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LI-FI (LIGHT FIDELITY)-THE FUTURE TECHNOLOGY IN WIRELESS COMMUNICATION

Prof. Akshada K. Dhakade[1], Adarsh V. Sakharkar[2], Prasad M. Gore[3]
[1]*Assistant Professor, Information Technology, DBNCOET Yavatmal, Maharashtra, India,* ***akshada23891@gmail.com***
[2]*Students, Name of the Department, Electronics, Institute GPY Yavatmal, Maharashtra, India,* ***adarshsakharkar1409@gmail.com***
[3]*Students, Name of the Department, Mechanical Institute GPY Yavatmal, Maharashtra, India,* ***prasadgore02@gmail.com***

ABSTRACT
Li-Fi stands for Light Fidelity. The technology is very new and was proposed by the German physicist Harald Haas in 2011 TED (Technology, Entertainment, Design) Global Talk on Visible Light Communication (VLC). Li-Fi is a wireless optical networking technology that uses light emitting diodes (LEDs) for transmission of data.This paper focuses on Li-Fi, its applications, features and comparison with existing technologies like Wi-Fi etc. Wi-Fi is of major use for general wireless coverage within building, whereas Li-Fi is ideal for high density wireless data coverage in confined area and especially useful for applications in areas where radio interference issues are of concern, so the two technologies can be considered complimentary.

Index Terms: *Li-Fi,LED(Light Emitted Diode), Wi-Fi, VLC*

1. INTRODUCTION

There are around 1.4 million cellular mast radio waves base stations deployed, with over 5 billion mobile phones. Mobile phones transmit over 600TB of data. Presently wireless communication uses radio waves. Spectrum is the one of the most essential requirement for wireless communication. With the advancement in technology and the number of users, the existing radio wave spectrum fails to cater to this need. To resolve the issues of scalability, availability and security, we have come up with the concept of transmitting data wirelessly through light using LED_s, which is called as Li-Fi is a latest technology that makes use of LED light which helps in the transmission of data much faster and flexible than data that can be transmitted through Wi-Fi.

Visible light communication (VLC) is a new way of wireless communication using visible light. Typical transmitters used for visible light communication are visible light LEDs and receivers are photodiodes and image sensors. We present new applications which will be made possible by visible light communication technology. Location-based services are considered to be especially suitable for visible light communication applications. An indoor visible data transmission system utilizing LEDs is proposed. In this system, these devices are used not only for illuminating rooms, but also for an optical wireless communication system[6].

The US federal communication commission has warned of a potential spectrum crisis because Wi-Fi is close to full capacity, Li-Fi has almost no limitation on full capacity. Visible light is part of the electromagnetic spectrum and its bandwidth is 10,000 times bigger than the radio frequency spectrum used by existing communication systems, affording vastly greater capacity. Researchers have reached data rates of over 10gbps, which is more than 250 times faster than super fast broadband. Li-Fi is expected to be 10 times cheaper and more environmentally friendly than Wi-Fi. Short range, low reliability and installation cost are the potential downsides. Li-Fi has the advantage of being able to be used in electromagnetic sensitive areas such as in aircraft cabins, hospitals and nuclear powerplants without causing electromagnetic interference.

Fig.1- Li-Fi Environment

1.1 Overview of Li-Fi

Li-Fi stands for LIGHT FIDELITY‘. Li-Fi is transmission of data through illumination by taking the fiber out of fiber optics by sending data through a LED light bulb that varies in intensity faster than the human eye can follow. Li-Fi is the term some have used to label the fast and cheap wireless-communication system, which is the optical version of Wi-Fi. Light reaches

nearly everywhere so communication can also go along with light easily.

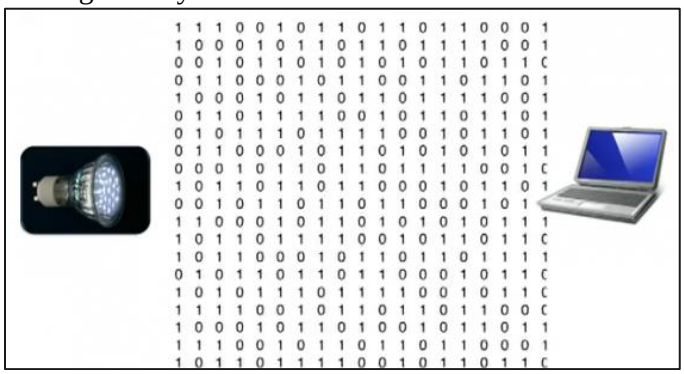

Fig. 2- Li-Fi Transmission

Light Fidelity is a branch of optical wireless communication which is an emerging technology. Bythe professor of mobile communications at the University of Edinburgh, UK, first time publically displayed the proof of Light Fidelity(Li-Fi),amethod of Visible Light communication(VLC). Li-Fi is the transfer of data through light by taking fiber out of fiber optics and sending data through LED light.Li-Fi technology 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. Wi-Fi is great for general wireless coverage within buildings, whereas Li-Fi is ideal for high density wireless data coverage in confined area and for relieving radio interference issues. Li-Fi provides better bandwidth, efficiency, availability and security than Wi-Fi and has already achieved blisteringly high speed in the lab. By leveraging the low-cost nature of LEDs and lighting units there are many opportunities to exploit this medium, from public internet access through street lamps to auto-piloted cars that communicate through their headlights. Haas envisions a future where data for laptops, smart phones, and tablets will be transmitted through the light in a room [6].

1.2Difference between Li-Fi and Wi-Fi

Feature	LiFi	WiFi
Full form	Light Fidelity	Wireless Fidelity
Operation	LiFi transmits data using light with the help of LED bulbs.	WiFi transmits data using radio waves with the help of WiFi router.
Interference	Do not have any interference issues similar to radio frequency waves.	Will have interference issues from nearby access points (routers)
Technology	Present IrDA compliant devices	WLAN 802.11a/b/g/n/ac/ad standard compliant devices
Applications	Used in airlines, undersea explorations, operation theaters in the hospitals, office and home premises for data transfer and internet browsing	Used for internet browsing with the help of WiFi kiosks or hotspots
Advantages	Interference is less, can pass through salty sea water, works in dense region	Prone to interference, can‘t pass through sea water, works in less dense region
Privacy	light is blocked by the walls, therefor more secured on data transfer	For RF signal, dry walls are transparent, therefore need to employ techniques to achieve secure data transfer.
Data transfer speed	About 1 Gbps	WLAN-11n offers 150Mbps, About 1-2 Gbps can be achieved using WiGig/Giga-IR
Frequency of operation	10,000 times frequency spectrum of the radio (In the Tera Hz range)	2.4GHz, 4.9GHz and 5GH

2.PRINCIPLE& TECHNOLOGY OF LI-FI

Heart of Li-Fi technology is high brightness LED‟s. These can be switched on and off faster since operating speed of led is less than 1 micro second than human eye can detect causing the light source to appear continuously. Switching on and off led is a logical „1‟ and switching it off isa logical „0‟.itis possible to encode data in light by varying rate at which led‟s flicker I and off to give different string of 1‟s‟ and 0‟s‟.

A light sensitive device (photodiode) receives signal operates and converts it back to original data. This method of using rapid [pulses of light to transmit information wirelessly is VLC (Visible Light Communication).

Itis band on use of visible light between blue (670 THz) and red(480 THz). Wi-Fi uses radio part of electromagnetic wave spectrum, Li-Fi uses optical spectrum. The principle of Li-Fi is based on sending data by amplitude modulation of light source in a well-defined and standardised way. This is a whole new spectrum of possibilities as compared to the radio eaves spectrum and 10000 times more in size [3].

3. ARCHITECTURE OF LI-FI SYSTEM

Li-Fi which can be the future of data communication appears to be a fast and cheap optical version of Wi-Fi. Being a Visible Light Communication (VLC), Li-Fi uses visible light of electromagnetic spectrum between 400 THz and 800 THz as optical carrier for data transmission and illumination. It uses fast pulses of light to transmit information in wirelessmedium. The main components of a basic Li-Fi system may contain the following:

a) A high brightness white LED which acts as transmission source.

b) A silicon photodiode with good response to visible light as the receiving element.

Switching the LEDs on and off can make them generate digital strings with differentcombination of 1s and 0s. To generate a new data stream, data can be encoded in the light byvarying the flickering rate of the LED. In this way, the LEDs work as a sender by modulatingthe light with the data signal. The LED output appears constant to the human because they aremade to flicker at a phenomenal speed (millions of times per second) and it's impossible forhuman eye to detect this frequency.

The Li-Fi transmitter system comprises of four primary subassemblies:

a. Bulb
b. RF Power Amplifier Circuit (PA)
c. Printed Circuit Board (PCB)
d. Enclosure

The Printed circuit board (PCB) controls the electrical inputs and outputs of the lamp and housesthe microcontroller used to manage different lamp functions. A Radio Frequency (RF) signal isgenerated by the Power Amplifier and is directed into the electric field of the bulb. As a resultof the high concentration of energy in the electric field, the contents of the bulb will getvaporized into a plasma state at the bulb's centre. And this controlled plasma in turn willproduce an intense source of light. All of these subassemblies are contained in an aluminiumenclosure as shown in Fig. 3

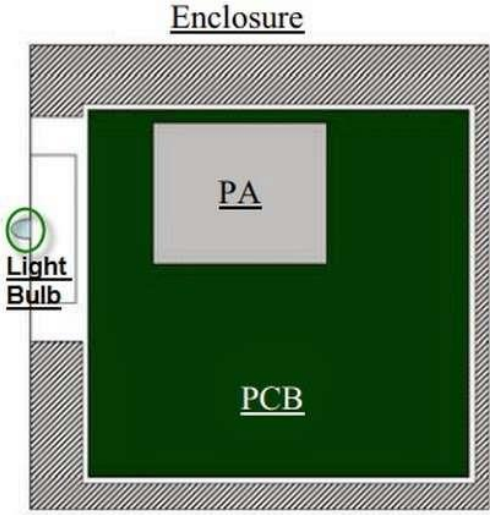

Fig. 3 Block Diagram of Li-Fi sub-assemblies

3.1 Li-Fi Bulb sub-assembly

The bulb sub-assembly is the main part of the Li-Fi emitter. It consists of a sealed bulbembedded in a dielectric material which serves two purposes: one, it acts as a waveguide forthe RF energy transmitted by the PA (Power Amplifier) and two, it acts as an electric fieldconcentrator that focuses the energy into the bulb. The collected energy from the electric fieldrapidly heats the material in the bulb to a plasma state that emits light of high intensity of Visible light spectrum. Figure 4 shows the sub-assembly of the bulb.

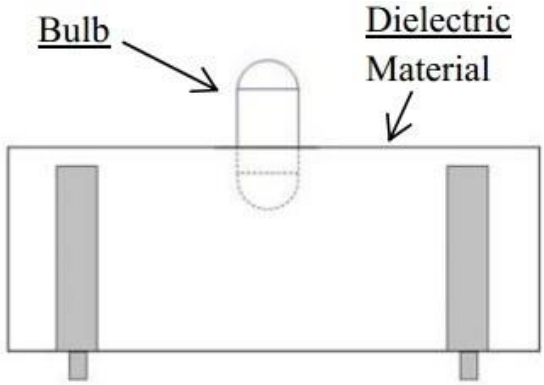

Fig 4: Bulb Sub Assembly

4. WORKING OF LI-FI

The working of Li-Fi is very simple. There is a light emitter on one end i.e. an LED transmitter,and a photo detector (light sensor) on the other. The data input to the LED transmitter is encodedin to the light (technically referred to as Visible Light Communication) by varying the flickeringrate at which the LEDs flicker 'on' and 'off' to generate different strings of 1s and 0s. The onoff activity of the LED transmitter which seems to be invisible (The LED intensity is modulatedso rapidly that human eye cannot notice, so the light of the LED appears constant to humans),enables data transmission in light form in accordance with the incoming binary codes: switching ON a LED is a logical '1', switching it OFF is a logical '0'. By varying the rate at which theLEDs flicker on and off, information can be encoded in the light to different combinations of1s and 0s.

In a typical setup, the transmitter (LED) is connected to the data network (Internet through the modem) and the receiver (photo detector/light sensor) on the receiving end receives the data as light signal and decodes the information, which is then displayed on the device connected tothe receiver. The receiver (photo detector) registers a binary '1' when the transmitter (LED) is ON and a binary '0' when the transmitter (LED) is OFF. Thus flashing the LED numerous timesor using an array of LEDs (perhaps of a few different colours) will eventually provide data ratesin the range of hundreds of Mbps. The Li-Fi working is explained in a block diagram (Fig.5).

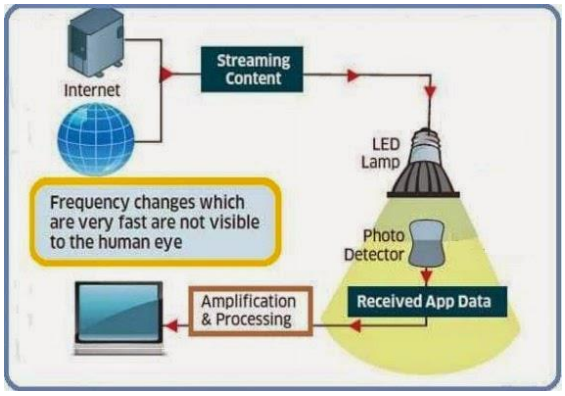

Fig 5: Block diagram of Li-Fi Sub System

5. ADVANTAGES OF Li-Fi

Advantages of Li-Fi technology include:

a) Efficiency: Energy consumption can be minimised with the use of LED illuminationwhich are already available in the home, offices and Mall etc. for lighting purpose.

b) High speed: Combination of low interference, high bandwidths and high-intensityoutput, help Li-Fi provide high data rates i.e. 1 Gbps or even beyond.

c) Availability: Availability is not an issue as light sources are present everywhere.Wherever there is a light source, there can be Internet. Light bulbs are present everywhere – in homes, offices, shops, malls and even planes, which can be used as a medium for thedata transmission.

d) Cheaper: Li-Fi not only requires fewer components for its working, but also uses only anegligible additional power for the data transmission.

e) Security: One main advantage of Li-Fi is security. Since light cannot pass through opaquestructures, Li-Fi internet is available only to the users within a confined area and cannot
be intercepted and misused, outside the area under operation.

f) Li-Fi technology has a great scope in future. The extensive growth in the use of LEDsfor illumination indeed provides the opportunity to integrate the technology into aplethora of environments and applications.

6. LIMITATIONS OF Li-Fi

Some of the major limitations of Li-Fi are:

a. Internet cannot be accessed without a light source. This could limit the locations andsituations in which Li-Fi could be used.
b. It requires a near or perfect line-of-sight to transmit data
c. Opaque obstacles on pathways can affect data transmission
d. Natural light, sunlight, and normal electric light can affect the data transmission speed
e. Light waves don't penetrate through walls and so Li-Fi has a much shorter range than Wi-Fi
f. High initial installation cost, if used to set up a full-fledged data network.
g. Yet to be developed for mass scale adoption.

7. APPLICATIONS OF Li-Fi

Some of the future applications of Li-Fi could be as follows:

a) **Education systems:** Li-Fi is the latest technology that can provide fastest speed forInternet access. So, it can augment/replace Wi-Fi at educational institutions and at companies so that the people there can make use of Li-Fi with the high speed.

b) **Medical Applications:** Operation theatres (OTs) do not allow Wi-Fi due to radiationconcerns. Usage of Wi-Fi at hospitals interferes/blocks the signals for monitoring equipments.

c) **Cheaper Internet in Aircrafts:** The passengers travelling in aircrafts get access to lowspeed Internet that too at a very high price.

d) **Underwater applications:** Underwater ROVs (Remotely Operated Vehicles) operatefrom large cables that supply their power and allow them to receive signals from theirpilots above. But the tether used in ROVs is not long enough to allow them to explorelarger areas.

e) Disaster management: Li-Fi can be used as a powerful means of communication in timesof disaster such as earthquake or hurricanes.

CONCLUSION

Although there's still a long way to go to make this technology a commercial success, itpromises a great potential in the field of wireless internet. A significant number of researchers and companies are currently working on this concept, which promises to solve the problem oflack of radio spectrum, space and low internet connection speed. By deployment of thistechnology, we can migrate to greener, cleaner, safer communication networks. Li-Fi is the upcoming andgrowing technology acting as catalyst for various other developing and newinventions/technologies. Therefore, there is certainty of development of future applications of the Li-Fi which can be extended to different platforms and various walks of human life.

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