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LI-FI TECHNOLOGY IN WIRELESS COMMUNICATION

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ABSTRACT

LI-FI is a broadcast of information during lighting, transfer information through a LED light bulb that intensity varies quicker than human eye can track. Whether you are by means of wireless internet in a coffee house, thieving it from the guy subsequently door, or participating for bandwidth at a convention, you have almost certainly gotten irritated at the slow speed you face when more than one apparatus is tapped addicted to the association. As more and more public and their many devices access wireless internet, stopped up airwaves are departing to make it one germen physicist Herald Haas has come up with a way out he calls "data and information throughout lighting" taking the fibber out of fibre optic by transfer data and information all the way through an LED light bulb that varies in intensity quickly than the human being eye can go behind that varies in intensity faster than the human eye can go behind. LIGHT, can generate data & information rates more rapidly than 10 megabits per second, which is faster than your average broadband link. He envisions a outlook where data and information for tablets, smart phones, and laptops is inherited through the light in an area. And safety would be snap if you can`t see the light, you can`t access the information.

Keywords: *LED, VLC, Wi-Fi, Li-Fi*

1. INTRODUCTION

Transfer of data from one place to a different place is one of the most important day-to-day manners. The current wireless networks that attach us to the internet are extremely slow when numerous devices are connected. As the amount of devices that access the internet increases, the fixed bandwidth accessible makes it extra and extra tricky to enjoy high data transfer rates and attach to a secure network. But, radio waves are just a minute part of the band available for data transfer.

A solution to this trouble is by the use of Li-Fi, Li-Fi stands for Light-Fidelity. Li-Fi is the broadcast of data through light by taking the fibre out of fibre optics by transfer data through an LED light bulb that varies in intensity more rapidly than the human eye can follow. Li-Fi is the word some have used to label the fast and economical wireless communication organism, which is the optical description of Wi-Fi. Li-Fi uses observable light instead of Gigahertz radio rays for data transmit.

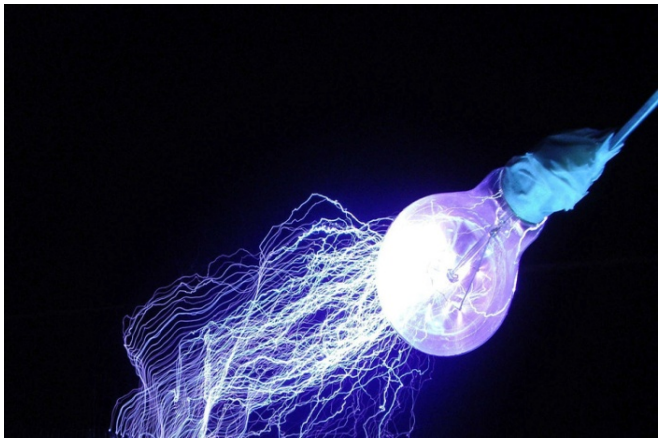

Figure 1: Li-Fi Bulb

The term was primary used in this circumstance by Harald Haas in his TED worldwide talk on perceptible Light proclamation. "At the understanding of courage of higher intensity of light-emitting diodes by this new techniques", said by Harald Haas in, UK," Very cleanly, if the Light Emitting Diode is on, you broadcast a digital 1, if it's off you broadcast a 0,"Haas says, "They can be switched on and off very rapidly, which gives nice opportunity for transmit data and information". That is attainable to prospectus in twist in the light by changing the rate at which the LEDs flicker on and off for send altered strings of 1s and 0s. The LED intensity modulated very fast that human eye cannot notice, so the output appears constant. More complicated techniques could dramatically increase VLC data and information rate. Terms at the University of Oxford and the University of Edinburgh are focusing on parallel information and data broadcast through collection of LEDs, where each LED transmits a dissimilar data flow. Other faction is using mixtures of green, blue and red colour LEDs to modify the light frequency encoding a dissimilar information path. Li-Fi, as it has been twice, has already achieved blisteringly high speed in the lab. PhD research scholar at the Heinrich Hertz Institute in Berlin, Germany, have reach information rates of over 500 megabytes per second using a standard white-light LED. The technology was established at the 2012 Consumer Electronics Show in Las Vegas using a pair of Casio smart phones to swap over data using light of altering intensity given off from their screens, visible at a distance of up to ten metres. Fig.1 Li-Fi environment In October 2011 a number of companies and industry groups formed the Li-Fi Consortium, to promote high-speed wireless communication systems and to defeat the limited amount of radio based wireless spectrum accessible by exploiting a absolutely dissimilar part of the electromagnetic spectrum. The consortiums consider it is possible to achieve more than 10 Gbps, in theory allow a high-description film to be downloaded in 30 seconds.

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2. STRUCTURE OF LI-FI ORGANISM

Li-Fi is a high-speed and economical optical version of Wi-Fi. It is based on Visible Light Communication (VLC).VLC is a data communication channel, which uses perceptible light between 400 THz (780 nm) and 800 THz (375 nm) as optical carrier for data & information broadcast and illumination. It uses rapid pulse of light to broadcast information & data wirelessly. The main components of Li-Fi system are as follows:

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

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

LEDs can be switched on and off to generate digital strings of dissimilar arrangement of 1 & 0. To produce a new information flow, data can be programmed in the light by changing the sparkling rate of the LED.

Figure 2: Data transfer via Li-Fi

The LEDs can be worn as a dispatcher or source, with the help of modulating the LED light by the data signal. The LED productivity appear stable to the human eye by asset of the fast flickering rate of the LED. Communication rate greater than 100 Mbps is possible by using high speed LEDs with the facilitate of a variety of multiplexing techniques. VLC rate of information can be improved by parallel data communication using an array of LEDs where each LED transmits a different data stream. The Li-Fi emitter system consists of 4 primary subassemblies [10]:

a) Bulb

b) RF power amplifier circuit (PA)

c) Printed circuit board (PCB)

d) 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 engrossment 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. 2) are contained in an aluminium enclosure [10]. 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 intends 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 electric field rapidly heats and produce energy to the material in the bulb to a plasma state that emits light of high intensity and full spectrum [10]. Figure 3 shows the bulb sub-assembly.

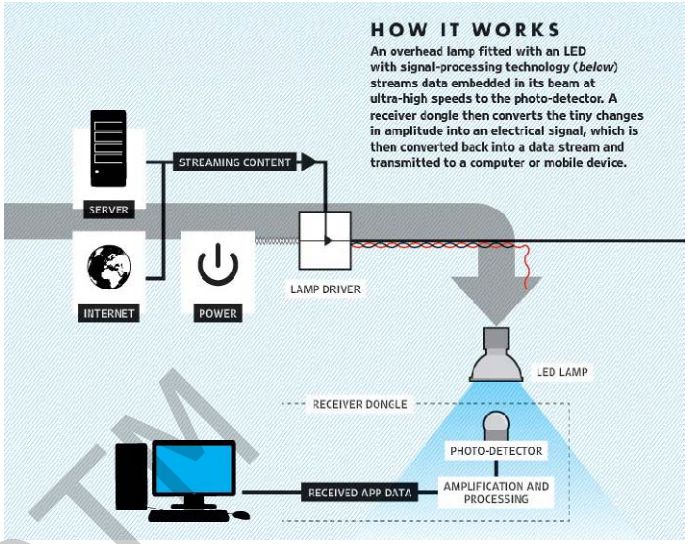

Figure 3: Data transmission using LED

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 glass and tungsten electrodes to metal seal, resulting in constructive 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 [2].

3. FUNCTIONING OF LI-FI

A new generation of high brightness light-emitting diodes forms the core part of light fidelity technology. The logic is very simple. If the LED is turn on, a digital pulse 1 is transmitted. If the LED is turnoff, a digital pulse 0 is transmitted. These high brightness LEDs can be switched on and off very quickly which gives us a very nice opportunities for transmitting data through light [12]. The working of Li-Fi is very simple. Therefore light emits on one end, for example, an LED, and a photo detector (light sensor) on the other end. The photo detector registers a binary 1 when the LED is on and a binary 0 if the LED is off. To make up a memorandum, flash the LED frequent times or use an array of LEDs of perhaps a few different colours, to obtain information in the range of hundreds of megabits per second.

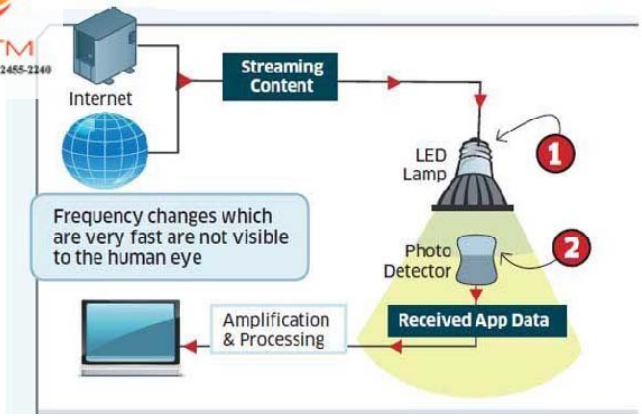

Figure 4: Block diagram of Li-Fi system

The block diagram of Li-Fi system is shown in Fig. 4. The data can be encoded in the light by varying the flickering rate at which the LEDs flicker on and off to generate dissimilar string of 1s & 0s.The LED intensity is modulated so rapidly that human eye cannot notice it, so the light of the LED appears constant to humans [13].

Light-emitting diodes (commonly referred to as LEDs and found in traffic and street lights, car put on the brakes lights, remote control part and countless other applications) can be switched on and off faster than the human eye can detect, foundation the light source to appear to be on continuously, even though it is in fact 'flickering'. The on-off movement of the bulb which looks to be invisible enables data transmission using binary codes: switching on an LED is a logical '1', switching it off is a logical '0'. By varying the rate at which the LEDs flicker on and off, information can be encoded in the light to dissimilar permutation of 1s & 0s. This type technique 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 5 shows a Li-Fi system 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 broadcast a dissimilar data stream. Other groups are using combination of green, blue and red LEDs to alter the light frequency encoding a different data channel.

4. LATEST ADVANCEMENTS IN LI-FI

Using a standard white-light LED, researchers at the Heinrich Hertz Institute in Berlin, Germany, have reached information and data rates of over 500 megabytes per second [1]. Using a pair of Casio smart phones, the technology was demonstrated at the 2012 Consumer Electronics Show in Las Vegas to exchange data using light of varying intensity given off from their panels, measurable at a detachment of up to 10 meters [1]. A consortium called Li-Fi Consortium was formed in October 2011 by a group of companies and industry groups to promote high-speed optical wireless systems and overcome the limited amount of radio based wireless spectrum. According to the Li-Fi Consortium, it is possible to achieve more than 10 Gbps of speed, theoretically which would allow a high-definition film to be downloaded in just 30 seconds [1]. Researchers at the University of Strathclyde in Scotland have begun the task of bringing high-speed, ubiquitous, Li-Fi technology to market [11].

5. CONTRAST AMONG LI-FI & WI-FI

Li-Fi is the name given to describe visible light communication technology applied to obtain high speed wireless communication. It derived this name by virtue of the similarity to Wi-Fi. Wi-Fi works well for general wireless coverage within buildings, and Li-Fi is perfect for more compactness wireless data exposure inside a confined area or room and for relieving radio interference issues. Table I shows a comparison of transfer speed of various wireless technologies. Table II shows a comparison of various technologies that are used for connecting to the end user.

Table 1. Comparison of speed of various wireless technologies [1]

Technology	Speed
Wi-Fi – IEEE 802.11n	150 Mbps
Bluetooth	3 Mbps
IrDA	4 Mbps
WiGig	2 Gbps
Giga-IR	1 Gbps
Li-Fi	>1Gbps

Wi-Fi at present offers high data and information rates. The IEEE 802.11.n in most implementations provides up to 150Mbit/s although practically, very less speed is received.

5.1 Problems in Wi-Fi

The following are the essential problems with radio waves:

a) **Capacity**: Wireless data is transmitted through radio waves which are limited and expensive. It has a limited bandwidth. With the rapidly growing world and development of technologies like 3G, 4G and so on we are running out of spectrum.

b) **Efficiency**: There are 1.4 million cellular radio base stations that consume massive amount of energy. Most of the energy is used for cooling down the base station instead of transmission. Therefore efficiency of such base stations is only 5%.

c) **Availability**: Availability of radio waves is a big concern. It is not advisable to use mobile phones in aero planes and at places like petrochemical plants and petrol pumps.

d) **Security**: we can penetrate the radio waves through walls. They can be intercepted. If someone has knowledge and bad intentions, they may misuse it. This causes a major security concern for Wi-Fi.

5.2 Compensation of li-fi

LiFi technology is based on LEDs or other light source for transmit of information & data. Transmit of the information & data can be with the assist of all kind of light, no matter the part of the spectrum that they belong. That is, the light can fit in to the unseen, ultraviolet or the able to be seen part of the spectrum. Also, the speed of the communication is more than sufficient for downloading movies, games, music and all in very less time. Also, Li-Fi removes the limitations that have been put on the user by the Wi-Fi.

a) **Ability**: Light has 10000 times wider bandwidth than radio waves [5]. Also, light sources are already installed. So, Li-Fi has got better capacity and also the equipments are already available.

b**) Effectiveness**: 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.

With the advent of Li-Fi, now it is not mandatory to be in a region that is Wi-Fi enabled to have access to the internet. One can simply stand under any form of light and surf the internet as the connection is made if light is present. Figure 6 gives a description of Li-Fi along with its advantages.

5.3 Disadvantages of Li-Fi

One of the major demerits of this technology is that the artificial light cannot penetrate into walls and other opaque materials which radio waves can do. So a Li-Fi enabled end device (through its inbuilt photo-receiver) will never be as fast and handy as a Wi-Fi enabled device in the release air. Also, a different shortcoming is that it only works in straight line of sight. Still, Li-Fi could emerge as a boon to the rapidly depleting bandwidth of radio waves. And it will certainly be the first choice for accessing internet in a confined room at cheaper cost.

6. 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 now the light, it can be worn safely in aircrafts and hospitals where Wi-Fi is banned because they are prone to obstruct with the radio waves. All the street lamps can be transferred to Li-Fi lamps to transmit data as well as information. As a result of it, it will be likely to way in 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:** There in not allow Wi-Fi in operation theatres (OTs) due to radiation effect. Usage of Wi-Fi at hospitals interferes with the mobile & personal computer which blocks the signals for monitoring apparatus. So, these causes the patient's health may be affected. To overcome this and to make OT tech know-how Li-Fi technology can be useful for accessing internet and to be in command of medical equipments. This can even be helpful to robotic surgeries as well as other automatic procedures.

c) **Cheaper Internet in Aircrafts:** The travellers travelling in aeroplanes get access to slow internet at a very high rate. Also Wi-Fi is may interfere with the navigational systems of the pilots. In aircrafts Li-Fi can be used for data & information broadcast. Li-Fi can easily offer high speed internet through every light source such as overhead reading bulb, etc are current inside the airplane.

d) **Underwater applications:** ROVs (Remotely Operated Vehicles) operate underwater from large cables that supply their power and agree to 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.

7. CONCLUSION

There are a plethora of possibilities to be gouged upon in this field of technology. If this technology becomes justifiably marketed then every bulb can be used analogous to a Wi-Fi hotspot to transmit data wirelessly. By virtue of this we can ameliorate to a greener, cleaner, safer and a resplendent future. The concept of Li-Fi is attracting a lot of eye-balls because it offers a genuine and very efficient alternative to radio based wireless. It has a bright chance to replace the traditional Wi-Fi because as an ever increasing population is using wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This concept promises to solve issues such as the shortage of radio-frequency bandwidth and boot out the disadvantages of Wi-Fi. Li-Fi is the upcoming and on growing technology acting as competent for various other developing and already invented technologies. Hence the future applications of the Li-Fi can be predicted and extended to different platforms and various walks of human life.

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