devices. The data link layer would be replaced by Arduino Drivers. The 3 higher levels would theoretically functions exactly like the Wi-Fi, transmitting data through electromagnetic spectrum.

Equipment:

- 2x Arduino Boards
- 1x 220 ohm resistor
- 1x photo resistor
- 3x jumper wires
- 1x LED light bulb

Steps:

1. Connect LED light bulb to the 1st Arduino Board (Sending End), with the minus wire (shorter leg) to the Ground Port and plus wire (longer leg) to the -10 port.
2. As for the 2nd Arduino Board (Receiving End), users can follow the exact same connection for Circuit 2 in

https://www.instructables.com/id/Li-Fi-Build-Your-Own-Safe-Wireless-Communication-N/ , replacing the 10k ohm wire with a 220 ohm wire.

3. As we are using Arduino Boards, the Arduino Web Editor is used to apply code to the board.

For the Transmitter, the code is as follow:

```
int led = 13;
int serialData = 0;
int data = 0;
void setup()
{
Serial.begin(9600);
pinMode(led, OUTPUT);
}
void loop()
{
 if (Serial.available() > 0)
 {
 serialData = Serial.read();
 Serial.println(serialData);
 data = data +1;
 }
 if (data >0)
{
 digitalWrite(led, HIGH);
delay (1000);
digitalWrite(led, LOW);
data = 0;
```

```
}
}
```

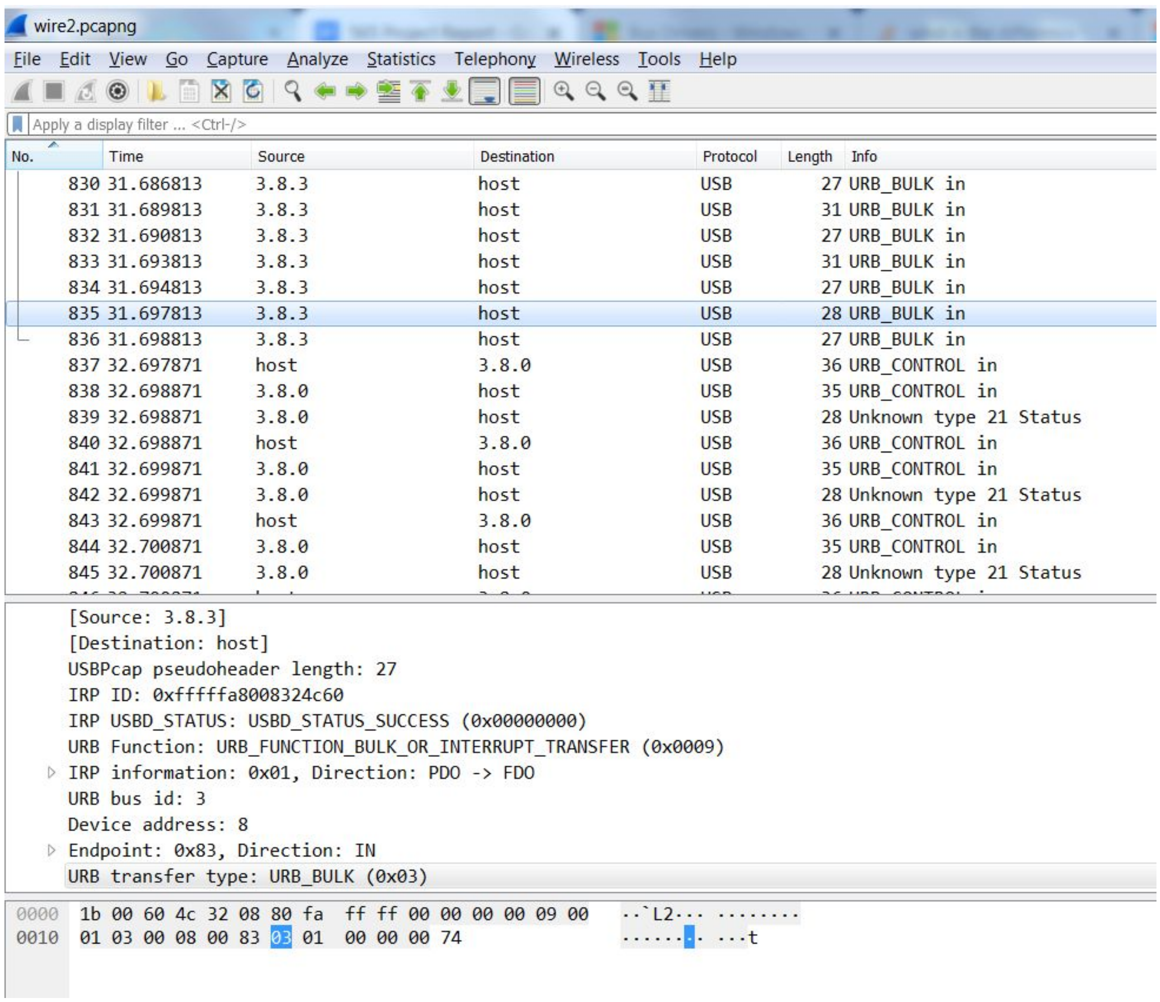
For the Receiver, the code is as follow:

```
unsigned long StartTime = millis();
unsigned long Value;
unsigned long EndTime;
int Message;
boolean StartedCounting = false;

void setup() {
  Serial.begin(9600);
}
void loop() {
  int sensorValue = analogRead(A0);
  delay(1);
  // Serial.printIn(sensorValue);

  if (StartedCounting==false && sensorValue>850){
    StartTime = millis();
    StartedCounting= true;
  }

  if (StartedCounting== true && sensorValue<850){
    Value = millis() - StartTime;
    Message= Value/1000;
```

```
    StartedCounting= false;
    Serial.print("Message: ");
    if (Message == 1){
      Serial.print("Penguins");
    }
    else if (Message == 2){
      Serial.print("hi");
    }
    else if (Message == 3){
      Serial.print("#notreallythough");
    }
    else if (Message == 4){
      Serial.print("HELP");
    }
    else if (Message == 5){
      Serial.print("Apple");
    }
    else if (Message == 6){
      Serial.print("LI-FI is the future");
    }
    else if (Message == 7){
      Serial.print("wazzup?");
    }
  }
}
```

(Code should not be copied from the website given in Step 2, as Arduino has updated their coding database and the code found is Step 2 no longer works as intended to)

WireShark: As our Li-Fi prototype transmitted data while connected to the USB port of our laptops, WireShark recorded the following protocols, which primarily are tied to USB protocols:



From the photo, we can see that the following protocols under USB are recorded:

- FDO: Functional Device Object, more than often written by vendor of the device, mandatory to load any operational function for a device.

- PDO: Physical Device Object, a.k.a Bus Drivers, acts as a “bus” to connect different functional device object.

- URB: data packets

- URB Bulk: The actual buffer data length transmitted through USB

<u>Conclusion:</u>

Li-Fi has both advantage and disadvantage when used to transmit data. To start off, we can see that Li-Fi can in fact transmit data much faster than our Wi-Fi, has a much higher capacity to transmit data in the VLS as compared to radio frequency spectrum, the costs to set up being much lower than WiFi, and we can dim down the LED light to non-human-visibility and still be able to transmit data. Most importantly, because Li-Fi does not generate any radio frequency electromagnetic interference, we can use it to transmit data even in places where WiFi are mandatory to be turned off. Because LED are so common in our current era, we can use it to connect everything that transmit data aside from our usual devices. Cars for example, can use LED to transmit data on road and traffic condition, alerting other drivers on real-time problems. Hospitals, where doctors could monitor patients’ status without needing to walk out from their office, or visitors could still get data from the internet without worrying about electromagnetic interference. However, Li-Fi, like every other thing, has its own downside. Firstly, the data transmitted does not penetrates through walls, meaning that there could be a limited range that data are transmitted through Li-Fi, but it could also prove to have a much higher security from hacking. Furthermore, although the sender and receiver LED does not require direct line of sight and can bounce off walls, it still eventually require unobstructed sight. Meaning that if somebody were to cover off one of the light bulb completely, data will not be able to be transmitted.

References

https://www.kernel.org/doc/html/v4.15/driver-api/usb/URB.html

https://docs.microsoft.com/en-us/windows-hardware/drivers/kernel/bus-drivers

https://docs.microsoft.com/en-us/windows-hardware/drivers/kernel/function-drivers

https://www.techworld.com/data/what-is-li-fi-everything-you-need-know-3632764/

http://www.ted.com/talks/harald_haas_wireless_data_from_every_light_bulb

http://gearburn.com/2014/01/lifi-beats-wi-fi-with-1gb-wireless-speeds-over-pulsing-leds/

http://www.adsadvance.co.uk/purelifi-aims-at-combating-cyber-crime.html

https://web.archive.org/web/20151104172117/http://caledonianmercury.com/2013/11/29/the-futures-bright-the-futures-li-fi/0043351

https://www.ijedr.org/papers/IJEDR1601019.pdf

https://www.instructables.com/id/Li-Fi-Build-Your-Own-Safe-Wireless-Communication-N/