

# A Brief Introduction of the Li-Fi Technology, its Implementations and Applications

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**Abstract-** The use of LEDs is not limited only to illumination, but can be used to transmit data at a much higher rate in comparison to Wi-Fi. The mechanism is called Li-Fi and uses VLC (Visible Light Communication) for the transfer of data. Light Fidelity is abbreviated as Li-Fi. This paper draws attention on the construction, working and application of the Li-Fi system.

**KEYWORDS-** Li-Fi, Wi-Fi, VLC, photodiode, wireless communication

## 1. INTRODUCTION

Presently, the wireless communication that we are using is through radio waves which have got a number of disadvantages being primarily the radiations that harm the human body. The other disadvantages include the slow speed. The remedy to this slow speed and harmful radiations is Li-Fi (Light Fidelity). Li-Fi was first introduced by Harald Hass in a TED talk in Edinburgh, UK. Li-Fi uses VLC (visible light communication) for the transmission of data, thus its speed being 1000 times faster than Wi-Fi [1]. Li-Fi is the transmission of data through illumination by taking the fiber out of fiber optics by sending data through an LED light bulb that varies in intensity much faster than the human eye can follow [2]. Since the reach of Li-Fi is within the reach of the illumination, hence it is safe from being hacked and thus is more secure. The difference between VLC and Li-Fi is that VLC has a unidirectional, point-to-point light communication at low data rates while Li-Fi introduces advanced networking capabilities, higher speed, and multiple access. Li-Fi is fully networked, bidirectional, and high-speed wireless communication using light [3].

Li-Fi can be also called optical Wi-Fi since it uses visible light for the transmission of data unlike Wi-Fi that uses radio waves. Due to low cost and availability of LEDs, we can use the Li-Fi technology for attaining a greater speed in all the places, e.g. It can be used in the headlight of cars to receive data so that accidents do not occur, it can be used in our houses to access data at a very high speed, it can be used in underwater transmission, etc.

This paper explains the new Li-Fi technology, its basic architecture, working, applications, and how this new technology can surpass all the other technologies we have now. It includes future research based on mobile and other applications.

## 2. WORKING OF LI-FI

Li-Fi works on the Visible Light Communication principle. The data is sent in the form of binary bits. The working is very simple: When the transmitter transmits the signal, the transmitted data is sent in like 1 or 0 which are binary bits. The transmission of digital 1 means that the signal should switch 'ON' the output while the transmission of digital 0 means the output should be switched 'OFF'. This transmission of binary bits 1 or 0 happens so fast that it is out of reach of human eye, it appears as a continuous glow to our eye [4].

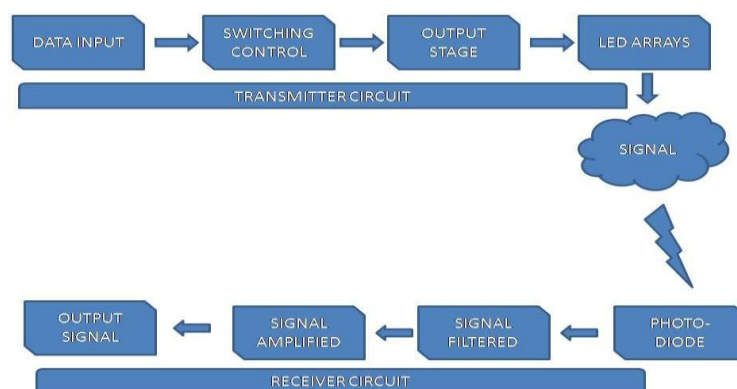


Figure1. Working of Li-Fi technology

Figure1 shows the basic working of Li-Fi. The data is transmitted by the transmitter in the form of binary bits 1 and 0, which is transmitted through an LED light connected to it. The LED driver then rectifies the higher voltage, alternating current to low voltage, direct current. The on-off activity of the LED transmitter enables data transmission in the form of light with the incoming binary codes: switch 'ON' means that the transmitter is sending '1', and switch 'OFF' means that signal '0' is transmitted. The rate of flickering of the LED signal is so fast that it is unnoticed with the human eye and by varying which a different output can be obtained in the receiver. {An example of the signal send is shown in figure2}. The receiver in the form of a photodiode (a light detector) detects the light coming from the LED which is then amplified, processed, and received by the receiver connected to the output.



**Figure2.** Data transmitted in the form of binary bits '1' and '0'

Source: (<https://www.aircraftinteriorsinternational.com/features/li-fi-the-next-big-thing-in-inflight-connectivity.html>)

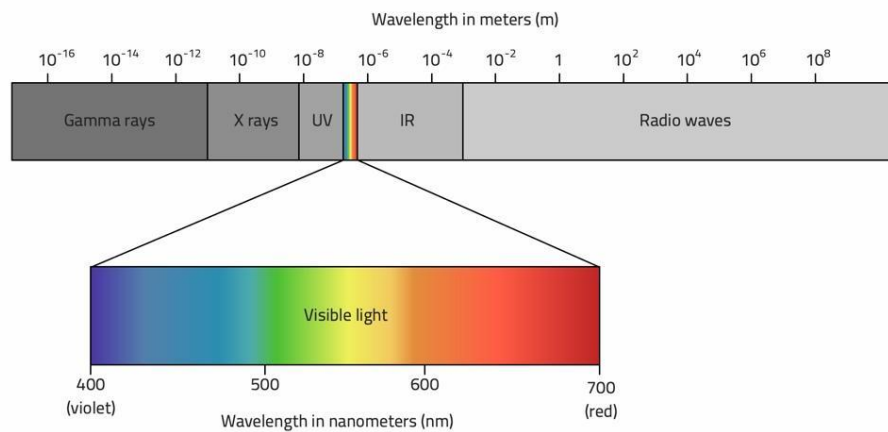
### 3. WHY VISIBLE LIGHT COMMUNICATION?

The electromagnetic spectrum has many wave regions {as shown in Figure 3}:

Gamma rays, X-Rays, UV rays, Visible light rays, Infrared waves and radio waves. Any of the above waves could be used in attaining the data transmission technique. But the selection of Visible Light Communication in attaining data transmission has many benefits over the other above mentioned waves:

- Gamma rays are ionizing radiations and are biologically hazardous. Since Gamma rays have high penetration power, they can harm internal organs.
- X-rays also have health-related issues. Exposure to high radiation levels can cause vomiting, bleeding, fainting, hair loss, etc.
- UV rays have also got health issues. Exposure to Ultraviolet rays can cause premature aging of the skin, wrinkles, etc. They can cause the cornea to become inflamed.
- Infrared rays due to its harmful radiation towards the human body cannot be used in data transmission. It can cause premature skin aging and inflammatory cellular infiltration.
- The radio-waves which we are using in day-to-day life are expensive and have less security. It is also harmful to the human body.

We see that all the waves that are above mentioned have some disadvantages related to health issues and we cannot compromise on that. But Visible light rays have no health-related issues and are easily available everywhere and are very cheap. Thus, we can use Visible light rays for data transmission.



**Figure3.** Electromagnetic spectrum

Source: (<https://www.radio2space.com/components-of-electromagnetic-spectrum/>)

**Table 1.** Technology with respect to their speed

Technology	Speed
Wi-Fi	~100Mbps
Bluetooth	~4Mbps
Li-Fi	~1Gbps
NFC	(100kbps to 424kbps)

#### 4. HISTORY OF LI-FI

The term Li-Fi was first coined by Harald Hass during a 2011 TED Global talk in Edinburgh. Haas promoted this technology in his 2011 TED Global talk and helped start a company to do further research and market about it. Pure LiFi, formerly known as pure VLC, is an original equipment manufacturer (OEM) firm set up to research and thus commercialize Li-Fi products for integration with existing LED-lighting systems [5]. VLC technology was introduced in the year 2012 using Li-Fi. By the year 2013, data speeds of over 1.6 Gbit per second were demonstrated over a single color LED [6]. In the month of April in 2014, the Russian company Stins Coman introduced a Li-Fi wireless local network called BeamCaster. Their current module transfers data at 1.25 gigabytes per second, but they claimed boosting speeds up to 5 GB/s in the near future [7]. In the same year, a new record was done by Sisoft that was able to transfer data speed of up to 10 GB/s across a light spectrum through LED lamps [8]. In the month of August in the year 2018, Kyle Academy, a secondary school in Scotland, started the use of Li-Fi within the school. Students are now able to transfer and receive data through a connection between their computers and a USB device that translates the rapid on-off current from the ceiling LEDs to data [9]. In the month of June 2019, a French company Oledcomm tested its Li-Fi technology at the Paris Air Show. Oledcomm has also hoped to collaborate with Air France in the future to test Li-Fi on flights [10].

#### 5. LI-FI OVER WI-FI

Wi-Fi uses radio waves for the transmission of data, which emits harmful radiations that are related to health issues. The frequency of the visible light region is more in comparison to the frequency of the radio waves region, which means that the visible region will have a greater bandwidth in comparison. Greater bandwidth means the most data we can download at one time. E.g. If we have a 250Mbps package from our Internet Service Provider (ISP), then our bandwidth would be 250Mbps. Li-Fi is better for security purposes than Wi-Fi because the data transmission will happen in front of our eyes.

**Table 2.** Comparison between Li-Fi and Wi-Fi

Parameter	Wi-Fi	Li-Fi
Spectrum	RF	Visible Light
Data Transfer Rate	(100Mbps-1Gbps)	More than 1Gbps

Cost	High	Low
Availability	Low	More
Bandwidth	Limited	Unlimited
Range	<10m (Based on the intensity of light)	<300m
Power consumption	High	Low

## 6. APPLICATIONS OF LI-FI

Li-Fi has many applications in the coming future:

1. Data transfer in phones: The core idea is to implement the Li-Fi module into the cell-phone coupled with a receiver. As we know, Li-Fi operates at a speed of ~1Gbps, we can expect the same with mobile data transfer [2]. With the transmitter and receiver phones in hand connected to the LED (to transmit data in the form of light) and photodiode (to receive the data) respectively, data transfer is possible. The transmitter phone connected with an LED light (flashlight would also work if connected to the data transmitter part of the phone) will transmit data. The receiver is durable enough to handle that much data gain speed. The receiver phone should be connected with a photodiode (to receive the light) in the data receiving part of the phone. That way we can transfer data in phones at a very high speed. There should be an application installed into both the phones with the help of which the users can send or receive data according to their means.
2. Airplane: Wi-Fi or cellphone access to the internet is banned on airplanes, because of fears of interference with airplane devices. Some years ago, the internet was offered using Wi-Fi which costs very high. This could be made cheaper if we introduce Li-Fi systems into it. Each seat has a light connected to it, if that is utilized to provide network access, then internet access would be possible at a very cheaper rate and that will not cause any interference.
3. Underwater applications: Wi-Fi doesn't work underwater, but the use of Li-Fi technology will make it possible to transmit data underwater without using cables (at present data transmission is done with cables) [11].
4. Traffic: By the use of Li-Fi technology in the headlights of cars and bikes, accidents could be prevented. The drivers will be able to receive data from all the cars that are running within a particular range, thus preventing accidents. In the future, it could also be possible if we introduce Li-Fi technology to traffic lights, they will send data regarding the speed and populated cars or bikes nearby a particular car, thus preventing accidents [11].
5. Outdoor access: Wi-Fi is limited to indoor access because we cannot operate it outside the range of Wi-Fi. But using Li-Fi, we can access the internet even outdoors due to the presence of lights everywhere. Each light if introduced with Li-Fi technology can transmit data thus internet access could be possible outside.

## 7. ADVANTAGES OF LI-FI

Li-Fi has many advantages in comparison to the other technologies that we have today. Some of them are:

1. Greater speed: Since Li-Fi has a much higher speed rate, it can be used in cell phones to transmit data at a very high speed in comparison to Wi-Fi. This could be done by introducing an LED light connected to the transmitter phone which will send data in the form of light (binary bits). The receiver phone will have a photodiode connected to it which will receive the data from the transmitted phone. The transfer of data will occur at very high speed (~1Gbps), which means we can download a movie in some seconds.
2. Security: Since the use of Li-Fi happens in front of the user's eyes (within the illumination of the light) and not behind walls, thus Li-Fi is more secure.
3. Availability: Due to the presence of LED lights, Li-Fi could be accessed anywhere.
4. Cheaper: The transmission of data happens because of the presence of LED bulbs which is really cheaper in comparison to Wi-Fi.
5. Complexity: The introduction of Li-Fi is quite easy because it is based on very simple technology as compared to other technologies.

## 8. DISADVANTAGES OF LI-FI

The disadvantages of Li-Fi are as follows:

1. Li-Fi cannot be accessed beyond the illumination range of light (it cannot be accessed behind a wall).
2. Due to interference by the other sources of light, there will be noise.
3. If some external disturbance comes in between the receiver and transmitter, Li-Fi doesn't work.
4. Li-Fi only works in the direct line of sight (since light travels in a straight line).
5. If a mirror or a reflecting device comes in front of the transmitter, the data could be diverted and thus another user can access the data.

## 9. CONCLUSION

Li-Fi is the future technology which with its faster speed can replace all the other technologies behind. The much higher rate of speed of Li-Fi will help people to access data within seconds. The applications of Li-Fi in cell phones, traffic management, underwater, etc will make Li-Fi a very emerging and vast technology. After all the LEDs get introduced with Li-Fi, it will make human life more reliable and simpler.

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