ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 12, Issue, 06, pp.12090-12093, June, 2020

DOI: https://doi.org/10.24941/ijcr.39056.06.2020

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

LI-FI IN FUTURE TECHNOLOGY: WORKING, APPLICATION & LIMITATION

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ARTICLE INFO

Article History:
Received 20th March, 2020
Received in revised form
19h April, 2020
Accepted 17th May, 2020
Published online 30th June, 2020

Key Words:
Mobile Computing, Wireless Communication, 6G, Wi-Fi, Future Technology.

ABSTRACT

In this paper we have discussed everything about light fidelity (Li-Fi) like working principle, application, advantages, limitation etc. The comparison with Wi-Fi has also been discussed in latter part of paper. The fifth generation mobile communication technology (5G) has already being launched in different countries. The speculative study towards 6G technology has been started by many researchers. After 10 years or more than 10 years, we could assume that 6G might be the reason of the drastic change in the field of data speeds and mobile networks. For the successful deployment of 6g, LIFI technology will be come out as an effective solution for many industries. In the era of 6G technology, we will have more IoT devices, driverless car which enable road safety and new ways of health monitoring, here LIFI act as fundamental in 6G. LEDs bulbs of LIFI will help to serve thousands of applications in enabling smart cities and smart homes. In this paper we have studies how LIFI technology will help and support the 6th generation mobile communication technology.

Citation: ***Jyothsna and Saurabh Sambhav.*** **2020.** "Li-fi in future technology: working, application & limitation", *International Journal of Current Research*, 12, (06), 12090-12093.

INTRODUCTION

LI-FI (Light Fidelity) was founded by prof. Harald Hass, at the University of Edinburgh, UK. He was a German professor, At a TED talk in July 2011; he introduced the technology of LIFI in front of the audience (Khandelwal et al., 2016). In his demonstration of LIFI, he showed that how the amplitude of light bulbs changes at very high speed which can be used for the energy transmission. He used the LED bulbs for the transmission of a Video and then he showed the video on the screen (Nischay, 2017). A company named Pure LIFI was also launched by prof. Harald Hass with the thought that it can be used in the future. In October 2011, the Pure LIFI Company formed a LIFI consortium, group of industries was also involved in it (Albraheem, 2018). The objective of company was to implement a high speed wireless communication through LIFI. Later, to eliminate the limitations of radio waves, many companies step forward and start making VLC (visible light communication) as well as LIFI products (Kalaiselvi, 2017). In 2012, LIFI was demonstrated with the VLC technology. In that demonstration, a single color LED bulb was used for the data transmission and the result showed that it transferred data at a speed of 1.6 Gbps (Haas Harald, 2020; Huang, 2019; Saad, 2020).

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By September 2013, it was found that many Chinese companies started making LIFI kits. We can say that it is quite early stage to formally define 6G, but hypothetically there is no doubt that 6G is taking its shape. 6G will be the kind of generation stage where we could meet with super smart cities and fully connected with a plethora of autonomous services for mobile phones/tablets, IoT devices, driverless cars and many more. The true implementations of Artificial Intelligence could be done in 6G (Nawaz, 2020). High level of security and more privacy will be the main key features of 6G. Light fidelity or LIFI which was invented 8 years ago by Professor Harald Hass with the idea of "wireless data from every light" (Elmeadawy et al., 2019). It uses common household LEDs bulbs for the data transfer. This technology says that our light bulb can be our router (Alfattani, 2018). LIFI can be 100 times faster than Wi-Fi, offering a speed of 100 Gbps-1Tbps which will be the need of our future 6G. In 6g there will be more IoT devices (Mukku, 2019). It is assume that IoT will hold huge business potential and to implement IoT in many industries we can easily use LIFI technology there. The IoT devices can be more compatible and we can say that it will be in-sync with this technology. It will also enhance more functionality of IoT and made it more secure. Many researchers are focusing on LIFI because it is a viable solution for the IoT industries and also to the many other industries. In 5G, we have ultra-high-definition three-dimensional data (Al-Janabi et al., 2017). Then coming to the 6G, we could expect that there will be features of ubiquitous virtual existence, Autonomous transport, smart

Table 1. Frequency spectrum range

Optical (300GHz to 30THz)	VL (394.7-833.3 THz)	Red	394.7-491.8 THz
		Orange	491.8-507.6 THz
		Yellow	507.6-526.3 THz
		Green	526.3-600 THz
		Blue	600-666.7 THz
		Violet	666.7-833.3 THz

Table 2. Comparison sheet for LIFI and WIFI

Features	LIFI	WIFI
Operations	Transmission of data using light with the help of LED bulbs.	Transmission of data using radio waves.
Technology	IrDA complaint devices	WLAN 802.11a/b/g/an/ad complaint devices
Interference	Do not have any interference issues as compared to Wi-Fi	It faces interference issues from nearby access points(routers)
Data speed	About 100Gbps-1Tbps	About 1-2Gbps
Data density	LIFI can able to work in extremely high dense environment.	Due to interference issues, work in less dense environment.
Range	Based on light intensity(<10m)	Based on radio propagation and interferences(<300m)
Power consumption	Low	High
Cost	Low	High
Bandwidth	Unlimited	Limited

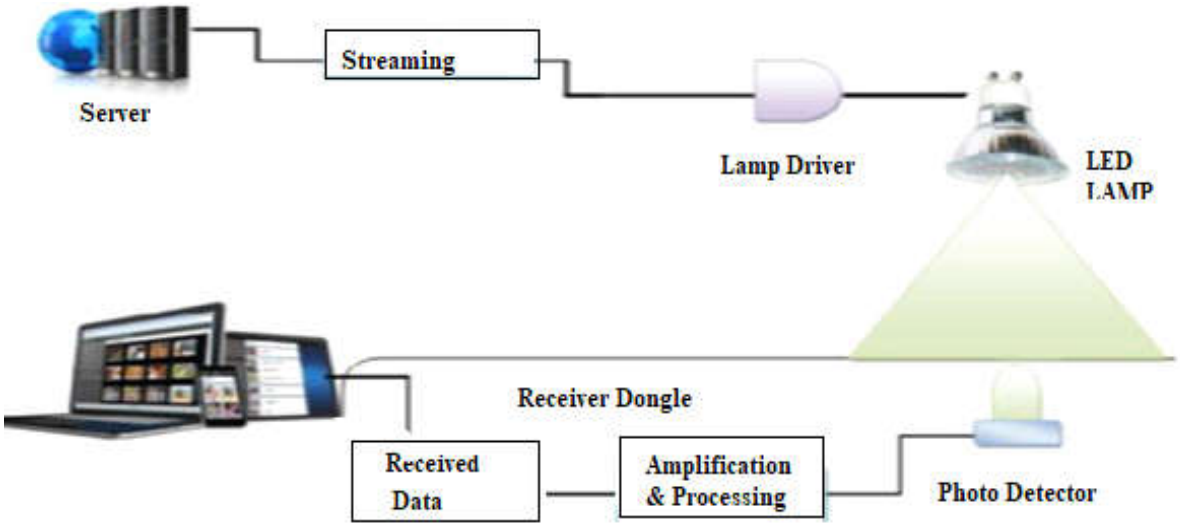

Figure 1. Showing basic structure of LI-FI system

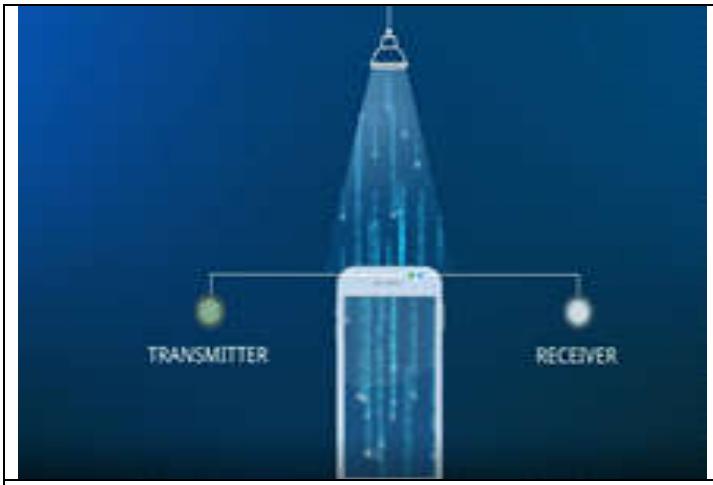

Figure 2. Transferring data into mobile

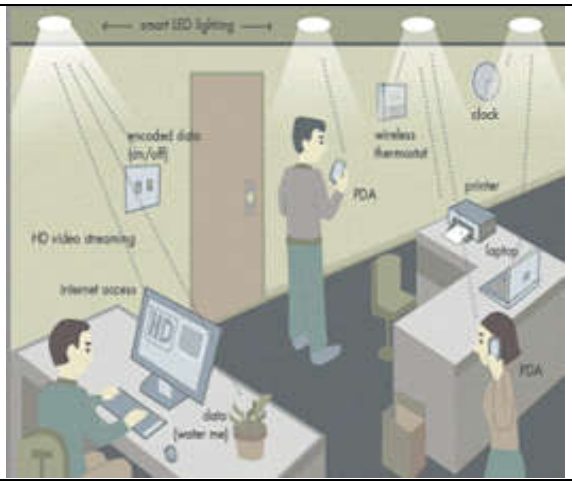

Figure 3. Indoor applications

health and smart homes, more secure communication and enterprise wireless solutions. This is dense and heterogeneous in nature and there we could use the technology like Li-Fi which provide earlier we have text and voice data in 1G and 2G, then pictures and Videos with HD quality in 3G and 4G (Chatterjee et al., 2015).

Starting with the basic difference between different generations of technology i.e. data rates. In 5G, data rate is increase from 1Gbps to at least 10Gbps per user in some use cases (Rathee et al., 2014; Ramadhani, 2018). Researchers says that there could be 100 Gbps to 1 Tbps data rates will be streamed to 6G users with very low latency.

Working Principle: In upcoming days, societies will become more and more data-centric, data-dependent and automated systems. 6G communications will make it possible to implement the above services with providing high QoS (Quality of service). Wireless connectivity in 6G are excepting to be 100 times higher than 5G. However, the demands will be daunting and LIFI will be able to full fill it by providing network that will transfer much greater amount of data, at very high speed. In the network of 3G and 4G we are using RF based wireless communications. RF-based wireless communications have certain restrictions such as limited spectrum, interference issues, and regulation. RF will be insufficient to meet the demand of the network and services of 5G and 6G. To provide uniform Quality of Experience, massive connectivity, and high capacity demands, it is expected that the network of 6G will be more wireless connectivity with ultra-high security. Through LI-FI the data rates of 100Gps had already been confirmed including with some amazing features, so it will support high data rate services for outdoors and indoors. LIFI is bidirectional network. Multiple LED Light bulbs are embedded in the LIFI that will form a wireless network and transmission of data using light.

A sub-assembly bulb which is inserted in the dielectric material is center of the LIFI system. A PCB (Printed Circuit Board) is the controller of the every signal generated by the Light of the lamp and it also contains a microcontroller that manages the different function of the lamp. The function of RFPA is to generate a radio frequency which will later convert into an electric field. The dielectric material has two functions. First one is, it act as a guide which guide the radio frequency energy which is radiated by the Power Amplifier. Second is, it helps to concentrate that the electric field will focus on the energy in the bulb. All the components of the system are contained in the aluminum enclosure, so that the electric signal will strictly concentrate on the energy of the bulb in LIFI. The complete system will work on the basis of energy's concentration in the electric field is transformed into the plasma, and in turn it will produces high intensity of light beams. When an electrical current is applied to the LED Light bulbs, the bulbs will emitted a stream of light (called photons). As we know that LED light bulbs are semiconductor devices, so it means that the light flowing through the bulbs produces a very high speed of changes in their brightness. By modulating the light at different rates, will allow us to send a signal. A detector received the signal and the detector interprets the changes in light intensity (signal) as data. The human eyes unable to see the intensity modulation produced by the LED light bulbs and the seamless communication happened just same as the radio waves systems. Data is transmit in the binary form of light pulses and it also relies on the OWC (optical Wireless technology), because if we use optical cables in LIFI then we will able to transmit data over large distance. These are the some advantages we can get on LI-FI and also overcome the certain limitations of RF:

Interference: RF is more vulnerable in the interference when used in various devices like cordless phones, nearby WIFI and microwaves. LIFI signal worked based on the concept that where there is light, then there is LIFI. The area of illumination is the area of LIFI; it can simply avoid interference or act as interference free. In the RF hostile zones such as aero planes, power plants and hospitals LIFI perform better.

Low latency: The latency factor of LIFI is three times lower than RF. It can easily enable smart homes, automation services and innovation in 6G. The application of AR and VR is also going to be high while using LIFI in 6G.

Localisation: Each light of LIFI has unique IP address which means advanced geofencing can be easily deployed in LIFI. It is fully networked.

Bandwidth: If we would compare LIFI to the Radio wave then there are certain advantages, such as RF band lies between 3 KHz to 300 GHz which will again insufficient to meet the requirement of 5G and 6G technologies which need 252 GHz to 370 GHz. LIFI devices will allow unregulated and desirable bandwidth that will require in 6G. The size of the infrared and visible light spectrum which we used in LIFI together is approximately 2600 times the size of the entire radio frequency spectrum of 300 GHz. Here is the data showing the ranges of each color of light separately. Light may have various ranges of connectivity. It can allow having communications of data from nanometer to greater than 10,000 km. Light can easily implement to set up the connections between various types of devices (like we use to connect devices in IoT) such as point to point, machine to various machines, device-to-device, chip-to-chip, vehicle-to-vehicle, and vehicle-to-infrastructure.

The LIFI technology have one of the great features of complete mobility that will fulfill the demand of 6G network and help to implement it everywhere. We could see that where there is a light, there is a LIFI. Ultra-high level of security is the main advantage of using LIFI technology, as it will require in 6G. It is almost impossible to hack the data, because it cannot penetrate obstacles. Especially for the health purpose exchange of information can be done through in highly secure manner. So, it will also help 6G by providing the feature of high level security. Large amount of energy can also be saved using this technology. Consumption of energy is one of the important components. Many industries are working on this, LIF has a key features of saving energy. LIFI use LEDs which consume very small power and provide illumination as well. If we compare to the RF sensor, LEDs sensors consume very less energy. LIFI-based communication technologies will provide energy-efficient communication systems in 6G.

Comparison with Wi-Fi: We are using Wi-Fi in this 4th generation of mobile communication. LIFI is not going to replace the wifi but it have certain advantages over wifi that overcome the Challenges or obstacles for the successful implement of 6G networks. There is a comparison chat below which described both the technology differences in detail.

Limitations: LIFI technology cannot work in the dark. Presence of light is essential.

- LIFI cannot pass through solid object like walls and obstacles.
- LIFI cannot work under the sunlight, because if we use LIFI in sunlight then sunlight will block the path of the light ray generated by LEDs bulbs.
- Interference from external sources like sun may cause interruption in the path of transmission of data in LIFI.

Application

Due to its properties like energy efficient, directional mode light propagation, security, high data transfer rate, wall blocking etc.

LIFI has been used in many real life applications.

- Interference free wireless communication
- Underwater radio communication
- Traffic management system
- Healthcare applications
- EMI Sensitivity and Medical instruments
- Data Security

Conclusion

We are predicting that 6G will be launched in between 2022 and 2030. The demand of high wireless connectivity in 6G will be more and there LIFI technology could be able to perform well because of its great features like ultra-high security, high data rates and most important low energy consumption. The upcoming demands of 6G networks are high capacity, massive connectivity, low latency, high security, low-energy consumption, high QoS, and highly reliable connectivity. Only RF based systems cannot be able to provide this demand for 6G networks. We must need this kind of technology to implement for future generation. Thus we have discussed everything about Li-Fi in 6^{th} generation technology including working principle, advantages and limitation.

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