DATA TRANSMISSION THROUGH LI-FI

Project report submitted in fulfillment of the requirements for the Degree of

BACHELOR OF TECHNOLOGY
IN
ELECTRONICS AND COMMUNICATION

By

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DECLARATION

We hereby declare that the work reported in the B.Tech thesis entitled **"Data Transmission through Li-Fi"** submitted at **Jaypee University of Information Technology, Waknaghat, Solan,** is an authentic record of our work carried out under the supervision of **Dr. Naveen Jaglan**. We have not submitted this work elsewhere for any other degree or diploma.

Akshat Bhatnagar **Rhea Kukreti**

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We wish to convey our sincere thanks to all faculty members of Department of Electronics and Communication.

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CHAPTER 1

INTRODUCTION

Three decades after the first commercially-available mobile communication system were first presented, wireless communication has become an essential product such as electricity & gas. The dramatic increment in mobile data traffic in the last couple of decades has incited the gigantic distribution of wireless systems. Hence, we have seen copious warnings of a looming "RF spectrum crisis" [1] because versatile data requirements are increasing exponentially while system spectral efficiency saturates in spite of newly offered gauges and unbelievable innovative developments in this field [2]. Most recently, VLC has been distinguished as a possible answer for moderating an approaching RF spectrum emergency.

Presently, WiFi is the fundamental wireless communication medium which utilizes radio waves and is utilized everywhere, for example, workplaces, schools, homes, universities, colleges and so on. Be that as it may, the fundamental issues of Wi-Fi are shortage of radio waves, constant exhaustion of data transfer capacity, RF impedances, cost of transmission capacity and the utilization of repeaters. Different parts of electromagnetic spectrum incorporate X-beams, Gamma beams and Ultraviolet lights yet they are not good for wireless communication as they are risky for human body. Other than the said issues because of broad use the radio recurrence waves are getting blocked and the limit is diminishing. So as to beat this trouble in future, light fidelity (Li-Fi) technology was concocted in 2011 by Dr. Herald Haas which does not transmit the data through radio waves but rather through visible light.

The demand for information usage has expanded exponentially in the most recent decade, individuals need to be associated with the Internet constantly, on numerous gadgets, update the most recent happenings and so forth. With the approach of IoT, more gadgets will

associate with LTE which will cause congestion and lead to a decline in speed. To unravel this emergency, numerous choices had been deliberated and one of them was to use the unutilized visible light spectrum which was used for Li-Fi.

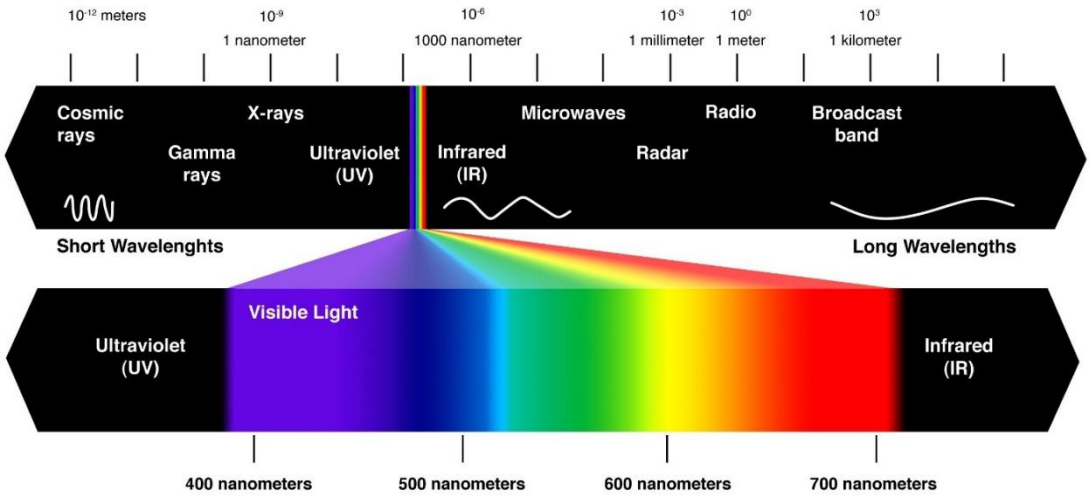

Figure 1: Electromagnetic Spectrum
SOURCE: pinimg.com

Li-Fi represents Light-Fidelity which gives transmits data through illumination of an LED light. Li-Fi utilizes Light Emitting Diodes (LED) which are energy efficient in terms of illumination and have high modulating bandwidth.

With the arrival of the high illumination, incoherent light producing LED, it is legitimate to think of visible spectrum for wireless communication which may be realized with LiFi, an innovation originally started in 2011 [3]. LiFi broadens the idea of VLC (visible light communication) to accomplish bi-directional, fast and secure wireless interchanges [4]. It is critical to take into account that LiFi manages client flexibility and also multiuser admittance.

The high switching speed of the LEDs allow them to regulate as per the surge of bits that are being transmitted. This communication happens in a parallel stream with the end goal that

more data is getting sent all the while. The switching speed is not visible to the unaided eyeas it is too fast and therefore the transmission isn't noticeable. German physicist Harald Haas of University of Edinburgh was the one to first propose this technology. Li-Fi, essentially is light-based Wi-Fi with a big contrast being that it utilizes light rather than radio waves to send information. This Li-Fi framework would comprise of customary, off-the-rack, LED bulbs that provide illumination and also data transmission. It uses the visible light segment of the electro-magnetic spectrum (380 - 780 nm). In this manner, it has multiple times more space available and increasingly accessible data transmission is available. Theoretically, it may achieve speeds of up to 224 Gbps. [5]

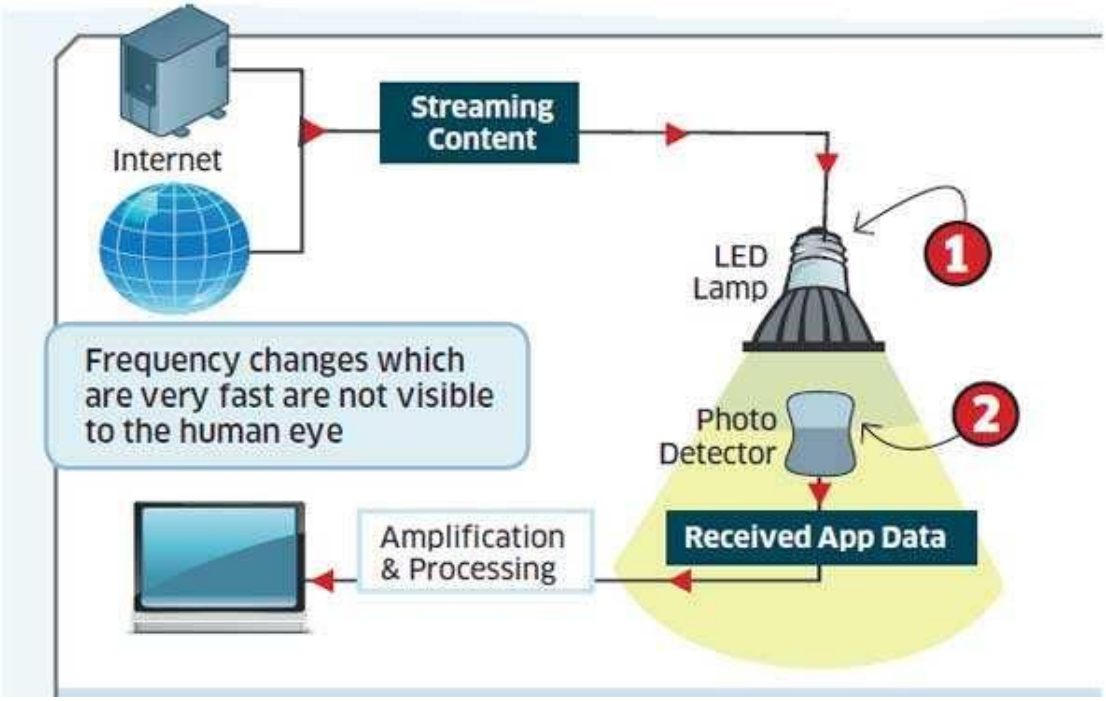

Figure 2: Diagram of a Li-Fi system
SOURCE: quora.com

The point of this project shows the planned daily practice of Li-Fi and its highlights to expand the different applications where Li-Fi may be used and to increase the performance of data transmission. The cutting edge society is exceptionally influenced by present day modern communication technologies. Practically most levels of people are utilizing the web

to finish tasks through wireless system. Because number of clients are incrementing in using wireless systems, this has sadly prompted an expansion in speed diminishes, system complexity and deficiency of radio data transfer capacity, an expanded risk of resistance of radio frequencies. Besides, safety & proficiency on the web are ruling issues these days. In spite of the fact that Wi-Fi gives us speeds of 150mbps, it isn't enough to suit the scores of foreseen users. To resolve the impediment of Wi-Fi, another technology is much needed and, there already are gigantic new advances contributing to make modern conditions for the end client. Therefore, Li-Fi was presented and may give a connection which is multiple times quicker than customary WiFi. LiFi gives improved viability and safety as compared to WiFi. It has picked up quite a large prevalence in a little scope of years. This innovation gives us speed as well as innocuous and economical future in the field of communication. The tremendous use of Li-Fi will settle some problems of Wi-Fi. This project made a thorough investigation on Li-Fi, operational systems, and other researches which utilized Li-Fi.

CHAPTER 2

REVIEW OF LITERATURE

Amid the most recent decade, we have seen persistent articles of enhanced point-to-point data link rates utilizing white LEDs in experiments performed in labs. As of late, data rates of greater than 1 Gbps have been accounted for utilizing white phosphor LEDs, [6] and 3.4 Gbps was achieved with a red-green-blue (RGB) LED. [7] Another comparable Gbps wireless framework with a white phosphor LED was presented utilizing a MIMO design. The most astounding rate that has ever been accounted for using a solitary shading LED is approximately 3.5 Gbps.[8] The test has been done by analysts at the University of Edinburgh. A hypothetical structure for a feasible limit of the IM/DD (intensity modulation and direct detection) frameworks utilizing OFDM (orthogonal frequency division multiplexing) was set up, [9] and an experiment on the effect that non-linearities have on the attainable SNR in functional OFDM based VLC frameworks was performed.[10] Up till now, research related to OWC has been centered around fruitful usage of physical connection links and confirmations of this concept.[11]

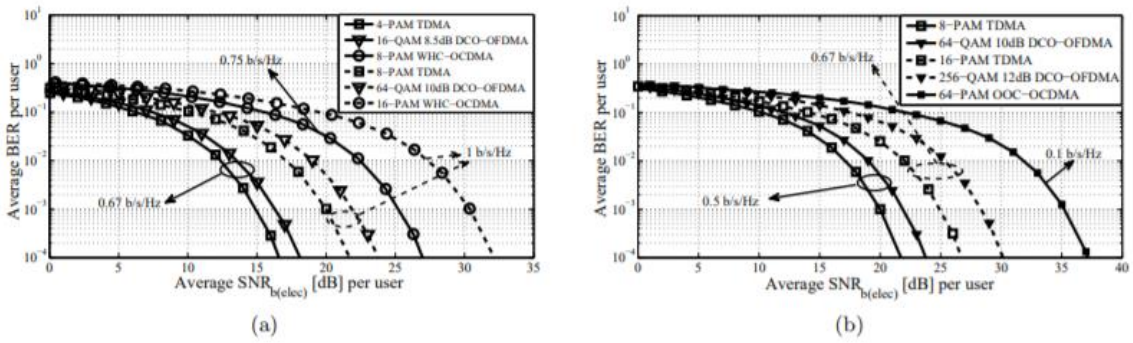

Figure 3: Evaluation of diverse multiple access schemes: (a) TDMA vs. OFDMA vs. CDMA in a three-user scenario; (b) TDMA vs. OFDMA vs. CDMA in a six-user scenario.
SOURCE: Tsonev, D, Videv, S & Haas, H 2013, Light fidelity (Li-Fi): towards all-optical networking

This is the thing that we call Li-Fi: the organized, versatile, rapid VLC answer for wireless communication.[12] The idea for a LiFi wireless system is that it would supplement RF wireless systems that already exist, and give critical spectrum release by permitting cell and frameworks to unburden a substantial segment of data traffic.

Li-Fi was presented first by Harald Haas, an educator at University of Edinburgh in Scotland and he brought the possibility of "Wireless data from each light". Haas and his examination aide, Mostafa Afgani, first sent data by utilizing light flag in 2007. [13]

The “Li-Fi” term was first utilized in a TED Global chat by Hass on Visible Light Communication. He called it signal as D-Light which was utilized to deliver data rates higher than 10mbps and that is a lot faster than our broadband connection. [14]

P.Tupe (2015) planned a Voice Activated Li-Fi Operated Surveillance System. The framework controlled development of a robot or machine by using voice administrator with assistance of LiFi and a voice recognition software. In the framework data that we receive from amplifier in voice form used a voice reorganization software. Whenever input speech did not coordinate with database speech, at that point it is re-transmitted. This framework give more straightforward and more secure communication with no hurtful impact to condition. By and by this framework has a few issues, for example, need a lines of lights, can't utilize a typical light and utilizing robot is costly. [15]

S.Sonoli & M.D.Reddy (2015) executed a Patient Monitoring System which was based on LiFi. This framework observed the wellbeing of the patient and if there is any crisis, it sends data to receiver with assistance of Li-Fi. They utilized two constraints to screen patient wellbeing. Checking a patient’s saline container persistently and screen the pressure. On the off chance that that goes to least dimension, at that point sensor identified it and initiated the encoder. The data was sent using Li-Fi transmitter, to the receiver. This framework devours less energy & increments security. [16]

Y.H.Chung & A.Sewaiwar (2013) have put forward a framework called Color Clustered Bi-Directional Li-FI Using QAM-DCO-OFDMA dependent on LI-FI. The framework utilizes QAM (Quadrature Amplitude Modulation). Clients would be dispensed into isolated shading groups made by LEDs and the client information is sent through apportioned shading pillars accomplished by a shading sensor. Transmission then takes place through an RGB LED. Transmitters at the two closures are utilizing various hues for sending data, on account of the Bi-directional connection, less resistance is acknowledged in the framework. Since every client is designated with various shading groups, multi-user access is simple here. [17]

Christain B.D.et.all (2014) has introduced a framework titled Online Web Server Management dependent on Li-Fi. The framework utilizes obvious light to exchange data and utilized various trusting advancements too. Two modules for data transmission are used here, client module and goal module. Li-FI is associated with PC framework using a sensor with a GPS/GSM gadget. The fundamental thought here is exchange of data by means of brightening. Intensity of an LED light differs by varying the current flowing through it. By utilizing multi-jump technology the unwavering quality and speed is expanded. [18]

López R.D planned a Li-Fi framework. The task is to construct a total communication framework, and he used visual light rather than radio frequencies. Expectation from the framework is that to accomplish a consistent framework where data can be sent in a controlled situation from 1 to 100 MHz. In doing this errand Li-Fi is utilized. It is a rapid and completely organized wireless communication component, similar to Wi-Fi, yet the framework utilizes light. Utilizing Li-Fi is a less expensive and powerful. Be that as it may, The Transmitter utilized in the framework has a restricted spectrum due to the power force of its LEDs and furthermore a few shortcomings were there in providing a path. [19]

Waje S. has presented another framework named data Transmission System Indoor situating and route which is for the most part managed light sensors. Framework utilizes lighting sensors with respect to data transmission. Framework used for indoor situating & route. In

this framework bright light was utilized to transmit data, which is figure by utilizing a heartbeat recurrence regulation way. A productive transmitter circuit is being planned here by addition of a couple of parts to a business electronic counterweight circuit for luminous lights with low cost. This framework can make interior routing easier by an exactness on the comparative route and open air wearable GPS sensors are utilized in extensive interior territories. It doesn't have any mind boggling establishments and is hence exceptionally down to earth. The framework can be for the most part gainful for versatile and wearable PCs. [20]

K.S.Kerps (2015) did structure a framework titled Road management and wellbeing dependent on Li-Fi. One may use headlights of vehicles. Right when the vehicle goes through the strip mall, the pc at strip mall receives a code. Police may use this information if vital. Individual by then pays the service tax and push ahead. Thusly, information about each and every vehicle is gathered stored away in to a standard monitor. All of these PCs at all mall are orchestrated with one another. Henceforth they may interchange required information about the vehicle. The single sent by additional vehicle administers the sign, the sign turns to green and it remains so till the vehicle passes, and once that happens it changes to its standard strategy for movement. Hence when the emergency vehicle proceeds, it will make the sign green making way for it. [21]

A.patani et.(2015) actualized a project named highway route based on LI-FI. The essential riggings of the task are the receiver and transmitter. The transmitter that they have utilized is termed a smart pole. Parts of smart pole are LEDs and also a crystal oscillator. The parts are for the most part centered to keep up consistent dimension of voltage. The receiver and transmitter both have microcontrollers. It already has information programmed into it. This framework utilized a vehicle as a receiver, which has a photodetector so as to receive data. This framework is increasingly secure so data can't be hindered without reasonable line of sight. [22]

Q.Huang et.all (2014) represented a framework named Integrating Li-Fi Wireless Communication and Energy Harvesting framework dependent on Li-Fi. While sending wireless sensors, supply of energy and transmission of data are the principle aim. Regardless of whether control gather wireless sensors might consequently bolster themselves by gathering surrounding energy, the nearness of solid energy sources to help reliable transmission is a major thing. Li-Fi is hopeful to essential reason the inquiry Li-Fi gives collected capacity to control a wireless sensor with exceptional comfort of intensity reproducing using the lighting game plan tested. The mix of Li-Fi & power gathering wireless sensor advancements will acquire huge favorable position in the structure of next development high accomplishment structures since power collect sensors don't confront the expecting effectiveness inconvenience. Li-Fi empowers a lot faster transmission speed contrasted with current RF electromagnetic robotization, that proficiency gather sensors will rapidly convey natural parameters rapidly for control reasons. [23]

CHAPTER 3

WORKING PRINCIPLE OF LI-FI

The working standard of light fidelity is very straightforward. The primary piece of Li-Fi technology is mounted within the high brightness LED. It turns on and off exceptionally fast. When the LED is ON binary data 1 is transmitted and when it is OFF binary 0 is transmitted. A light source or LED bulbs are used as the transmitter at one side and at the receiver end we have a light sensor or photo detector. When an LED flashes it carries on like a trigger which the photo detector recognizes. To send a message, the LED can be flashed multiple times or a number of LEDs of numerous colours are utilized to acquire data rates in the range of hundreds of mbps. Photo detector will give yield in the binary arrangement like 0 or 1, depending upon what the photo detector senses.

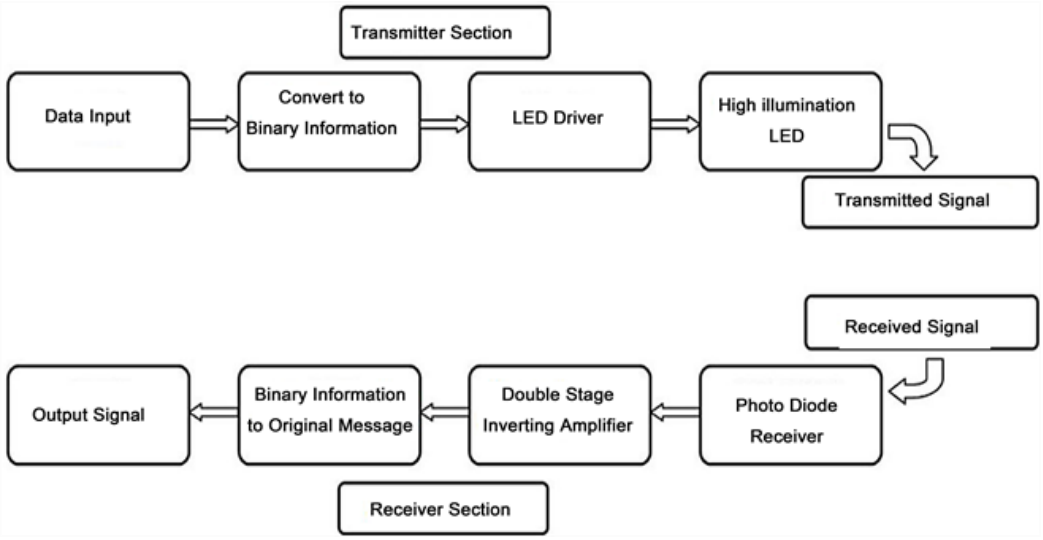

Figure 4: Diagram of a Li-Fi system
SOURCE: Kahn, J.M. and Barry, J.R. (1997) Wireless Infrared Communications. Proceedings of the IEEE, 85, 265-298.

At the transmitter, the data will be changed to binary by utilizing an ADC and then fed into an LED driver circuit that is inhibited using a signal processor. Driver circuit deals with the On-Off Keying modulation [25]. Data is transmitted in the form of optical pulses through the channel as the LED flickers at high speeds.

The optical pulses will be deciphered by a photodetector to a simple electrical signal at the receiver which is then enhanced by an amplifier and after that changed over to binary through a comparator. The LEDs can be networked, access data can be accessed by numerous clients using solitary LED light or start moving from a single LED light onto the next without influencing their entrance.

The main parts are an Arduino Uno, and an LED. Other than the parts needed for creating and catching the signals, more equipment is expected to filter & translate the signal. For instance, a proper band pass filter may be utilized to sift through approaching signal with non-ideal frequencies; an optical channel may be a good method to filter out lights of non-ideal wavelengths. A lens to focus approaching light can be used if light power is less. On account of advanced data transmission, digital signal processors at the two parts of the framework are used to process approaching and active data [26].

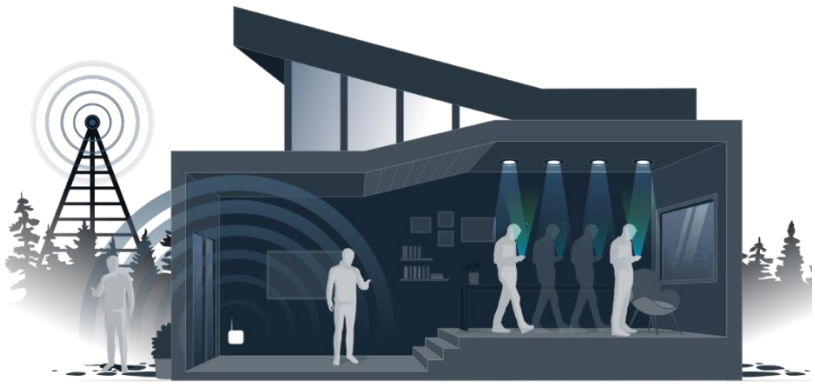

Figure 5: Li-Fi in comparison with Wifi
SOURCE: pureLifi.com

LiFi technology has a few favorable circumstances over WiFi. In LiFi LED's are utilized for both enlightenment and data transmission reasons where as in Wi-Fi Electromagnetic waves are utilized for data transmission. These days, this is a rising technology which is utilized in a lot of applications, for example, security, maps in urban conditions, cell communication, and so on. In this strategy the data is changed over into 0-1 scheme before being fed to LED driver circuit.

LiFi utilizes light for transmission of data while electro-magnetic waves at radio frequency are utilized by WiFi for the same. Because of less impedance brought about by contrast with radio recurrence waves, LiFi is utilized in more congested environments. In figure 5 the fundamental contrasts between LiFi and WiFi are shown.

Feature	Li-Fi	Wi-Fi
Full Form	Light Fidelity	Wireless Fidelity
Operation	Li-Fi transmits data using light with the help of LED bulbs.	Wi-Fi transmits data using radio waves with the help of Wi-Fi router.
Interference	Do not have any interference issues similar to radio frequency waves.	Will have interference issues from nearby access points(routers)
Technology	Present IrDA compliant devices	WLAN 802.11a/b/g/n/ac/ad standard compliant devices
Applications	Used in airlines, undersea explorations, operation theatres in the hospitals, office and home premises for data transfer and internet browsing	Used for internet browsing with the help of Wi-Fi hotspots
Merits (advantages)	Interference is less, can pass through salty sea water, works in dense region	Interference is more, cannot pass through sea water, works in less dense region
Privacy	In Li-Fi, light is blocked by the walls and hence will provide more secure data transfer	In Wi-Fi, RF signal cannot be blocked by the walls and hence need to employ techniques to achieve secure data transfer.
Data transfer speed	About 1 Gbps	WLAN-11n offers 150 Mbps, About 1 - 2 Gbps can be achieved using Wi-Gig/Giga-IR
Frequency of operation	10 thousand times frequency spectrum of the radio	2.4 GHz, 4.9 GHz and 5 GHz
Data density	Works in high dense environment	Works in less dense environment due to interference related issues
Coverage distance	About 10 meters	About 32 meters (WLAN 802.11b/11g), vary based on transmit power and antenna type
System components	Lamp driver, LED bulb (lamp) and photo detector will make up complete Li-Fi system	Requires routers to be installed, subscriber devices(laptops, PDAs, desktops) are referred as stations

Figure 6: LiFi vs. Wifi
SOURCE: Kahn, J.M. and Barry, J.R. (1997) Wireless Infrared Communications. Proceedings of the IEEE, 85, 265-298.

CHAPTER 4

DESIGN OF LI-FI SYSTEM

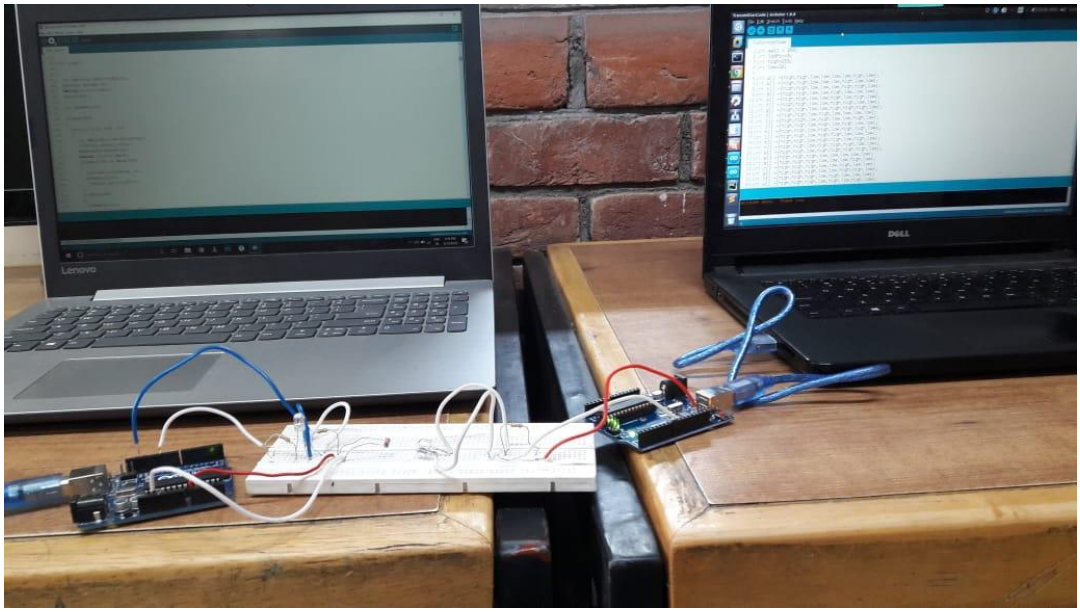

Figure 7: Transmission through Li-Fi

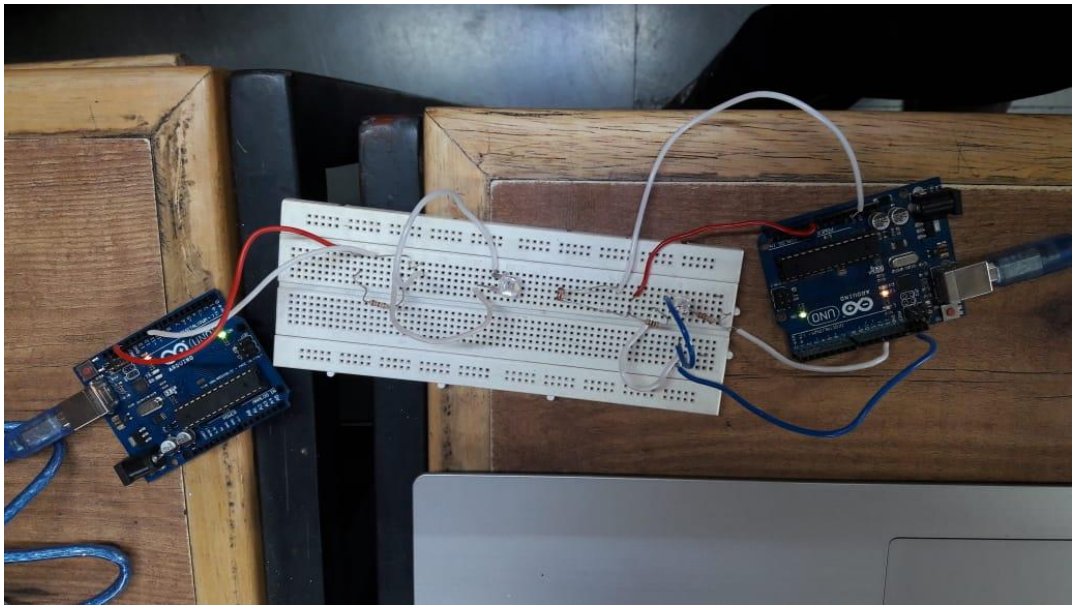

Figure 8: Physical Circuit

4.1 Transmitter

The job of transmitter is converting advanced information to visible light. LEDs are a reasonable component in light of their linear relation among light intensity and current [27]. The main aim is to balance the intensity of an LED i.e., the power of a light corresponding to the data being sent.

When a LED flashes it is then recognized by a photodetector as a trigger. So the LED is flashed several times to develop a message or even a variety of LEDs of a number of colours are utilized to attain data rates in range of several mbps.

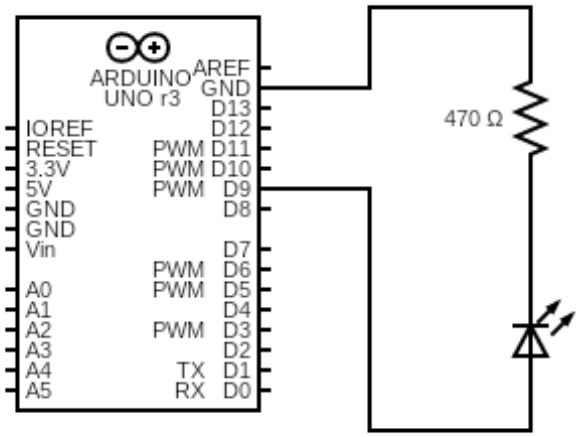

Figure 9: Transmitter Circuit

4.1.1 Light Emitting Diode (LED)

At the point when a light-transmitting diode is switched on, electrons are released and are recombined with gaps inside the device, and photons are discharged. This is known as electroluminescence, and intensity of light (comparing to energy of the photons) is dictated through the energy band gap in a semiconductor. LEDs can have

significant benefits over radiant light sources counting longer lifetime, lower energy utilization, improved physical heartiness, and quicker switching.

When energy level changes in a semiconductor diode, LEDs radiate light. This creates photons, few of which are produced in the form of light. The discrepancy in energy levels in the semiconductor used for the LED dictate the wavelength of radiated light. Solid state configuration enables LEDs to withstand stuns, vibrations, frequent switching and many environmental conditions without compromising their long lives of commonly over 1,00,000 hours.

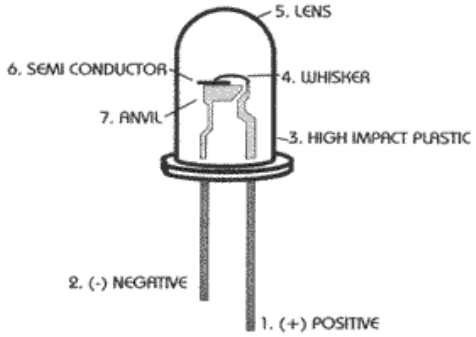

Figure 10: Light emitting diode

SOURCE: www.WiringDiagram.com

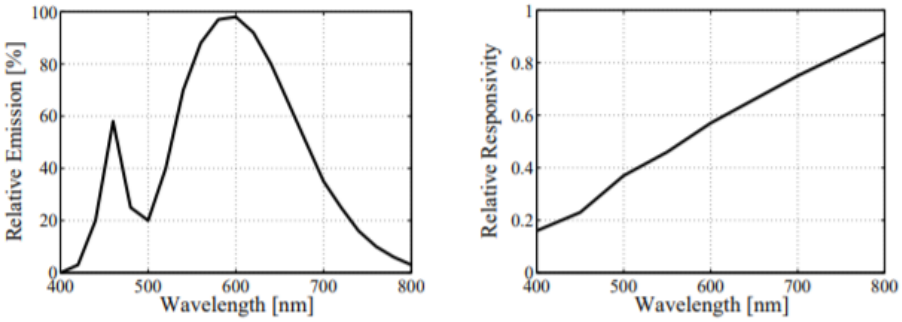

Figure 11: (a) White-phosphor LED spectrum (b) Photodetector responsivity

SOURCE: Light fidelity (Li-Fi): Edinburgh Research Explorer

4.2 Receiver

Receiver can get the signal with the assistance of photo resistor by gleaming of light. The fluctuations in the fast dimming of LED bulbs are then changed by the collector into electrical signals. In LiFi, flickering LED lights encode signals at high recurrence to transmit data, and despite the fact that the blinking stays imperceptible to the human eye, light sensors can get the signal and decipher it as a type of wireless data transmission. The approaching light is changed into an electrical signal by the receiver and is sent to the microcontroller.

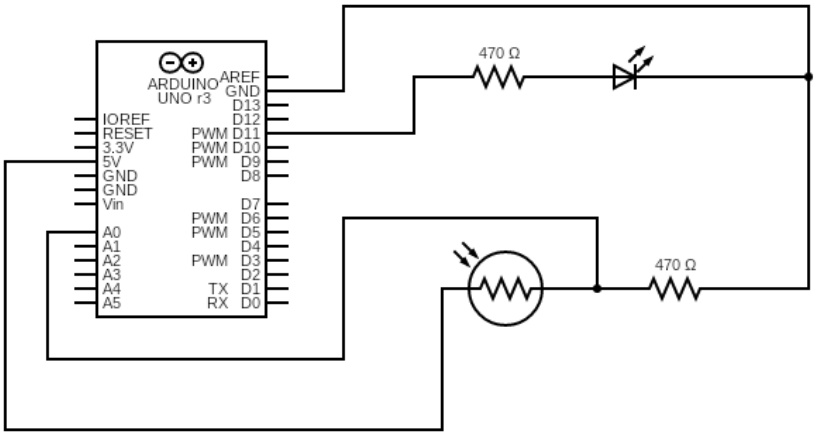

Figure 12: Receiver Circuit

4.2.1 Light Dependent Resistor

In this project with the aim of photo detection, a Light Dependent Resistor (LDR) is utilized. A LDR has variable resistance which fluctuates with the adjustment in the intensity of the light that falls upon it, therefore, it displays photo conductivity. In this manner, LDR can be utilized in a light detecting circuit. It is made of high resistance semiconductor. A photoresistor can have a high resistance of several megohms (Mω) in the darkness, while it can have a resistance as small as a couple of hundred ohms in the light. If incident light on an LDR surpasses a particular frequency, bound electrons get enough energy to hop into the conduction band

because of photons consumed by the semiconductor. The free electrons (and their hole counterparts) conduct electricity, thereby lowering the value of resistance.

The relation between resistance and illumination for an LDR is given as:

$$\mathbf{R = A.E\text{^}a}$$

Where E is the Illumination in lux, R is Resistance in Ohms & A, a are constants

The magnitude of 'a' depends on the manufacturing process. It typically ranges from 0.7 to 0.9

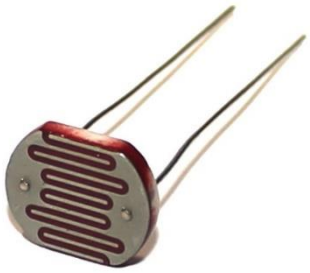

Figure 13: Light Dependent Resistor
SOURCE: www.electricalelibrary.com

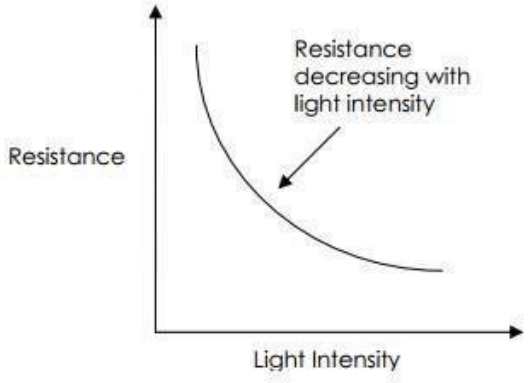

Figure 14: LDR resistance vs light intensity graph
SOURCE: www.kitronik.co.uk

The most widely recognized sort of LDR has resistance that rises with decrease in the light force falling on the gadget (as appeared in figure 14). The opposition of a LDR may commonly have accompanying protections:
Daylight = 5,000Ω
Dark = 20,000,000Ω

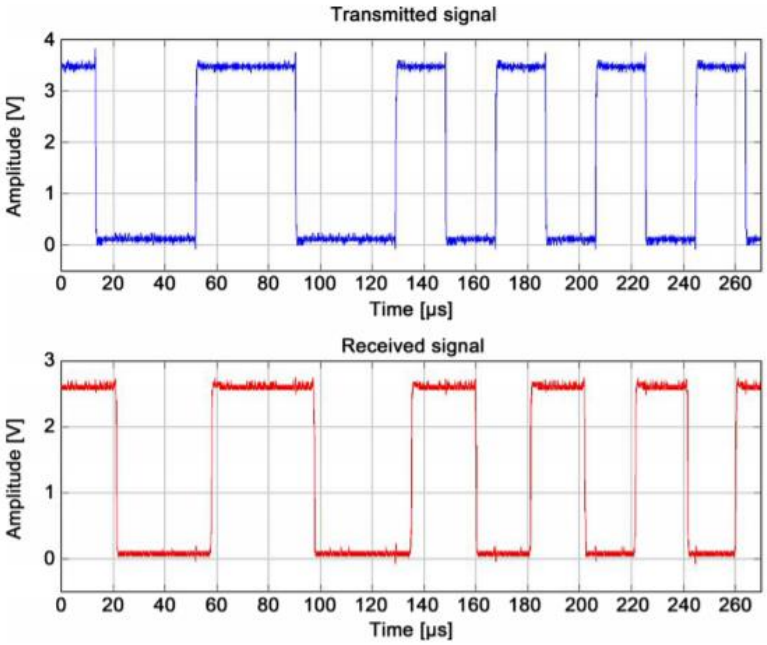

Figure 13: Example of a signal sent from transmitter to receiver
SOURCE: Goswami, P. and Shukla, M.K. (2017) Design of a Li-Fi Transceiver. Wireless Engineering and Technology, 8, 71-86. https://doi.org/10.4236/wet.2017.84006

4.3 Encoding style

This segment defines the most regularly utilized encoding strategy that we utilized in this task. OOK (On-off keying) is one of the least complex strategy to show data. In this, logic value 0 represents LOW & logic value 1 represents HIGH. In the field of VLC, that implies the LED is switched on to send one and switched off to send zero. Suppose PeM and PeS are error probabilities of a low bit received as high and a high bit received as low, respectively, at that point for the receiver: [28] [29]

$$P_{eS} = P_{eM} = \frac{1}{2} erfc\left(\sqrt{E_b/4N_o}\right)$$

Where erfc is the error function & Eb / No is the energy to noise spectral density ratio.

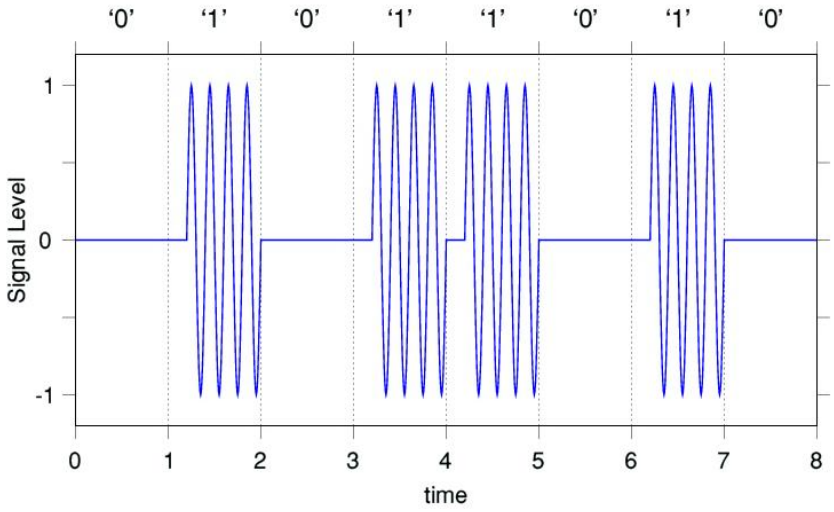

Figure 14: Simple on/off keying
SOURCE: www.st-andrews.ac.uk

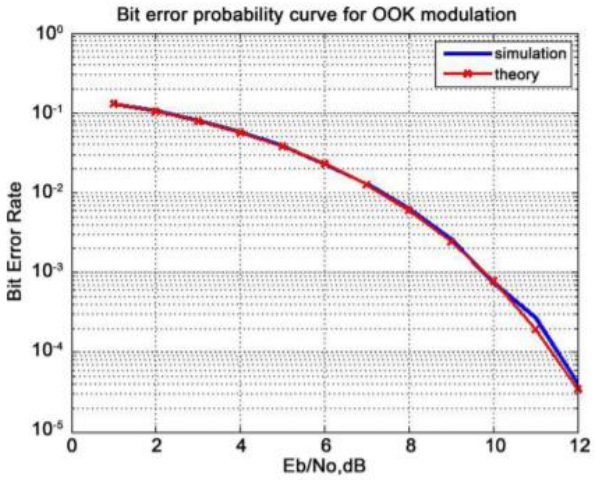

Figure 15: BER vs. SNR plot for On Off Keying
SOURCE: Goswami, P. and Shukla, M.K. (2017) Design of a Li-Fi Transceiver. Wireless Engineering and Technology, 8, 71-86. https://doi.org/10.4236/wet.2017.84006

4.4 Working of Circuit

Two basic components of the project are the transmitter & receiver. The transmitter we use is a monochromatic LED. It is connected to a digital/analog pin of our chosen microcontroller, which is the Arduino Uno. Through the code, we've assigned each character the binary representation of its ASCII value. The serial monitor detects the character, matches it with its corresponding binary value and accordingly sets the brightness of the LED. Each character is 8 bits long. The digital/analog pin sends a value of desired duty cycle to alter the brightness of the LED. By using on-off coding, we send the data through the LED in terms of 0s and 1s (binary).

At the receiver, we've used a Light Dependent Resistor (LDR) to detect the illumination of the LED. The LDR, which is a light-controlled variable resistor, senses the light around it and its resistance decreases with increasing light intensity. There is an LED connected with the LDR which blinks when the LDR detects the highest intensity of the LED, which represents digital 1. The LED is put in place to indicate that the LDR is receiving data. The LDR then is connected to a digital/analog pin of the Arduino Uno on the receiver side. The pin read input voltages and maps them into integer values. These values are then calibrated through the code to detect voltages equivalent to 0s and 1s. In the receiver code, we've set each character with binary representation of its ASCII value. The code reads 8 bits at a time from what is received by the LDR and matches the value to the 8 bit representation of the character. Upon receiving and mapping data successfully, we see the characters sent by the transmitter, printed on the serial monitor of the receiver.

Hence we successfully observe transmission of textual data from one computer to another through the use of Li-Fi.

CHAPTER 5

CODE

5.1 Transmitter Code:

```
int wait = 50;
int ledPin=9;
int h=255;
int l=50;

int a[] ={h,h,l,l,l,l,h,l};
int b[] ={h,h,l,l,l,h,l,l};
int c[] ={h,h,l,l,l,h,h,l};
int d[] ={h,h,l,l,h,l,l,l};
int e[] ={h,h,l,l,h,l,h,l};
int f[] ={h,h,l,l,h,h,l,l};
int g[] ={h,h,l,l,h,h,h,l};
int h[] ={h,h,l,h,l,l,l,l};
int I[] ={h,h,l,h,l,l,h,l};
int j[] ={h,h,l,h,l,h,l,l};
int k[] ={h,h,l,h,l,h,h,l};
int l[] ={h,h,l,h,h,l,l,l};
int m[] ={h,h,l,h,h,l,h,l};
int n[] ={h,h,l,h,h,h,l,l};
int o[] ={h,h,l,h,h,h,h,l};
int p[] ={h,h,h,l,l,l,l,l};
int q[] ={h,h,h,l,l,l,h,l};
int r[] ={h,h,h,l,l,h,l,l};
int s[] ={h,h,h,l,l,h,h,l};
int t[] ={h,h,h,l,h,l,l,l};
int u[] ={h,h,h,l,h,l,h,l};
int v[] ={h,h,h,l,h,h,l,l};
int w[] ={h,h,h,l,h,h,h,l};
int x[] ={h,h,h,h,l,l,l,l};
int y[] ={h,h,h,h,l,l,h,l};
int z[] ={h,h,h,h,l,h,l,l};
int space[] = {h,h,h,h,h,h,h,l};

int aa[] ={h,l,l,l,l,l,h,l};
int bb[] ={h,l,l,l,l,h,l,l};
int cc[] ={h,l,l,l,l,h,h,l};
int dd[] ={h,l,l,l,h,l,l,l};
int ee[] ={h,l,l,l,h,l,h,l};
int ff[] ={h,l,l,l,h,h,l,l};
int gg[] ={h,l,l,l,h,h,h,l};
int hh[] ={h,l,l,h,l,l,l,l};
int II[] ={h,l,l,h,l,l,h,l};
int jj[] ={h,l,l,h,l,h,l,l};
int kk[] ={h,l,l,h,l,h,h,l};
int ll[] ={h,l,l,h,h,l,l,l};
int mm[] ={h,l,l,h,h,l,h,l};
int nn[] ={h,l,l,h,h,h,l,l};
int oo[] ={h,l,l,h,h,h,h,l};
int pp[] ={h,l,h,l,l,l,l,l};
int qq[] ={h,l,h,l,l,l,h,l};
int rr[] ={h,l,h,l,l,h,l,l};
int ss[] ={h,l,h,l,l,h,h,l};
int tt[] ={h,l,h,l,h,l,l,l};
int uu[] ={h,l,h,l,h,l,h,l};
int vv[] ={h,l,h,l,h,h,l,l};
int ww[] ={h,l,h,l,h,h,h,l};
int xx[] ={h,l,h,h,l,l,l,l};
int yy[] ={h,l,h,h,l,l,h,l};
int zz[] ={h,l,h,h,l,h,l,l};

int n0[] = {h,l,h,h,h,h,h,l};
int n1[] ={h,l,h,h,h,l,h,l};
int n2[] ={h,h,h,h,h,h,l,l};
int n4[] ={h,h,h,h,h,l,l,l};
int n3[] ={h,h,h,h,l,h,h,l};
int n5[] ={h,h,h,h,h,l,h,l};
int n6[] ={h,l,h,h,h,h,l,l};
int n7[] ={h,l,h,h,h,l,l,l};
int n8[] ={h,l,h,h,l,h,h,l};
int n9[] ={h,l,l,l,l,l,l,l};
```

```
void setup() {


 Serial.begin(9600);
 pinMode(4, OUTPUT);

}

void loop() {


 if(Serial.available()>0){

  int alpha = Serial.read();
 analogWrite(ledPin,255);
 if(alpha=='A'){
  for (int i = 0; i < 8; i++) {
  analogWrite(ledPin, a[i]);
  delay(wait);}
 }


 if(alpha=='B'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, b[i]);
  delay(wait);}
 }

 if(alpha=='C'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, c[i]);
  delay(wait);}
 }

 if(alpha=='D'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, d[i]);
  delay(wait);}
 }

 if(alpha=='E'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, e[i]);
  delay(wait);}
 }
 if(alpha=='F'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, f[i]);
  delay(wait);}
 }

if(alpha=='G'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, g[i]);
  delay(wait);}
 }
if(alpha=='H'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, h[i]);
  delay(wait);}
 }
if(alpha=='I'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, I[i]);
  delay(wait);}
 }
if(alpha=='J'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, j[i]);
  delay(wait);}
 }
if(alpha=='K'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, k[i]);
  delay(wait);}
 }
if(alpha=='L'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, l[i]);
  delay(wait);}
 }
if(alpha=='M'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, m[i]);
  delay(wait);}
 }
if(alpha=='N'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, n[i]);
  delay(wait);}
 }
if(alpha=='O'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, o[i]);
```

```
  delay(wait);}
}
if(alpha=='P'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, p[i]);
  delay(wait);}
}
if(alpha=='Q'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, q[i]);
  delay(wait);}
}
if(alpha=='R'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, r[i]);
  delay(wait);}
}
if(alpha=='S'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, s[i]);
  delay(wait);}
}
if(alpha=='T'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, t[i]);
  delay(wait);}
}
if(alpha=='U'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, u[i]);
  delay(wait);}
}
if(alpha=='V'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, v[i]);
  delay(wait);}
}
if(alpha=='W'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, w[i]);
  delay(wait);}
}
if(alpha=='X'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, x[i]);
  delay(wait);}
}
if(alpha=='Y'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, y[i]);
  delay(wait);}
 }
 if(alpha=='Z'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, z[i]);
  delay(wait);}
 }
 if(alpha==' '){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, space[i]);
  delay(wait);}
 }


if(alpha=='a'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, aa[i]);
  delay(wait);}

 }
 if(alpha=='b'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, bb[i]);
  delay(wait);}
 }

 if(alpha=='c'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, cc[i]);
  delay(wait);}
 }

 if(alpha=='d'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, dd[i]);
  delay(wait);}

 }

 if(alpha=='e'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, ee[i]);
  delay(wait);}


 }
```

```
if(alpha=='f'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, ff[i]);
  delay(wait);}

}

if(alpha=='g'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, gg[i]);
  delay(wait);}

}

if(alpha=='h'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, hh[i]);
  delay(wait);}


}

if(alpha=='i'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, II[i]);
  delay(wait);}


}

if(alpha=='j'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, jj[i]);
  delay(wait);}


}

if(alpha=='k'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, kk[i]);
  delay(wait);}


}

if(alpha=='l'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, ll[i]);
  delay(wait);}

}

if(alpha=='m'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, mm[i]);
  delay(wait);}


}

if(alpha=='n'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, nn[i]);
  delay(wait);}


}

if(alpha=='o'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, oo[i]);
  delay(wait);}


}

if(alpha=='p'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, pp[i]);
  delay(wait);}


}

if(alpha=='q'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, qq[i]);
  delay(wait);}


}

if(alpha=='r'){
  for (int i = 0; i <8; i++) {
```

```
  analogWrite(ledPin, rr[i]);
  delay(wait);}

}

if(alpha=='s'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, ss[i]);
  delay(wait);}

}

if(alpha=='t'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, tt[i]);
  delay(wait);}


}

if(alpha=='u'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, uu[i]);
  delay(wait);}


}

if(alpha=='v'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, vv[i]);
  delay(wait);}


}

if(alpha=='w'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, ww[i]);
  delay(wait);}


}

if(alpha=='x'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, xx[i]);
  delay(wait);}
}

if(alpha=='y'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, yy[i]);
  delay(wait);}


}

if(alpha=='z'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, zz[i]);
  delay(wait);}

}

if(alpha=='0'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, n0[i]);
  delay(wait);}

}

if(alpha=='1'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, n1[i]);
  delay(wait);}


}

if(alpha=='2'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, n2[i]);
  delay(wait);}


}

if(alpha=='3'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, n3[i]);
  delay(wait);}
  }
```

```
if(alpha=='4'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, n4[i]);
  delay(wait);}

}

if(alpha=='5'){
  for (int i = 0; i < 8; i++) {
  analogWrite(ledPin, n5[i]);
  delay(wait);}


}

if(alpha=='6'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, n6[i]);
  delay(wait);}


}

if(alpha=='7'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, n7[i]);
  delay(wait);}


 }

 if(alpha=='8'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, n8[i]);
  delay(wait);}


 }

 if(alpha=='9'){
  for (int i = 0; i <8; i++) {
  analogWrite(ledPin, n9[i]);
  delay(wait);}

 }

 }

 else
 analogWrite(ledPin, 0);

}
```

5.2 Receiver Code:

```
int ldrPin=A0;
int ledPin=11;
int noise=0;
char text=NULL;

int a[] ={1,1,0,0,0,0,1,0};
int b[] ={1,1,0,0,0,1,0,0};
int c[] ={1,1,0,0,0,1,1,0};
int d[] ={1,1,0,0,1,0,0,0};
int e[] ={1,1,0,0,1,0,1,0};
int f[] ={1,1,0,0,1,1,0,0};
int g[] ={1,1,0,0,1,1,1,0};
int h[] ={1,1,0,1,0,0,0,0};
int I[] ={1,1,0,1,0,0,1,0};
int j[] ={1,1,0,1,0,1,0,0};
int k[] ={1,1,0,1,0,1,1,0};
int l[] ={1,1,0,1,1,0,0,0};
int m[] ={1,1,0,1,1,0,1,0};
int n[] ={1,1,0,1,1,1,0,0};
int o[] ={1,1,0,1,1,1,1,0};
int p[] ={1,1,1,0,0,0,0,0};
int q[] ={1,1,1,0,0,0,1,0};
int r[] ={1,1,1,0,0,1,0,0};
int s[] ={1,1,1,0,0,1,1,0};
int t[] ={1,1,1,0,1,0,0,0};
int u[] ={1,1,1,0,1,0,1,0};
int v[] ={1,1,1,0,1,1,0,0};
int w[] ={1,1,1,0,1,1,1,0};
int x[] ={1,1,1,1,0,0,0,0};
int y[] ={1,1,1,1,0,0,1,0};
int z[] ={1,1,1,1,0,1,0,0};
int space[] = {1,1,1,1,1,1,1,0};

int aa[] ={1,0,0,0,0,0,1,0};
int bb[] ={1,0,0,0,0,1,0,0};
int cc[] ={1,0,0,0,0,1,1,0};
int dd[] ={1,0,0,0,1,0,0,0};
int ee[] ={1,0,0,0,1,0,1,0};
int ff[] ={1,0,0,0,1,1,0,0};
int gg[] ={1,0,0,0,1,1,1,0};
int hh[] ={1,0,0,1,0,0,0,0};
int II[] ={1,0,0,1,0,0,1,0};
int jj[] ={1,0,0,1,0,1,0,0};
int kk[] ={1,0,0,1,0,1,1,0};
int ll[] ={1,0,0,1,1,0,0,0};
int mm[] ={1,0,0,1,1,0,1,0};
int nn[] ={1,0,0,1,1,1,0,0};
int oo[] ={1,0,0,1,1,1,1,0};
int pp[] ={1,0,1,0,0,0,0,0};
int qq[] ={1,0,1,0,0,0,1,0};
int rr[] ={1,0,1,0,0,1,0,0};
int ss[] ={1,0,1,0,0,1,1,0};
int tt[] ={1,0,1,0,1,0,0,0};
int uu[] ={1,0,1,0,1,0,1,0};
int vv[] ={1,0,1,0,1,1,0,0};
int ww[] ={1,0,1,0,1,1,1,0};
int xx[] ={1,0,1,1,0,0,0,0};
int yy[] ={1,0,1,1,0,0,1,0};
int zz[] ={1,0,1,1,0,1,0,0};

int n0[] = {1,0,1,1,1,1,1,0};
int n1[] ={1,0,1,1,1,0,1,0};
int n2[] ={1,1,1,1,1,1,0,0};
int n4[] ={1,1,1,1,1,0,0,0};
int n3[] ={1,1,1,1,0,1,1,0};
int n5[] ={1,1,1,1,1,0,1,0};
int n6[] ={1,0,1,1,1,1,0,0};
int n7[] ={1,0,1,1,1,0,0,0};
int n8[] ={1,0,1,1,0,1,1,0};
int n9[] ={1,0,0,0,0,0,0,0};


void setup()

{
  Serial.begin(9600);
  pinMode(ldrPin,INPUT);
  noise=analogRead(ldrPin);
  //Serial.println(noise);
}

void loop()

{
  int rec=analogRead(ldrPin);
  rec=rec-(noise-10);
  Serial.println(rec);
  delay(200);
```

```
int binData[8];

if(rec>200)
{
  for(int i=0; i<8; i++)
  {
    int data=analogRead(ldrPin);
    //Serial.println(data);
    data=data-(noise-10);
    Serial.println(data);
    if(data>100 && data<300)
    {
      analogWrite(ledPin, 0);
      binData[i]=0;
      //Serial.println("0");
    }
    if(data>300)
    {
      binData[i]=1;
      analogWrite(ledPin, 255);
      //Serial.println("1");
    }
    delay(50);
  }

  int flag=0;

  while(rec>500){


  for(int i=0; i<8; i++){
    if(binData[i]==a[i])
    flag=65;

    else
    flag=-65;

    }

    //if(flag==65)
    //break;


  for(int i=0; i<8; i++){
    if(binData[i]==b[i])
    flag=66;

    else
    flag=-66;

    }

    if(flag==66)
    break;


  for(int i=0; i<8; i++){
    if(binData[i]==c[i])
    flag=67;

    else
    flag=-67;

    }

    if(flag==67)
    break;


  for(int i=0; i<8; i++){
    if(binData[i]==d[i])
    flag=68;

    else
    flag=-68;

    }

    if(flag==68)
    break;


  for(int i=0; i<8; i++){
    if(binData[i]==e[i])
    flag=69;

    else
    flag=-69;

    }

    if(flag==69)
    break;
```

```
for(int i=0; i<8; i++){
 if(binData[i]==f[i])
 flag=70;

 else
 flag=-70;

 }

 if(flag==70)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==g[i])
 flag=71;

 else
 flag=-71;

 }

 if(flag==71)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==h[i])
 flag=72;

 else
 flag=-72;

 }

 if(flag==72)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==I[i])
 flag=73;

 else
 flag=-73;

 }

 if(flag==73)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==j[i])
 flag=74;

 else
 flag=-74;

 }

 if(flag==74)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==k[i])
 flag=75;

 else
 flag=-75;

 }

 if(flag==75)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==l[i])
 flag=76;

 else
 flag=-76;

 }

 if(flag==76)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==m[i])
 flag=77;

 else
```

```
 flag=-77;

 }

 if(flag==77)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==n[i])
 flag=78;

 else
 flag=-78;

 }

 if(flag==78)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==o[i])
 flag=79;

 else
 flag=-79;

 }

 if(flag==79)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==p[i])
 flag=80;

 else
 flag=-80;

 }

 if(flag==80)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==q[i])
 flag=81;

 else
 flag=-81;

 }

 if(flag==81)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==r[i])
 flag=82;

 else
 flag=-82;

 }

 if(flag==82)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==s[i])
 flag=83;

 else
 flag=-83;

 }

 if(flag==83)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==t[i])
 flag=84;

 else
 flag=-84;

 }

 if(flag==84)
```

```
  break;


for(int i=0; i<8; i++){
  if(binData[i]==u[i])
  flag=85;

  else
  flag=-85;

  }

  if(flag==85)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==v[i])
  flag=86;

  else
  flag=-86;

  }

  if(flag==86)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==w[i])
  flag=87;

  else
  flag=-87;

  }

  if(flag==87)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==x[i])
  flag=88;

  else
  flag=-88;

  }

  if(flag==88)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==y[i])
  flag=89;

  else
  flag=-89;

  }

  if(flag==89)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==z[i])
  flag=90;

  else
  flag=-90;

  }

  if(flag==90)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==aa[i])
  flag=97;

  else
  flag=-97;

  }

  if(flag==97)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==bb[i])
```

```
 flag=98;

 else
 flag=-98;

 }

 if(flag==98)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==cc[i])
 flag=99;

 else
 flag=-99;

 }

 if(flag==99)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==dd[i])
 flag=100;

 else
 flag=-100;

 }

 if(flag==100)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==ee[i])
 flag=101;

 else
 flag=-101;

 }

 if(flag==101)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==ff[i])
 flag=102;

 else
 flag=-102;

 }

 if(flag==102)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==gg[i])
 flag=103;

 else
 flag=-103;

 }

 if(flag==103)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==hh[i])
 flag=104;

 else
 flag=-104;

 }

 if(flag==104)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==II[i])
 flag=105;

 else
 flag=-105;
```

```
  }

  if(flag==105)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==jj[i])
  flag=106;

  else
  flag=-106;

  }

  if(flag==106)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==kk[i])
  flag=107;

  else
  flag=-107;

  }

  if(flag==107)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==ll[i])
  flag=108;

  else
  flag=-108;

  }

  if(flag==108)
  break;



for(int i=0; i<8; i++){
  if(binData[i]==mm[i])
  flag=109;

  else
  flag=-109;

  }

  if(flag==109)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==nn[i])
  flag=110;

  else
  flag=-110;

  }

  if(flag==110)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==oo[i])
  flag=111;

  else
  flag=-111;

  }

  if(flag==111)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==pp[i])
  flag=112;

  else
  flag=-112;

  }

  if(flag==112)
  break;
```

```
for(int i=0; i<8; i++){
 if(binData[i]==qq[i])
 flag=113;

 else
 flag=-113;

 }

 if(flag==113)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==rr[i])
 flag=114;

 else
 flag=-114;

 }

 if(flag==114)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==ss[i])
 flag=115;

 else
 flag=-115;

 }

 if(flag==115)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==tt[i])
 flag=116;

 else
 flag=-116;

 }

 if(flag==116)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==uu[i])
 flag=117;

 else
 flag=-117;

 }

 if(flag==117)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==vv[i])
 flag=118;

 else
 flag=-118;

 }

 if(flag==118)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==ww[i])
 flag=119;

 else
 flag=-119;

 }

 if(flag==119)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==xx[i])
 flag=120;
```

```
  else
  flag=-120;

  }

  if(flag==120)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==yy[i])
  flag=121;

  else
  flag=-121;

  }

  if(flag==121)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==zz[i])
  flag=122;

  else
  flag=-122;

  }

  if(flag==122)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==space[i])
  flag=32;

  else
  flag=-32;

  }

  if(flag==32)
  break;
```

```
for(int i=0; i<8; i++){
  if(binData[i]==n0[i])
  flag=48;

  else
  flag=-48;

  }

  if(flag==48)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==n1[i])
  flag=49;

  else
  flag=-49;

  }

  if(flag==49)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==n2[i])
  flag=50;

  else
  flag=-50;

  }

  if(flag==50)
  break;


for(int i=0; i<8; i++){
  if(binData[i]==n3[i])
  flag=51;

  else
  flag=-51;

  }
```

```
 if(flag==51)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==n4[i])
 flag=52;

 else
 flag=-52;

 }

 if(flag==52)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==n5[i])
 flag=53;

 else
 flag=-53;

 }

 if(flag==53)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==n6[i])
 flag=54;

 else
 flag=-54;

 }

 if(flag==54)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==n7[i])
 flag=55;

 else
 flag=-55;

 }

 if(flag==55)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==n8[i])
 flag=56;

 else
 flag=-56;

 }

 if(flag==56)
 break;


for(int i=0; i<8; i++){
 if(binData[i]==n9[i])
 flag=57;

 else
 flag=-57;

 }

 if(flag==57)
 break;

}

 if(flag==65)
 text='A';

 if(flag==66)
 text='B';

 if(flag==67)
 text='C';

 if(flag==68)
 text='D';
```

```
if(flag==69)
text='E';

if(flag==70)
text='F';

if(flag==71)
text='G';

if(flag==72)
text='H';

if(flag==73)
text='I';

if(flag==74)
text='J';

if(flag==75)
text='K';

if(flag==76)
text='L';

if(flag==77)
text='M';

if(flag==78)
text='N';

if(flag==79)
text='O';

if(flag==80)
text='P';

if(flag==81)
text='Q';

if(flag==82)
text='R';

if(flag==83)
text='S';

if(flag==84)
text='T';
```

```
if(flag==85)
text='U';

if(flag==86)
text='V';

if(flag==87)
text='W';

if(flag==88)
text='X';

if(flag==89)
text='Y';

if(flag==90)
text='Z';

if(flag==32)
Serial.print(" ");

if(flag==97)
text='a';

if(flag==98)
text='b';

if(flag==99)
text='c';

if(flag==100)
text='d';

if(flag==101)
text='e';

if(flag==102)
text='f';

if(flag==103)
text='g';

if(flag==104)
text='h';

if(flag==105)
text='i';
```

```
if(flag==106)
text='j';

if(flag==107)
text='k';

if(flag==108)
text='l';

if(flag==109)
text='m';

if(flag==110)
text='n';

if(flag==11)
text='o';

if(flag==112)
text='p';

if(flag==113)
text='q';

if(flag==114)
text='r';

if(flag==115)
text='s';

if(flag==116)
text='t';

if(flag==117)
text='u';

if(flag==118)
text='v';

if(flag==119)
text='w';

if(flag==120)
text='x';

if(flag==121)
text='y';

if(flag==122)
text='z';

if(flag==48)
text='0';

if(flag==49)
text='1';

if(flag==50)
text='2';

if(flag==51)
text='3';

if(flag==52)
text='4';

if(flag==53)
text='5';

if(flag==54)
text='6';

if(flag==55)
text='7';

if(flag==56)
text='8';

if(flag==57)
text='9';


  Serial.print(text);

 }

 delay(10);
}

}
```

CHAPTER 6

ADVANTAGES & DISADVANTAGES

6.1 Advantages

1. **Speed:** LiFi provides a speed of around a hundred times faster than what WiFi can currently achieve. Quicker communication would mean better communication and better quality.

2. **Efficiency:** LiFi is considerably more efficient regarding cost and power utilization. It utilizes LED bulbs for transmission, and these bulbs can double as standard lighting for a family unit and reduce energy usage of LiFi, making it more proficient than technologies that currently exist and not needing any extra equipment.

3. **Availability:** Since LED bulbs are used, LiFi can be accessible anywhere if we replace off-the-shelf LED bulbs with LiFi compatible bulbs.

4. **Security:** As LiFi works on visible sectrum, it cannot enter through opaque items such as dividers or walls making it hard for unapproved access, unlike WiFi which can be easily accessed from beyond walls and make it less protected against unapproved access.

6.2 Disadvantages

1. **Special Hardware Needs:** LiFi needs specialized equipment to use which isn't available on a huge scale right now. The current technology must be renovated so that LiFi can be executed on an extensive scale and people can utilize it.

2. **Cost Factor:** There has been an immense amount invested into its R&D since the technology is new and thus LiFi is pricey.

3. **Uplink Issues:** LiFi has shown very high downlink speeds. There have never been any significant mentions of the uplink and how it is being realized.

4. **Interference:** A LiFi signal is susceptible to intervention from everyday lightings such as household lighting, sunlight, street lights etc because it uses visible light for its transmission.

5. **Limited Range:** LiFi is constrained by two fundamental factors: failure of light to infiltrate opaque articles (such as dividers in a room) and dispersion of light.

CHAPTER 7

CONCLUSION

LiFi is in its initial stages and it offers a surprising degree of research scope and transformation. Countless researchers have concentrated on this technology to help higher data transmission. LiFi gives encouraging features to advance the data communication. Since available bandwidth is restricted, the wireless transmissions are winding up blocked, and it is harder to utilize wireless technology with precision. The LiFi technology can offer an answer for this issue. Additionally it will form better prospects for people to come and can offer real and powerful modifications to radio wave communications. LiFi will go on to change the situation of wireless communication in countless ways in the future.

Li-Fi is spreading exponentially since it is quicker, secure and has increased capacity than Wi-Fi. Transmission and Reception of data happens in form of light energy which is utilized for many applications. Transmission using the visible light spectrum enables light to adjust at a quick rate so that it can be picked by receivers equipped with light sensors at high speeds of several megabytes per second, enabling the light source to transmit data. The usage of Li-Fi technology gives an incredible opportunity to supplant radio based wireless technologies. This system could be very gainful in overseeing traffic and consequently setting up a smart city.

LiFi is ready to affect millions. LiFi can drive Industry 4.0 applications, open the IoT, add to the fifth generation of cellular frameworks (5G) and beyond, allow LaaS (light as a service) in lighting businesses, sanction new astute transportation systems, make new cyber secure wireless systems improve street safety when there are an ever increasing number of driverless vehicles, empower better methods for wellbeing of senior citizens, and offer many resolutions to reduce the digital divide.

LiFi would have a synergist impact for two chief enterprises: I) wireless communication industry, and II) lighting business. In 2 decades, LED lights will aid a huge number of real world applications and it will remain a fundamental piece of developing smart urban areas. LaaS and IoT will be ruling themes in lighting businesses and will bring about the new courses of action when LEDs last for decades. LaaS, along with LiFi will, in this way, enable the lighting business to enter a market that has generally been about wireless communications.

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