

# Li-Fi the Next Generation of Wireless Communication through Visible Light Communication (VLC) Technology

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## ABSTRACT

Li-Fi stands for Light-Fidelity. This technology is very new and was proposed by the German physicist Harald Haas in 2011. Light based communication system is the backbone of the future of the communication system. Li-Fi is a wireless technology that uses light emitting diodes (LEDs) for transmission of data. The development of the wireless communication leads to advance research in LiFi technology. The term Li-Fi states to visible light communication (VLC) technology that uses as medium to deliver high-speed communication in a fashion similar to Wi-Fi. Li-Fi comprises a wide range of frequencies and wavelengths, from the Infrared through visible and down to the Ultraviolet spectrum. The immense use of Li-Fi may solve some bottleneck of data transmission in Wi-Fi technology. With the innovation in technology and the number of users, the existing radio-wave spectrum fails to accommodate this need. To resolve the issues of scalability, availability and security, we have come up with the concept of transmitting data wirelessly through light using visible light communication (VLC) technology. This paper objective is to study and describe the LiFi technology. The improvement of the wireless communication leads to advance research in LiFi technology through Visible Light Communications (VLC) Technology.

**Keywords :** Visible Light Communications (VLC), Light Emitting Diodes (LEDs), Radio Frequency (RF), Infrared (IR), Remotely Operated Vehicles (ROVs), Line of Sight (LOS).

## I. INTRODUCTION

With incessantly growing needs of telecommunication world, there is an increased thrust for higher bandwidth that facilitates faster and secure data transmission. Present telecommunication industry relies on radio waves of electromagnetic spectrum for data transmission. Inappropriately, the radio wave spectrum has certain key limitations: Capacity, Efficiency, Availability and Security. So using the Light Emitting Diodes that offers in the transmission of data much faster and reliable than the data that can be transmitted through Wi-Fi. Li-Fi is a wireless communication system in which light is used as a

carrier signal instead of traditional Radio Frequency as in Wi-Fi. Li-Fi technology communicates with the help of Visible Light Communication (VLC) spectrum and has no side effect as we know the light is very much part of our life and so much faster. Moreover Li-Fi makes possible to have a wireless Internet in specific environments, where Wi-Fi is not allowed due to interferences or security considerations.

## II. BACKGROUND

The history of wireless communication based on electromagnetic waves dates back to the Photophone, invented by Alexander Graham Bell in the late 19th

century. It was the first device used to communicate without wires and Bell's invention used the light produced by the sun to carry the information [6]. There are around 1.4 million cellular staff radio waves base stations installed, with over 5 billion mobile phones.

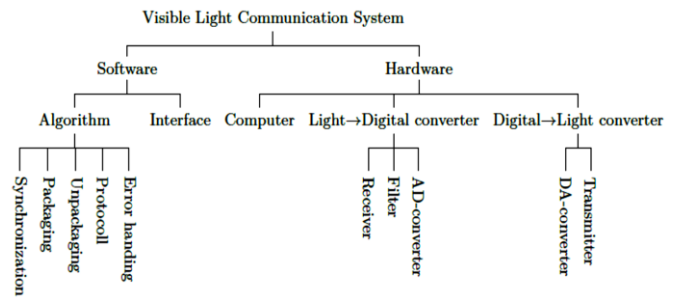
Mobile phones transmit over 600TB of data. With the advancement in technology and the number of users, the existing radio wave spectrum fails to satisfy to this need [1]. A new generation of wireless communications is considered as the fourth stage of the revolution mobile trade. This enables connectivity between different objects and machines all over the world [2]. Currently internet have become a major demand; people are in search of Wi-Fi hot spots. This is the advanced scenario in today communication system which enables the need of LEDs, Light Emitting

Diodes that provides in the transmission of data much faster and reliable than the data that can be transmitted through Wi Fi [3].

### III. METHODS AND MATERIAL

#### A. ISSUES IN WIRELESS COMMUNICATION

Transfer of data from one place to another is one of the most important daily activities. When the multiple devices are connected to the existing wireless networks that connect us to the internet are very slow. As the number of devices increasing the internet access, the fixed bandwidth which is available makes it more and more difficult to utilize high data transfer rates and connect to a 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 the proposed system LiFi. Li-Fi is transmission of data through light by sending data through an LED bulb that varies in intensity faster than the human eye can follow and the faster data



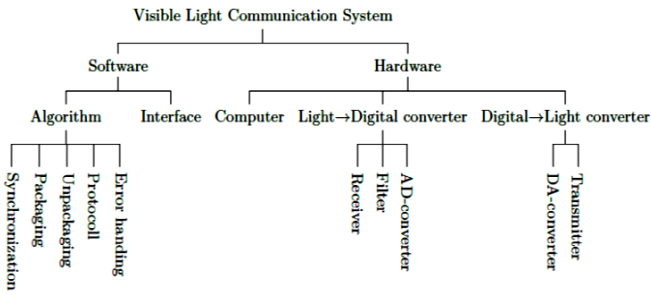
transmission speed. Li-Fi is the new technology has used to label the fast and cheap wireless communication system, which is the next optical version of Wi-Fi [4]. With the innovation in technology and the number of users, the existing radio-wave spectrum fails to accommodate this need. To resolve the issues of scalability, availability and security, we have come up with the concept of transmitting data wirelessly through light using visible light communication (VLC) technology.

#### B. VISIBLE LIGHT COMMUNICATION (VLC) SYSTEMS

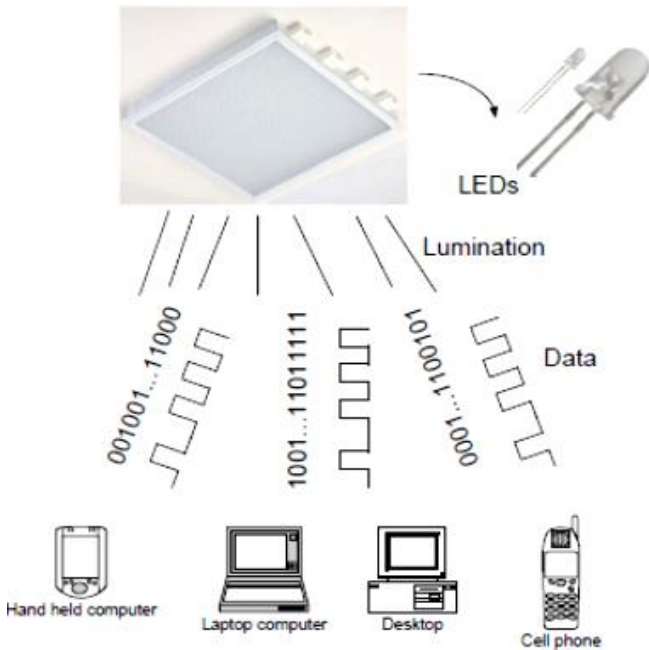
Visible Light Communication (VLC) has enlarged great interest in the last decade due to the quick developments in Light Emitting Diodes (LEDs) fabrication. Efficiency, durability and long life span of LEDs make them auspicious residential lighting equipment as well as alternative cheap and fast data transfer equipment [5]. One of the ideas laid forward for wireless optical communication is the visible light communication method. The signals in the 380-780 nm wavelength interval of the electromagnetic spectrum are the light signals that can be detected by the human eye. It is possible to attain illumination and data transfer simultaneously by means of LEDs that is the prominent lighting equipment lately. By this way, both internal lighting of a room and data transfer will be attained without the need of an additional communication system. This technology is given the name of Visual Light Communication [6].

Fundamental entries in a VLC system are the transmitter (LEDs), receivers (photo detectors),

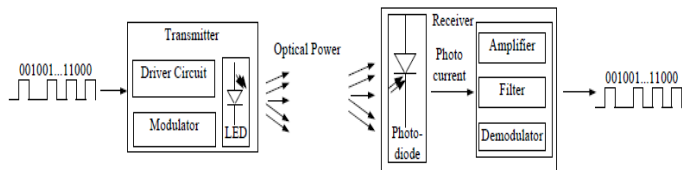
modulation of data to optics and the optical communication channel as shown in Fig -3:



**Fig -1:** Visible Light Communication (VLC) Systems [6]



**Fig -2:** Basic VLC configuration [5]



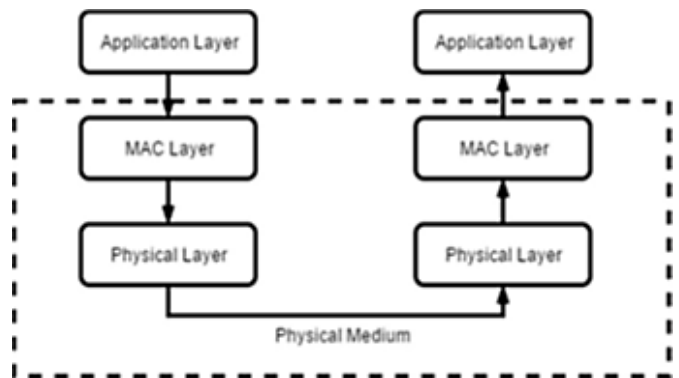
**Fig -3:** Block diagram of a VLC architecture [5]

**C. LED (LIGHT EMITTING DIODE) VLC TECHNOLOGY**

LED (Light Emitting Diode) Visible Light Communications (VLC) systems are familiar as creating a possible valuable addition to future generations of technology, which have the potential to utilize light for the purposes of advanced

technological communication at ultra-high speed greater than that of current wireless systems. One of the goals of researchers is to allow 100 megabits of data transference per second (Mbps) in offices and homes by modulation of light from promoted lighting systems. If it is developed correctly, the possibility exists that many of the problems associated with present day infrared, radio wave and microwave communications systems could be at least partially resolved, and a more biologically friendly system made existing to industries and the general public.

An auxiliary advantage is that VLC systems can transmit data more securely over short distances than radiofrequency/microwave communications devices whose signals can be easily detected outside the rooms and buildings they invent in [7].



**Fig -4 :** Layered architecture of VLC

**D. WHY USE VISIBLE LIGHT COMMUNICATION (VLC)**

- ✚ The Gamma rays cannot be used as they could be dangerous [10].
- ✚ X-rays has related 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 [10].
- ✚ Radio waves penetrate through the walls so they arises security issues.

✚ Hence we left with the only the visible- “Light Spectrum”.

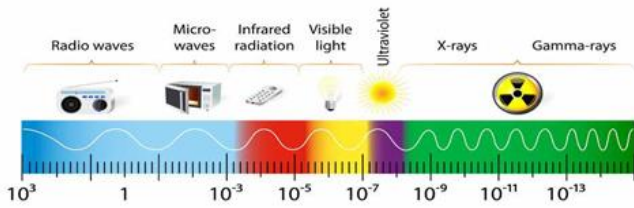


Fig -5: The Electromagnetic Spectrum

### E. WHAT IS LI-FI?

Li-Fi is a Visible Light Communications (VLC) system. Like Wi-Fi it's a bidirectional wireless communication technology. But, where Wi-Fi uses radio waves to transmit data, Li-Fi uses visible light from LED light bulbs fitted with a special chip. It's a little like Wi-Fi, but has reached speeds 100 times faster in testing, making it far more suited to the demands of the future of data [8]. Li-Fi and Wi-Fi are quite similar as both transmit data electromagnetically.

However, Wi-Fi uses radio waves while Li-Fi runs on visible light. As we now know, Li-Fi is a Visible Light Communications (VLC) system. This means that it accommodates a photo-detector to receive light signals and a signal processing element to convert the data into 'stream able' content [9].

### F. LI-FI IS A WIRELESS TECHNOLOGY?

Li-Fi is a wireless technology as it uses visible light communication or infrared or even near ultraviolet spectrum. It does not use the radio frequency like the Wi-Fi technology we use today [10].

### G. LIFI SYSTEM CONSTRUCTION [11]

LiFi uses pulses of light to transmit data over wireless networks. The main mechanisms of LiFi systems are:

✓ High brightness white LED, which acts as the transmission source.

✓ A good silicon photodiode, as a receiving element.

By using LiFi, it is possible to get the high speed of 100Mbps and more with the help of various multiplexing techniques. The LiFi emitter system consists of 4 main subassemblies:

- Bulb
- RF power amplifier circuit (PA)
- Printed Circuit Board (PCB)

### H. WORKING STYLE OF LIFI

It is applied by using a light bulb at the downlink transmitter. Normally the light bulb glows at a constant current supply however fast and elusive variations in current can be made to produce the optical outputs since it just uses the light, hence can be easily applied to any such area where radio frequency communication is often challenging [11]. The source of light continuously appears because the LED can be turned ON and OFF quickly and the amount is rapidly modulated that human eye cannot fastening even though it is flickering. The LEDs activity of ON-OFF which invisible and enables the transmission of data using the binary codes i.e. 0s and 1s, for switch ON LED it is a logical '1', and for switch OFF LED it is a logical '0'. This method of using rapid pulses of light to transmit information wirelessly is technically referred to as visible light communication (VLC) [12].

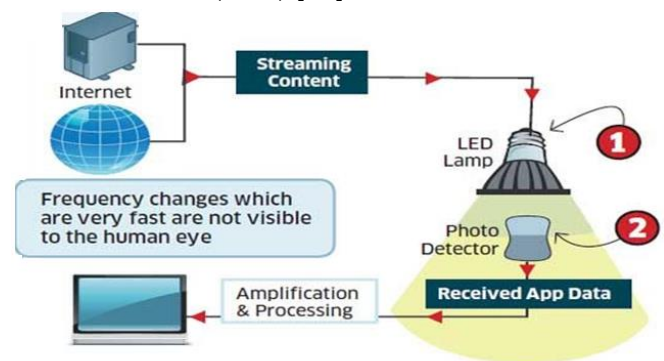


Fig -6: Innovative Architecture for Future Li-Fi Wireless Technology

## ❖ TRANSMITTER

LED is used as the transmitter or sender of signal here. The wavering in the LED is basically the signal that is to be sent. The quick ON (transmits 1) and OFF (transmits 0) of the LED is used to encode a string of data signal. Now this technique can be upgraded by using multiple LEDs or LEDs of different colours like red, green, blue for more complex data communications. Tentatively, the speed of data communication through Li-Fi can be up to 10Gbps [13].

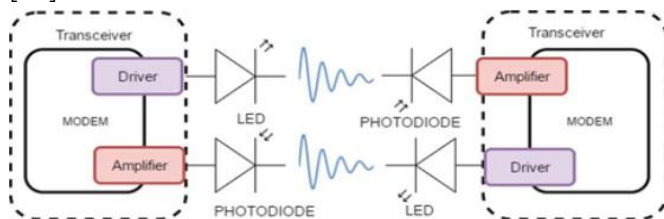


Fig -7: Transceiver LiFi based on VLC

## ❖ RECEIVER

Since Li-Fi uses visible light to transmit data, it is important to convert them into digital signals with the help of modulation. It includes silicon photo diode which shows good response to visible wavelength, optical concentrator and filter and an amplifier. The optical concentrator is used to compensate for high spatial attenuation due to the beam divergence from the LEDs to illuminate large area [13].

## IV. RESULTS AND DISCUSSION

### A. ADVANTAGES OF LI-FI

- ✚ High speed.
- ✚ High Data Transfer Rate.
- ✚ High Connectivity.
- ✚ Highly Secured and Reliable.<sup>[14]</sup>
- ✚ Low Cost.
- ✚ Use Light as carrier.
- ✚ Very high operating frequency.

- ✚ Li-Fi makes use of a free band that does not prerequisite any licensing.<sup>[15]</sup>
- ✚ Li-Fi Can be used securely in aircrafts without affecting airline signals unlike Wi-Fi.
- ✚ The issues of the scarcity of radio frequency bandwidth can be sorted out by Li-Fi.<sup>[15]</sup>
- ✚ Li-Fi also known as Green information technology as it does not effect on the birds, human body's etc. corresponding to the radio waves or any other communication waves. Li-Fi does not have any side effect on any living thing. <sup>[17]</sup>

### B. DISADVANTAGES OF LI-FI

- ✚ High Power Required.
- ✚ Low Range.
- ✚ Reflection of light takes place. <sup>[14]</sup>
- ✚ Cannot penetrate into walls.
- ✚ Reliability and Network coverage are also major issues.
- ✚ Any interference from the exterior light sources like normal bulbs, opaque materials in the route of transmission will cause disturbance in communication.<sup>[16]</sup>

### C. APPLICATIONS AREAS OF LI-FI

#### A. Educational Systems

Li-Fi is the latest technology that can provide fastest speed for Internet access. So, it can be a good alternative of Wi-Fi at educational institutions and at companies so that the people there can make use of Li-Fi with the high speed.

#### B. Traffic Management

In traffic signals Li-Fi can be used to communicate with passing vehicles (through the LED lights of the Vehicles) which can help in managing the traffic in a better manner resulting into smooth flow of traffic

and controlling the traffic struck and increasing accident ratios in developing countries. The LED car lights can alert drivers when other vehicles are too close via LiFi technology.

**C. Better Replacement for Other Technologies**

Li-Fi uses Visible Light Communication Technology (VLC) Instead of Radio Waves. So, it can be easily installed at those places where Bluetooth, Infrared, Wi-Fi can't work properly.

**D. Underwater Applications**

Li-Fi can even work underwater where Wi-Fi fails completely, if the cables of the Remotely Operated Vehicles (ROVs) which operate at a long distance from the surface are replaced with light (LEDs), which is water-logged then it is easier to access the internet [16].

**E. Exclusive Medical Applications**

Wi-Fi cannot be installed at Hospitals/Operation Theatres/Medical Laborites as these radio waves can interfere with the Cellphones/Tablets PC which can block the signals for monitoring equipments thus proving hazardous to the patient's health. Usage of Li-Fi provides more advanced monitoring techniques and operation strategies.

**F. Cheaper Internet in Aircrafts**

The passengers travelling in aircrafts have to prescribes to put their electronic devices in the Flight Mode or No Internet Mode, because in an aircraft as these signals may interfere with the navigation signals. So, Wi-Fi is practically impossible in this scenario.Li-Fi can easily provide high speed Internet via every light source such as overhead reading LEDs present inside the airplane.

**Difference between LIFI and WIFI**

Parameters	Li-Fi	Wi-Fi
Transmitter	LED	Antenna
Frequency	band 1000 times of THz	2.4 GHz
Standard	IEEE 802.15.xx	IEEE 802.11xx
No of users All over	Under The Lamp.(LEDs)	Depend on access Point.
Data Transmission	Bits	Radio waves
Topology	Point to Point	Point to Multipoint
Communication	Based on Visible Light Communication (VLC).	Based on Radio Frequency Communication
Availability	Anywhere, available in Airplanes and Underwater	Limited
Power Consumption	Less	More
Environment Impact	Low	Medium
Cost	Low	High
Bandwidth	Unlimited	Limited

**G. Industrial Automation**

Anywhere in industrial areas data has to be transmitted, Li-Fi is capable of interchanging slip rings, sliding contacts and short cables, such as Industrial Ethernet. Due to the real time capability of Li-Fi, it is also an alternative to common industrial Wireless standards.

**H. Safety Environments**

In explosion risk environments, the use of electrical equipment, including mobile phones, is generally greatly restricted. The use of Li-Fi to pass data will simplify the configuration of data networks in such



environments, and can permit new systems to enhance security in these environments [19].

## V. CONCLUSION

Li-Fi is the trend of today and near future. It is one of the cheapest and efficient modes of data transfer. It surely can replace the traditional Wi-Fi networks and can further be extended to different platforms to make it easily accessible and portable which will thus cater to the growing demands of the increasing population. One of limitation however is that it only works in direct line of sight (LOS) but this would solve the problems like the shortage of radio-frequency bandwidth and allow internet (WI-FI) to be used in places and situations where it cannot be used currently like the hospitals or aircrafts. There are billions of light bulbs worldwide, they just need to be replaced with LEDs ones that transmit data. Visible Light Communication (VLC) is very cheaper to Wi-Fi because it uses light rather than radio-frequency signals.

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