

## Visible Light Communication (Li-Fi)

**Kartik Wat**

*Prof. Ram Meghe Institute  
of Technology & Research,  
Badnera, India*

**Neha Mattani**

*Prof. Ram Meghe Institute  
of Technology & Research,  
Badnera, India*

**Aditya Gole**

*Prof. Ram Meghe Institute  
of Technology & Research,  
Badnera, India*

### Abstract

*This report possesses information about the Visible Light Communication using Li-Fi technology. This latest Technology LI-FI describes transmission of “data through illumination” taking the fiber out of fiber optic by sending data through an LED light bulb that varies in intensity faster than the human eye can follow. It’s the same idea behind infrared remote controls but far more powerful. Using Li-Fi technology, it is possible to exploit the high crest factor of orthogonal frequency division multiplexing (OFDM) commonly accepted as a disadvantage in radio frequency (RF) communications, to turn commercially available light emitting diode (LED) light bulbs into broadband wireless transmission systems.*

### 1. Introduction

Li-Fi basically known as “light fidelity” is an outcome of twenty first Century. LiFi is based on a unique ability of solid state lighting systems to create a binary code of 1s and 0s with a LED flickering that is invisible for human eyes. Data can be received by electronic devices with photodiode within area of light visibility. This means that everywhere where LEDs are used, lighting bulbs can bring not only the light but wireless connection at the same time. With increasing demand for wireless data, lack of radio spectrum and issues with hazardous electromagnetic pollution, LiFi appears as a new greener, healthier and cheaper alternative to WiFi. Moreover LiFi makes possible to have a wireless Internet in specific environments

(hospitals, airplanes etc.) where WiFi is not allowed due to interferences or security considerations.

Light Fidelity is a branch of optical wireless communication which is an emerging technology. The basic ideology behind this technology is that the data can be transmitted through LED light whose intensity varies even faster than the human eye. The LED fitted Li-Fi module is as shown in figure 1.



**Figure 1. LED fitted Li-Fi Module**

As the transmission of the data takes place through the light emitting diodes (LED's) the amount is comparatively small. In modern times, it is called as the optimized version of WI-FI. The advantageous thing is wireless communication which decreases the cost enormously. HARALD HASS, who is considered to be the father of Li-fi from university of Edinburgh, UK says that the heart of this technology lies in the intensity and the potential of the light emitting diodes. The major reason which lead the modern man through this invention is that the confinement of Wi-Fi to

comparatively small distance. As there are more and more devices coming up day-by-day the signals are being clogged up due to heavy traffic, there aroused a need for an error free transmission technology. And the solution to this problem was the Li-fi technology.. It has been designed in such a way that it overcomes the disadvantages that occurs during the usage of wi-fi. In general terms, Lifi works even under water thereby causing a great benefit to the military operations.

## 2. PRESENT SCENARIO

We have 1.4 million cellular mast radio waves base stations deployed all over the globe (fig.1). We also have over 5 billion of cellular mobile phones. Mobile phone transmits more than 600 Tb of data every single day. Wireless communication has become a utility like electricity & water. At present Wi-Fi is widely used as the mode of data transfer which is based on Radio Wave Communication Technology.

Prof. Harald Haas continues to hit the world that there is a possibility for communication through light. LI-FI technology has the possibility to change how we access the internet, stream videos, receive emails and much more. The technology truly began during the 1990's in countries like Germany, Korea, and Japan where they discovered LED's could be retrofitted to send information. This type of light would come in familiar forms such as infrared, ultraviolet and visible light. Research into VLC has been conducted in earnest since 2003, mainly in the UK, US, Germany, Korea and Japan. Experiments have shown that LEDs can be electronically adapted to transmit data wirelessly as well as to provide light. VLC is faster, safer and cheaper than other forms of wireless internet, advocates say -- and so could eliminate the need for costly mobile-phone radio masts. Firstly, the demonstration took place using two Casio smart phones.

The data was made to exchange between the phones using light. Even though the distance was nominal, it is sure that there would be a rapid increase in the distance of transmission. As there is a limited amount of Radio based wireless spectrum available, a number of companies formed a consortium called Li-fi Green and blue LEDs to alter the light's frequency with each frequency encoding a different data channel. Such advancements promise a theoretical speed of 10 Gbps – meaning you can download a full high-definition film in just 30 seconds. But blazingly fast data rates and depleting bandwidths worldwide are not the only reasons that give this technology an upper hand. Since Li-Fi uses just the light, it can be used safely in aircrafts and hospitals that are prone to interference from radio waves.

There is a consortium in order to promote high speed optical wireless systems .The members of this consortium believes that a speed of 10 Gbps can be achieved in no time. To bring LiFi innovation to every home OLEDCOMM created MyLEO, the first LED light bulb which can send wirelessly high quality music thanks to its colors. The system is also wirelessly controlled by mobile device. First presentation of My LEO will be done at the Mobile World Congress 2013.

## 3. Working of Li-Fi

There are many situations in which people get frustrated with the dull performance signals of Wi-Fi at a place with many network connections in seminars conferences etc. To overcome this, a brilliant idea was first put forth by Harald Haas from University of Edinburgh, UK, in his TED Global talk on VLC. His idea was very simple that if the LED is “on” then the digital 1 can be transmitted and if the LED is “off” then the digital 0 can be transmitted .LED's can be switched on and off very quickly. We have to just vary the rate at which the LED's flicker depending upon the data we want to encode. Further enhancements can be made in this method, like using an array of LEDs for parallel data transmission, or using mixtures of red. Refer figure 2.

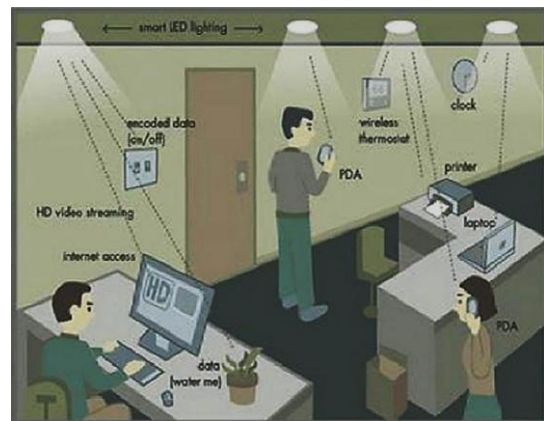


Figure 2. Li-Fi module in Practical Use

## 4. Comparison between Li-Fi & Wi-Fi

LI-FI is a term of one used to describe visible light communication technology applied to high speed wireless communication. It acquired this name due to the similarity to WI-FI, only using light instead of radio. WI-FI is great for general wireless coverage within buildings, and li-fi is ideal for high density wireless data coverage in confined area and

for relieving radio interference issues, so the two technologies can be considered complimentary.

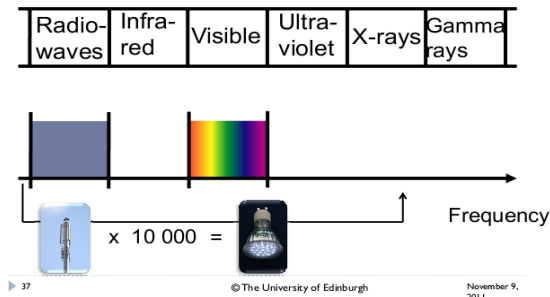
**Table 1. Comparison between current and future wireless Technology**

Technology	Speed	Data Intensity
Wireless(current)		
WI-FI IEEE802.11n	150 Mbps	*
Bluetooth	3 Mbps	*
IrDA	4 Mbps	***
Wireless (future)		
WiGig	2 Gbps	**
Giga-IR	1 Gbps	***
Li-Fi	>Gbps	****

But there are some issues with Wi-Fi discussed below.

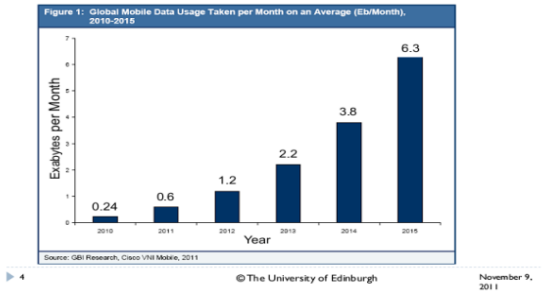
**4.1. Capacity:**

We transmit wireless data through radio waves which have restricted bandwidth. Radio waves are scar and expensive and we only have certain range of it. Though at present there is advancement of the new generation technologies like 3G, 4G, L.T.E., Etc. communication networks, we are running of out of the frequency spectrum provided by Wi-Fi signals shown in figure 4. On the other hand Li-Fi uses pure white LED light which has spectrum 10000 times wider than normal Wi-Fi signals. So ultimately very huge bandwidth and fast data transfer refer figure 5.



**Figure 5. The frequency spectrums**

**Mobile Data Usage per Month**



**Figure 4. Mobile data usage graph**

**4.2. Efficiency:**

Wi-Fi signals consumes massive amount of energy. In all energy consumption, most of energy is used for cooling down the base station rather than being completely used for data transmission. Efficiency of such base station is very poor and is almost about 5% and thus it raises a very big problem.

**4.3. Availability & Security:**

Radio waves are not available everywhere and it has range limitations. Also there are some security related issues like, it is not advisable to use mobile phones in airplanes as it can disturb the avionics system and disturb the RADAR signals. High frequency radio waves can be dangerous at places like petrochemical plants and petrol pumps as these waves can ignite the chemicals. There are some issues related with data security that radio waves penetrate through walls and thus can be intercepted by the third person. If a person has knowledge and bad intentions then he may misuse it.



**Figure 6.Safe & secure Li-Fi network in airplanes**

This can even work underwater where Wi-Fi fails completely, thereby throwing open endless opportunities for military. Also the visible light has very huge spectrum. Visible light provides 10,000 times more frequency spectrum compared to the radio waves. The speed and bandwidth of the signal is directly proportional to the frequency spectrum of that wave form. As the visible light has much big frequency spectrum allocation than traditional radio waves, Li-Fi provides 10,000 times data transfer speed than Wi-Fi. A single radio wave transmits bits of binary data using single stream at a time. Due to limitations in the bandwidth allocation the parallel data transfer can't be achieved. But due to large bandwidth allocation possible in Li-Fi using Visible Light Communication technique, parallel data transmission is highly possible resulting high speed data transfer using a single LED lamp as shown in the fig.

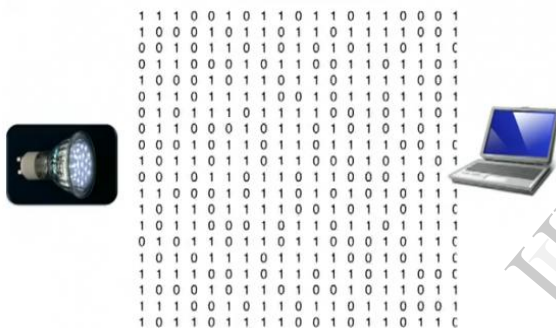


Figure 7. Parallel Data Transmission using LED

## 5. Applications

There is a wide necessity for data transfer and by the end of the day every field involves the use of technologies. One such technology is Li-Fi which can have its applications extended in areas where the Wi-Fi technology lacks its presence like medical technology, power plants and various other areas where Li-Fi proved its excellence of the undersea awesomeness.

## 5.1 Future applications

### 5.1.1 Education systems

As with the advancement of science the latest technology is the LIFI which is the fastest speed internet access service. So this will lead to the replacement of WIFI at institutions and at companies so that all the people can make use of LIFI with same speed intended in a particular area.

### 5.1.2 Extends our life span

As operation theatres do not allow WIFI due to radiation concerns. Usage of WIFI at hospitals interferes with the mobile and pc which blocks the signals for monitoring equipment. Therefore the replacement for this Wi-Fi is Li-Fi as Hass has mentioned in his TED TALK that LIFI has 10,000 times the spectrum of Wi-Fi. Because the lights are not only allowed in operation theatres but also the most dazzling fixtures in the lights of the cars by the number of accidents can be reduced. Data can be easily transferred by making use of LIFI lamps with the street lamps.

### 5.1.3 Replacement for others technologies

This technology doesn't deal with radio waves, so it can easily be used in the places where Bluetooth, infrared, WIFI and Internet are banned. In this way, it will be most helpful transferring medium for us. It includes other benefits like:

- A very wide spectrum over visible wave length range.
- Extremely high color fidelity.
- Instant start time.
- Easy terminal Management.
- Dynamic dark i.e. brightness Modulation of lamp output to enhance
- Video contrast.
- Trouble-free integration into existing light engine platform.

Li-Fi is the upcoming and on growing technology acting as competent for various other developing and already invented technologies. Since light is a major source for transmission in this technology it is very advantageous and implementable in various fields that can't be done with the Wi-Fi and other technologies. Hence the future applications of the Li-Fi can be predicted and extended to different platforms like education fields, medical field, industrial areas and many other fields.

## 6. Conclusion

The possibilities with the Li-Fi communication are numerous and can be explored much further. With this technology, we can use every LED light source or any light source with proper amplification as a Li-Fi hotspot for high speed internet data transfer providing Cleaner, Greener, Safer & Brighter future .

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