Lifi: Wireless Visible Light Communication

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***Abstract*— Now days, Wi-Fi is the most widely used data access technology. It is used anywhere and everywhere including educational institutions, houses, airports, cafeterias and restaurants. Thus there is an exponential growth in its usage. As a result, there is congestion in bandwidth and capacity is drying up. This in turn has raised the design complexities and there is a lot of interference due to radio waves. Light-Fidelity (Li-Fi) has an edge over all these. Li-Fi which is a wireless visible light communication came into existence since 2011. Light-Fidelity is a wireless communication system in which light is used as a carrier signal instead of traditional radio frequency as in Wi-Fi. In near future Li-Fi will be considered as the most efficient technology for data access. The principle focus of this paper is on Li-Fi technology in comparison with Wi-Fi technology along with its advantages, applications and its challenges.**

Keywords*— *Li-Fi technology, Wi-Fi technology, Light Emitting Diode, EM Spectrum.

I.INTRODUCTION

The data communication initially was through copper cables which were replaced by optical fibers. There are about 1.4 million base stations, 5 billion cellular mobile phones, and there is more than 600TB of data transfer every month. Later, the Wi-Fi technology came into existence .This wireless technology created a tremendous revolution in the world of communication. It has become an integral part of life like any other utilities namely electricity, water supply etc. Hence the demand for Wi-Fi network has been increasing to greater extent. Due, to this there is bandwidth congestion as radio waves are scarce, expensive and limited range. These 1.4 million base stations or cellular masks consume lot of energy. Most of this energy is not used for transmission but for cooling them. The efficiency of these base stations is just 5% which is a big problem. The radio waves can penetrate easily through walls which lead to security snap.

Li-Fi wireless communication system which is used to describe visible light communication technology applied to high speed wireless communication overcomes all the above mentioned drawbacks. The word Li-Fi was first coined by German physicist, Harald Hass in 2011 in TED Global Talk on visible light communication [1, 2]. It acquired this name due to similarity to Wi-Fi, using light instead of radio waves. In October 2011 a number of companies and industry groups formed the Li-Fi consortium, to promote high-speed optical wireless systems and to overcome the limited amount of radio based wireless spectrum available by exploiting a completely different part of the electromagnetic spectrum [3, 4, 5]. This technology was demonstrated in 2012 at consumer electronics show in las Vegas using a pair of Casio Smartphone's to exchange data using light of varying intensity given off from their screens, detectable at a distance of up to 10 meters [6, 7]. Microchips inside LED will do the processing of data. The light intensity can be manipulated to send data by tiny changes in amplitude. The technology transfers thousands of streams of data simultaneously in higher speed with the help of special modulation technique [8].

II. PRINCIPLE OF LI-FI TECHNOLOGY

Light Emitting Diode is the integral part of Li-Fi technology. LED is not just light emitting diode it is a sophisticated electronic device which can be made to oscillate at phenomenal speeds. The light emitted from LED appears to be continuous as the property of the LED to switch between on and off is very fast, which is less than 1 μs, than the human eye can detect. The data is transmitted as sequence of binary ones and zeros by varying the rate at which LED flickers on and off. The switching OFF of LED is logic '0'and the switching ON of LED is logic '1'. This method of using rapid pulses of light to transmit information wirelessly is technically referred as Visible Light Communication (VLC). Modulation is so slight and that it is imperceptible to the human eye. A photo detector receives the modulated signal and converts it back into original sequence of information.VLC technology allows the realization of indoor navigation, geo information and position measurement.

A. Visible Light Communication

Li-Fi is a fast and cheap version of wireless communication, which is based on visible light communication (VLC) as its uses the already existing bulbs. The Visible light communication is a data communications medium which uses visible light between 400 THz (780 nm) and 800 THz (375 nm) as optical carrier for data transmission

and illumination [9]. Visible light is not injurious to vision. Typical example of visible light communication is given in fig.1 below.

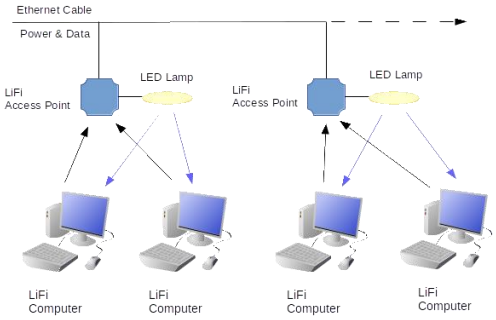

Fig. 1 Typical Example of Visible light communication: Use of LED illumination as a transmitter [1]

The importance of using VLC is that

- Frequency above 3 THz is not regulated by radio regulating laws as shown in fig.2
- Radio waves are limited and expensive

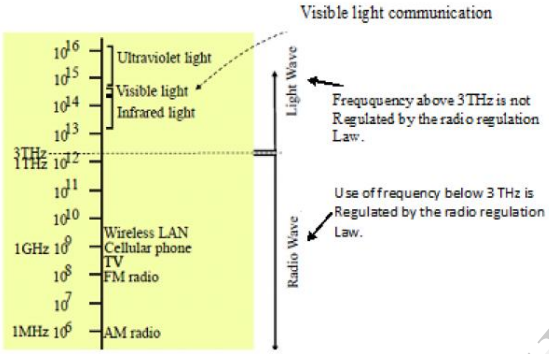

Fig. 2 Spectrum of radio and light wave.

- Infrared light is used for short-range communication such as, Infrared wireless LAN, television remote controls and in other indoor applications. UV light, X-Rays and Gamma Rays are good to use but are harmful for humans.
- Visible light LED can be used almost everywhere as visible light is harmless, which makes visible light LED's ideal for ubiquitous data transmitter. Growth rate of LED lighting is expected to triple from 2009 to 2012 & market share of LED lighting will be more than 30 % of total lighting market in 2016.
- The spectrum of Visible light is 10,000 times greater than that of radio waves.

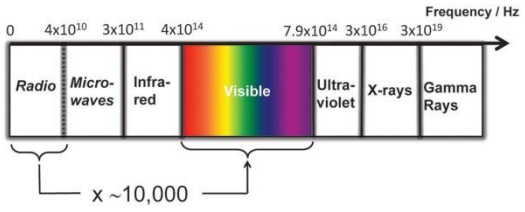

Fig.3 Electro MagneticSpectrum

- Photo sensors can be used as receivers because of high sensibility and high detection capability.
- The use of image sensors as receiver is also possible.
- Security is imparted as light cannot penetrate through walls.

B. Devices used in visible light communication

Fig.4 shows the example of devices used in visible light communication

Fig. 4 Devices used in Visible light communication

Typical, VLC uses transmission devices like visible light LEDs and fluorescent lamps. By controlling current, light intensity of the LED can be modulated. For the transmission of data up to the rate of 10bits/s fluorescent lamps can be used. But to achieve higher speed up to 500Mbps LED's are used. The various receivers which are used in VLC are pin photo diode, Avalanche photo diode and image sensors as shown in fig 5 below .Pin photo diodes supports speed up to 1Mbps.For very accurate and precise reception ,Avalanche photo diodes are used. Reception of data and acquisition of images can be simultaneously achieved using image sensors.

Fig. 5 (a) Pin photo diode (b) Avalanche photodiode (c) Image sensor

III. CONSTRUCTION AND WORKING OF LI-FI TECHNOLOGY

LED's which are few millimeters in size produces 23,000 lumens of brilliant white which is used as a source in Li-Fi technology. As these LED have very high lumen density they are used at the downlink transmitter. The illumination of LED is controlled by the flow of constant current through it .The light intensity is changed at a faster pace and making slight variation higher rate of data transmission can be achieved .Operation of Li-Fi is shown in fig. 6 below. The Li-Fi transmitter cosists of an LED which the signal processing technology are embedded. These lamps transmit bit streams at very high speeds of 10Gbps (download Full HD movie in 30 seconds). The devices include the smartphones, laptops; desktops have to be incorporated with receiver dongle. The receiver dongle is the image sensor. It receives the bit streams

and converts the slight changes in amplitude into an electrical signal, which is then converted back into a data stream & transmitted to the terminal devices.

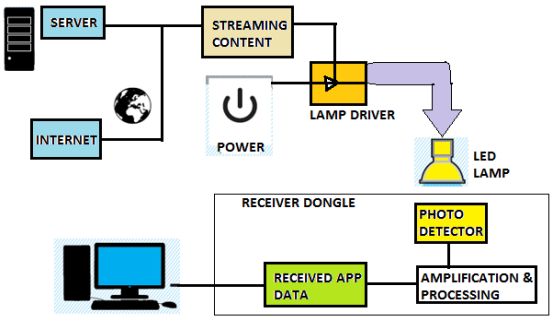

Fig. 6 Working of Li-FI

IV. APPLICATIONS

1) Road Safety:

- Accidents can be prevented as the head lights of the cars mutually exchange information regarding the distance between them.
- The LEDs on top of the ambulances can communicate with the traffic lights help to ease traffic congestion.

2) Used in hazardous, sensitive and prohibited environment:

- In petroleum or chemical plants where transmission of RF frequencies would be hazardous [12].
- In oil rigs where it's difficult to lay cables.
- In hospitals where RF waves are prohibited [11].
- It will transform air travel by allowing over head cabin lights to connect to mobiles and laptops in flight.

3) Li-Fi can even work underwater where Wi-Fi fails completely thereby throwing open endless opportunities for military/navigation operations.

4) In navigation and geo information.

5) Millions of street lamps can be converted to Li-Fi lamps to transfer data.

V. DIFFERENCES BETWEEN LI-FI AND WI-FI

Li-Fi is a terminology which is used to describe visible light communication technology applied to high speed wireless communication. 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 [11]. Comparisons of two technologies are given below in table 1.

TABLE I
COMPARISON BETWEEN LI-FI VS. WI-FI

SL. N0	Parameters	Wireless Technologies	
		Light Fidelity	**Wireless Fidelity**
1.	Speed for data transfer	Faster transfer speed (>1Gbps)	Data Transfer speed (150Mbps)
2.	Medium through which data transfers occurs	Used Light as a carrier	Used Radio spectrum
3.	Spectrum Range	Visible light spectrum has 10,000 time broad spectrum in comparison to radio frequency	Radio frequency spectrum range is less than visible light spectrum.
4.	Cost	Cheaper than Wi-Fi because free band doesn't need license and it uses light.	Expensive in comparison to Li-Fi because its uses radio spectrum.
5.	Network topology	Point to point	Point to point
6.	Operating frequency	Operating frequency	2.4 GHz

VI. CHALLENGES FOR LI-FI

Li-Fi technology is facing some challenges.

- Li-Fi requires line of sight.
- When there obstacle the data transfer is blocked [12].
- High installation cost of Visible light communication systems.
- A major challenge facing Li-Fi is how the receiving device will transmit back to transmitter.
- . A side effect of Li-Fi is that your power cord immediately becomes your data stream, so if you have power, you have internet [13].

VII. CONCLUSION

Li-Fi technology can be considered as the future technology for data transmission. Researchers are developing micron sized LED which are able to flicker on & off around 1000 times quicker than larger LED. They offers faster data transfers and take up less space so we could save space or add more LED's to further boost the channel of communication. Over all it can be concluded that Li-Fi has an edge over other data transmission technique.

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