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Light Fidelity: A New Prototype in Wireless Communication

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***Abstract*— Light Fidelity (Li-Fi) is a label for wireless-communication systems using light as a carrier instead of traditional radio Frequencies [1], as in Wi-Fi. Li-Fi has the advantage of being able to be used in sensitive areas such as in Aircraft without causing interference. However, the light waves used cannot penetrate walls. It is typically implemented using white LED light bulbs at the Downlink transmitter. The operational procedure is very simple-, if the LED is on, you transmit a digital 1, if it's off you transmit a 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 [2] depending upon the data we want to encode. Li-Fi can be useful in future as a replacement and backup of Wireless Fidelity (Wi-Fi) for indoor communication because it can provide high data rate of transmission along with high capacity to utilize more users as its spectrum bandwidth is much broader than the radio spectrum. In this paper we will look at the different aspects of the Li-Fi based indoor communication system, summarizes some of the research conducted so far and we will also proposed a Li-Fi based communication model keeping in mind coverage area for multiple user and evaluate its performance under different scenarios. Such advancements promise a theoretical speed of 10 Gbps-meaning one can download a full high-definition film in just 30 seconds.**

***Index Terms*— VLC, PrintedCircuitBoard(PCB), Li-Fi, Wi-Fi, RF(Radio Frequency).**

I. INTRODUCTION

In current era, every day the exchange information over the internet via various media. Wi-Fi is the name given to innovation of a mainstream remote systems administration that utilize radio waves to give remote rapid Internet and system associations. Its supportive position is very ideal with practically every running structure and action gadget. Wi-Fi is also called "remote devotion" [1] and it sometimes create problems of security, speed, extend, unwavering quality, control utilization, absence of encryption. Due to these problems we are searching for the new technology that is able to overcome problems of Wi-Fi. The new invention is named as Light Fidelity (Li-Fi) [1].

Fig 1: Overview of Visual Light Communication

Light Fidelity (Li-Fi) is a new paradigm of revolution which is a process of moving toward higher frequency spectrum in the field of indoor wireless communication. The term was initially authored by German physicist Harald Haas at TED argue in 2011, where the author examined utilizing lights as switches. According to him, "The greatest vision is that light bulbs will become part of broadband communications equipment, so that the light emitting diode is not only able to provide light but also become a more necessary tool for visible light communication" [7]. Li-Fi would use transceiver fitted LED lamps that can serve dual purpose lighting a room as well as transmit and receive information in bits. In this a part of the electromagnetic spectrum other than RF are used [7]. The thought behind it is to utilize a type of obvious light correspondence rather than radio waves like ordinary Wi-Fi switches, empowering much speedier information exchange speeds. It is based communication system which is different from Visible light communication (VLC) system because VLC is only a point to point communication system which supports point to multipoint communication. VLC innovation conveys rapid, bi-directional portable correspondences like Wi-Fi, however in a more secure way [5]. The other name given to it is Optical Version of Wi-Fi. It is one of the latest technology in the present time related to technology that uses, LEDs. It is a 5G technology of visible light communication system [2]. In Li-Fi system, data rate can

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be related with LEDs so LEDs selection plays a vital role [5].

The working principle of Li – Fi Technology is very simple. Whenever the LED is ON, digital 1 is transmitted and Whenever the LED is OFF, digital 0 is transmitted. Unlike Wi – Fi where electricity is required to keep turned on the router, Li – Fi utilizes the already under consumption electricity that is lightning bulb, hence decreases the electricity cost [4]. LED's in a system results in more transmission of data.

Fig 2: Li-Fi Technology

Researchers at the University of Oxford and Edinburgh are focusing on analogous data communication by means of arrays of LEDs, where each LED transmits a dissimilar data stream than earlier. Some groups are using mixtures of red, green and blue LED bulbs to alter the frequency of light, so that each frequency can encode a different data channel [7]. Our future where data for computers, mobile phones, and tablets can be send out by using the light in a room instead of RF routers and security would be increased as- if you can't see the light, you can't access the data**.**

II. CONSTRUCTION

Li-Fi is a fast and cheap optical version of Wi-Fi. It is based on Visible Light Communication (VLC). VLC is a data communication medium, which uses visible light between 400 THz (780 nm) and 800 THz (375 nm) as optical carrier for data transmission and illumination. It uses fast pulses of light to transmit information wirelessly. The main components of Li-Fi system are as follows:

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.

LEDs can be switched on and off to generate digital strings of different combination of 1s and 0s. To generate a new data stream, data can be encoded in the light by varying the flickering rate of the LED. The LEDs can be used as a sender or source, by modulating the LED light with the data signal. The LED output appears constant to the human eye by virtue of the fast flickering rate of the LED. Communication rate greater than 100 Mbps is possible by using high speed LEDs with the help of various multiplexing techniques. VLC data rate can be increased by parallel data transmission using an array of LEDs where each LED transmits a different data stream. The Li-Fi emitter system consists of 4 primary subassemblies [7]

a) Bulb

b) RF power amplifier circuit (PA)

c) Printed circuit board (PCB)

d) Enclosure

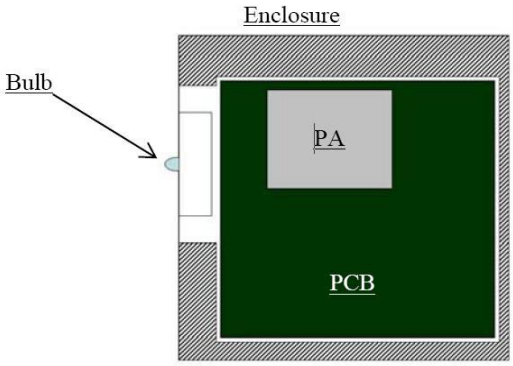

Fig 3: Block diagram of Li-Fi sub-assemblies [10]

The PCB controls the electrical inputs and outputs of the lamp and houses the microcontroller used to manage different lamp functions. A 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 center; this controlled plasma generates an intense source of light.

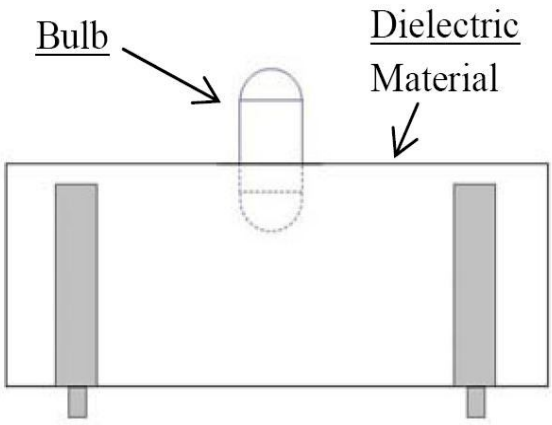

Fig 4: Bulb sub-assembly [10]

All of these subassemblies are contained in an aluminum enclosure. 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. 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.

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III. WORKING

Li – Fi Technology utilizes the principles of VLC (Visual Light Communication). The idea behind Li-fi is implemented by using white LED light bulbs at the downlink Transmitter. For illumination, a constant current is applied to LEDs. The optical output can be made to vary at very high speeds, by fast variations of the input current. It works as, when the LED is on then the logic "1" is transmitted and when the LED is off then the logic 0 is given. LED's flickering occurs at a very fast rate and which is not visible to the human eye. In this method much advancement could be possible by use of an array of LEDs for parallel data transmission.

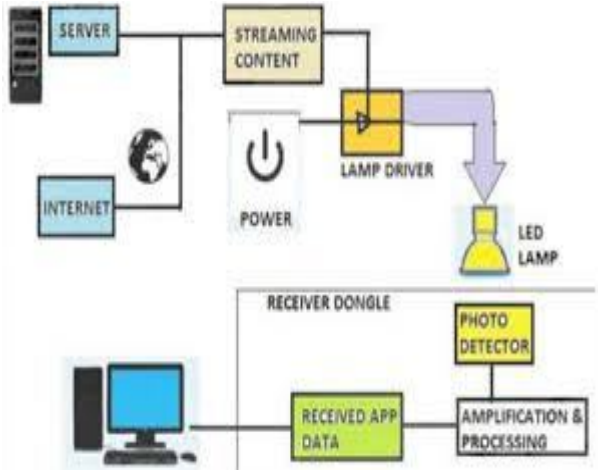

Fig 5: How Li-Fi Works

Encoding and Decoding the data involve in communication while transmitting/ receiving it, is one of the most important step that need to be follow to accomplish an error free transmission. Therefore, we can use various Encoding/Decoding techniques like 4B/5B, NRZ, Manchester, Differential Manchester, etc. with dedicated quantization bit. To accomplish this, we just need a microcontroller and a transceiver. By this we can theoretically achieve the speed of 10 Gigabytes per second [3].

These types of advancements promise a speed of 10Gbps – that is one can download a full HD film in just 30 seconds Internet connection, switch and LED lamp are all connected to the lamp driver through optical fiber cable. Photo detector receives the signal and performs further operations. Detector is further connected to PC's, Laptops or LAN port. When the LED is ON, the conversion of the digital data into the light form is done by microchip. On receiving the light signal the Light detector converts it again into the original digital form [2].

Due to the physical properties of these components, information can only be encoded by using the intensity of the emitted light. Different LED's of different color like red, blue, orange, yellow can be used in Li-Fi Communication System. But if we talk about high data rates, 1 Giga bits per second has been reported using phosphor-coated white LEDs and 3.4 Giga bits per second has been red- green-blue (RGB) LEDs, the highest speed that has ever been reported from a single color incoherent LEDs is 3.5 Giga bits per second [6]. To have a data rate of hundreds of megabytes per seconds, different colored LEDs are used.

TABLE 1. METHOD TO GENERATE WHITE LIGHT.

White light production method	Advantage	Disadvantage
Blue light with yellow phosphor coating	Easy to implement and cost Effective	phosphor coating limits the speed at which LED can switched to a few MHz
RGB light	Easy to modulate the data using three different color wavelength LEDs	Not cost effective

LED luminaire commonly use white light to perform both the function of illumination and communication. One way of producing white light is to use blue LED with yellow phosphor coating.

Fig 6: Use of LED

When a beam of blue light passes through yellow phosphor coating layer it becomes white light. Another way is to use a combination of red, green and blue (RGB) LEDs. When red, green and blue light properly mixed together it becomes white light. As the light emitted by LEDs are incoherent in nature so therefore there is a need of Intensity Modulation (IM). In IM signal is modulated in to optical signal of instantaneous power. This signal is received at a receiver by using Direct Detection (DD) method. In Direct Detection (DD) a photodiode is used to convert the optical signal power into a proportional current.

IV. LI-FI VERSUS WI-FI

Features	Li-Fi	Wi-Fi
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 intereference issues similar to radio frequency waves.	Will have intereference 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 wifi hotspots
Merits(advantages)	Interference is less, can pass through salty sea water, works in densy region	Interference is more, can not pass through sea water, works in less densy region
Privacy	In LiFi, light is blocked by the walls and hence will provide more secure data transfer	In WiFi, RF signal can not be blocked by the walls and hence 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 thousand times frequency spectrum of the radio	2.4GHz, 4.9GHz and 5GHz
Data density	Works in high dense environment	Works in less dense environment due to interference related issues
Coverage distance	About 10 meters	About 32 meters (WLAN 802.11b/11g), vary based on transmit power and antenna type
System components	Lamp driver, LED bulb(lamp) and photo detector will make up complete LiFi system.	requires routers to be installed, subscriber devices(laptops,PDAs,desktops) are referred as stations

Li-fi is not the replacement of Wi-Fi technology. It can be considered as incredible companion of the Wi-Fi technology. It operates between 380 nm to 780 nm optical range. Li-Fi is used to exchange data incredibly rapidly and securely at much lower power level compare to Wi-Fi

V. CONCLUSION

Li-fi is getting worldwide attention due to its futuristic technology where every bulb can be converted into a whole new Wi-Fi hotspot. Li-fi is emerging and vast technology, a lot of research can lead us to the betterment of the world.it also resolves the issues of limitations of radiofrequency bandwidth. By using this technology information can be transmitted and received at very higher rates with simply turning on and off of the LEDs. This technology is much secured compared to Wi-Fi. It will allow inter access in places such as Operation Theater and aircrafts where internet access usually not allowed in highly sensitive region and in education system. With the help of this technology road disasters can be control to some limit. Li-fi can be used as a tool for saving life in the districts hit by natural calamities like earthquake etc. Possibilities for the future use of Li-fi are abundant if every bulb is transformed into the use of Li-fi to transfer information then we soon will take step forward in the direction of cleaner, safer, green and brighter future.

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