Li-Fi- Internet at the Speed of Light

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Abstract— Li-Fi or Light Fidelity refers to Visual light communication systems using light-emitting diodes for medium to high-speed communication in a similar manner as Wi-Fi. Li-Fi is the result of the research of a germen physicist Harald Hass which he calls "data through illumination." He envisions 'data from the laptops, smart phones and tablets to be transmitted through the light in the room'. Wi-Fi makes up to 60% of the total internet traffic and Li-Fi is a better alternative to Wi-Fi in wireless communication. This paper proposes a survey on Li-Fi Technology. Li-Fi has data rate of 100 megabytes per second which is faster than your average broadband connection [9]. It provides security as the visible light is unable to penetrate through the walls which is a major issue with Wi-Fi as it uses radio waves for transmission .The concept of Li-Fi is data communication on fast flickering of light which is not detected by human eye but it is focused on photo detector which converts the on-off state into binary digital data. It has gained a huge popularity in two years of its invention. Such technology has brought not only greener but safer and cheaper future of communication which is the need of the hour.

Key words: Li-Fi, Wi-Fi, LED, VLC, Wireless Communication

I. INTRODUCTION

Li-Fi is a wireless optical networking technology that uses light-emitting diodes (LEDs) LED light bulbs similar to those currently in use in many energy-conscious homes and offices. However, Li-Fi bulbs are outfitted with a chip that modulates the light appropriately for optical data transmission. Li-Fi data is transmitted by the LED bulbs and received by photoreceptors [1].

In simple words, Li-Fi is a light based communication technology. That means unlike Wi-Fi that uses radio waves, Li-Fi uses light waves.

Fig. 1: Li-1st, the First Li-Fi equipment

The concept of Li-Fi is currently attracting a great deal of interest because it is a very efficient alternative to Wi-Fi. A growing number of people access wireless internet, thus the airwaves are becoming increasingly clogged and causing unavailability of free bandwidths to every device, making it more and more difficult to get a reliable, high speed signal. Li-Fi is present wherever there is availability of light, in turn eradicating the necessity of having hot-spots only at selected places.

Li-Fi and Wi-Fi uses electromagnetic spectrum for data transmission, but whereas Wi-Fi utilizes radio waves, Li-Fi uses visible light communication. Light also has frequency range 10,000 times greater than radio waves, and therefore proves to have 100 times higher data rate than Wi-Fi, following the idea – higher the frequency higher the data rate.

Li-Fi has already achieved high speeds in the lab with a breakthrough 224Gbps speed. It's believed that this technology has the potential to change everything about the way we use the Internet today.

The present paper deals with the, the comparison made between Wi-Fi and Li-Fi technology. This paper also discusses the working, implementation and improvements in Li-fi technology.

II. PRINCIPLE OF LI-FI

The basic principle behind Li-Fi is the use of LEDs that can be switched on and off very quickly. If the LED is ON, 1 is transmitted and when it is OFF, 0 is transmitted. Thus it is possible to encode data by varying the rate at which the LEDs flicker between on and off to give different strings of 1s and 0s. This modulation is so fast that the human eye doesn't even notice the change [3]. A light sensitive device (photo detector) then receives the signal and converts it into the original data.

III. VISUAL LIGHT COMMUNICATION

VLC is a data communication technique that uses visual light between 400THz-800 THz as an optical carrier for data communication. Li-Fi is based on VLC. Light is part of the electromagnetic spectrum just like the radio waves but at a much higher frequency. Thus the waves that carry the energy, cycle at a much higher rate than radio waves. This means light has the capacity to transmit large amount of data in lesser amount of time than radio waves.

The vast potential of unused, unregulated, safe green spectrum in the visible light spectrum is used by Li-Fi. Moreover, the visible light spectrum is 10,000 times larger than the entire radiofrequency spectrum.

IV. CONSTRUCTION OF LI-FI SYSTEM

A. Source

An LED is used as a communication source that is guided by the PCB and powered by the PA. It is then enclosed in an aluminum enclosure. The Li-Fi emitter system consists of 4 primary sub-assemblies:

- 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.

- RF power amplifier circuit (PA):An RF (radio frequency) signal is generated by the solid-state PA(Power Amplifier) and is guided into an electric field about the bulb.
- Printed Circuit board (PCB):It controls the electric inputs and outputs of the lamp and houses the microcontroller used to manage different lamp functions.
- Enclosure: All of these subassemblies are contained in an aluminum enclosure [2].

Fig. 2 shows the block diagram of Li-Fi sub-assemblies

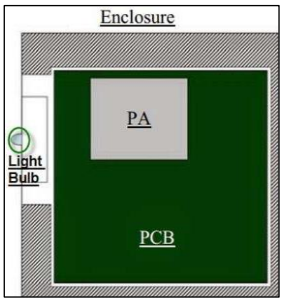

Fig. 2: Block diagram of Li-Fi sub-assemblies

B. Receiver

A silicon photodiode is used as a receiving element as it shows good response to visible wavelength region. Fig. 3 shows a photodiode receiver.

Fig. 3: Photodiode Receiver

C. Function of the Bulb Assembly

In the bulb sub-assembly, a sealed bulb is embedded in a dielectric material. This design is more reliable than conventional light sources that insert degradable electrodes into the bulb. The dielectric material serves two purposes. First as a waveguide for the RF energy transmitted by the PA and second 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 [2].Fig. 4 shows the bulb sub-assembly.

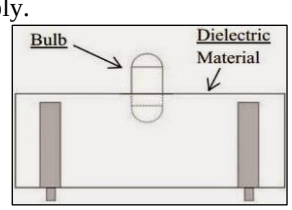

Fig. 4: Bulb Sub-Assembly

V. WORKING OF LI-FI

Li-Fi is implemented using white LED bulbs at the downlink transmitter. By fast and subtle variations of the current, the optical output can be made to vary at extremely high speeds. This property of optical current is used for Li-Fi setup. If the LED is on, a digital 1 is transmitted and if it is off, a 0 is transmitted. A software code makes the bulb flicker at extremely high speeds which are not visible to the human eye. This flickering or pulsing is then converted into a signal by a receiver. Fig. 5 shows the block diagram of Li-Fi system.

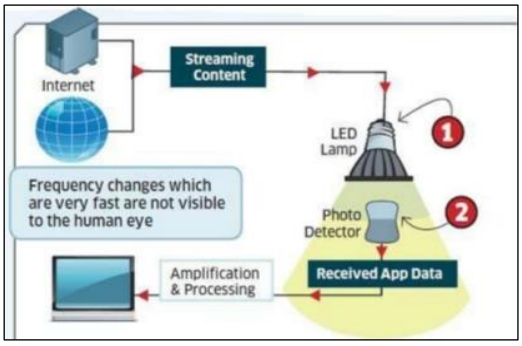

Fig. 5: Block diagram of Li-Fi system

Radio frequency communication requires radio circuits, antennas and complex receivers, whereas Li-Fi is much simpler and uses direct modulation methods similar to those used in low-cost infra-red communications devices such as remote control units. Infra-red communication is limited in power due to eye safety requirements, whereas LED light bulbs have high intensities and can achieve very large data rates [6].

Further enhancements can be made in this method by using an array of LEDs for parallel data transmission, or by using mixtures of red, green and blue LEDs to alter the light's frequency with each frequency encoding a different data channel [8].

VI. COMPARISON WITH WI-FI

Parameters	Li-Fi	Wi-Fi
Speed for data transfer	Faster transfer speed(>1 Gbps)	Lower transfer speed (150 Mbps)
Medium for data transfer	light	Radio spectrum
Spectrum range	Visible light spectrum has 10,000 time broad spectrum in comparison to radio frequency	Radio frequency spectrum range is less than visible spectrum
Cost	Cheaper than Wi-Fi as it uses light (no licensing required)	Costlier than Li-Fi as it uses radio spectrum
Operating frequency	100 THz	2.4 GHz
Security	High	low
Standard	IEEE 802.15	IEEE 802.11b
Operating band	Visible light band	RF band
Working	Direct binary data serving	Various topologies
Usage Location	Anywhere where light is available i.e. on roads, public places, flats, homes, industrial areas, power plants,	Areas under WLAN infrastructure usually inside a building

	hospitals.	
Development started	2011	1990

Table 1: Comparison of Li-Fi with Wi-Fi

VII. ADVANTAGES OF LI-FI

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

A. Bandwidth

The visible light spectrum is plentiful (10,000 more than RF spectrum), unlicensed and free to use.

B. Data density

Li-Fi can achieve about 1000 times the data density of Wi-Fi because visible light can be well contained in a tight illumination area whereas RF tends to spread out and cause interference.

C. High speed

Very high data rates can be achieved due to low interference, high device bandwidths and high intensity optical output.

D. Planning

Capacity planning is simple since there tends to be illumination infrastructure where people wish to communicate, and good signal strength can literally be seen.

E. Low Cost

Requires fewer components than radio technology. Hence, Cost is also less.

F. Energy

LED illumination is already efficient and the data transmission requires negligible additional power.

G. Environment

RF transmission and propagation in water is extremely difficult but Li-Fi works well in this environment.

H. Safety

Life on earth has evolved through exposure to visible light. There are no known safety or health concerns for this technology.

I. Non-hazardous

The transmission of light avoids the use of radio frequencies which can dangerously interfere with electronic circuitry in certain environments.

J. Containment

It is difficult to eavesdrop on Li-Fi signals since the signal is confined to a closely defined illumination area and will not travel through walls.

K. Control

Data may be directed from one device to another and the user can see where the data is going; there is no need for additional security such as pairing for RF interconnections such as Bluetooth.

VIII. CHALLENGES OF LI-FI TECHNOLOGY

Although there are a lot of advantages of LI-FI, there are still certain challenges which need to be overcome.

1) LI-FI requires Line of Sight.
2) If the apparatus is set up outdoors, it would need to deal with changing weather conditions.
3) If the apparatus is set up indoors, one would not be able to shift the receiver.
4) The problem of how the receiver will transmit back to the transmitter still persists.
5) Light waves can easily be blocked and cannot penetrate thick walls like the radio waves can.
6) We become dependent on the light source for internet access. If the light source malfunctions, we lose access to the internet.

IX. APPLICATIONS OF LI-FI

The LI-FI system finds a variety of uses in many fields from access to internet by the general public using street lamps to auto-pilot cars which communicate through their headlights. Moreover, in areas such as medicine and aircrafts where WI-FI cannot be used, LI-FI is an alternative which can provide faster data access rates. Some of the applications are discussed below:

A. Education System

LI-FI can replace WI-FI in educational institutions and provide faster internet speeds. All the people can make use of the same speed as has been designated.

B. Medical Applications

WI-FI is not allowed operation theaters because they can interfere with medical equipments. Moreover, their radiations pose risks for patients. LI-FI uses light and hence can be used in place of WI-FI.

C. Mobile Connectivity

Laptops, smart phones, tablets and other mobile devices can interconnect directly using Li-Fi .Shortrange links give very high data rates and also provides security.

D. Internet Access in Aircrafts

The use of WI-FI is prohibited inside airplanes because they can interfere with the navigational systems of the plane. The users get access to very low speed internet at high rates. Thus, LI-FI is a safe alternative to WI-FI in aircrafts since it uses light and can provide faster internet access.

E. 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. LI-FI can even work underwater where Wi-Fi fails completely, thereby throwing open endless opportunities for military operations.

F. Radio Broadcast

A large amount of power is required by radio masts in order to broadcast and this makes them quite inefficient. LEDs on the other hand require very low power to operate and this means that LI-FI also uses very little power.

G. 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.

H. RF Avoidance

Some people claim they are hypersensitive to radiofrequencies and are looking for an alternative. Li-Fi is a good solution to this problem

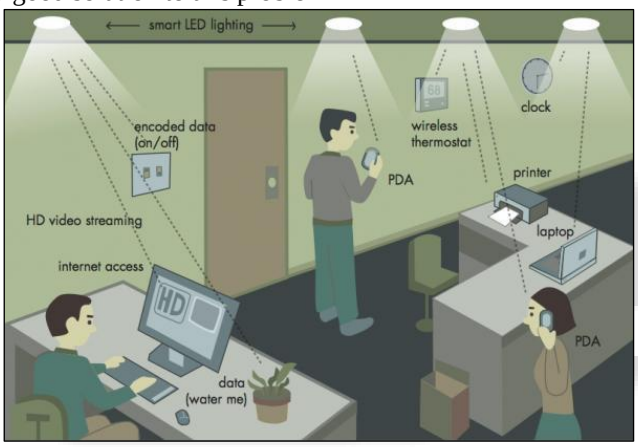

Fig. 6: Smart Home

X. CONCLUSION

LI-FI is an emerging technology and hence it has vast potential. A lot of research can be conducted in this field. It's latest and very efficient alternative to radio-based wireless technology. The possibilities are numerous and can be explored further. If this technology can be put into practical use, every bulb can be used something like a Wi-Fi hotspot to transmit wireless data and we can proceed toward the cleaner, greener, safer and brighter future. As growing number of people and their many devices access wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high speed signal. This may solve issues such as the short rage of radio frequency bandwidth and also allow internet where traditional radio based wireless is not allowed such as in aircraft or hospitals. One of the shortcomings however is that it only works in direct line of sight.

XI. THE FUTURE

The future of LI-FI is GI-FI. GI-FI or gigabit wireless refers to wireless communication at a data rate of more than one billion bits (gigabit) per second. It will allow wireless transfer of audio and video data at up to 5 gigabits per second, ten times the current maximum wireless transfer rate, at one-tenth the cost

REFERENCES

[1] Harald Haas. "Harald Haas: Wireless data from every light bulb"
[2] Rahul R. Sharma, Raunak and Akshay Sanganal, "Li-Fi Technology transmission of data through light" Int.J. Computer Technology & Applications, Vol 5 (1),150-154, Jan-Feb 2014
[3] Li-Fi – Internet at the Speed of Light, by Ian Lim, the gadgeteer, dated 29 August 2011
[4] Condliffe, Jamie, "Will Li-Fi be the new Wi-Fi?". New Scientist, 28 July 2011
[5] http://purelifi.com
[6] http://purelifi.com/what_is_li-fi/how-does-vlc-work/
[7] http://www.computerweekly.com/news/2240177285/LED-technology-to-bring-Wi-Fi-over-light
[8] Shubham Chatterjee , Shalabh Agarwal , Asoke Nath , "Scope and Challenges in Light Fidelity(LiFi) Technology in Wireless Data Communication" International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163 Issue 6, Volume 2 ,June 2015
[9] http://whatis.techtarget.com/definition/LiFi

