International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 07 | July 2021 www.irjet.net p-ISSN: 2395-0072

LI-FI TECHNOLOGY: TRANSMISSION OF DATA USING VISIBLE LIGHT

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Abstract: Li-Fi stands for Light-Fidelity. The technology is extremely new and was proposed by the German Dr. Harald Haas in 2011. Li-Fi provides transmission of data through light by sending data through an LED light bulb. Li-Fi refers to visible light communication (VLC) technology that uses as medium to deliver high-speed communication during a manner the same as Wi-Fi. Wi-Fi is providing a better wireless connection with the building or society while Li-Fi is right for top density wireless data coverage in confined areas where there are not any obstacles. Li-Fi provides high bandwidth, security, efficiency, and availability than Wi-Fi and has already achieved high speeds within the lab. Li-Fi is provided better than the performance of Wi-Fi. In this paper, we are going to see the future scope of this new technology for using visible light as the carrier in data transmission and networking.

Keywords: Li-Fi Technology, Wi-Fi Technology, LED, Data Transmission, visible light communication (VLC).

1.Introduction

In the era of growing people within the world, Li-Fi can be a replacement way of wireless communication that uses LED lights to transfer data wirelessly. Transmission of information with high speed is one of every of the most important day-to-day activities within the fast-growing world.

Dr. Harald Haas has proposed the term "Li-Fi" at his 2011 TED Global Talk where he introduced the concept of "wireless data from every light. He used a lamp with an LED bulb to transmit a video of a blooming flower that was then projected onto a screen. In simple terms, Li-Fi is assumed of as a light-based Wi-Fi i.e., rather than radio waves it uses light to transmit data Li-Fi is based on Visual Light Communication (VLC) that using light-emitting diodes (LEDs) to completely networked wireless system. Li-Fi enables the device to attach to the internet with no wire. Li-Fi includes frequencies and wavelengths range, from the infrared through visible and everyone the way all the way down to the spectrum.

The number of wireless devices has increased in tandem with the progress in wireless communications features. The next generation of wireless communication, 5 G, is expected to usher in a new age in wireless communications services and technologies, including smart automobiles, e-health, and smart grids, among others. Like Wi-Fi, Li-Fi is wireless come under IEEE 802.11 protocols, but it uses ultraviolet, infrared, and visible light communication instead of radio frequency waves, which has a much bigger bandwidth (10000 times).

Li-Fi uses gigabits class communication speeds for brief, medium, and long ranges and directional data transfer using line-of-sight, reflections.

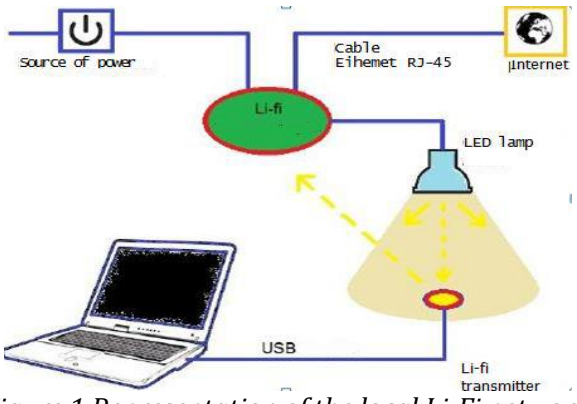

Figure 1 Representation of the local Li-Fi network.

A. What is Li-Fi

Li-Fi technology contains LED Lamp because of the media transmission and photodetector a receiver of transmitted data. The digital stream's data from the

Internet will be sent to the lamp driver on the transmitter side, which will turn the data into a light signal. The data will be sent via an LED light.

A photodetector or photosensor on the receiving side detects changes in LED light and transforms light photons into an electrical signal. The data will be received once it has been processed, amplified, and converted back to its original format by the receiving device.

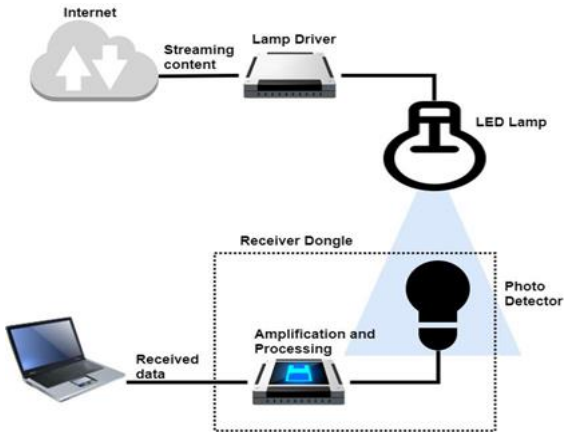

Figure 2 Basic Concept Diagram Li-Fi

B. Architecture of Li-Fi system

Li-Fi technology can be the future of data communication or transmission of data appears to be a fast and low optical version of Wi-Fi. On the transmitter side, the digital streams data from the Internet will be fed to the lamp driver, which is responsible to transform the data in a form of a light signal. The data will be sent via an LED light. On the receiver side, a photodetector or photosensor detects the variations of the LED light and converts light photons into an electrical signal. The receiver device will receive the data after it is processed, amplified, and converted back to its original format.

The main components of a Li-Fi technology may contain the following:

a) A white LED with a high brightness that serves as a transmission source.

b) A silicon photodiode with a good response to visible light because of the receiving element.

Switching the LEDs on and off can make them generate digital strings values with different combinations of 1's and 0's and create the information. To generate a new data stream, data are going to be encoded within the light by varying the flickering rate of the LED. In this way, the LEDs work as a sender by modulating the light with the information signal. The LED output appears constant to the human because they are made to flicker at an outstanding speed (millions of times per second) and it is impossible for the human eye to detect this frequency. A communication rate of more than 100 Mbps will be achieved by using high-speed LEDs with the help of various multiplexing techniques. Furthermore, the VLC data rate will be improved to as high as 10 Gbps by parallel data transmission via an arrangement of LED lights, which will all send an independent data stream.

The Li-Fi transmitter system comprises four primary subassemblies:

- Bulb
- RF Power Amplifier Circuit (PA)
- Printed Circuit Board (PCB)
- Enclosure

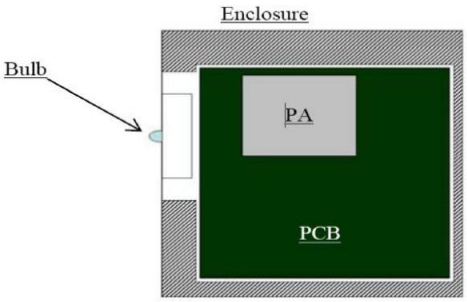

Figure 3 Block Diagram of Li-Fi sub-assemblies

The printed circuit board (PCB) manages the LED light electrical inputs and outputs and houses the microcontroller that manages the lamp's different input and output functions. A radio frequency (RF)

signal is generated by the ability Amplifier and is directed into the electrical field of the bulb. As a result of the high concentration of energy within the electric field, the contents of the bulb will get vaporized into a plasma state at the bulb's centre. This managed plasma, in return, will generate a bright light source. All these subassemblies are contained in an aluminium enclosure as shown in Fig. 3 above's

C. Working Principle

This communication scheme is a transmission of data through illumination. If very high-speed current gone through LED which varies the intensity and with ON-OFF activities of LED data transmitted using binary codes. while transferring the data and when the LED is ON so, represents the 1's is transmitted and when the LED is OFF so, represents the 0's is transmitted. This method is called visible light communication (VLC) and is used to rapid pulses of light to transmit data.

Figure 4 Li-Fi Transmission

2.Working of Li-Fi

Li-Fi is working on a Simple System. In this technique, light emits on one end, for example, an LED, and a photodetector on the other. The photodetector detects a binary one when the LED is on, and a binary zero if the LED is off. To build up a message, flash the LED numerous times or use an array of LEDs of perhaps some different colours to induce data rates within the range of hundreds of megabits-per-seconds.

Figure 5 Block diagram of LI-FI

Light-emitting diodes are going to be switched on and off with speed faster than the human eye can detect, causing the light source to look on continuously, even though it's really 'flickering'. The on-off activity of the bulb which is invisible enables data transmission using binary codes: switching on an LED could be a logical 1's, switching it off could be a logical 0's. Information can be encoded in the light onto different combinations of 1's and 0's by varying the rate at which the LEDs turn on and off. while transfer the data encoding is done within the light by varying the switching rate at which the LEDs flicker on and off to get a different combination of 1's and 0's.

In In LED Intensity modulation so rapid that the human eye cannot notice, therefore the light of the LED appears constant to humans.

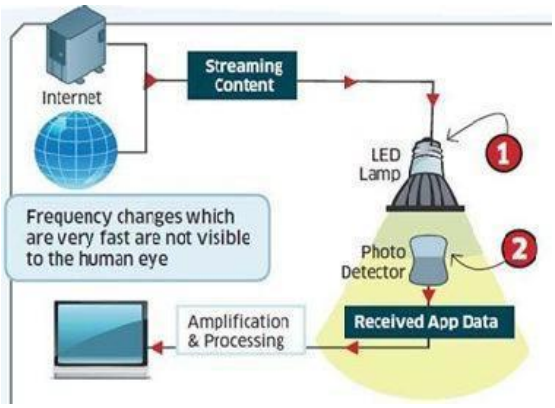

Figure 6 Data transmission using LED data stream

3.Literature Survey

Most of the people are using Wi-Fi Internet devices, which can be useful for two.4-5GHz RF to deliver wireless Internet access surrounded our home,

offices, schools, and a few public places also. We are quite dependent upon these nearly common services. While Wi-Fi can cover an entire house, school, the bandwidth is limited to 50-100 megabits per second (Mbps). Most of the people are using Wi-Fi Internet devices, which can be useful for two.4-5GHz RF to deliver wireless Internet access surrounded our home, offices, schools, and a few public places also. We are quite dependent upon these nearly common services. While Wi-Fi can cover an entire house, school, the bandwidth is limited to 50-100 megabits per second (Mbps).

This is the most up-to-date Internet service, but it is insufficient for transmitting large data files such as HD movies, music libraries, and video games. And most of the people are dependent upon 'the cloud service' or our own 'local storage device' to store all our files, including movies, photos, audio, and video devices, games, for that we require a large amount of bandwidth and speed to access this data. Therefore RF-based technologies like today's Wi-Fi are not the optimal way. Furthermore, Wi-Fi may not be the most effective mechanism to provide new features like precise interior location and gesture detection. Visible light communication (VLC) and, more recently, Li-Fi are terms used to describe optical wireless technology. On the opposite hand, offer a totally new paradigm in wireless technologies within terms of communication speed, usability, and adaptability, reliability. VLC is that the possible solution to the global wireless spectrum shortage. the technology could be a fast and cheap optical version of Wi-Fi. It is based on Visible Light Communication.

The VLC is a light base data communication medium using visible light between 350THz to 400THz as an optical carrier for data transmission and illumination data. By modifying the LED light transmission source and varying the flickering rate, the data is encoded in the light to produce a new data stream. This is a completely new spectrum of possibilities when compared to radio waves, and it is 10000 times larger. Visible light is not harmful to vision, and it is a required element of infrastructure, so it is widely available and simple to access. Whenever the number of radio cellular base stations (1.4 million) is compared to the number of light bulbs (14 billion) currently installed, the ratio is 1:10000.

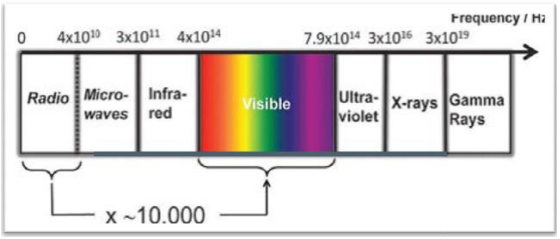

Figure 7 The electromagnetic spectrum

4. Modulation Techniques for VLC & LI-FI

This technique developed the digital modulation technique which can work with optical wireless communication using LEDs. Intensity modulation is a basic principle used depending on the variation of intensity of light, but the information varied. It will show the bi-polar signals like higher-order capacity-achieving modulation techniques used in radiofrequency. Higher-order modulation techniques like M-level quadrature amplitude modulation (MQAM) are essential to get data rates that are close to the Shannon capacity limit. The mapping of bi-polar to unipolar performance of signals, in a way that it out performance existing methods such as direct current optical-orthogonal frequency division multiplexing (DCO-OFDM) and asymmetrically clipped optical-orthogonal frequency division multiplexing (ACO-OFDM).

The VLC and Li-Fi system, which use the lighting system. The power can be strictly positive. It cannot show negative or complex. It will show the bi-polar signals like higher-order capacity-achieving modulation techniques used in radio frequency, the use of higher-order modulation techniques such as M-level quadrature amplitude modulation is essential to achieve data rates that are near to the Shannon capacity limit. The mapping of bipolar to unipolar performance of signals, in a way that its performance existing methods such as direct current optical-orthogonal frequency division multiplexing and asymmetrically clipped optical-orthogonal frequency division multiplexing. The VLC and Li-Fi system, which use the lighting system so, transferring the data using this technique we

required high average optical power to provide adequate illumination. It is a high-amplitude signal in higher-order modulation schemes clipped by the height power constraints of the LED, it should be led to high signal distortion. To solve this problem the Hadamard Coded Modulation (HCM) to achieve to create low error probabilities in LED-based VLC systems needing high average optical powers. This technique uses a quick Walsh-Hadamard Transform (FWHT) to modulate the information which is an alternative modulation technique to orthogonal frequency division multiplexing (OFDM).

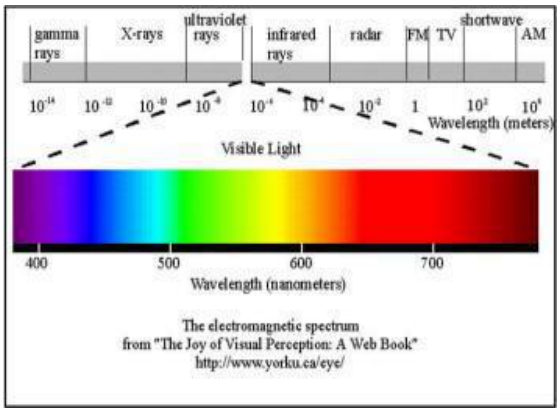

Figure 8 The electromagnetic spectrum

5. Li-fi and Wi-fi Combination

The combination of Li-fi and Wi-fi will provide many new and innovative developing features that have occurred to an integrated system. These features include security enhancement, a fast data rate, a larger service area, and enhanced indoor positioning are among these characteristics.

In Figure shows how Li-Fi technology will provide wireless data connections to stationary and quasi-stationary users, while the Wi-Fi network will be used by more mobile users. This kind of connection will alleviate RF network congestion while also increasing Wi-Fi system capacity to meet any potential future demand growth.

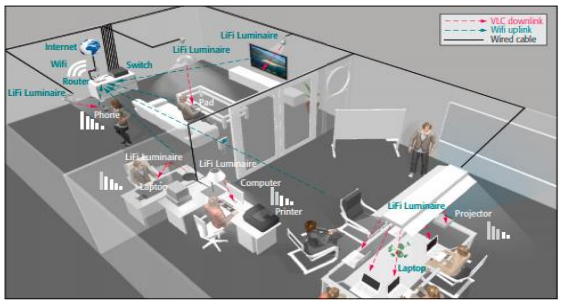

Figure 9 Li-fi and Wi-fi Combination

There are two techniques for merging Wi-Fi and Li-Fi that have been documented in the literature. The hybrid technique is the first strategy, while the aggregated technique is the second.

In the hybrid approach, Wi-Fi is used for uplink, and Li-Fi is used for downlink, but in the aggregated strategy, both Wi-Fi and Li-Fi are used simultaneously. In other words, a hybrid method uses a unidirectional Li-Fi connection to enable a conventional Wi-Fi downlink. Both bi-directional Li-Fi and Wi-Fi connections are completely exploited in the aggregated approach.

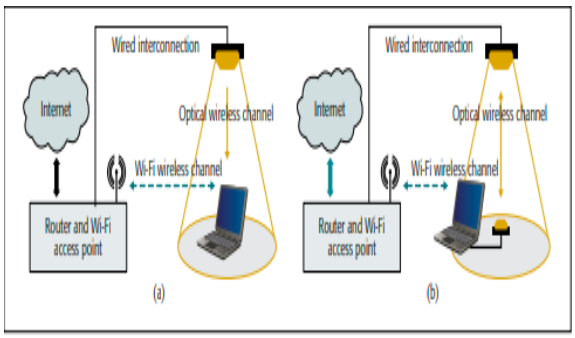

Figure 10 a) hybrid technique and b) the aggregated technique

6. Advantages of Li-Fi

a) **Efficiency**: Energy consumption could be reduced by using LED lighting, which is now available for lighting in homes, workplaces, and shopping malls. As a result, data transmission requires very little additional power, making it extremely cost and energy efficient.

b) **Availability**: There is no shortage of light sources because they can be found almost anywhere. There can be Internet whenever there is a light source. Light bulbs may be

found in homes, workplaces, stores, malls, and even planes, and can be implemented as a data transmission medium.

c) **Cheaper**: Li-Fi also has fewer components to perform, and it also requires very little extra energy for data transfer.
d) **Security**: Light waves, unlike radio waves, cannot go through walls. As an outcome, the data will be safely contained across the source of light, and anyone with malice is unable to access it.

7. Limitations of Li-Fi

a) A light source is required to access the Internet. These can limit certain kinds of places and situations in which Li-Fi is being used.
b) To send data, a near or perfect line-of-sight is needed.
c) Data transmission can be slowed by objects within the route.
d) The speed of data transfer can be caused by natural light, sunlight, and normal electric light.

8. Application of LI-FI

a) Li-Fi is cheaper than Wi-Fi.
b) The Li-Fi does not require a license.
c) It uses in Education System.
d) It can also use in the chemical department.
e) It can be utilized in power stations.
f) It can use Li-Fi in some offices, aircraft, and hospitals.
g) Streetlamps can be used to transfer to Li-Fi lamps to transfer data.
h) The Visible light spectrum is a free spectrum band and radio wave.
i) It uses in Radio broadcast Systems.

9. Conclusion

Li-Fi is the latest technology that uses LED lambs for wireless communications and the best wireless communication growing technology acting as competent for various other developing and inventing technologies. Li-Fi delivers very high data rates because the visible light band is 10,000 times larger than the radio spectrum. It is a low-cost, energy-efficient lighting solution that may be used anywhere. It also features a basic circuit with a built-in security function. Li-Fi has a lot of potential for improving data connectivity. The airways are increasingly getting jammed as the quantity of accessible bandwidth is restricted, making it harder to operate wire-free technologies with accuracy. The LI-FI technology may be able to provide a solution to this issue.

This technology is in its development, and therefore more useful applications will come in the near future. Therefore, with its inadequacies, it will not be able to totally replace current radio systems; rather, this will pair up to meet the growing that needs large bandwidth put together by the rising number of wireless devices. this wonderful technology is used practically, then maybe in future, each bulb can be used something like a Wi-Fi hotspot to brighter future. This bulb works similar to a Wi-Fi hotspot, transferring wireless data, and it signifies that we are progressing toward a better, greener, safer, and brighter future. Li-Fi is currently attracting the best deal of interest and a very efficient alternative to radio wave-based wireless.

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