

# LI-FI TECHNOLOGY TRANSMISSION OF DATA THROUGH LIGHT

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**Abstract**—Li-Fi stands for Light-Fidelity. Li-Fi technology, proposed by the German physicist—Harald Haas, provides transmission of data through illumination by sending data through an LED light bulb that varies in intensity faster than the human eye can follow. This paper focuses on developing a Li-Fi based system and analyzes its performance with respect to existing technology. 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 interference issues. Li-Fi provides better bandwidth, efficiency, availability and security than Wi-Fi and has already achieved blisteringly high speed in the 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 communicate through their headlights. Haas envisions a future where data for laptops, smart phones, and tablets will be transmitted through the light in a room.

**Index Terms** - Li-Fi, Wi-Fi, high-brightness LED, photodiode, wireless communication.

## I. INTRODUCTION

Transfer of data from one place to another is one of the most important day-to-day activities. The current wireless networks that connect us to the internet are very slow when multiple devices are connected. As the number of devices that access the internet increases, the fixed bandwidth available makes it more and more difficult to enjoy high data transfer rates and connect to a secure network. But, radio waves are just a small part of the spectrum available for data transfer. A solution to this problem is by the use of Li-Fi. Li-Fi stands for Light-Fidelity. Li-Fi is transmission of data through illumination by taking the fiber out of fiber optics by sending data through an LED light bulb (shown in Fig. 1) that varies in intensity faster than the human eye can follow[1]. Li-Fi is the term some have used to label the fast and cheap wireless communication system, which is the optical version of Wi-Fi. Li-Fi uses visible light instead of Gigahertz radio waves for data transfer [2].

The idea of Li-Fi was introduced by a German physicist, Harald Haas, which he also referred to as data through illumination. The term Li-Fi was first used by Haas in his TED Global talk on Visible Light Communication. According to Haas, the light, which he referred to as D-Light, can be used to produce data rates higher than 10 megabits per second which is much faster than our average broadband connection [3]. Li-Fi can play a major role in relieving the heavy loads which the current wireless systems face since it adds a new and unutilized bandwidth of visible light to the currently available radio waves for data transfer. Thus it offers much larger frequency band (300 THz) compared to that available in RF communications (300GHz). Also, more data coming through the visible spectrum could help alleviate concerns that the electromagnetic waves that come with Wi-Fi could adversely affect our health [4]. Li-Fi can be the technology for the future where data for laptops, smart phones, and tablets will be transmitted through the light in a room. Security would not be an issue because if you can't see the light, you can't access the data. As a result, it can be used in high security military areas where RF communication is prone to eavesdropping. In sec II we have explained the working. In section IV we have compared Wi-Fi and Li-Fi. And in section VI we have concluded.

## II. WORKING OF LI-FI

A new generation of high brightness light-emitting diodes forms the core part of light fidelity technology. The logic is very simple. If the LED is on, a digital 1 is transmitted. If the LED is off, a digital 0 is transmitted. These high brightness LEDs can be switched on and off very quickly which gives us a very nice opportunities for transmitting data through light [5]. The working of Li-Fi is very simple. There is a light emitter on one end, for example, an LED, and a photo detector (light sensor) on the other. The photo detector registers a binary one when the LED is on; and a binary zero if the LED is off. To build up a message, flash the LED numerous times or use an array of LEDs of perhaps a few different colors, to obtain data rates in the range of hundreds of megabits per second [6]. The block diagram of Li-Fi system is shown in Fig. 4



Fig. 1. Li-Fi bulb [8]

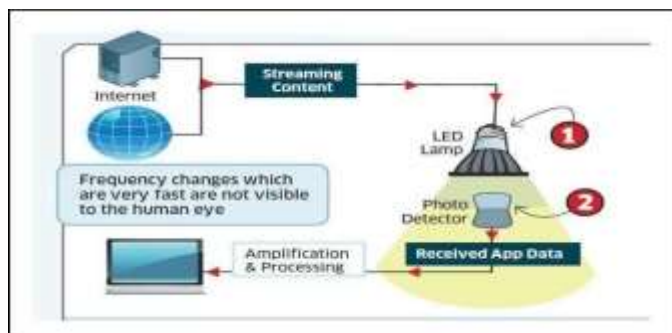


Fig. 2. Block diagram of Li-Fi system [6]

The data can be encoded in the light by varying the flickering rate at which the LEDs flicker on and off to generate different strings of 1s and 0s. The LED intensity is modulated so rapidly that human eye cannot notice, so the light of the LED appears constant to humans [6]. Light-emitting diodes (commonly referred to as LEDs and found in traffic and street lights, car brake lights, remote control units and countless other applications) can be switched on and off faster than the human eye can detect, causing the light source to appear to be on continuously, even though it is in fact 'flickering'. The on-off activity of the bulb which seems to be invisible enables data transmission using binary codes: switching on an LED is a logical '1', switching it off is a logical '0'. By varying the rate at which the LEDs flicker on and off, information can be encoded in the light to different combinations of 1s and 0s. This method of using rapid pulses of light to transmit information wirelessly is technically referred to as Visible Light Communication (VLC), though it is popularly called as Li-Fi because it can compete with its radio-based rival Wi-Fi. Figure 5 shows a Li-Fi system connecting devices in a room [7].



Fig. 3. Li-Fi system connecting devices in a room

Many other sophisticated techniques can be used to dramatically increase VLC data rate. Teams at the University of Oxford and the University of Edinburgh are focusing on parallel data transmission using array 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 frequency encoding a different data channel.

### III. RECENT ADVANCEMENTS IN LI-FI

Using a standard white-light LED, researchers at the Heinrich Hertz Institute in Berlin, Germany, have reached data rates of over 500 megabytes per second [1]. Using a pair of Casio smart phones, the technology was demonstrated at the 2012 Consumer Electronics Show in Las Vegas to exchange data using light of varying intensity given off from their screens, detectable at a distance of up to ten meters [1]. A consortium called *Li-Fi Consortium* was formed in October 2011 by a group of companies and industry groups to promote high-speed optical wireless systems and overcome the limited amount of radio based wireless spectrum. According to the Li-Fi Consortium, it is possible to achieve more than 10 Gbps of speed, theoretically which would allow a high-definition film to be downloaded in just 30 seconds [1]. Researchers at the University of Strathclyde in Scotland have begun the task of bringing high-speed, ubiquitous, Li-Fi technology to market [11].

### IV. COMPARISON BETWEEN LI-FI & WI-FI

Li-Fi is the name given to describe visible light communication technology applied to obtain high speed wireless communication. It derived this name by virtue of the similarity to Wi-Fi. Wi-Fi works well for general wireless coverage within buildings, and Li-Fi is ideal for high density wireless data coverage inside a confined area or room and for relieving radio interference issues.

Table I shows a comparison of transfer speed of various wireless technologies. Table II shows a comparison of various technologies that are used for connecting to the end user. Wi-Fi currently offers high data rates. The IEEE 802.11.n in most implementations provides up to 150Mbit/s although practically, very less speed is received.

#### Advantages of Li-Fi

Li-Fi technology is based on LEDs or other light source for the transfer of data. The transfer of the data can be with the help of all kinds of light, no matter the part of the spectrum that they belong. That is, the light can belong to the invisible, ultraviolet or the visible part of the spectrum. Also, the speed of the communication is more than sufficient for downloading movies, games, music and all in very less time. Also, Li-Fi removes the limitations that have been put on the user by the Wi-Fi.

- Capacity: Light has 10000 times wider bandwidth than radio waves [5]. Also, light sources are already installed. So, Li-Fi has got better capacity and also the equipment's are already available.
- Efficiency: Data transmission using Li-Fi is very cheap. LED lights consume less energy and are highly efficient.
- Availability: Availability is not an issue as light sources are presents everywhere. There are billions of light bulbs worldwide; they just need to be replaced with LEDs for proper transmission of data.
- Security: Light waves do not penetrate through walls.

So, they can't be intercepted and misused. With the advent of Li-Fi, now it is not mandatory to be in a region that is Wi-Fi enabled to have access to the internet. One can simply stand under any form of light and surf the internet as the connection is made if light is on.

Technology	Speed
Wi-Fi – IEEE 802.11n	150 Mbps
Bluetooth	3 Mbps
IrDA	4 Mbps
Li-Fi	>1 Gbps

Technology	Connection	Security	Reach	Impact	Cost	Bandwidth Expansion
Wi-Fi	Wireless- EMF	Good	Excellent	unknown	Good	Limited
Hardwired	Cables	Excellent	Fair	None	Good	Limited
Li-Fi	Wireless- Light	Excellent	Excellent	None	Low	Exceptional

## V. APPLICATIONS OF LI-FI

There are numerous applications of this technology, from public internet access through street lamps to auto-piloted cars that communicate through their headlights. Applications of Li-Fi can extend in areas where the Wi-Fi technology lacks its presence like medical technology, power plants and various other areas. Since Li-Fi uses just the light, it can be used safely in aircrafts and hospitals where Wi-Fi is banned because they are prone to interfere with the radio waves. All the street lamps can be transferred to Li-Fi lamps to transfer data. As a result of it, it will be possible to access internet at any public place and street. Some of the future applications of Li-Fi are as follows:

Education systems: Li-Fi is the latest technology that can provide fastest speed internet access. So, it can replace Wi-Fi at educational institutions and at companies so that all the people can make use of Li-Fi with the same speed intended in a particular area. Medical Applications: Operation theatres (OTs) do not allow Wi-Fi due to radiation concerns. Usage of Wi-Fi at hospitals interferes with the mobile and pc which blocks the signals for monitoring equipment's so, it may be hazardous to the patient's health. To overcome this and to make OT tech savvy Li-Fi can be used to in presents.

## VI.CONCLUSION

There is a plethora of possibilities to be gouged upon in this field of technology. If this technology becomes justifiably marketed then every bulb can be used analogous to a Wi-Fi hotspot to transmit data wirelessly. By virtue of this we can ameliorate to a greener, cleaner, safer and a resplendent future. The concept of Li-Fi is attracting a lot of eye-balls because it offers a genuine and very efficient alternative to radio based wireless. It has a bright chance to replace the traditional Wi-Fi because as an ever-increasing population is using wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This concept promises to solve issues such as the shortage of radio-frequency bandwidth and boot out the disadvantages of Wi-Fi. Li-Fi is the upcoming and on growing technology acting as competent for various other developing and already invented technologies. Hence the future applications of the Li-Fi can be predicted and extended to different platforms and various walks of human life.

Accessing internet and to control medical equipment's. This can even be beneficial for robotic surgeries and other automated procedures.

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