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A PATH FOR HORIZING YOUR INNOVATIVE WORK

LI-FI TECHNOLOGY OVER WI-FI

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Abstract: Li-Fi stands for Light-Fidelity. Li-Fi technology, proposed by the German physicist—Harald Haas, provides transmission of data through illumination by sending data through an LED light bulb that varies in intensity faster than the human eye can follow. The Li-Fi is the latest technique that is used into the various business sectors mostly in the shopping mall. Li-Fi is a Visible Light Communication (VLC) technology developed by a team of scientists. Li-Fi provides better bandwidth, efficiency, availability and security than Wi-Fi and has already achieved blisteringly high speed in the lab. In this paper we are going to explain the construction, working, advantages, disadvantages, etc. of Li–Fi technology. We are also shown the application where it works. "Li-Fi is typically implemented using white LED light bulbs.

Keywords: Li-Fi, VLC, LED, PCB

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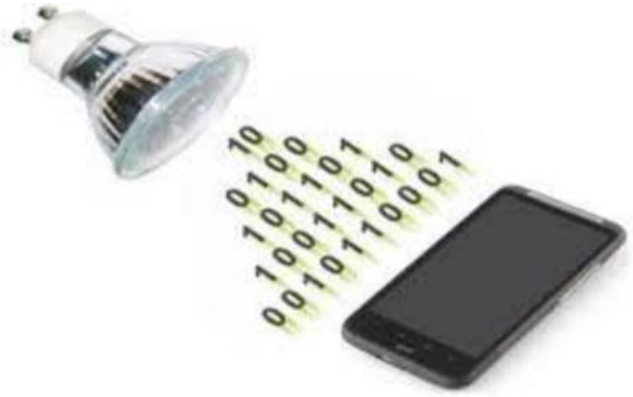
INTRODUCTION

In simple language, Li-Fi can be thought of as light based Wi-Fi. Li-Fi or Light Fidelity , refers to Visible light communications systems using light from light emitting diode as a medium to deliver networked, mobile, high-speed communication in a similar manner a Wi-Fi. Li-Fi can be used to off-load data from existing Wi-Fi networks to provide capacity for the greater downlink demand as complementary to the existing wireless or wired network infrastructure. Li-Fi could lead to everything electronic being connected to the internet with the lights on the electronics being used as internet access point. The Li-Fi market is projected to be worth over $6 billion per year by 2018.

Visible light communications (VLC) signals work by switching bulbs on and off incredibly quickly – too quickly to be noticed by the human eye. Although Li-Fi bulbs would have to be kept on to transmit data, the bulbs could be dimmed to the point that they were not visible to humans and yet still functional. The light waves cannot penetrate walls which makes a much shorter range, though more secure from hacking, relative to Wi-Fi. Direct line of sight isn't necessary for Li-Fi to transmit signal and light reflected off of the walls can achieve 70 Mbps**.** Wi-Fi and Li-Fi transmit data over the electromagnetic spectrum, but whereas Wi-Fi utilizes radio waves, Li-Fi uses visible light. While the US Federal Communications Commission has warned of a potential spectrum crisis because Wi-Fi is close to full capacity, Li-Fi has almost no limitations on capacity. The visible light spectrum is 10,000 times larger than the entire radio frequency spectrum. Researchers have reached data rates of over 10 Gbps. Which is more than 250 times faster than superfast broadband? Li-Fi is expected to be ten times cheaper than Wi-Fi. Short range, low reliability and high installation costs are the potential drawback.

Harald Haas, a professor at the University of Edinburgh who began his research in field in 2004, gave a debut demonstration of what he called a Li-Fi prototype at the TED Global conference in Edinburgh on 12th July 2011



Overview of LIFI [7]

II. LI-FI CONSTRUCTION

The LIFI product consists of 4 primary sub-assemblies [15]:

- Bulb
- RF power amplifier circuit(PA)
- Printed circuit board(PCB)
- Enclosure

The PCB controls the electrical inputs and output of the lamp and houses the micro controller used to manage different lamp functions.

An RF (radio-frequency) signal is generated by the solid-state PA and is guided into an electric 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 centre; this controlled plasma generates an intense source of light. All of these subassemblies (shown in Fig.1) are contained in an aluminium enclosure[15].

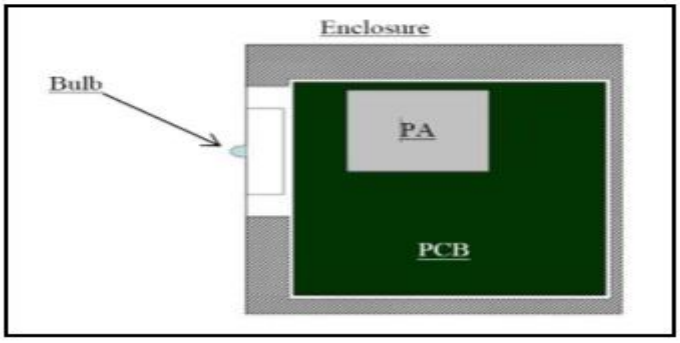


Fig.1-Lifi Block Diagram [15]

The bulb sub-assembly is the heart of the Li-Fi emitter. It consists of a sealed bulb which is embedded in a dielectric material. This design is more reliable than conventional light sources that insert degradable electrodes into the bulb [3]. The dielectric material serves two purposes. It acts as a waveguide for the RF energy transmitted by the PA. It also acts 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 [15]. Figure 2 shows the bulb sub-assembly. Bandwidth of Li Fi is more efficient and the consortium of Li Fi and the light emitting the data in the form of 0's and 1's within the range. Representation of Spectral Power Distribution of LED light which transmits the data in the form of 00000111111111100101…. And it will be received by the Photo detector and amplification processing is done.[4]

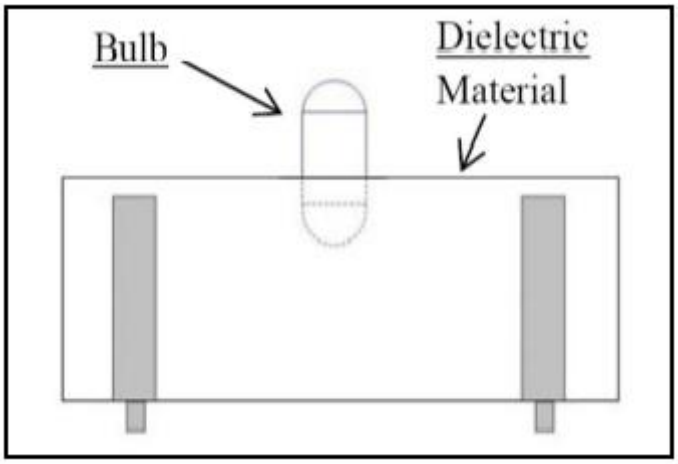


Fig. 2-Bulb sub-assembly [4]

III. WORKING OF LI-FI

The working of Li-Fi is very simple. There is a light emitter on one end, for example, an LED, and a photo detector (light sensor) on the other. The photo detector registers 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 a few different colors, to obtain data rates in the range of hundreds of megabits per second.The working of lifi is shown lin Fig.3.The data can be encoded in the light by varying the flickering rate at which the LEDs flicker on and off to generate different strings of 1s and 0s.The LED intensity is modulated so rapidly that human eye cannot notice, so the light of the LED appears constant to humans.

Li-Fi is typically implemented using white LED light bulbs at the download link transmitter. These devices are normally used for illumination only by applying a constant current. However, by fast and suitable variations of the current, the optical output can be made to vary at extremely high speeds. This very property of optical current is used in Li-Fi setup. The operational procedure is very simple, if the LED is on, you transmit a digital 1, if it's off you transmit a digital 0.The LEDs can be switched on and off very quickly, which gives nice opportunities for transmitting data. Hence all that is required is some LEDs and a controller that code data into those LEDs. All one has to do is to vary the rate at which the LED's flicker depending upon the data we want to encode. Further enhancement can be made in this method, like using an array of LEDs for parallel data transmission, or using mixtures of red, green and blue LEDs to alter the light's frequency with each frequency encoding a different data channel. Such advancements promise a theoretical promise, a theoretical speed of 10Gbps –meaning one can download a full high-definition film in just 30 second

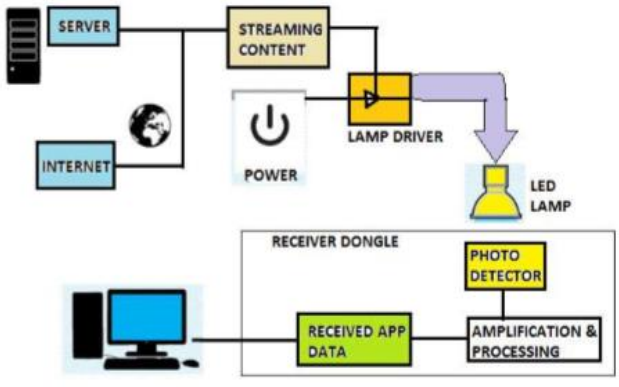


Fig.3- Working of LIFI [2]

To further get a grasp of Li-Fi consider an IR remote. It sends a single data stream of bits at the rate of 10,000-20,000 bps. Now replace the IR LED with a Light Box containing a large LED array. This system, as shown in fig.1 is capable of sending thousands of such at very fast rate.

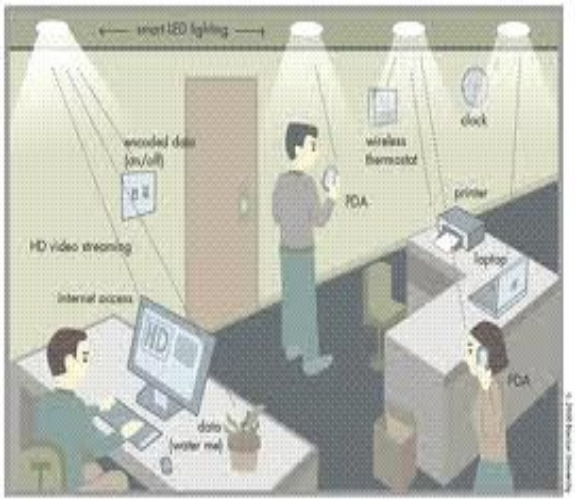


Fig.4 - Demonstration (Lifi system connecting devices in a room)[11]

Light is inherently safe and can be used in placed where radio frequency communication is often demand problematic, such as in aircraft cabins or hospitals. So visible light communication not only has the potential to solve the problem of lack of spectrum space, but can also enable novel application. The visible light spectrum is unused; it's not regulated, and can be used for communication at very high speeds.

IV. ADVANTAGES AND DISADVANTAGES OF LI-FI

a) Advantages

Li-Fi removes the limitations that have been put on the user by the Wi-Fi.

a) Capacity: Light has 10000 times wider bandwidth than radio waves [12]. Also, light sources are already installed. So, Li-Fi has got better capacity and also the equipment's are already available.

b) Efficiency: Data transmission using Li-Fi is very cheap. LED lights consume less energy and are highly efficient.

c) Availability: Availability is not an issue as light sources are present everywhere. There are billions of light bulbs worldwide; they just need to be replaced with LEDs for proper transmission of data.

d) Security: Light waves do not penetrate through walls. So, they can‘t be intercepted and misused.

b) Disadvantages

The major disadvantage here is the fact that these signals cannot penetrate walls. So if you want to move from one room to another, you will need to have a wired bulb present in that room as well.

V. FUTURE APPLICATIONS OF LI-FI

There are numerous applications of this technology, from public internet access through street lamps to auto-piloted cars that communicate through their headlights.

Applications of Li-Fi can extend in areas where the Wi-Fi technology lacks its presence like medical technology, power plants and various other areas. Since Li-Fi uses just the light, it can be used safely in aircrafts and hospitals where Wi-Fi is banned because they are prone to interfere with the radio waves.

All the street lamps can be transferred to Li-Fi lamps to transfer data. As a result of it, it will be possible to access internet at any public place and street.

Some of the future applications of Li-Fi are as follows:

a) Education systems: Li-Fi is the latest technology that can provide fastest speed internet access. So, it can replace Wi-Fi at educational institutions and at companies so that all the people can make use of Li-Fi with the same speed intended in a particular area.

b) Medical Applications: Operation theatres (OTs) do not allow Wi-Fi due to radiation concerns. Usage of Wi-Fi at hospitals interferes with the mobile and pc which blocks the signals for monitoring equipments. So, it may be hazardous to the patient's health. To overcome this and to make OT tech savvy Li-Fi can be used to accessing internet and to control medical equipments. This can even be beneficial for robotic surgeries and other automated procedures.

c) Cheaper Internet in Aircrafts: The passengers travelling in aircrafts get access to low speed internet at a very high rate. Also Wi-Fi is not used because it may interfere with the navigational

systems of the pilots. In aircrafts Li-Fi can be used for data transmission. Li-Fi can easily provide high speed internet via every light source such as overhead reading bulb, etc. present inside the airplane.

d) Underwater applications: Underwater ROVs (Remotely Operated Vehicles) operate from large cables that supply their power and allow them to receive signals from their pilots above. But the tether used in ROVs is not long enough to allow them to explore larger areas. If their wires were replaced with light — say from a submerged, high-powered lamp — then they would be much freer to explore. They could also use their headlamps to communicate with each other, processing data autonomously and sending their findings periodically back to the surface [1]. Li-Fi can even work underwater where Wi-Fi fails completely, thereby throwing open endless opportunities for military operations.

e) Disaster management: Li-Fi can be used as a powerful means of communication in times of disaster such as earthquake or hurricanes. The average people may not know the protocols during such disasters. Subway stations and tunnels, common dead zones for most emergency communications, pose no obstruction for Li-Fi [1]. Also, for normal periods, Li-Fi bulbs could provide cheap high-speed Web access to every street corner.

f) Applications in sensitive areas: Power plants need fast, inter-connected data systems so that demand, grid integrity and core temperature (in case of nuclear power plants) can be monitored. Wi-Fi and many other radiation types are bad for sensitive areas surrounding the power plants. Li-Fi could offer safe, abundant connectivity for all areas of these sensitive locations. This can save money as compared to the currently implemented solutions. Also, the pressure on a power plant‘s own reserves could be lessened. Li-Fi can also be used in petroleum or chemical plants where other transmission or frequencies could be hazardous.

g) Traffic management: In traffic signals Li-Fi can be used which will communicate with the LED lights of the cars which can help in managing the traffic in a better manner and the accident numbers can be decreased [1]. Also, LED car lights can alert drivers when other vehicles are too close.

h) Replacement for other technologies: Li-Fi doesn‘t work using radio waves. So, it can be easily used in the places where Bluetooth, infrared, Wi-Fi, etc. are banned.

VI.COMPARISON 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. Comparisons of two technologies are given below in table 1. [6]

COMPARISON BETWEEN LI-FI VS. WI-FI

S. No.	Parameters	Wireless Technologies	
		Light Fidelity	Wireless Fidelity
1.	Speed for data transfer	Faster transfer speed (>1 Gbps)	Data Transfer speed (150 Mbps)
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	Hundreds of Tera Hz	2.4 GHz

VII. CONCLUSION

If this technology can be put into practical use, every bulb can be used something like Wi-Fi hotspot to transmit wireless data and will proceed toward the cleaner, greener, safer and brighter future. As a growing number of people and their many devices access wireless internet we can use Li-Fi technology. This technology can be used in aircraft or hospitals. As we see there are not many disadvantages in this technology so we can use it in many applications in future.

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