

A Comprehensive Study on Light Fidelity (Li-fi) Technology

Sudip Mitra¹, Shree Sarkar², Prof. (Dr.) Narendra Nath Jana³

Dept. of Computer Science and Engineering, Government College of Engineering and Leather Technology, Kolkata¹

Dept. of Computer Science and Engineering, Budge Budge Institute of Technology, Kolkata, India²

Dean of Academics & Head of the Department of Electrical Engineering, Budge Budge Institute of Technology, Kolkata, India³

Abstract - Light Fidelity (Li-Fi) is a Visible Light Communication (VLC) based technology that making a light as a media of communication replacing the cable wire communication. Li-fi or Light Fidelity was invented by Professor Harald Hass of university of Edinburgh. Haas says his invention, which he calls D-Light, can produce data rates faster than 10 megabits per second, which is speedier than your average broadband connection. He envisions a future where data for laptops, smartphones, and tablets is transmitted through the light in a room. And security would be a snap—if you can't see the light, you can't access the data. This paper presents an introduction of the Li-Fi technology including the architecture, modulation, performance, and the challenges. The result of this paper can be used as a reference and knowledge to develop some of the Li-Fi technology.

Key Words: Light Fidelity, LI-FI, WI-FI, LED, D-Light (Data Light), Visible Light Communication

I. 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. Li-Fi and Wi-Fi has the difference related to the congestion, density, security, safety, and speed. The more Wi-Fi enabled device is exist, the congestion may occur. In the technology of Wi-Fi we can't add more routers if the user is increased, while we can add the light in Li-Fi. Efficiency and safety of the internet are the dominating issues right now. The performance of Li-Fi is claimed that more better than the performance of Wi-Fi. The rate speed of Li-Fi is 1000 times faster than Wi-Fi [2]. For safety of the internet, Li-Fi is more secure than the Wi-Fi based on the spread of the signal. Li-Fi has a light characteristic that light cannot go through the wall. It is different from the signal of Wi-Fi can go through anywhere. Based on those two technologies, in a simple conclusion is Li-Fi has more secure communication rather than the Wi-Fi. The vulnerability exists if there are leakage in the wall while having an indoor communication. Security threat that may exist is an intruder can spoof the data using the leakage wall.

II. WHAT IS LI-FI?

Li-Fi technology consist of LED Lamp as the media transmission and photo detector as a receiver of transmitted data. Lamp driver is needed to make LED working properly. While amplification and processing are responsible to manage the signal that comes from the photo detector.

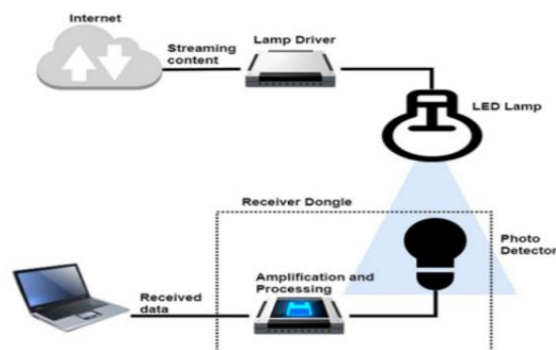


Fig. 1: Li-fi Concept Diagram

III. WHY USE VISIBLE LIGHT COMMUNICATION?

The Gamma rays cannot be used as they could be dangerous. X-rays has similar health issues. Ultraviolet light is good for place without people, but otherwise dangerous for the human body. Infrared, due to eye safety regulation, can only be with low power. Radio waves penetrate through the walls so they arises security issues. Hence we left with the only the visible- "Light Spectrum".



Fig. 2: Different Rays

Since visible light has no harmful effects, it can be safe to use and is also having a larger bandwidth. VLC^[4] is a data communication medium, which uses visible light in the range of 400THz to 800THz as optical carrier for data transmission and illumination.

IV. APPLICATION AND ADVANTAGES

Airways: We were facing the problem in communication media at the time of travelling in the airways, because the whole airways communications are performed on the basis of radio waves. We can overcome this drawback by using LI-FI technology.

Fill Green information technology: LI-FI never gives any side effects on any living thing like radio waves and other communication waves which effects on the birds, human bodies, etc.

Increase Communication Security: Light can't penetrate to the wall so in visible light communication, security is higher than any other communication technology.

Multi User Communication: LI-FI helps to share multiple things at a single instance which supports the broadcasting of network.

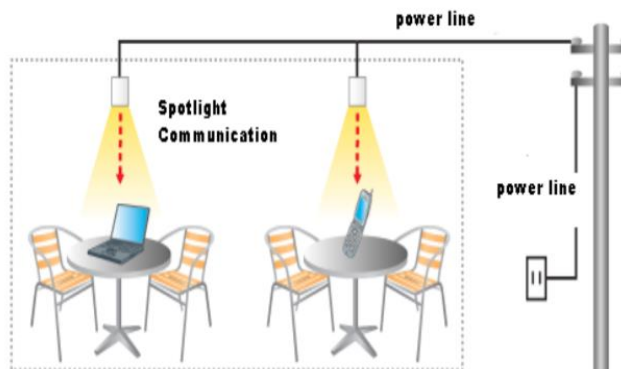


Fig. 3: Multiuser Communication

Traffic lights also can communicate to the car and with each other as cars have LED-based headlights, LED-based back lights, and cars can communicate with each other and prevent accidents in by exchanging information.

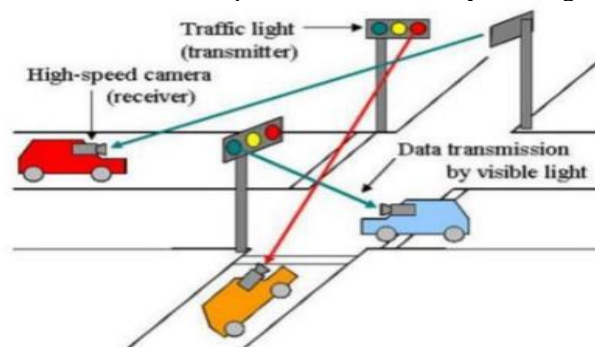


Fig. 4: Road to Vehicle Visible Light Communication

V. IMPLEMENTATION OF LI-FI

Basic concept for working principle in Li-Fi Technology are pointing into: Transceiver and Light as a media transmission. Figure 5 is a basic concept block diagram for Li-Fi. This basic concept indicates as a duplex communication. The rates of Li-Fi is 14Gbps using three off- the- shelf laser diodes (red, green, and blue) and predict the rate until 100Gbps when the whole visible spectrum is used.

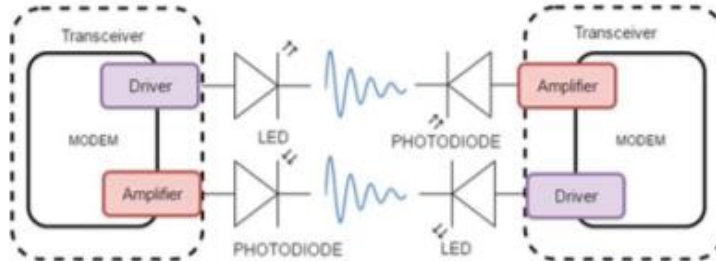


Fig 5: Transceiver Li-Fi based on VLC

I. TRANSCEIVER

Transceiver is a block that act as a transmitter and receiver at the same time. This transceiver consists of LED to transmit the light and photodiode to receive the light. Amplifier is embedded to strength the power of light received from the photodiode. The modem is used to modulate and demodulate the signal. The signal that comes from the photodiode is analog and it converts into digital in the modem. While the signal that ready to transmit, the digital signal convert into analog signal in the modem and sent by LED^[5].

II. MODULATION

The modulation signals is used to switch LED at desired frequencies that contains information to be transmitted.

- Single Carrier Modulation (SCM)
- Multiple Carrier Modulation (MCM)

VI. THE ARCHITECTURE OF LI-FI

In layered architecture, Li-Fi consist of 3 stages i.e. application layer, MAC layer and Physical Layer^[6].

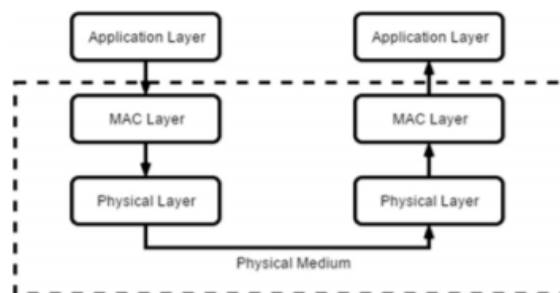


Fig. 6: Layered Architecture Visible Light Communication

- **IEEE 802.15.7 LAYERED ARCHITECTURE**

I. PHYSICAL LAYER

Physical layer responsible in transmission and reception, activation and deactivation of optical transceiver, and detection of state of transmission channel, is it idle or busy state.

II. MAC LAYER

Three network topologies are defined in MAC layer: Peer to peer, star, and broadcast [6].

a) PEER TO PEER:

There are two device that communicate. One of them is act as a coordinator.

b) STAR:

Communication happens in several devices. One of them is act as a coordinator and it's used as a illumination infrastructure.

c) BROADCAST:

One device i.e . a coordinator sends data to a several devices. The communication is unidirectional way.

VII. THE PERFORMANCE OF LI-FI

Efficiency and safety of the internet are the dominating issues now. Li-fi was found in 2011 by Scientist Harold Haas from UK. The design is to overcome the disadvantage of Wi-Fi. Li-Fi enabling the system using fully networked wireless communication and could provide a connection that's 100 times faster than Wi-Fi. It can reach speeds up to 3Gpbs.

Table 1: Speed and Standards of Wi-Fi

<i>802.11b</i>	<i>1999</i>	<i>11 Mbps</i>
<i>802.11a</i>	<i>1999</i>	<i>54 Mbps</i>
<i>802.11g</i>	<i>2002</i>	<i>54 Mbps</i>
<i>802.11n</i>	<i>2007</i>	<i>72 – 600 Mbps</i>
<i>802.11ac</i>	<i>2013</i>	<i>433 Mbps – 1.33 Gbps</i>

Table 2: Speed of Li-Fi

1	OOK ^[7]	803 Mbps
2	OFDM ^[8]	2.1 Gbps
3	DMT ^[9]	3.4 Gbps
4	PPM ^[10]	30 Mbps
5	PAM ^[11]	20 Mbps
6	CAP ^[12]	1.1 Gbps

For security, Li-Fi is tougher than a Wi-Fi. It is because the coverage area of Li-Fi is only on their illuminate area. The signal of Li-Fi cannot go through the wall. While the signal of Wi-Fi can go through the wall, it can cause the vulnerabilities in data loss and data leakage.

VIII. THE CHALLENGES

- Li-Fi is a technology that has a good perform in an indoor infrastructure while it's not happen in the outdoor area. The coverage in outdoor area for Li-Fi needs to be set up in order the quality of connection can give a good performance. Li-Fi is integrated with the Wi-Fi to get a good performance in an outdoor or in a mobile infrastructure.
- Visible light can't penetrate through brick walls as radio waves and is easily blocked by somebody simply walking in front of LED source.

CONCLUSIONS

In this paper, we outlined the working of Li-Fi, the application, the implementation, the modulation that it's used, the architecture, the performance, and at last the challenges. LI-FI may solve issues such as the shortage of radio-frequency bandwidth and is aimed at creating new communication channels with the use of existing equipment. Li-Fi has a good performance in the transfer rate, Li-Fi is not good enough when deploy in an outdoor in sunlight or other condition. This technology may solve issues such as shortage of radio frequency bandwidth and also allow the internet where the traditional radio based wireless isn't allowed such aircraft and hospitals but Li-Fi will probably not completely replace Wi-Fi, these two technologies can be used together to achieve more efficient and secure network.

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BIOGRAPHY



Sudip Mitra is a Bachelor of Technology candidate in the Department of Computer Science and Engineering at Government College of Engineering and Leather Technology, Kolkata. He received Diploma in Engineering in Computer Science and Technology from Budge Budge Institute of Technology, Kolkata at 2019. He has been recognized as Google Information Technology Support Professional at 2020. His primary research interest in Systems, Networks and Artificial Intelligence. He is the member of National Society of Professional Engineers (US) since 2021.



Shree Sarkar is a Bachelor of Technology candidate in the Department of Computer Science and Engineering at Budge Budge Institute of Technology, Kolkata. She received Diploma in Engineering in Computer Science and Technology from Budge Budge Institute of Technology, Kolkata at 2019.



Prof. (Dr.) Narendranath Jana has 33 years of experience: 13 years in Industry and 20 years in Academics. He did his B.E. in Electrical Engineering from IEST, Shibpur in 1986 and Masters from IIT Kharagpur in 1987. He worked with Fuji Electric Ltd, Tokyo, Japan for technical knowhow transfer on variable capacitance (MEMS) based Pressure/Flow transmitter. He completed his PhD from Jadavpur University in 2008. The area of his PhD work is Circuit topology on resonant inverter for Induction Cooktop. He has also worked as Director, Head of the institute in College of Engineering & Management, Kolaghat. He has 9 international journal publications and guided a PhD Scholar. Presently he is working in Budge Budge Institute of Technology, Budge Budge, Kolkata as Dean of Academics.