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Li-Fi (Light Fidelity)

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***Abstract*— Now a days people across the world, uses all the social apps such as Gmail, Facebook, Whatsapp, twitter and many more unlimitedly, for which we need a Wi-Fi connection. This infinite use of Wi-Fi is unfortunately leading to an increase in the network complexity, shortage of bandwidth, error full and unsecured communication. This implied the pressure to invent something that overcomes all these complexities. As a result, an optical version of wireless communication technology called Li-Fi (light fidelity) was invented. A Li-Fi is a wireless communication network which uses LED light bulb to transmit the data. In short, Li-Fi is a light based Wi-Fi. Li-Fi uses the Light Emitting Diode's flickering effect to transfer the data. Li-Fi has an ability to reduce energy consumption, increase the bandwidth capacity, speed up the transfer rate and many more. This paper presents a clear view of what is a Li-Fi, how it works, what are the uses and application of it in the current scenario.**

***Keywords*—LED, Li-Fi, optical communication, RF, VLC, Wi-Fi.**

I. INTRODUCTION

Li-Fi [3] is high speed wireless optical network technology [5], which is bidirectional and uses LED with higher intensity for efficient data transmission. The Li-Fi technology was proposed by Prof. Harald Haas [4] at the TED global talk [6]. Li-Fi is a proposed optical version of Wi-Fi, where in it uses optical fiber [7] for data transmission. The Li-Fi transmits data over the electromagnetic spectrum [8] using visible light, infrared and near ultraviolet light rays whereas Wi-Fi uses radio frequency waves of comparatively lesser bandwidth. Li-Fi uses LED's light as internet access points and a medium to deliver networked high speed communication similar to that of Wi-Fi [2]. The encoding of data in Li-Fi is based on flickering rate [9] of LED (on and off). The receiver receives the data at a speed of 10Mbps. The Li-Fi is comparatively more efficient and faster than Wi-Fi.

Figure 1: overview of Li-Fi

The figure 1 shows an overview of Li-Fi where, the end devices such as mobile, camera, and computers are using the LED light to transfer the data.

II. GENISIS OF LI-FI

"Li-Fi" uses light for data transmission instead of radio frequency waves. This term was introduced by Harald Haas at TED Global conference.

Prof. Harald Haas began his research about this at the University of Edinburgh and demonstrated about prototype of Li-Fi at TED Global conference conducted on 12th July 2011 in Edinburgh [10]. He tried to transmit a video of blooming flowers using a table lamp with a LED bulb by blocking the light periodically from the lamp to prove that light from LED was the source of input. He achieved a transmission data rate about 10Mbps and achieved 123Mbps two months later. Accessing the internet, stream videos, receiving mails and much more can be changed using this technology.

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To develop high speed wireless optical systems and to enhance limited bandwidth provided by radio frequency waves, a number of industry groups and companies created the Li-Fi consortium [11] in October 2011. In 1990's, countries like Germany, Korea, and Japan rendered the thought of sending data using LED lights. This organization's goal is to achieve a transmission data rate of more than 10Gbps using Li-Fi technology which is faster than usual broadband connection. The Consumer Electronics Show in Las Vegas explained the exchange of data using a pair of Casio smartphones using a light of varying intensity which is detectable up to a distance of ten meters.

Li-Fi can be used in various fields such as aircrafts, nuclear power plant without causing Interference. A Pure VLC [12] firm was set up in 2012 to market Li-Fi. Li-Fi is a part of the VLC (Visible Light Communication) PAN IEEE 802.15.7 standard [13].

The Customer Electronics Show in Las Vegas presented a first VLC smartphone in 2014 from January 7th -10th. This phone uses a technique called Sun Partner's Wysips CONNECT [14], which converts light waves into useful energy and is capable of receiving and decoding signals without using the battery's energy. A VLC system for shoppers at store was developed by Philips lighting company [15]. This system uses the LEDs in the downloaded app on their smartphone and this LED points the location of the LEDs in the store.

III. Requirements For Li-Fi Construction

The Li-Fi architecture consists of:

- LED light bulb
- Controller to code the data into LEDs
- Transmitter
- Photo detector
- Light receiver(Photoreceptor [16])

IV. Design

The lamp device is connected to the internet. The streaming content must have a proper integration with the internet network, so that we can easily work by using the visible light as the transmission medium.

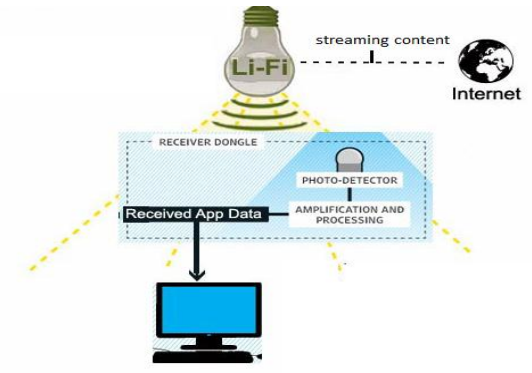

Figure 2: design of Li-Fi

There will be an encoder at the back side of LED bulb to encode the data into LED's. There will be photo detector that detects the data encoded light and transmits it to the receiver end. The figure 2 shows the outline design of Li-Fi.

V. Working

Li-Fi is implemented using white LED bulbs at the transmitter end, which is a semiconductor device that can blink rapidly to develop binary signals consisting of 0's and 1's. The LED's are controlled or illuminated by providing constant current, if the current is varied then the optical output will change at extremely high speeds. Using this flickering nature of LED we can transmit the data, i.e., if LED is "on" then we transmit a digital 1 else if it is "off" then we transmit a digital 0. The tiny changes in the data can be made by varying the intensity of light. The intensity of LED is modified so rapidly that human eyes cannot notice it.

A research on LED led to an invention of micro LED, which can easily be integrated on any of the system. Micro LED [17] are smaller in size(micron)but, has a capacity of transmitting the data 1000times faster than the old LED's using its fast flickering rate.

We can use array of LED's to establish parallel data transmission. We can also use the mixtures of red, green and blue LED's to encode different data channels by altering the frequencies.

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We need a device that is capable enough to load the data to be transmitted into the LED. For this purpose we use a controller which codes the data in to the LED according to which ,the LED will eject the varying intensity of lights, i.e., based on the data to be encoded, the controller will define the flickering rate of the LED's.

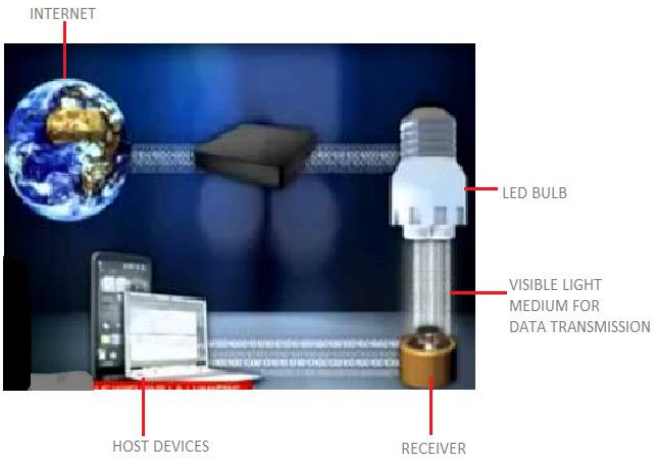

Figure 3: working of Li-Fi

The transmitted data is received at the receiver end by using a receiver chip. The receiver chip is made up of avalanche diodes [18] where in, if a single photon strikes it, then it will produce a cascade of electrons, which in turn amplifies the signal.

The figure 3 tells about the working of Li-Fi. Here the information fetched from internet is sent to the host device using Li-Fi. The LED will transmit the data in medium of electromagnetic spectrum through its flickering effect. This flickering light is recognized by the receiver and it amplifies the signal and sends it to the end system.

Since LED light is only the source of data, if some obstacles such as wall come in between the bulb and the receiver, then the data transmission will not occur. This is the major drawback of Li-Fi.

VI. WI-FI VS. LI-FI

TABLE I
COMPARISON OF WI-FI WITH LI-FI

WI-FI	LI-FI
Wi-Fi uses radio waves spectrum as a medium for data transfer	Li-fi uses visible light as a medium for data transfer
Bandwidth is less	Bandwidth is more
It is costlier	It is cheaper
Usage of Wi-Fi is restricted in hospitals, power plant, under water ,airlines etc.	We can use Li-Fi in any of the remote places.
Data transfer rate around 150Mbps	Data transfer rate is >1Gbps
Operating frequency is less	Operating frequency is more
Security is less	Security is more

Therefore, Li-fi operates in an efficient way than Wi-Fi.

VII. APPLICATION OF LI-FI

The major applications of Li-fi are:

- The usage of Wi-Fi, Bluetooth and internet are not allowed in hospitals, Operation Theater and near medical devices, due to the harmful nature of radio waves which will cause damage to the equipment's [19].
  As an alternative we can use the Li-fi, which will overcome this problem. Since Li-fi uses harmless visible light it will not cause damage to any kind of equipment's.
- Since the radio waves cannot penetrate in to the water we cannot use Wi-Fi under the water.

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We can use Li-fi in such cases where in the light can Penetrate in to the water. This nature of Li-fi will be useful in military operations carried under sea.

- We can use Li-fi in airlines (overhead lights) instead of slow speed Wi-Fi.
- We can use light communication in power plants instead of harmful radio frequency communication.
- Li-Fi can be used for road safety and traffic management using street light as optical medium.

VIII. Advantages Of Li-fi

- Li-fi is secure from hacking [20].
- Li-fi doesn't impose any limitations on capacity.
- Li-fi is 250 times faster than the super-fast broadband.
- Li-fi is 10 times cheaper than Wi-Fi.
- Li-fi has capability of downloading a HD movie in just 30 seconds.
- Eliminates neighboring network interference.
- Energy consumption is very less.
- Li-fi doesn't have the problem of frequency bandwidth.

IX. Limitations Of Li-fi

- It supports only shorter range data transfers (due to obstacles such as wall).
- It has low reliability.
- Installation costs are more.

X. Conclusion

The Li-Fi (Light Fidelity) is a newly emerging wireless communication technology, using which we proceed towards a protective and shine full future. The concept and nature of Li-Fi is attracting many people from this current world of Wi-Fi. Li-Fi is a very efficient alternative to radio based wireless communication, wherein we use harmless visible light spectrum as the medium for data transfer instead of dangerous radio frequencies. The capacity, security, cost, high bandwidth and other useful features of Li-Fi are so advantageous, that it will definitely occupy the position of Wi-Fi in future.

Using Li-Fi we can turn every street light as Wi-Fi hotspots and transmit the data at higher transmission rate. The application of Li-Fi in hospitals, airlines, power plant and other places are convincing the people to use Li-Fi than Wi-Fi. However the downsides of Li-Fi will be cleared very soon and it will emerge as the best wireless communication network in future.

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