# Li-Fi: Smart Wireless Transmission Technology

A. Sangeetha
Department of Computer Science and Engineering Mount
Zion College of Engineering and Technology

***Abstract*: Li-Fi means Light-Fidelity. This new technology was proposed by the German physicist Harald Haas in 2011. Li-Fi provides transmission of data through illumination by sending data through an LED light bulb that varies in intensity faster than human eye. Li-Fi is a wireless optical networking technology that uses light emitting diodes (LEDs) for transmission of data. The term Li-Fi refers to visible light communication (VLC) technology that uses light as medium to deliver high-speed communication in a manner similar to Wi-Fi and complies with the IEEE standard IEEE 802.15.7. The IEEE 802.15.7 is a high-speed, bidirectional and fully networked wireless communication technology based standard similar to Wi-Fi's IEEE Wi-Fi is useful for general wireless coverage within buildings while Li-Fi is ideal for high density wireless data coverage in confined areas where there are no obstacles. Li-Fi provides better bandwidth, efficiency, availability and security than Wi-Fi.**

***Keywords: Li-Fi, LED, data transmission, Visible light communication, Wi-Fi .***

## I. INTRODUCTION

Li-Fi basically known as "Light Fidelity" is an outcome of 21st century. The basic ideology behind this technology is that the data can be transmitted through the LED light whose intensity varies even faster than the Human-eyes. The term was coined by Harald Haas is a form of visible light communication and a subset of optical wireless communications (OWC) and could be a complement to RF communication (Wi-Fior Cellular network), or even a replacement in contexts of data broadcasting. It is so far measured to be about 100 times faster than some Wi-Fi implementations, reaching speeds of 224 gigabits per second [1]

The disadvantage of traditional Wi-Fi routers is that multiple devices in a space can interfere with each other. Li-Fi however can use multiple lights in a room without interference. In modern times, it is called as the optimized version of Wi-Fi. The advantageous thing is the wireless communication which decreases the cost enormously. there are more and more devices coming up day-by-day the signals of Wi-Fi are being clogged up due to heavy traffic, there arised a need for an error free transmission technology. And the solution to this problem was the Li-Fi technology. [2]

With Li-Fi is possible to encode the data into the light by varying the rate at which the LED's flicker ON and OFF which is too quickly to be noticed by the human eye. Li-Fi enables devices to use their in-built stand by LED lights to transmit data.

## II. IDEA OF LI-FI

### *Li-Fi HISTORY*

Professor Harald Haas, from the University of Edinburgh in the UK, is widely recognized as the original founder of Li-Fi. He coined the term Li- Fi and is Chairman of Mobile Communications at the University of Edinburgh and co-founder of pure Li-Fi. The consortium believes it is possible to achieve more than 10Gbps speed using this optical wireless technology also known as Li-Fi. It gets affected if line of sight is not used, the speed of data transmission will reduce or data transmission will stop. Pure Li-Fi, formerly pure VLC, is an original equipment manufacturer (OEM) firm set up to commercialize Li-Fi products for integration with existing LED-lighting systems. Philips lighting company has developed a VLC system for shoppersat stores. They have to download an app on their smartphone and then their smartphone works with the LEDs in the store. The LEDs can pinpoint where they are at in the store and give them corresponding coupons and information based on where aisle they are on and what they are looking at .[2]

### *WHAT IS Li-Fi?*

Like Wi-Fi, Li-Fi is a wireless internet connection standard. However, rather than operating on radio waves, Li-Fi operates using visible light waves. The term Li-Fi was coined by pure Li-Fi's CSO, Professor Harald Haas, and refers to light based communications technology that delivers a high-speed, bidirectional networked, mobile communications in a similar manner as Wi- Fi. Although Li-Fi can be used to off-load data from existing Wi-Fi networks, implementations may be used to provide capacity for the greater downlink demand such that existing wireless or wired network infrastructure may be used in a complementary fashion.

Li-Fi is the use of the visible light portion of the electromagnetic spectrum to transmit information at very high speeds. This is in contrast to established forms of wireless communication such as Wi-Fi which use traditional radio frequency (RF) signals to transmit data. [1, 2, 3]

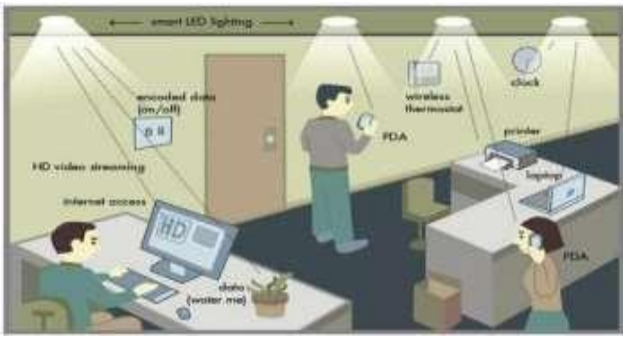


Figure 1: Li-Fi Environment

With Li-Fi, data is transmitted by modulating the intensity of the light, which is then received by a photo-sensitive detector, and the light signal is demodulated into electronic form. This modulation is performed in such a way that it is not perceptible to the human eye. Li-Fi is a category of Optical Wireless Communications (OWC). OWC includes infra-red and ultra-violet communications as well as visible light.

However, Li-Fi is unique in that the same visible light energy used for illumination may also be used for communication.

The technology uses protocols similar to the RF-band 802.11 protocols, with additional standards to eliminate the impacts of interference and impacts of ambient lighting. Despite this, however, the technology cannot be deployed in outdoors in sunlight or in other odd conditions. [3]

While Li-Fi does come with the advantage of not interfering with radio signals, a lot of the benefits are overpowered by the simple fact that visible light cannot travel through walls, an essential factor which gives old-school Wi-Fi a huge advantage. This line-of-sight limitation does make the system more secure and gives better control over emissions, but it's unclear what the minimum distance for signal reception would be if clear line- of-sight is achieved. With that in mind, it is easy to imagine the signal being intercepted by someone with a telephoto lens and an optical sensor tuned appropriately. While Li-Fi was touted as a possible channel for wireless communications on airplanes, widespread adoption of onboard Wi-Fi on most US airlines makes this use case less and less pertinent. [3]

In this context, the visible light spectrum is 10,000 times bigger than the radio-wave spectrum in which all of our wireless communications take place. With our Wi-Fi networks getting ever more crowded as more and more connected devices join the fray, internet performance is only going to suffer. A completely different spectrum is one obvious solution, and that's just what Li-Fi promises to provide access to. Li-Fi is also potentially much more energy efficient than Wi-Fi, which requires costly and power-hungry masts to operate.

The infrastructure for Li-Fi, meanwhile, is already partially in place, and a connection could eventually be as simple to initiate as turning on a lamp. [4]

*WORKING OF LI-FI*

When a constant current is applied to an LED light bulb a constant stream of photons are emitted from the bulb which is observed as visible light. If the current is varied slowly the output intensity of the light dims up and down. Because LED bulbs are semi-conductor devices, the current, and hence the optical output, can be modulated at extremely high speeds which can be detected by a photo-detector device and converted back to electrical current. The intensity modulation is imperceptible to the human eye, and thus communication is just as seamless as RF. Using this technique, high speed information can be transmitted from an LED light bulb.[5]

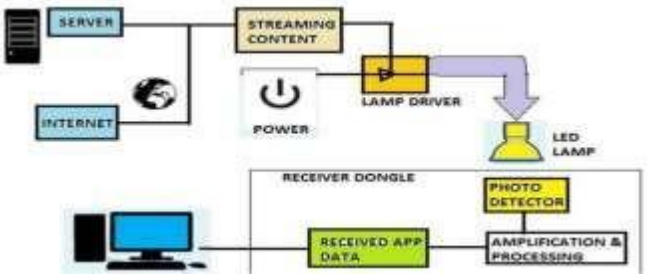


Figure 2: Working of Li-FI

Radio frequency communication requires radio circuits, antennas and complex receivers, whereas Li-Fi is much simpler and uses direct modulation methods similar to those used in low-cost infra-red communications devices such as remote control units. Infra-red communication is limited in power due to eye safety requirements, whereas LED light bulbs have high intensities and can achieve very large data rates. Dr. Harass succeeded in 2011 creating an 800 mbps capable wireless network by using nothing more than normal red, blue, green, and white LED light bulbs, thus the idea has been around for a while and various other global teams are also exploring the advancement possibilities. 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 is a technology that uses light emitting diodes to transmit data wisely. Visible light communication (VLC) uses rapid pulses of light to transmit information wisely that cannot be detected by human eye.

*LI-FI CONSTRUCTION*

The components of Li-Fi system:

i) A high brightness white LED which acts as transmission source.

ii) A silicon photodiode with good response to visible light as the receiving element.

LEDs can be switched on and off to generate digital strings of different combination of 1s and 0s. To generate a new data stream, data can be encoded in the light by varying the flickering rate of the LED. The Li-Fi System consists of 4 primary sub- assemblies:

a) Bulb

b) RF Power Amplifier circuit (PA)
d) Enclosure
c) Printed Circuit Board(PCB)

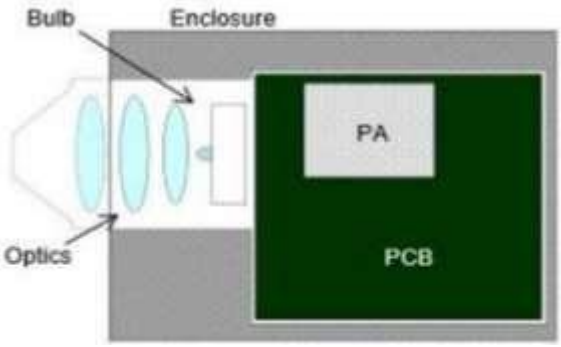


Figure 3: Li-FI Block Diagram

**The PCB** : Controls the electric inputs and outputs of the lamp and houses the microcontroller used to manage different lamp functions. An RF (Radio-Frequency) signal is generated by the solid-state PA and is guided into an electronic field about the bulb. The high concentration of energy in the electric field vaporizes the contents of the bulb to a plasma state at the bulb's center; this controlled plasma generates an intense source of light. All of these sub-assemblies are contained in an aluminum enclosure.

**Function of The Bulb**: At the heart of LIFI™ is the bulb sub-assembly where a sealed bulb is embedded in a dielectric material. This design is more reliable than conventional light sources that insert degradable electrodes into the bulb. The dielectric material serves two purposes; first as a waveguide for the RF energy transmitted by the PA and second as an electric field concentrator that focuses energy in the bulb. The energy from the electric field rapidly heats the material in the bulb to a plasma state that emits light of high intensity and full spectrum.

**Light Distribution:**

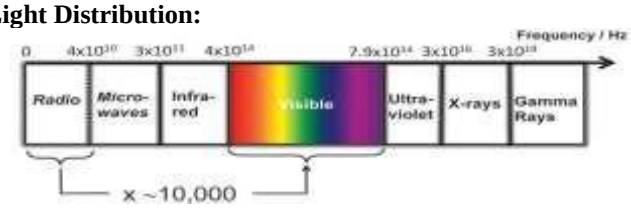


Figure 4: Light Distribution

- Gama rays can't be used as they could be dangerous.
- X-rays have similar 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 used with low power.

## III. COMPARISON BETWEEN LI-FI AND 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. Li- Fi features include benefits to the capacity, energy efficiency, safety and security of a wireless system with a number of key benefits over Wi-Fi but are inherently a complementary technology. [4, 5, 7, 8]

*TABULATION:*

| Parameter | Li-Fi | Wi-Fi |
|---|---|---|
| **Development Year** | 2011 | 1999 |
| **Range** | 10 meters | 20-100 meters |
| **Parameter** | Li-Fi | Wi-Fi |
| **IEEE standard** | 802.15.7 | 802.11b |
| **Speed** | 500Mbps, upto 10 Gbps, 100Gbps | 11 Mbps |
| **Capacity** | Visible light 10000 times than Radio waves | Radio waves form only a small fraction of the entire EM spectrum |
| **Secure** | More secure | Less secure |
| **Spectrum range** | 10000 times than Wi-Fi: 430–770 THz | Radio spectrum range:3 Hz to 3000 GHz |
| **Network Topology** | Point-to-point | Point-to-Multi point |
| **Communication** | Visible Light Communication | RF Communication |
| **Carrier** | Optical intensities | Electric field |
| **Routing Device** | LEDs | Access Points |
| **Infrastructure Cost** | Less | More |
| **Signal - to - Noise Ratio** | Very high. | May be more |
| **Beam Forming technique** | 10 meters | 20-100 meters |
| **Power Consumption** | Less | More |
| **Architecture** | Atto Cell | Femto Cell |

*ADVANTAGES OF LI-FI OVER RADIO WAVES*

- High data transmission rates of up to 10Gbps can be archived. Potentially much faster speeds.
- Li- Fi uses light rather than radio frequency signals so are intolerant to disturbances.
- While travelling in planes, the VLC can be used without affecting the airline signals.
- Security is a side benefit of using light because that Light cannot pass through walls, lot more secure.
- This also means there's less interference between devices.
- VLC could be used safely in aircraft without affecting airlines signals.
- Integrated into medical devices and in hospitals as this technology doesn't deal with radio waves, so it can easily be used in all such places where Bluetooth, infrared, Wi-Fi and internet are broadly in use.
- Like Bluetooth, Wi-Fi, infrared and internet, the VLC can also be used all locations.

## IV. APPLICATIONS OF LI-FI

- Street Lamps.
- Traffic control applications
- Hospitals & Healthcare
- Aircraft & Aviation
- Underwater Communications
- Smart Lighting
- Mobile Connectivity
- Hazardous Environments
- Vehicles & Transportation
- RF Avoidance
- Location Based Services (LBS)
- Toys

## V.CONCLUSION:

Li-Fi is the upcoming and on growing technology acting as competent for various other developing and already invented technologies. Since light is d 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. The possibilities are numerous and can be explored further. If this technology can be put into practical use, every bulb can be used like a Wi-Fi hotspot to transmit wireless data and we will proceed towards the cleaner, greener, safer and brighter future.

## REFERENCES

[1] Anthony Cuthbertson, "LiFi internet: First real-world usage boasts speed 100 times faster than WiFi". Retrieved 3, December 2015.
[2] http://en.wikipedia.org/wiki/Li-Fi
[3] N. Kulkarni, "Li-Fi Probably Won't Be The New Wi-Fi For Most People", Techcrunch Network, Nov. 2015, http://techcrunch.com/2015/11/29/li-fi-probably-wont-be-the-new-wi-fi-for-most-people/
[4] Jon Mundy, "What is Li-Fi and how could it make your internet 100 times faster". Trusted Reviews, 03 December 2015. http://www.trustedreviews.com/opinions/what-is-lifi
[5] S. Panda, M.Soyaib, A. Jeyasekar "Li-Fi Technology –Next Gen Data Transmission through Visible Light Communication", National Conference on Emerging Trends in Computing, Communication & Control Engineering, September, 2015. http://www.ijirset.com/upload/2015/ncet2k15/22_Li_-Fi_Modify_CSE.pdf
[6] An IEEE Standard for Visible Light Communications visiblelightcomm.com, dated April 2011. It is superfast modern internet technology.
[7] J.Rani, P. Chauhan, R. Tripathi, "Li-Fi (Light Fidelity)-The future technology In Wireless communication", International Journal of Applied Engineering Research, ISSN 0973-4562 Vol.7 No.11 (2012).
[8] S. Saini, Y. Sharma, "Li-Fi the Most Recent Innovation in Wireless Communication ", International Journal of Advanced Research in Computer Science and Software Engineering 6(2), February - 2016, pp. 347-351.
[9] D. Khandal , S. Jain, "Li-Fi (Light Fidelity): The Future Technology in Wireless Communication", International Journal of Information & Computation Technology. ISSN 0974-2239 Volume 4, Number 16 (2014), http://www. irphouse.com