Journal of Advanced Research in Electronics Engineering and Technology
Volume 10, print Issue 1 - 2023, Pg. No. 1-4
Peer Reviewed Journal

Research Article

Illuminating Insights: A Comprehensive Review of Li-Fi Technology and Its Diverse Applications

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I N F O

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How to cite this article:
Gupta S , Mishra S . Illuminating Insights: A Comprehensive Review of Li-Fi Technology and Its Diverse Applications. *J Adv Res Electro Engi Tech* 2023; 10(1): 1-4.

Date of Submission: 2023-02-10
Date of Acceptance: 2023-03-15

A B S T R A C T

Data transmission is a very prevalent practise in the modern, forward-thinking period of science. We have used Wi-Fi technology to send the vast bulk of our data up until this point. However, we also have the option of using light itself as a source for the data transfer. The term Li-Fi, which stands for "light fidelity," refers to the method of transmitting data via light. In the Li-Fi protocol, the visible light acts as the communication route. This is the most modern technology in the area of data exchange to be developed in recent years. Furthermore, this technology is currently being created as a result of the growing number of studies being done on this specific topic in order to facilitate its advancement. This optical communication technology is currently the most cutting-edge topic of discussion from a scientific perspective. Visible light communication, or VLC, is what Li-Fi employs, hence this technology's pace of data transfer is fairly quick.

Keywords: Li-Fi, Light Fidelity, Wireless Communication Medium, Latest Technology, Visible Light, and LED are Some of the Keywords Associated with this Topic

Introduction

Li-Fi is one of the most recent and well-liked wireless communication technologies. The blazing-fast gearbox it provides is responsible for its overwhelming popularity. We must mention the slow data transfer rate of the most recent communication or transmission medium if we are talking about it. If there are more than two connected devices at once, the speed will also be divided among them. In addition, we must look into the history of the Li-Fi standard. Li-Fi was first introduced in 2011 at the TED Global Talk in Edinburgh by Dr. Mostafa Afgani, a co-founder of pureLiFi, and Harald Haas, a professor of mobile communications at the University of Edinburgh. Li-Fi and Visible Light Communication (VLC), which was developed around the year 1880 and similarly uses a visible light component of the electromagnetic spectrum in the process of data transmission, have some similarities. This innovation served as the basis for Li-Fi. LEDs, also referred to as light-emitting diodes, are used in this wireless optical networking system to facilitate end-to-end data transfer. While Li-Fi creates electromagnetic waves like other communication systems do, because to the benefits it provides, Li-Fi lacks any of these other types of waves when used for communication. Installing LI-Fi might have a big impact on the hospital, lab, and aeroplane. There are numerous potential uses for this technology in the future as a result of these benefits.

Although Wi-Fi and Li-Fi are relatively similar technologies, they also differ significantly in certain key areas. For instance, Li-Fi modifies the signal and transmits it using the intensity of the light rather than radiofrequency to transfer data. Theoretically, it has been shown that Li-Fi is capable of 100 gigabits per second of data transmission. Additionally, Li-Fi can reduce the significant strain now placed on the wireless technology that we use today. It

offers a frequency range running at 400 THz, in contrast to RF communication medium, which can only operate at 300 THz. Information on the LI-FI Technology The optical wireless communication (OWC) technology, which serves as the foundation for Li-Fi, uses LEDs as the medium for data transmission via a specialised network. As a result, the method's Li-implementation Fi's is similar to Wi-Fi in several ways. When we switch the current to the LEDs, Visible Light Communications starts up precisely at that time and runs at a breakneck speed. Human eyes are unable to detect it since it occurs so swiftly and without any flickering.

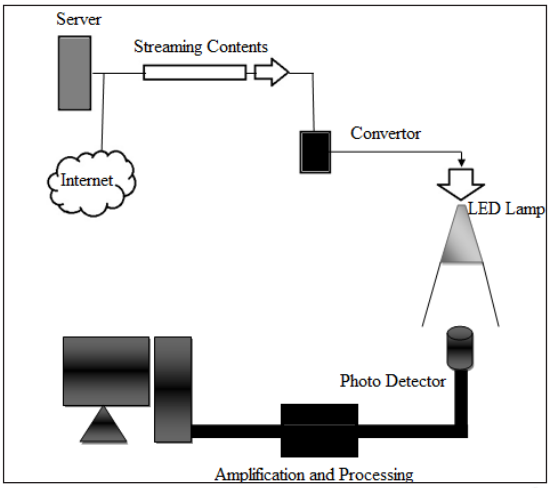

Figure 1. Block Diagram of Li-Fi

For the purpose of data transfer, we need to install the Li-Fi LEDs. The light is responsible for the transfer of all of the data by itself. because the data packet is carried by light and transmitted to the receiver end of the connection. Therefore, the light that will be generated from the LEDs will serve as the primary medium via which the data will be sent from the source to the destination. But the light that is emitted comes from LEDs, which can be dimmed to a level where it is not visible to the human eye. Because of this, human eyes are unable to perceive the light that is emitted by LEDs.

Li-Fi, which is an alternative to Wi-Fi, is likewise capable of transmitting data throughout the electromagnetic spectrum. The most significant distinction between the two is that although the process of Wi-Fi involves the production of radio waves, the procedure of Li-Fi involves the presence of infrared light and an ultraviolet form of visible light. This is the primary distinction between the two.

There is a significant problem with Wi-Fi in that it makes full use of the possible spectrum. On the other hand, Li-Fi does not have any constraints on its capacity and hence does not have this problem.

In addition, the most significant advantage of the Li-Fi technology is that, in comparison to the spectrum of radio frequencies, its spectrum of visible light is 10,000 times greater. When compared to Wi-Fi, the cost of using LI-Fi is around one tenth of what it would be using Wi-Fi. Because the LI-Fi installation process requires a limited range, it has a lower initial cost, and it has a higher degree of dependability. It is conceivable for Li-Fi to be reliable under these circumstances since the participation of a hacker or intruder in the overall mechanism of Li-Fi is extremely little, or we might even argue that the chance of their presence is zero. Therefore, in response to the security problem, the use of Li-Fi rather than Wi-Fi is recommended.

The Operation of the LI-FI Mechanism

In the case of Wi-Fi, the medium of transmission is the radio frequency; however, in the case of Li-Fi, the transmission mechanism is carried out by the light spectrum. Seeing as how the Light itself will serve as the data carrier. The light emitted from the solid-state LED that makes up the modulated light is what carries the data. The current photosensitive detector that is a part of the LI-Fi system is the one that demodulates the data once it has been modulated. After that, the data stream produced by the demodulated light frequency signal will be converted into an electronic format. After then, the existing signal will be managed, which means that depending on the circumstances, it will either be quicker or slower, unidirectional or bidirectional.

Figure 2. Li-Fi System with the connecting devices in a room

Due to its capacity to transmit signals from source to destination in a very high speed mode, Li-Fi provides a significant possibility for the Internet in this way. Li-Fi can carry data at a maximum speed of 100 Gbps, which is approximately 14 times quicker than Wi-Fi. When the LED is turned on, a virtual pipe (imagine) will be created between the transmitter and receiver once they are set up. The visible light is too dim for regular human eyes to directly detect it. The data packet is carried by this light photon as it travels to the destination side, which in this instance is the receiver.

LI-Architectural FI's Makeup

The following is a list of all of the most important parts of a basic Li-Fi system:

1. The primary light source for the transmission will be a white LED that is capable of producing a high amount of brightness.

2. a photosensitive detector that has the capability of providing a satisfactory response to the receiver for the visible light response.

On the other hand, the transmitter of Li-Fi is made up of four components that are linked to one another:

a Light Bulb, a Radio Frequency Amplifier Circuit, a Printed Circuit Board (PCB), and an Enclosure are the components of this System.

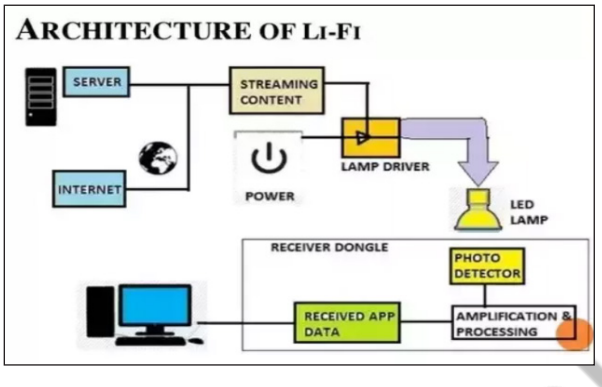

Figure 3. Architecture of Li-Fi

Table 1 showing the comparison between different wireless technology and their transfer speed

Basis	Wi-Fi	Li-Fi
Spectrum Used	Visible Light	Radio Frequency
Range	Based on Light Intensity (< 10m)	Based on Radio Propagation & interference (<300m)
Data Transfer Rate	Very High (~ 1 Gbps)	Low (~100Mbps-1 Gbps)
Power Consumption	Low	High
Cost	Low	High
Bandwidth	Unlimited	Limited
Standard	IEEE 802.15.7	IEEE 802.11

Table 2 showing the comparison between Li-Fi and Wi-Fi

Technology	Speed
Li-Fi	~1 Gbps
Wi-Fi	~150 Mbps
IrDA	~4 Mbps
Bluetooth	~3 Mbps
NFC	~424 Kbps

Applications of LI- FI

Health Technologies: As we well know, Wi-Fi releases radio waves that are particularly hazardous to patients as well as the radio waves that medical equipment uses to understand them. In that situation, Li-Fi technology allows you to utilise the internet in running rooms.

Quicker bank transactions: Li-Fi connections are incredibly fast, over a hundred times faster than Wi-Fi. Faster bank transactions aboard aeroplanes can arise from that kind of outstanding performance.

Airlines: Li-Fi is available in airlines and offers new passenger applications, as well as advantages for pilots. It does not run the risk of electromagnetic interference and is significantly safer than Wi-Fi.

Safer Environments: Using Li-Fi to transport data will make it easier to configure data networks in these settings and may even open the door to new security-enhancing systems.

Li-Fi employs light rather than radio frequency, which is problematic for people.

In the sea, Wi-Fi does not function, but Li-Fi may be simply used.

Security: Since light cannot pass through walls, Li-Fi offers consumers security advantages.

Li-Fi could address problems with Wi-Fi technology, such as the lack of radio frequencies.

Sensitive Data: There are a number of fields where EMI Sensitivity and data security are major concerns. The greater development of secure networked medical devices, patient records, etc., can be made possible via Li-Fi.

Advantages of LI-FI

Speed: Unlike radio waves used in Wi-Fi technologies, light waves utilised in Li-Fi can transport more information. since radio waves occupy a spectrum that is over 10,000 times longer than that of visible light. Li-Fi is 100 times faster than Wi-Fi technology because of this.

Availability: Li-Fi allows you to access the internet from any source of light. Future public lighting will be able to

wirelessly connect with building, street and transportation lighting. You will also be able to access the internet from anywhere in the globe when this technology is widely available.

Efficiency: Due to its high data transfer rate and parallel data transmission, Li-Fi technology is significantly more efficient than Wi-Fi, which results in an expanding efficiency.

Security: Because line-of-sight (LOS) data connection is used in Li-Fi technology, it offers a high level of security. It covers a relatively small region, preventing unauthorised people from gaining access to the Li-Fi signal in an undesirable manner.

Price: Because LEDs are used, Li-Fi is reasonably priced. It is considerably less expensive than Wi-Fi technology.

Bandwidth: Compared to Wi-Fi, Li-Fi technology can transfer data more quickly.

Li-Fi technology is really straightforward to use and set up.

Li-Fi technology is employed in many Internet of Things (IoT) applications since it requires less power to operate.

Limitations of LI-FI

Range Restrictions: Light waves are limited in their ability to travel through opaque barriers like walls. Sensors, though, could be able to circumvent this. The distances will be widened with the aid of these sensors.

If we don't have a light source, we can't use this technology because it depends on it. Additionally, this can restrict the places and circumstances in which Li-Fi can be used.

The outside signal interception is one of the main possible disadvantages of adopting this technology. The signal could be disrupted by another light source, such as sunshine. Utilising this Li-Fi technology requires building new infrastructure, which raises the cost.

Li-Fi technology can only communicate over very short distances and between devices that have a Li-Fi receptor since it operates at extremely high frequencies (400–800 THZ).

Conclusion

Li-Fi technology is currently in the early stages of development. Due to the fact that this technology is quite recent in terms of science and technology. Li-Fi and Wi-Fi are somewhat comparable. But the utilised spectrum is the primary distinction between Wi-Fi and Li-fi. In contrast to Li-Fi, which uses the visible light spectrum, Wi-Fi uses radio frequency. Li-Fi is considered to be more beneficial for humans than Wi-Fi from the standpoint of improved health. This technology also has a stronger future outlook in terms of security. According to this claim, Li-Fi is economically the most suitable because its implementation is not too expensive. However, there is also a need for this technology to advance further so that we can communicate data to the receiver end by turning on the Light.

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