

Li-Fi Technology –Next Gen Data Transmission through Visible Light Communication

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ABSTRACT: With the escalating digital aerospace and wireless communication, the number of devices accessing the internet has reached a new level. Principally, network complexity and scarcity of wireless radio bandwidth leading to possible menace to radio frequency intrusion. Consequently, there is a pressing need to find new means of wireless communication which is fast, reliable and error free. The German physicist Dr. Harald Hass introduced a technique to cope up with this problem by sending data through an LED light bulb that varies in intensity even faster than the human eye can follow. He coined this technique as Li-Fi technology- Light Fidelity. Li-Fi is basically the subset of visible Light Communication (VLC), uses LED bulbs as hot-spots and provides higher data rates than Wi-Fi. Li-Fi is ideal for high density wireless data coverage in confined area and for relieving radio interference issues. Hence, a future can be envisioned having light as transmitting medium to our laptops, smart phones and tablets. And security wouldn't be snapped if the device can't access the data.

KEYBOARDS: Li-Fi,Wi-fi,LED,VLC,Photo Dectector, Wireless communication.

I. INTRODUCTION

Communication, the most emerging part in everybody's life is through exchanging information either on wired or wireless devices. Wi-Fi is the most versatile and effective technology which compact with radio/microwave frequencies for data transmission. The availability of high sensitivity receivers which provides broad coverage at low frequencies and line of sight (LOS) communication at high frequencies. Due to ever-increasing stipulation for wireless communications, Wi-Fi is facing many challenges namely capacity, availability, efficiency and security. German Physicist Harald Hass coined the term Li-Fi and promoted in his 2011 TED Global talk by giving demonstration of an LED light bulb to transmit a video with the speed more than 10 mbps. Li-Fi is transmission of data through illumination using LED light bulbs, this term is used to label fast and cheap communication system which is an advanced version of Wi-Fi or say it the optical version of Wi-Fi. When the LED switched on digital 1 is transmitted and when it's off digital 0,thus can be switched on and off very quickly(Shown in Fig.1). It is also possible to encode data in light by varying the rate at which the LEDs flicker to produce different strings of 0s and 1s. The intensity is modulated so fast that the human eye can't notice thus the output appearing constant. More advancement could drastically increase the VLC data rate. In the near future, the wireless technology is being replaced by a drift from Wi-Fi to Li-Fi technology because of its innumerable advantages .While Wi-Fi is predicated on the availability of a microwave signal, Li-Fi has the ability to turn any lamp into a network connection operating at much higher frequencies. Li-Fi also offers more privacy than Wi-Fi.

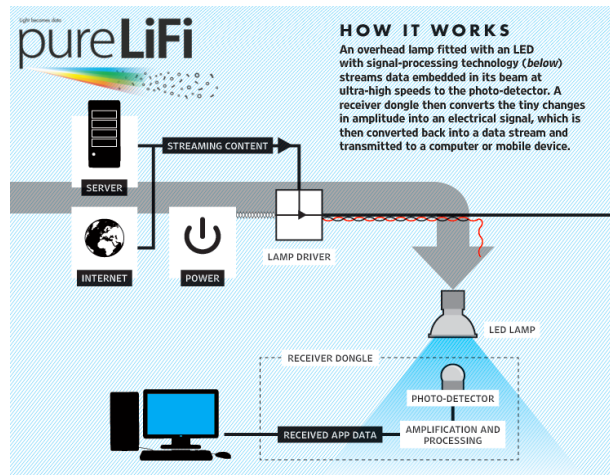


Fig 1: Pictorial representation of Li-Fi technology

Dr. Haras succeeded in 2011 creating an 800 mbps capable wireless network by using nothing more than normal red, blue, green, and white LED light bulbs, thus the idea has been around for a while and various other global teams are also exploring the advancement possibilities. Li-Fi is a wireless communication system in which light is used as a carrier signal instead of traditional radio frequency as in Wi-Fi. Li-Fi is a technology that uses light emitting diodes to transmit data wisely. Visible light communication (VLC) uses rapid pulses of light to transmit information wisely that cannot be detected by human eye. This paper will focus on Li-Fi technology over Wi-Fi technology and challenges for the new era VLC technology.

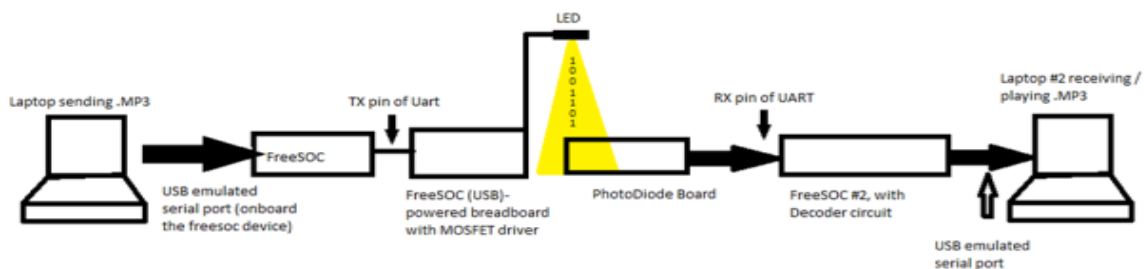


Fig 2: Block Diagram of Li-Fi System

II. CONSTRUCTION

The main components of Li-Fi system are as follows:

- A high brightness white LED which acts as transmission source.
- 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 Li-Fi System consists of 4 primary sub-assemblies:

- Bulb
- RF Power Amplifier circuit(PA)
- Printed Circuit Board(PCB)
- Enclosure

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. All of these subassemblies (shown in Fig.3) are contained in an aluminum enclosure.

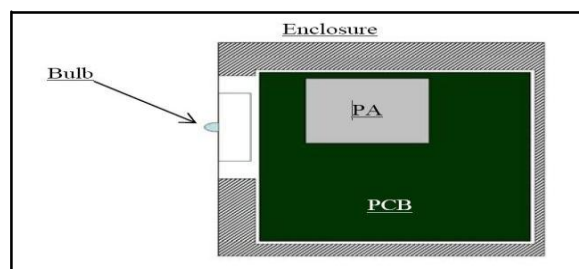


Fig.3: Block diagram of Li-Fi technology

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 [Fig.4]. 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. Figure 4 shows the bulb sub-assembly

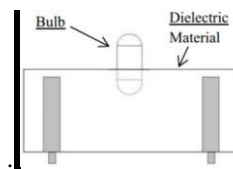


Fig 4. Li-Fi Bulb Sub-assembly

There are various inherent advantages of this approach which includes high brightness, excellent colour quality and high luminous efficacy of the emitter- in the range of 150 lumens per watt or greater. The structure is mechanically robust without typical degradation and failure mechanisms associated with tungsten electrodes and glass to metal seals, resulting in useful lamp life of 30,000+ hours. In addition, the unique combination of high temperature plasma and digitally controlled solid state electronics results in an economically produced family of lamps scalable in packages from 3,000 to over 100,000 lumens.

III. WORKING

The new generation of high brightness light-emitting diodes (LED) forms the core part of light fidelity technology. These high brightness LEDs can be switched on and off very quickly facilitating for transmitting of data through light. In order to transmit a message, the mechanism must consist of a light emitter on one end, for example, an LED and a photo detector (light sensor) on the other (Shown in Fig.2). The photo detector which converts this light into electrical signals registers a binary 1 when the LED is on and 0 if off flash, times to acquire data rates in the range of 100 Mbps device connected to it. Voltage regulator and level shifter circuits are used on both the sides to convert a voltage level between transmitter and receiver. The modulation of LED couldn't be noticed by human eyes, causing the light source appeared to be continuous. Its likely to be applicable for traffic and street lights, car brake lights, remote control units and countless other applications. This method of using rapid pulses of light to transmit information wirelessly is

technically referred to as Visible Light Communication (VLC), though it is popularly called as Li-Fi because it can compete with its radio-based rival Wi-Fi. Figure shows a Li-Fi connecting devices in a room. Many other sophisticated techniques can be used to dramatically increase VLC data rate. Teams at the University of Oxford and the University of Edinburgh are focusing on parallel data transmission using array of LEDs, where each LED transmits a different data stream. Other groups are using mixtures of red, green and blue LEDs to alter the light frequency encoding a different data channel.

Li-Fi is a superset of different optical wireless technologies involving communication, positioning, natural user interfaces and many more.

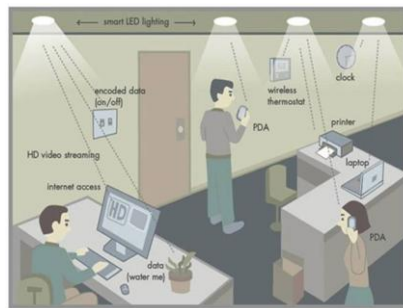





Fig.5: Environment with Li-Fi Technology

COMPARISON AMONGST LED, INCANDESCENT LIGHT BULBS AND CFL

Energy Efficiency & Energy Costs	 Light Emitting Diodes(LEDs)	 INCANDESCENT LIGHT BULBS	 COMPACT FLUROSCENTS(CFLS)
Life Span(average)	6-8 WATTS	60 WATTS	13-15 WATTS
Watts of electricity used (5 incandescent bulbs per year equivalent)	55 KWh/yr	547 KWh/yr	128KWh/YR
Annual Operating Cost(5 incandescent bulbs per year equivalent)	RS 385/YEAR	RS3830/YEAR	RS 900/YEAR
On/off Cycling: Switching a CFL on/off quickly, in a closet for instance, may decrease the lifespan of the bulb.	NO EFFECT	SOME	YES CAN REDUCE LIFESPAN DRASTICALLY

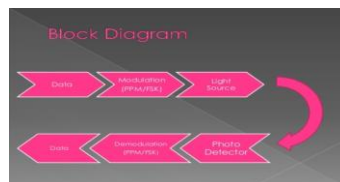


Fig 6:Working Principle

IV. ADVANTAGES

- LI-Fi can solve problems related to the insufficiency of radio frequency bandwidth because this technology uses Visible light spectrum that hasn't been utilised greatly, yet .

- High data transmission rates of up to 10Gbps can be archived.
- While travelling in planes ,the VLC can be used without affecting the airline signals.
- Like Bluetooth, Wi-Fi, infrared and internet, the VLC can also be used all locations.
- Since the Li-Fi is confined within a small range and doesn't penetrate through walls, it provides privacy and security to the data.



Fig 7: Li-Fi Usage

Li-Fi VERSUS Wi-Fi		
PARAMETERS	LIFI	WIFI
Operating band	Visible Light band	Radiofrequency band
Range	Short range (based on LED light intensity)	About 100m
Frequency	4-8×10 ¹⁴ Hz(Visible light)	2.4-5 GHz
Data transfer rate	>1Gbps	Downlink speed: 10.9 Mbps Uplink Speed: 2.8 Mbps
Power consumption	Medium	Medium
Standard	IEEE 802.15	IEEE 802.11b
Cost	Low	High
Security	Highly secured	Less

V. CHALLENGES OF LI-FI

Apart from many advantages over Wi-Fi, Li-Fi technology is facing some problems such as:

- 1) Li-Fi requires line of sight.
- 2) Receiving device would not be shift in indoors.
- 3) A major challenge is how the receiving device will transmit data back to transmitter.
- 4) Other disadvantage is visible light can't penetrate through brick walls as radio waves and is easily blocked by somebody.

VI. APPLICATIONS

The steep increase in the use of LEDs for lighting gives the opportunity to incorporate Li-Fi technology in to a large number of LED Environment. The Li-Fi technology will be more useful for "more content consumption" applications such as you tubes, Skype, & for audio, video downloads etc.

A. Health technologies:

The Wi-Fi emits radio waves which are very harmful for the patients and the radio waves interpret the medical instruments. Thus we can use internet in operating rooms by Li-Fi technology. For no longer time now medical

technology would lag behind the rest of the wireless world. Till now operating rooms did not allowed Wi-Fi over radiation concerns, and there was also a whole lack of dedicated spectrum.

B. Airlines:

In Airlines passengers concur to pay extra amount of money for the dial up service in the aircraft. Li-Fi could easily introduce "high-speed" transmission service which would be interruption free and differs from other wireless signals on the board.

C. Li-Fi uses light rather than radio frequency signals.

D. Under water in sea Wi-Fi does not work at where Li-Fi will work.

E. There are around 19 billion bulbs worldwide, they just need to be replaced with LED ones that transmit data, we reckon VLC is at a factor of ten, cheaper than Wi-Fi.

F. Security is another benefit, since light does not penetrate through walls.

G. In street for traffic control. Cars have LED based headlights, LED based backlights, and car can communicate each other and prevent accidents in the way that they exchange information. Traffic light can communicate to the car and so on.

H. Li-Fi may solve issues such as the shortage of radio frequency bandwidth.

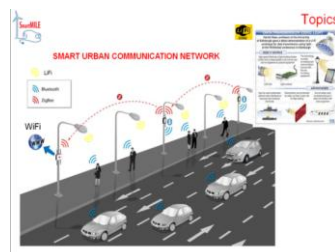


Fig 8 : Li-Fi utility

VII.RECENT ADVANCEMENT

i. Li-Fi for smart cities:

The simplicity of the li-fi technology using LED light bulbs to transmit data, including high speed data connections that might be served from street lights could add to the emergence of smart cities.

ii. Li-Fi technology is a true enabler of internet of things and everything:

Researchers at the Li-Fi centre, University of Edinburgh stated that Li-Fi node could be built on strong communication and networking capabilities of optical wireless physical and above TCP/IP layers with a clear vision to connect things and everything anytime, everywhere with very minimal capital expenditure(CAPEX) and operation expenditure(OPEX). Exploring genuinely, the purpose of the light is to enable seeing and by turning this light to a Scottish horse rider for internet data to wireless through the space is exemplary.

iii. In the future, topology matters the most:

Researchers published worldwide indicates that future networks will be faster but capacity problems could still remain . It further reveals that ‘topology’ – the makeup of transmitters providing the network signal- will be increasingly important for meeting demand in densely-populated areas.

iv. Reliable communication and improved networking in a Li-Fi network:

Li-Fi is a high-speed, bi-directional and fully networked broadband wireless technology which is aimed at offloading the existing Wi-Fi technology. A Li-Fi access point can serve multiple users simultaneously within the area of its coverage, and this is termed as 'optical at to cell'.

v. Li-Fi Access nodes Networking Technology – its inherent Programmable features:

Quantum mechanics to develop systems to control the number of photons in light emitted from a simple off-the-shelf LED light bulb by changing the frequency of the light, making it the most perfect carrier for wirelessly transmitting internet data in the smallest cell network among 5G wireless communication networks.

vi. Light brings users super-fast wireless internet:

Lights in shop windows, cars and classrooms can be used to access the wireless internet. Li-Fi could prove to be seven times faster than wi-fi and enable to download an entire HD movie in a couple of seconds.

VIII. CONCLUSION

Currently, the Li-Fi concept is attracting a great deal of interest, because it provides an authentic and efficient alternative to wireless devices which use radio waves.

Researchers are developing micron LED which are able to flicker on & off around 1000 times quicker than larger LED. It offers data transfer which would take up less space resulting in adding more LED'S to further boost the channel of communication. Also 1000 micron sized LED can fit into area required by 1mm large single LED. A sq mm sized array of micron sized LED's could therefore communicate 1000*1000 (a million) times as much information as a single 1mm LED. It's ascertain that the future for Li-Fi is bright. Li-Fi consortium believes it is possible to achieve more than 10 gbps, theoretically allowing a high definition film to be downloaded in 30 secs.

The world is moving towards digital space. 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 hotspots to transmit wireless data. Li-Fi may solve issues such as the shortage of radio-frequency bandwidth and is aimed at creating new communication channels with the use of existing equipment. Every bulb can be used to transmit a data and will lead towards the cleaner, greener, safer and brighter future.



Fig. 9: The Li-Fi Technology

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