Lifi Technology: An Upcoming Technology

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Abstract- *Light Fidelity (LiFi) is a Visible Light Communication(VLC) based technology that making a light as media of communication replacing cable wire communication. LiFi is evolve to overcome the rate speed in WiFi, while using LiFi the rate speed can reach until 14 Gbps. LiFi compiles with the IEEE 802.15.7. The IEEE 802.15.7 is a high speed, bidirectional and fully networked wireless communication technology based standard similar to WiFi`s IEEE 802.11.*

This paper presents an introduction of the LiFi including the architecture, working, why to use LiFi and challenges to LiFi.

Keywords- What is Light-Fidelity, architecture of LiFi, performance of LiFi, Why LiFi over WiFi, Challenges to LiFi

I. INTRODUCTION

In the era of overcrowded (data communication) world, LiFi is a new way of wireless communication that uses LED lights to transmit data wirelessly. It is designed to use LED light bulbs similar to those currently in use in many energy-conscious homes and offices. However, LiFi bulbs are outfitted with a chip that modulates the light imperceptibly for optical data transmission. LiFi data is transmitted by the LED bulbs and received by photoreceptors.

LiFi is first introduced by Harald Haas during 2011 TEDGlobal talk in Edinburgh.

Professor Harald Haas coined the term LiFi at his 2011 TED Global talk where he introduced the idea of wireless data from every light. He is a Chair Professor of Mobile Communications at the University of Udinburgh and co-founder of pure LiFi along with Dr. Mostafa Afgani.

The general term visible light communication (VLC), whose history dates back to the 1880s, includes any use of the visible light portion of the electromagnetic spectrum to transmit information. The D-Light project at Edinburgh`s Institute for Digital Communications was funded from January 2010 to January 2012. Haas promoted this technology in his TED Global talk and helped start a company to market it. Pure LiFi, formerly Pure VLC is an original equipment manufacturer firm set up to commercialize Li-Fi products for integration with existing LED-lighting systems.

II. WHAT IS LIGHT-FIDELITY

Li-Fi-light fidelity is similar to Wi-Fi technology and it is one of the future wireless communication technologies. The main feature of this technology includes fully networked, bidirectional and high-speed wireless. Nowadays, the most trending domain in wireless communication is Wi-Fi and internet users are also being increased every year. For obtaining better speed, efficiency, bandwidth, Li-Fi technology has evolved. The data transmission in this technology can be done using light because the light intensity changes quicker than the human eye for capturing. The range of data transmission in L-Fi is faster 100 times than Wi-Fi.

Li-Fi system mainly includes two parts namely the transmitter and receiver. The input signal at the transmitter section can be modulated with a specific time period then send the data using LED bulbs in 0's and 1's form. Here, the flashes of LED bulbs are denoted with 0's and 1's. At the receiver end, a photodiode is used to receive the LED flashes strengthens the signal & gives the output.

The block diagram of Li-Fi system is shown below, and the transmitter section includes the input, timer circuit, an LED bulb. The input of the transmitter can be any kind of data like text, voice, etc. The timer circuit in this section is used to provide the necessary time intervals among every bit, and these are transmitted to the receiver end in the form of LED flashes.

The receiver section includes photodiode as well as amplifier. Here, photodiode receives the LED bulb flashes then changes the flashes into electrical signals. Finally, the amplifier receives the signals from the photodiode and amplifies to provide the output.

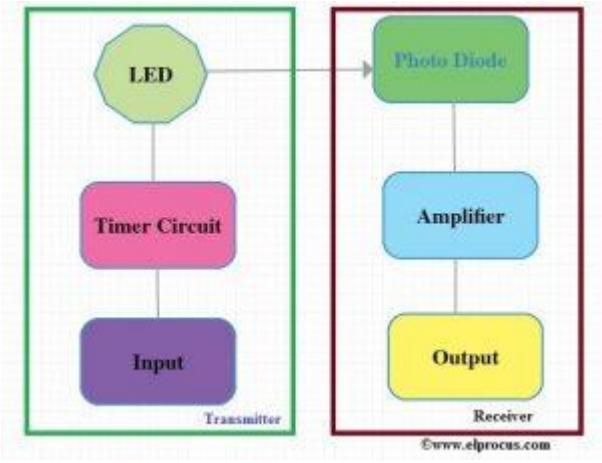

Fig. LiFi block diagram

Li-Fi is a VLC (visible light communications) system and the speed of this system is very high. Li-Fi uses normal LEDs to allow the data to transfer and increase the speed up to 224 Gigabits/sec. The data transmission of this technology can be done via illumination. The essential devices of this system are the bright light emitting diodes.

The ON/Off activity of LEDs permits a type of data transmission in the form of binary codes but the human eye cannot recognize this transform & the bulbs appear with a stable intensity.

LED can be switched on and off faster since operating speed of LED is less than 1 microsecond, than the human eye can detect, causing the light source to be appear continuously.

III. ARCHITECTURE OF LIFI

Below figure is the layered architecture of LiFi. In the layered architecture, LiFi consist of three stages i.e. Application layer, MAC layer, and physical layer. IEEE 802.15.7 defines only two standard i.e. PHY and MAC layer.

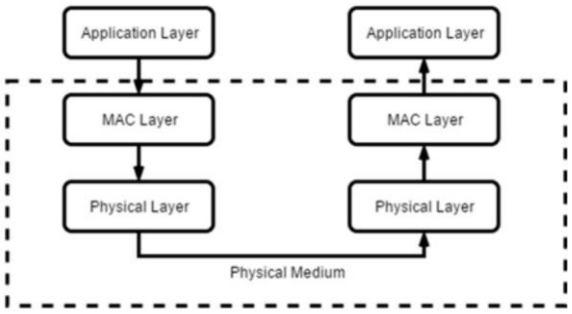

Fig. Layered architecture of VLC

A. PHY layer

PHY layer responsible in transmission and reception, activation and deactivation of transceiver and detection of state of transmission channel, is it idle or busy state. There are operation modes in PHY layer. The differences of each operation modes are shown in below table 1.

Table 1. Operation modes PHY layer

Operating modes	Usage	Categories	Rate
PHY I	Outdoor	Low	11.6 Kbps – 266.6 Kbps
PHY II	Indoor	Moderate	1.25 Mbps – 96 Mbps
PHY III	Multiple optical transceiver	CSK Modulation	12 Mbps – 96 Mbps

B. MAC layer

Three network topologies are defined in MAC layer: peer to peer , star, broadcdast.

a. Peer to peer
   There are two devices that communicate. One of them acts as the coordinator.
b. Star
   Communication happens in several devices. One of them acts as the coordinator and it is used as a illumination infrastructure.
c. Broadcast
   One device i.e. A coordinator sends data to a several devices. The communication is unidirectional way.

PROPAGATION CHANNEL

Propagation channel in LiFi is not different than in VLC. According to inddor environment characterized by six different link configuration refers to IR links. Transmitter and receiver communicate in two criterions, i.e. Direct or indirect line-of-sight(LOS) that required in propagation channel. These two criterions are based on degree of directionally of the transmitter and receiver (LOS) others is based on the reflection of the light(non LOS). In the LOS the links between the transmitter and receiver is pointing or directed to each other. While in the non-LOS the light is sreqading by the reflection of the ciling or diffusing reflecting surface. The characteristic of each criterion is summerized in below table 2.

Table 2. Characteristic of IR link

	Directed	Hybrid	Nondirected
Line of sight	Maximizes power efficiency	Combine transmitter & receiver having different degrees of directionality	Wide-angle transmitter and receivers
	Minimize path loss and reception of ambitent light noise		Convenient to use, for mobile terminals
Non light of sight	Rely upon reflection of the light from ceiling or some other diffusely reflecting surface Increase link robustness and ease of use Allowing the link to operate even when barriers Referred to as a Diffuse link		

The important parameter to get the high data rates is avaibility of line-of-sight(LOS) optical link. A non-directed LOS transmission is like to limit the achievable data rates. While the lightening scenario may vary, it is important to adaption a dynamic rate to achieve a robust VLC link. According to LOS is maybe no longer needed. K.D. Langer built rate-adaptive visible light communication at 500Mbps arrives at plug and play. He developed a bidirectional high-speed real time VLC system.

IV. PERFORMANCE OF LIFI

Efficiency and safety are issues now. LiFi was found in 2011 by Scientist Harold Hass from UK. The design is to overcome the disadvantage of WiFi. The speed of WiFi is upto 1500mbps and it is not sufficient to accommodate a huge user.

Table 3. speed and standards of WiFi

Standard	Release date	Max Speed
802.11b	1999	11 Mbps
802.11a	1999	54 Mbps
802.11g	2002	54 Mbps
802.11n	2007	72-600 Mbps
802.11ac	2013	433 Mbps – 1.3 Gbps

Table 4. Speed of LiFi

Reference	Modulation	Data
[1]	OOK	803 Mbps
[2]	OFDM	2.1 Gbps
[3]	DMT	3.4 Gbps
[4]	PPM	30 Mbps
[5]	PAM	20 Mbps
[6]	CAP	1.1 Gbps

LiFi enabling the system using fully networked wireless communication and could provide a connection that's 100 times faster than WiFi. It can reach speeds up to 3Gbps by using DMT modulation. The other speed of LiFi with the different modulation also shown in above table. M.D.Renzo et all using Spatial Modulation for MIMO Wireless System in LiFi, the transmit speed is up to 10Gbpss. The rate speed of LiFi can be higher than 3Gbps while the technology is on research and developing. The rate speed of LiFi is based on the using of the modulation. Dr. P. Kuppusamy et. All doing a survey of LiFi and comparing it with WiFi there are sereval characteristics that used for comparing. The difference of WiFi and LiFi is shown in below table 5.

Table 5. Difference of WiFi and LiFi

Parameter	LiFi	WiFi
Transmitter and Receiver	LED	Antenna
Inbuilt device	Under research and development	WiFi card/chip
Average operation speed	Greater than 10Gbps	150-600 Mbps
Frequency band	1000 times of THz	2.4 GHz
Standard	IEEE 802.15.xx	IEEE 802.11xx
No. of users	Alll over under the lamp	Depend on access point
Coverage area	10 meters	20-100 meters varies based on type of transmission power and antenna
Interface	No interface issues with RF waves	Interface with neighbor AP routers
communication	Based on VLC	Based on radio frequency comm.
efficiency	More, LEDs consume less energy and highly efficient	Less, radio base stations consume high amount of energy
secure	More, light cant penetrate through walls and can't be intercept by anyone outside the illumination of LED	Less, high pentrating power of radiowaves and anyone can intercept
suitability	Suitable for high data rates and secure communication	Suitable for Aps with high coverage regions

V. WHY LIFI OVER WIFI

Spectrum

the spectrum available for WiFi is limited to an area near 5 Ghz, while LiFi information is transmitted on beams of light, whose range is an enormous chunk of electromagnetic spectrum, clustered around 500,000 Ghz. Thus, the range of frequencies available to transmit LiFi data is virtually limitless. Because of this, LiFi has the capacity to absorb any amount of users transmitting any amount of data, while even now, there is some danger of WiFi running out of room in congested areas.

Maturity

Maturity is an advantage for WiFi. This stable technology is well-established, with a mature and slowly evolving set of standards that are easy for manufacturers to adhere to. In addition, a wide array of compatible, predictable hardware and software products are available for designers to rely on.

Signal penetration

Light waves and radio waves, which are the basis of WiFi and LiFi, differ vastly on what they can pass through and what stops them. For example, solid walls stop light light waves, so this can be interpreted as built-in security for LiFi, as restricted information will not be available to outsiders, Yet light waves will transmit through water, which will be useful for a wide range of industrial, military, and IoT purposes.
Range and transmission capacity

A single modulated LED can transmit over a range of about 10 meters, but there is no reason that a much wider range isn't possible with multiple LEDs spaced over a wider area. WiFi's effective range is about 30 meters. Typical transmission capacities for both services are in order of 1 Gbps, but both WiFi and LiFi have inherent capacity for much higher rates.

As of this writing, WiFi is the undisputed champion of wireless data transmission. There is definite interest in LiFi on the part of manufacturers, but the technology hasn't reached any kind of critical mass as of yet. But based on the several conditional advantages that LiFi does enjoy, and limitations of WiFi spectrum avaibility, it's safe to expect considerable interest in LiFi over the coming years.

VI. CHALLENGES TO LIFI

Modulation

The key of LiFi communication is the using of modulation. A modulation in LiFi is to carry a binary data by turning the LED on and off quickly. There are many aspects in LiFi related to modulation, illumination and dimming scheme is the first concern. Illumination is the spread of the light that making the LEDs can be as a media in data communication. The challenge is how the modulation is enabling the illumination of LEDs in order can send the data while the illumination is low. While the dimming process is to proportional of LEDs brightness. The challenge in dimming technology is how the LiFi can fulfill the user satisfaction in order the dimming of LED can stay safe for the user .

Interference

In optical illumination based on data communication, the hard part is to provide the optical uplink service. It is because the uplink service can interfere the downlink signal. These problem is one of the challenge in the interference signal issue. In LiFi, the transmitter should be able to maintain a directional link during the transmission.

Infrastucture

The basic infrastructure in LiFi is indoor and outdoor. Same as in the optical characteristic, a LiFi also has an effect shadowing while transmission. This shadowing effect off course will give an effect in the process of sending and receiving the data. There is a few research about the effect of shadowing in the LiFi communication.

Security

According to a threat like eavesdropping can happen in LiFi. It happens when there is gap between the floor and the door, the light may spread out between them. The crack from inside floor and shielded windows also can be a leakage.

Coverage

LiFi 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 LiFi needs to be set up in order the quality of connection can give a good performance. According to LiFi is integrated with the WiFi to get a good performance in an outdoor or in a mobile infrastructure.

VII. CONCLUSION

In this paper, we outlined the working of LiFi, the modulation that its used, the architecture, the performance, and at last the challenges. The purpose of LiFi technology is to provide a high-speed data communication using visible light spectrum. Now LiFi is on-going of research, it has a potential advantage that can make a supplement RF communication and can be used to improve wireless network performance. Although LiFi has a good performance in the transfer rate, LiFi is not good enough when deploy in an outdoor in sunlight or other condition. LiFi will probably not completely replace WiFi, these two technologies can be used together to achieve more efficient and secure network. Paris is one place that has been implemented the LiFi technology. There are offices, hospitals, retail stores, public street lighting as well as metro station at Defense, and Curtius museum in Liege in 2012. The four key criteria that is used are: the LiFi can operate within a complex physical environment, the system can provide the bi-directional communication, traffic and security information can be pushed to smartphones, system of audio-messaging is developed to enable tourist and people to be guided.

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