

# Li-Fi Technology: New Revolution In The Field Of Data Communication

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**Abstract-** Light Fidelity (Li-Fi) technology makes the data transmission possible through visible light which enables user to transmit large amount of data at very high speed. The Li-Fi provides better bandwidth, efficiency, availability and security as compared to existing technologies (Wi-Fi). The technology's base component is LED (Light Emitting Diodes) bulb. By taking into account the low cost nature of LEDs and lightning units there are many opportunities to exploit this medium and in the future a street lamp can be used for public internet access as well as a number of Li-Fi hotspots can be created and used optimally.

**Keywords:-** Li-Fi, LED, Light Dependent Resistor, visible light communication, Wi-Fi, wireless communication.

## I. INTRODUCTION

Nowadays, data is transferred round the clock (24\*7) across the globe. Sometimes due to congestion in network and bandwidth data transfer is not possible. Li-Fi technology is an evolving technology which will solve all the issues related to data transfer. The technology was introduced by a German physicist, Harald Haas, in his TED global talk on Visible light communication. According to Haas, this technology can be used to produce data rates higher than 10 megabits per second which is much faster than our average broadband connection. This light was referred as D light by him<sup>[1]</sup>. As Li-Fi technology uses the visible spectrum of light which is abundantly available there will be no issues regarding its bandwidth as well as the radiation concerns which occur due to the existing technologies.

The persistence of vision plays an important role in the transmission of the signal via Li-Fi. In this technology the data is converted into binary signal and then sent via LED bulb. The data rate to be achieved should be such that it should overcome persistence of vision. This transmitted data is then sensed by either of the photo sensing circuits which then converted back into its original form. In this paper we rely on LDR (Light Dependent Resistor) for converting light signal into electric signal.

## II. PRINCIPLE OF LI-FI COMMUNICATION

The Li-Fi technology is the data through illumination which means sending data through an LED light bulb that varies in intensity faster than the human eye can follow in the form of 0's and 1's for transfer of data. This flickering of LEDs to transmit the data wirelessly is referred as visible light communication (VLC).

### (A) Visible Light Communication

Li-Fi is optical version of Wi-Fi that uses visible light communication for data transfer using visible light between 400 THz (780 nm) and 800 THz (375 nm). The premise behind VLC is that because lighting is nearly everywhere, communications can ride along for nearly free. One of the biggest attractions of VLC is the energy saving of LED technology, which makes visible light LEDs ideal for ubiquitous data transmitter<sup>[2]</sup>.

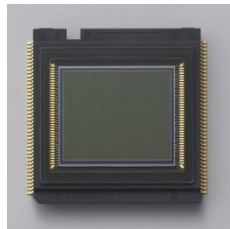
Driven by the progress of LED technology, visible light communication is gaining attention in research and development. The VLC Consortium (VLCC) in Japan was one of the first to introduce this technology.

### (B) Devices Used In Visible Light Communication

Various devices can be used in visible light communication. For transmission purpose visible light LED bulb and fluorescent lamp are used and for reception side sensors like Pin photo diode, Avalanche photodiode, Image sensor and light dependent resistor (LDR) can be used.



Fig. 1 (a) Pin photo diode (b) Avalanche photodiode



(c) Image sensor



(d) LDR

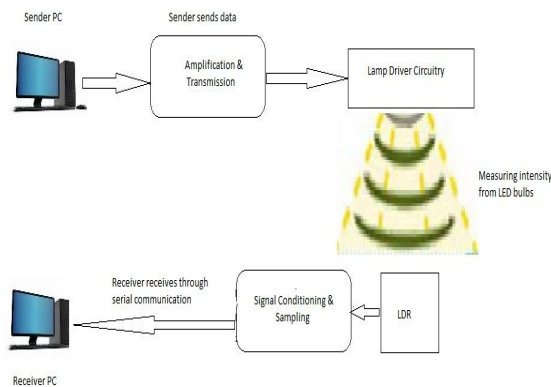
### III. CONSTRUCTION AND WORKING

The main principle of Li-fi is based on the transmission of 1's and 0's. If LED is ON logical 1 is transmitted and if LED is OFF logical 0 is transmitted [1, 3 and 8]. By switching phenomena of these LEDs the data is transmitted at high speed.

The following devices are used in construction of Li-fi technology:

- LED bulb
- Pin photo diode
- Avalanche photodiode
- Image sensors
- 8051 microcontroller

Li-Fi is implemented using white LED light bulbs as a downlink transmitter. These devices are used for illumination only by applying a constant current. By fast and subtle variations of the current, optical output can be made to vary at extremely high speeds [6]. This variation is used to carry high speed data. Working of Li-Fi is shown in below.



The input is given through the first image sensor and passed through the electronic circuit. An overhead lamp fitted with an LED transmits binary input data to the Light Dependent resistor(LDR). The resistance of LDR is very high and hence the changes emitted by the LEDs can be measured quickly. The data is further decoded by a microcontroller(8051) and displayed on the second image

sensor. The data transfer is so fast that within the blink of an eye the data is seen on both the image sensors. Thus by using the flickering of LED's (which appears constant to human eye) different combinations of 1's and 0' is obtained and the information is encoded [3]. Numerous possibilities and combinations of data is possible to transfer using Li-fi technology within fraction of seconds from one place to another.

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

Li-Fi technology gained its nomenclature from Wi-Fi technology. As Wi-Fi technology uses radio waves to transfer data (packets, images, videos, documents etc.) , in the same way Li-Fi technology uses visible light to transfer data.

The IEEE standard for Wi-Fi is 802.11n whereas for Li-Fi it is 802.15.7. The transfer speeds of the various technologies are mentioned below:

Technology	Max Speed
Wi-Fi (IEEE--802.11n)	150 Mbps
Bluetooth (IEEE--802.15.1)	3 Mbps
Li-Fi (IEEE--802.15.7)	>1 Gbps

### PROBLEMS IN WI-FI

The following are the basic issues faced while using radio waves:

**a) Capacity:** Large amount of wireless data is transmitted through radio waves which are limited and expensive. The biggest issue with radio waves currently is about "Spectrum crisis" in which the radio wave frequency spectrum is running out of bandwidths.

**b) Efficiency:** The issue with radio waves is that they have to be constantly regenerated if they have to travel a long distance. There are 1.4 million cellular radio base stations that dissipate large amount of energy. Most of the energy is used for cooling down the base station instead of transmission. Therefore efficiency of such base stations is only 5%.

**c) Availability:** Availability of radio waves is a major concern. It is not advisable to use mobile phones in aero planes and at places like chemical plants because of their interfering and inflammable nature.

**d) Security:** Radio waves can infiltrate through walls. They can be intercepted. If someone has the right software (knowledge) and bad intentions, they may misuse it. This is the biggest security concern related to radio waves.

The following table is the result of a study conducted in Copenhagen, Denmark while testing scope of Li-Fi under lab conditions and results when compared to Wi-Fi:

Parameter	Li-Fi	Wi-Fi
Speed	***	***
Range	*	**
Data density	***	*
Security	***	**
Reliability	**	**
Power available	***	*
Transmit/receive power	***	**
Ecological impact	*	**
Device-to-device connectivity	***	***
Obstacle interference	***	*
Bill of materials	***	**
Market maturity	*	***

\* low \*\* medium \*\*\* high

## V. ADVANTAGES OF LI-FI TECHNOLOGY

Li-Fi technology is based on LEDs and other similar light sources for transfer of data. The transfer is possible using all sources of light, no matter which part of spectrum is harnessed. Light used in Li-Fi can also belong to invisible part of the spectrum, ultraviolet as well as visible part of the spectrum. Also because of huge amount of available bandwidth, the speed of communication is very high and enormous amount of data (movies, games, music) can be downloaded within seconds.

Also, Li-Fi removes the limitations that have been put on the user by the Wi-Fi.

**a) Capacity:** Light has 10000 times wider bandwidth than radio waves [1]. So, Li-Fi has got better capacity and also the equipment's are already available.

**b) Efficiency:** Data transmission using Li-Fi is very cheap. LED lights consume less energy and are highly efficient.

**c) Availability:** There are billions of light bulbs worldwide; they just need to be replaced with LEDs for proper transmission of data.

**d) Security:** Light waves do not go through walls. So, they can't be intercepted and misused.

## VI. CHALLENGES

There were challenges faced while implementing our Li-Fi system. The surroundings had to be enclosed and free from other light interferences. The ambient lights also had to be eliminated for the system to be working. The position of the receiver and transmitter (bulbs) had to be properly adjusted i.e. in direct line of sight.

## LIMITATIONS

Apart from many advantages over Wi-Fi, Li-Fi technology is facing some challenges. The limitation of this technology is that light cannot penetrate through walls and other forms of light attenuate the intensity of light emitted out by the system. Also the user has to be in direct line of sight to avail the use of Li-Fi.

## VII. APPLICATIONS

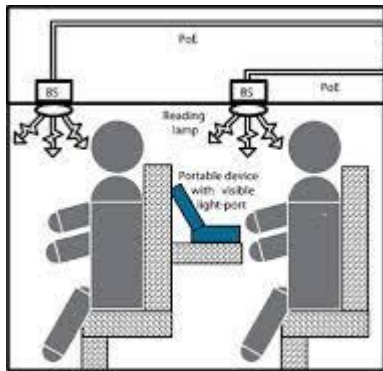
There are voluminous applications of this technology, from providing internet through street lamps to use LEDs to guide vehicles using their headlights. Applications of Li-Fi can extend in domains where Wi-Fi technology lacks its presence like medical technology, power plants and various other areas. Since Li-Fi uses light as a medium so it can be safely used in aircrafts and power plants where Wi-Fi is forbidden because of its interfering and inflammable nature of radio waves [6]. In the future, every street lamp can be used to access the internet with ease.

Some of the future applications of Li-Fi are as follows:

**1) Education Systems:** Li-Fi is the latest technology which provides fastest speed of internet access. So it can compensate for Wi-Fi at educational institutions and at companies so that all users can make use of Li-Fi with the same speed in a particular area.

**2) Medical Applications:** Operation theatres can be the perfect locations for Li-Fi as Wi-Fi is not permitted in hospitals due to their radiations. To overcome this issue and to make operation theatres tech savvy Li-Fi can be used to access internet and control medical reports. This can also help in easing surgeries and other automated processes.

**3) Cheaper internet in Aircrafts:** The Wi-Fi equipment is not used in aircrafts because of its interfering nature with navigational system of the pilots. Li-Fi can be easily used for data transmission in aircrafts and can be used as a overhead bulb for internet access.



Li-Fi application in aero planes

**4) Underwater applications:** Underwater ROV's (Remotely operated vehicle), submarines and other related systems are unable to access the internet under the sea [1]. Hence, Li-Fi is an efficient solution for data transfer underwater. If the equipment for communication inside the submarines were replaced by a high power lamp then the process of data transfer is possible underwater.

**5) Smarter power plants:** The power plants and chemical plants are spread over a huge area and transfer of data in the plant from one department to another takes a considerable amount of time. Also because of Wi-Fi's (radio waves) inflammable nature it is not suitable to deploy it in a power/chemical plant. Here Li-Fi technology proves to be a boon as it is a safe and economical option.

**6) Traffic Management:** If the traffic signals are installed with Li-Fi equipment connected to the timer it can ease traffic management by counting number of vehicle according to headlights and setting the timer of the signal according to the amount of vehicles at the signal. Also the accident numbers can be decreased using Li-Fi technology.

## VIII. CONCLUSION

The possibilities of this technology are ample and if put to use it can cater to a cleaner, greener, safer and a resplendent future. It has bright chance to replace the traditional Wi-Fi technology in the coming years and emerge as a reliable, high-speed and popular technology. Considering the issue of "Spectrum Crisis" the bandwidths of radio waves are running out at a fast rate (3G, 4G and so on) and the radio waves are becoming increasingly clogged due to it. This

technology pledges to solve issues of radio frequency bandwidth and boot out all the disadvantages regarding Wi-Fi technology. Researchers are developing micron sized LED which are able to flicker on & off around 1000 times quicker than larger LED. At such an enormous flickering speed it will be possible to download a 4 GB movie in seconds. When tested Li-Fi under lab conditions it reached speed upto 10Gbps. After studying all the above contents, we can be sure that the future for Li-Fi is very bright.

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