VISVESVARAYA TECHNOLOGICAL UNIVERSITY

JNANA SANGAMA, BELAGAVI-590018

A Seminar Report
On

"Visual Light Communication Using Li-Fi Technology"

submitted in partial fulfillment for technical seminar in

Bachelor of Engineering
In
Computer Science and Engineering

By

Sumit Kumar
USN: 1BG12CS101

Under the Guidance of

Dr. Divyashree B A
Professor
Department of Computer Science and Engineering

Vidyaya Amrutham Ashnuthe

B. N. M. Institute of Technology

12th Main, 27th Cross, Banashankari II Stage, Bengaluru 560070.

Department of Computer Science and Engineering

2015-2016

B. N. M. Institute of Technology

12th Main, 27th Cross, Banashankari II Stage, Bengaluru 560070.

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

2015-2016

Vidyaya Amrutham Ashnuthe

CERTIFICATE

Certified that the Seminar on topic **Visual Light Communication Using Li-Fi Technology** has been successfully presented at **BNM Institute of Technology** by **Sumit Kumar,** bearing 1BG12CS101**,** in partial fulfillment of the requirements for the *VIII Semester degree of* ***Bachelor of Engineering in Computer Science and Engineering*** *of Visvesvaraya Technological University, Belgaum* during academic year 2015-2016. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the departmental library. The Seminar report has been approved as it satisfies the academic requirements in respect of Seminar work for the said degree.

Dr. Divyashree B A
Project Guide
Professor

Dr. Sahana D. Gowda
Professor and HOD

DECLARATION

I, **Sumit Kumar [USN: 1BG12CS101]**, student of VIII Semester BE, in Computer Science and Engineering, BNM Institute of Technology hereby declare that the Seminar entitled "Visual Light Communication Using Li-Fi Technology**"** has been carried out by me and submitted in partial fulfillment of the requirements for the *VIII Semester degree of* ***Bachelor of Engineering in Computer Science and Engineering*** *of Visvesvaraya Technological University, Belgaum* during academic year 2015-2016.

Date :

Place : Bengaluru

SUMIT KUMAR

1BG12CS101

ACKNOWLEDGEMENT

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mention of the people who made it possible, whose constant guidance and encouragement crowned the efforts with success.

I would like to thank **Management** of **BNM Institute of Technology** for providing such a healthy environment for the successful completion of Seminar work.

I would like to express my thanks to the Director **Prof. T. J. Ramamurthy** and the Principal **Dr. Krishnamurthy G N** for their encouragement that motivated me for the successful completion of Seminar work.

It gives me immense pleasure to thank **Dr. Sahana D Gowda,** Professor and Head of Department for her constant support and encouragement.

Also, I would like to express my deepest sense of gratitude to my Seminar Guide **Dr. Divyashree B A**, Professor, Department of Computer Science & Engineering for her constant support and guidance throughout the Seminar work.

I would also like to thank the Seminar Coordinator **Smt. Sreevidya R. C,** Associate Professor, Department of Computer Science & Engineering and all other teaching and non-teaching staff of Computer Science Department who has directly or indirectly helped me in the completion of the Seminar work.

Last, but not the least, I would hereby acknowledge and thank my parents who have been a source of inspiration and also instrumental in the successful completion of the seminar work.

Sumit Kumar

USN: 1BG12CS101

ABSTRACT

Whether you're using wireless internet in a coffee shop, stealing it from the guy next door, or competing for bandwidth at a conference, you've probably gotten frustrated at the slow speeds you face when more than one device is tapped into the network. As more and more people and their many devices access wireless internet, clogged airwaves are going to make it increasingly difficult to latch onto a reliable signal. Li-Fi is typically implemented using white LED light bulbs. These devices are normally used for illumination by applying a constant current through the LED. However, by fast and subtle variations of the current, the optical output can be made to vary at extremely high speeds. Unseen by the human eye, this variation is used to carry high-speed data. Li-Fi stands for Light-Fidelity. In this technology data is transmitted through illumination by sending data through an LED light bulb that varies in intensity faster than the human eye can follow. Wi-Fi is great for general wireless coverage within buildings, whereas Li-Fi is ideal for high density wireless data coverage in confined area and for relieving radio interferences issues. Li-Fi provides better bandwidth, efficiency, availability and security than Wi-Fi and has already achieved blisteringly high speed in lab. By leveraging the low-cost nature of LEDs and lighting units there are many opportunities to exploit this medium, from public internet access through street lamps to auto-piloted cars that communicated through their headlights. In future data for laptops, smart phones, and tablets will be transmitted through the light in a room. Visual Light Communication (VLC) system based on white LEDs has emerged as an eco-friendly IT green technology using visible light spectrum in provision of both lighting and wireless access. Using this technology for communication will proceed towards the cleaner, greener, safer and brighter future.

CONTENTS

1. INTRODUCTION

In simple terms, Li-Fi can be thought of as a light-based Wi-Fi. That is, it uses light instead of radio waves to transmit information. And instead of Wi-Fi modems, Li-Fi would use transceiver-fitted LED lamps that can light a room as well as transmit and receive information. Since simple light bulbs are used, there can technically be any number of access points.

This technology uses a part of the electromagnetic spectrum that is still not greatly utilized- The Visible Spectrum. Light is in fact very much part of our lives for millions and millions of years and does not have any major ill effect. Moreover, there is 10,000 times more space available in this spectrum and just counting on the bulbs in use, it also multiplies to 10,000 times more availability as an infrastructure, globally.

It is possible to encode data in the light by varying the rate at which the LEDs flicker on and off to give different strings of 1s and 0s. The LED intensity is modulated so rapidly that human eyes cannot notice, so the output appears constant.

More sophisticated techniques could dramatically increase VLC data rates. Parallel data transmission using arrays of LEDs, where each LED transmits a different data stream. Other groups are using mixtures of red, green and blue LEDs to alter the light's frequency, with each frequency encoding a different data channel.

Light Fidelity is a bidirectional, high speed and fully networked wireless communication technology similar to Wi-Fi. The term was coined by Harald Haas and is form of visible light communication and a subset of optical wireless communication and could be a complement to RF communication, or even a replacement in contexts od data broadcasting. It is so far measured to be about 100 times faster than some Wi-Fi implementations.

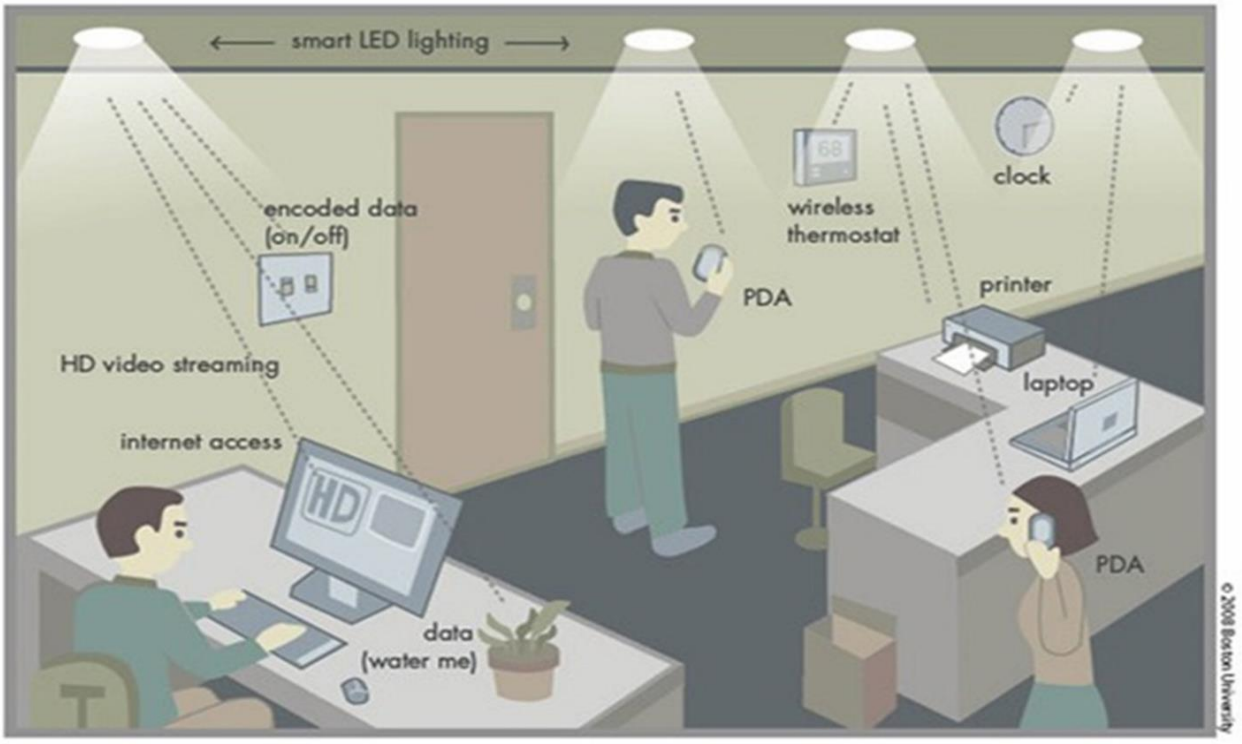

Figure 1.1 : Environment with Li-Fi Technology

The figure 1 shows the environment with the LI-FI technology where light bulbs are used as a data communication medium to PC, Laptop, Tablet and PDA as it all have photo detector connected to it as receiver. In the figure every smart LED bulbs works as hotspot and which transfers the data for a particular range based on the line of sight (LOS). Each requesting device has its own photo detector which receives the data transmitted by the LED.

2. LITERATURE SURVEY

Most of us are familiar with Wi-Fi (Wireless Fidelity), which uses 2.4-5GHz RF to deliver wireless Internet access around our homes, schools, offices and in public places. We have become quite dependent upon this nearly ubiquitous service. But like most technologies, it has its limitations.

While Wi-Fi can cover an entire house, its bandwidth is typically limited to 50-100 megabits per second (Mbps) today using the IEEE802.11n standard. This is a good match to the speed of most current Internet services, but insufficient for moving large data files like HDTV movies, music libraries and video games.

The more we become dependent upon 'the cloud' or our own 'media servers' to store all of our files, including movies, music, pictures and games, the more we will want bandwidth and speed. Therefore, RF-based technologies such as today's Wi-Fi are not the optimal way. In addition, Wi-Fi may not be the most efficient way to provide new desired capabilities such as precision indoor positioning and gesture recognition.

Optical wireless technologies, sometimes called visible light communication (VLC), and more recently referred to as Li-Fi (Light Fidelity), on the other hand, offer an entirely new paradigm in wireless technologies in terms of communication speed, flexibility and usability.

2.1 LIMITATIONS OF EXISTING SYSTEM

There are limitations of WI-FI based on the capacity, efficiency, security and availability Which is as follows:

2.1.1 CAPACITY

With the advent of new technology like 3G, 4G we are running out of radio spectrum as its capacity are drying up. Compare to this VLC spectrum has more spectrum space than radio spectrum as light boxes are already present and already installed.

2.1.2 EFFICIENCY

There are 14 lacks cellular radio base stations with efficiency of each station is just 5%. In base station most of the energy has been used for cooling system. Li-Fi is highly efficient because LED consumes less energy.

2.1.3 SECURITY

Radio waves can penetrate through walls and hence can be intercepted and misused it. Light waves do not infiltrate through walls. hence they can't be intercepted.

2.1.4 AVAILABILITY

We have to switch off mobile in aircraft and hospitals. Light is present everywhere.
Data is present where light is present.

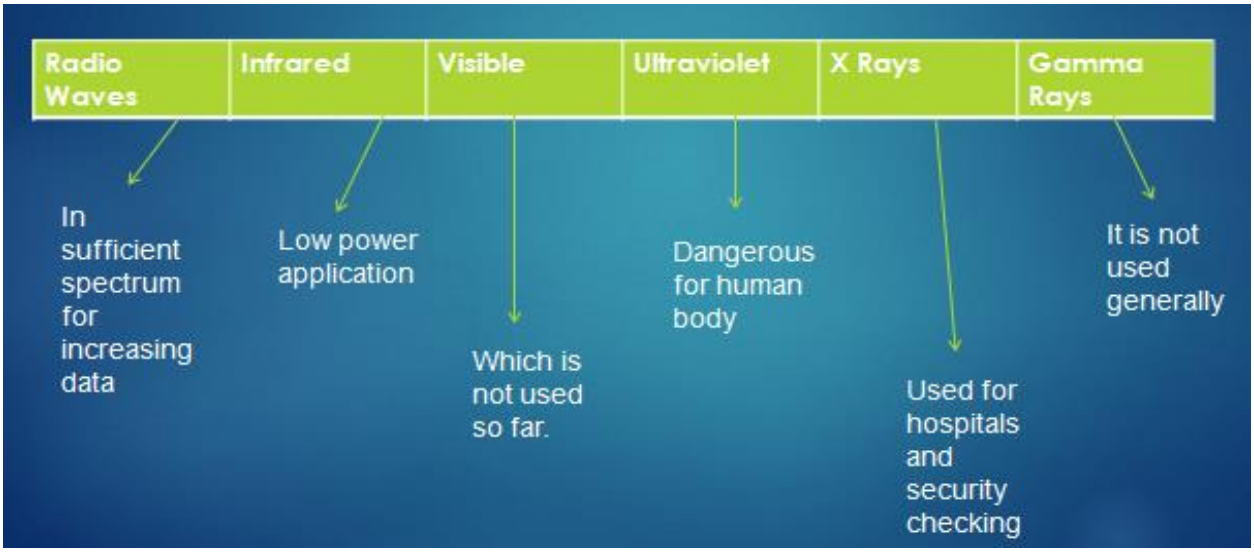

Figure 2.1 : Bandwidth Spectrum

Figure 2 shows the different bandwidth spectrum available. Radio waves one of the mostly used spectrum but due to increase in number of smart devices there is shortage of the spectrum and it is also not efficient to transfer large files. Infrared which is used in low power application and it does not provide high data rate. Ultraviolet ray is not used because it is dangerous for the human body. X Rays are basically used for medical purpose. Gamma Rays are generally not used. Visible spectrum which was not used so far can now be used to overcome the limitation of existing system by using visual light communication using LI-FI technology.

2.2 COMPARISON BETWEEN DIFFERENT COMMUNICATION TECHNOLOGY

TECHNOLOGY	SPEED	DATA DENSITY
	WIRED	
Fire Wire	800 Mbps	*****
USB 3.0	5 Gbps	*****
THUNDERBOLT	2 X 10 Gbps	*****
	WIRELESS (CURRENT)	
WI-FI-IEEE (802.11N)	150 Mbps	*
Bluetooth	3 Mbps	*
IrDA	4 Mbps	***
	WIRELESS (FUTURE)	
Wi-Gig	2 Gbps	**
Giga-IR	1 Gbps	***
LI-FI	>10 Gbps	****

Figure 2.2 : Comparison between different technology

Figure 3 shows the comparison between different technology used for communication. In wired we have different methods for communication such as fire wire, USB, thunderbolt these methods provide better speed as all used wired communication technology.

In wireless Technology we have Wi-Fi, Bluetooth and Infra ray these methods can be used for wireless communication. Current Wi-Fi standard is IEEE802.11n which provides a data rate of 150Mbps and Bluetooth provides data rate of 3Mbps which is very slow when we have to stream HD videos or large files. One solution for this is using Li-Fi which provide data rate of greater than 10Gbps and also it is one of the greener way for communication.

3. METHODOLOGY

3.1 WORKING PRINCIPAL

Li-Fi is typically implemented using white LED light bulbs at the downlink transmitter. These devices are normally used for illumination only by applying a constant current. However, by fast and subtle variations of the current, the optical output can be made to vary at extremely high speeds.

This varying property of optical current is used in Li-Fi setup. The operational procedure is simple if the LED is on, we transmit a digital 1, if it's off you transmit a 0. The LEDs can be switched on and off very quickly, which gives nice opportunities for transmitting data. Hence all that is required is some LEDs and a controller that code data into those LEDs. All has to do is to vary the rate at which the LED's flicker depending upon the data we want to encode. The flashing of the light actually happens much faster that human eyes cannot detect, so the output appears constant, allowing for a Li-Fi data connection to resemble a simple LED bulb.

The data are encrypted in the LEDs with the help of a controller and some LEDs. The logical 1 is transmitted when the LED is ON and logical 0 is transmitted when the LED is OFF. The LED flickers enormously so that the data are being transmitted at high speed over 10Gbps on theoretical basis. An array of LEDs is used for parallel data transmission and different colored LEDs to alter the LED frequency so that data is encrypted for different frequency. To encode the information in LED's, the flickering rate of the LED's is varied so that we can obtain different set of 0's and 1's.

Figure 3.1 : Binary Data

3.2 HOW LI-FI WORKS

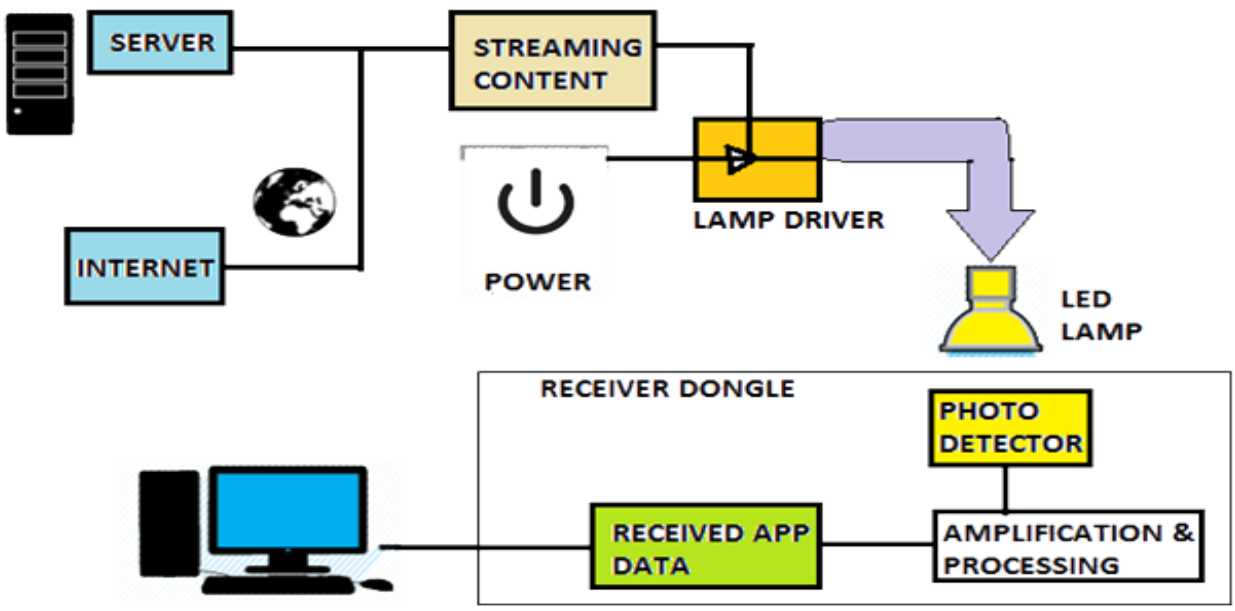

Figure 3.2 : Architecture Diagram of Li-Fi

In figure 5 On the Transmitter Side The streaming conent gets the data from the internet server or any other source of data. Once the data is received then it given to the Lamp Driver which takes the binary data from the streaming content and the Timer circuit generates a digital wave from the particular input. The waves generated is transmitted through the LED Lamp.

In figure 5 On the Receiver Side the Photo Detector will receives the waves from the LED and it is given as input to double stage input amplifire which amplifies the input signal and filtes the noice if it is present in the waves and then the binary data is converted to the respective data format. And then the signal is received by the destination device like PC, Mobile Phone or PDA.

3.2.1 TRANSMITTER

As per the given diagram, the transmitter section consists of the input, a timer circuit, and a LED bulb. The input can be any type of data that you wish to transmit, for example voice, text etc. The timer circuit is used to provide the required time intervals between each bit. These bits i.e. 1‟s and 0‟s are transmitted in the form of flashes of the LED bulb.

3.2.2 RECEIVER

The flashes of the bulb are received by the photodiode. The photodiode then converts the light energy into electrical signals. Next these electrical signals are amplified and the output is presented.

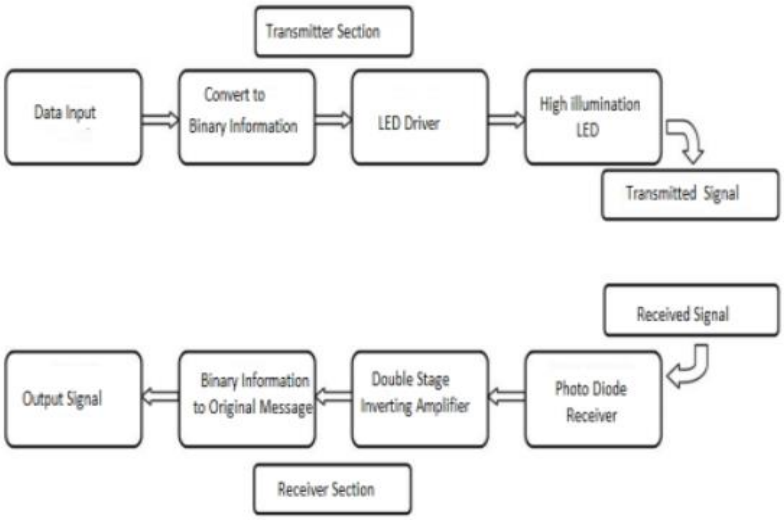

Figure 3.3 : Block Diagram of Li-Fi

Figure 6 shows the block diagram of Li-Fi, on the transmitter side first the input data is transmitted into binary form then it is passed to LED driver and then to the LED. It transmits the data in form of signal. The transmitted signal is received by the photo detector receiver and is given to double stage inverting amplifier and then binary information is converted back to original message.

3.3 DESIGN OF LI-FI

Li-Fi architecture consists number of LED bulbs or lamps, many wireless devices such as PDA, Mobile Phones, and laptops. Important factors we should consider while designing Li-Fi as following:

1. Presence of Light
2. Line of Sight(Los)
3. For better performance use fluorescent LED

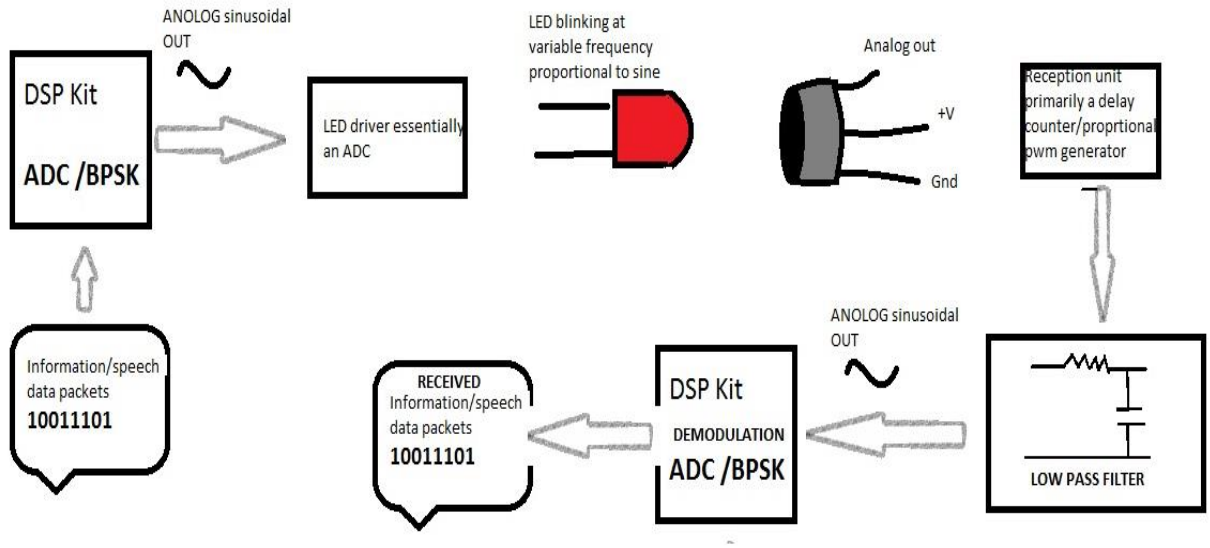

Figure 3.4 : Components Involved in Li-Fi

Figure 7 shows the component used to implement Li-Fi. First the binary data is given to the Analog to Digital Converter or Binary Phase Shift Key which process the binary data into analog signal and this signal is passed to the LED driver which converts it into digital signal and using timer the digital signal is generated and transmitted through the LED. The digital signal is received by the photo detector and the signal is modulated and passed through the low pass filter to remove the noise from the signal and then signal is converted back to the digital signal and the binary information is retrieved from the signal.

4. RESULTS AND DISCUSSION

4.1 LI-FI VS WI-FI

The Life is more advantageous than Wi-Fi technology, in case of Wi-Fi the user depends upon the source like routers but in case of Li-Fi it is not so. The Li-Fi technology uses light as a source for data transfer and the user can make use of any kind of light source for data transfer. Wi-Fi uses radio signals which can't be used underwater data transmission since the radio signals won't be able to pass through water but we know that the light can go through the water and Life is more helpful in underwater data transmission. The security concern in case of Wi-Fi is much compared to Life the radio waves can easily penetrate through the walls and the data can be easily hacked but the light can't penetrate through the walls therefore the data are more secured. The radio waves are more harmful which are not allowed in hospitals and in airlines but light is very much eco-friendly which can be used in hospitals and also in airlines. The data rate is greater than 1Gbps in case of Life but the data rate using Wi-Fi is 10Mbps, which finds the user more efficient to surf on the internet.

4.2 ADVANTAGES OF LI-FI

- The Li-Fi has data connectivity over 500Mbps.
- As light is used for data transfer the data interpretation is much less.
- While travelling in planes the VLC can be used without affecting the airline signals.
- Like Bluetooth, Wi-Fi, infrared and internet the VLC can also be used all locations.
- The medical devices used in the hospitals are integrated using Li-Fi and the treatment becomes easier.
- The underwater analysis can be carried out using light communication.
- Since the Li-Fi is confined within a small range and doesn't penetrate through walls, the data are more secured.
- The street light becomes a public hotspot and the user can surf on internet at any place in presence of the light source.
- The HD film can be downloaded within 30 sec.

4.3 DISADVANTAGES OF LI-FI

- Light can't pass through objects.
- A major challenge facing Li-Fi is how the receiving device will transmit back to the transmitter.
- Connectivity while moving.
- Interferences from external light sources like sun, light, normal bulbs, opaque materials.

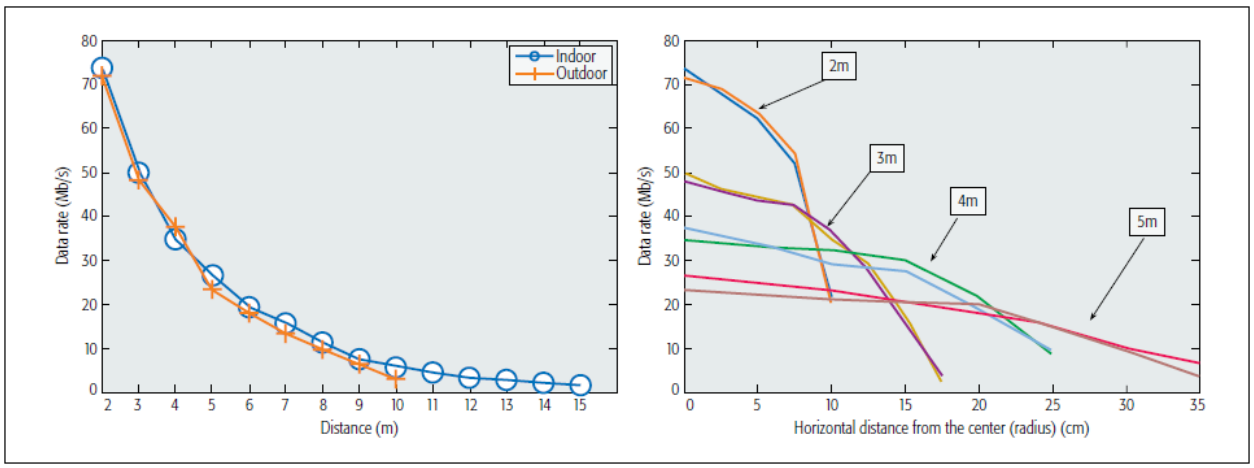

Figure 4.1 : Vertical and Horizontal difference between Li-Fi transceivers

Indoor and outdoor experiment are conducted to measure the achievable throughput of the Li-Fi frontends. The distance between the transmitter and receiver is varied in the range of 2-15 meters and 2-10 meters for the indoor and outdoor experiment, respectively. Figure 8 (left) shows that the achieved throughput is 74Mb/s and 25Mb/s at a vertical distance of 2m and 5m respectively.

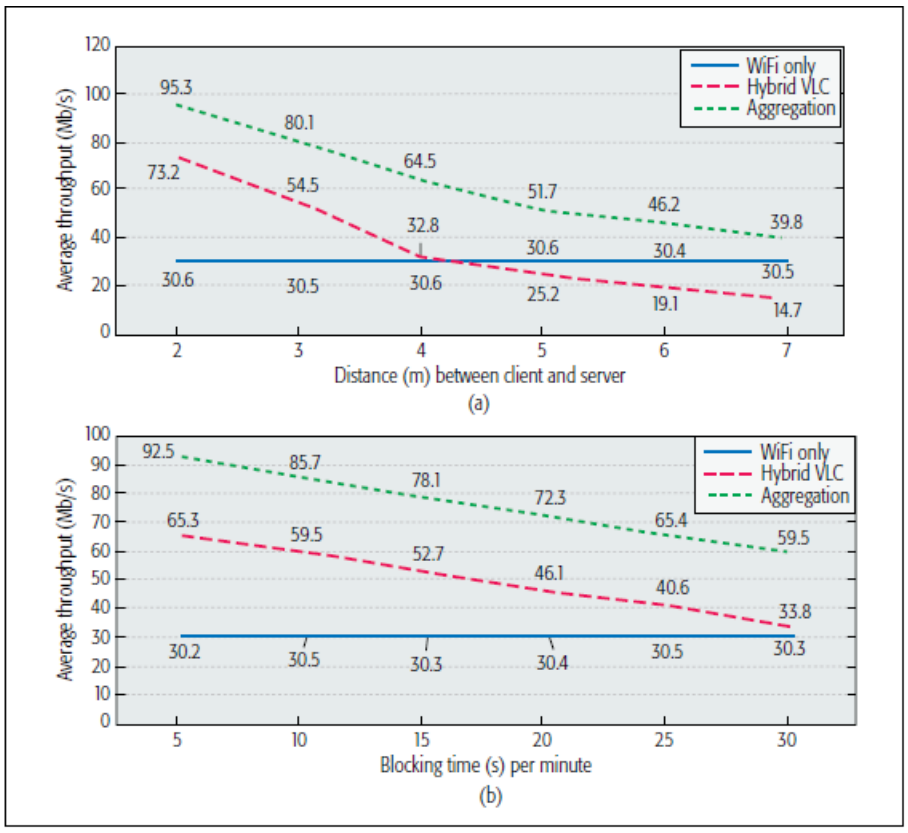

Figure 4.2: a) throughput vs. distance b) throughput vs blockage duration

Figure 9a shows the average throughput of the three system measured at different distance between Wi-Fi and Li-Fi frontends. Here the distance between transmitter and receiver is measured in meters and throughput is measured in Mb/s.

Figure 9b shows the average throughput achieved by the three system with the variation of periods in which the Li-Fi link was blocked.

5. CONCLUSION

The possibilities are numerous and can be explored further. If This technology can be put into practical use, every bulb can be used something like a Wi-Fi hotspot to transmit wireless data and we will proceed toward the cleaner, greener, safer and brighter future.

The applications of Li-Fi can be explored further, if we started to use LIFI practically then, each and every LED bulb that are available in streets, roads, public places like mall, etc., can be used as hotspot to transmit data The concept of Li-Fi is most welcomed by many people, just because of its data transfer speed. We can observe the speed of Li-Fi in dense population areas like metropolitan cities since many people will access the internet. Radio waves can be eradicated by the Li-Fi so that they can be freely used in hospitals, aircraft, and underground water. If we use Li-Fi We don't want to worry about the bandwidth, channel width of Wi-Fi router. The major drawback of Li-Fi is it can be used only with in the small area as it can't penetrate through walls it can also be considered as an advantage in terms of security purposes, but on the whole it sounds good in the developing field of wireless communication technology.

6. **REFERENCES**

- http://en.wikipedia.org/wiki/Li-Fi
- http://www.ispreview.co.uk/index.php/2013/01/tiny-led-lights-set-to-deliver-wifi-style-internet-communications.html
- http://www.lificonsortium.org/press3.html
- http://purelifi.com/top-10-li-fi-myths/
- http://computerinformationsite.com/2011/09/07/networking-through-lights-optical-data-transfer-using-li-fi/
- Wireless data from every light bulb Harald Haas, TED Global, Edinburgh

7. **REFERENCE PAPERS**

- IEEE Paper on What is Li-Fi? By Liang Yin, Yunlu wang, Cheng Chen
- LI-FI Technology – A Visible Light Communication Jay H. Bhut, Dharmrajsinh N. Parmar, Khusbhu V. Mehta