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Li-Fi Technology
Transmission of Data through Light

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Abstract - Today internet has become a fundamental need of each and every person. People use wired or wireless networks for accomplishing their tasks. As number of users get increased wireless network speed decreases proportionally. Though Wi-Fi gives us speed up-to 150mbps, it is still insufficient to accommodate number of desired users. Li-Fi technology which was proposed by the German physicist— Harald Haas has proved to provide transmission of data through illumination. The data is sent through an LED light bulb that alters in intensity faster than the human eye can follow. This paper focuses on developing a Li-Fi based system and evaluate its performance with respect to existing technology.

Keywords **- Wireless-Fidelity (Wi-Fi), Light-Fidelity (Li-Fi), Light Emitting Diode (LED), Radio Frequency (RF), Visible Light Connection (VLC).**

1. Introduction

Light- Fidelity, commonly known as Li-Fi, can be thought of as a light-based Wi-Fi. That is, it uses visible light spectrum instead of RF spectrum to transmit information. And instead of Wi-Fi devices, Li-Fi would use transceiver-fitted LED lamps that can transmit and receive information as well as light a room. Since simple light bulbs are used, therefore technically there can be any number of access points hence many hotspots are created.

This technology uses the visible light spectrum, which is a part of electromagnetic spectrum, and is still not greatly utilized to a great extend. Light is in fact very much part of our lives since past billions of years and is not know have any major ill effect on our body or on our surrounding environment.

It is possible to encode data in the light spectrum by varying the rate at which the LEDs gleam ON and OFF to give different strings of 1's and 0's. The LED intensity is modulated so rapidly that a human eye is not capable of noticing, so the output appears constant to a normal human eye.

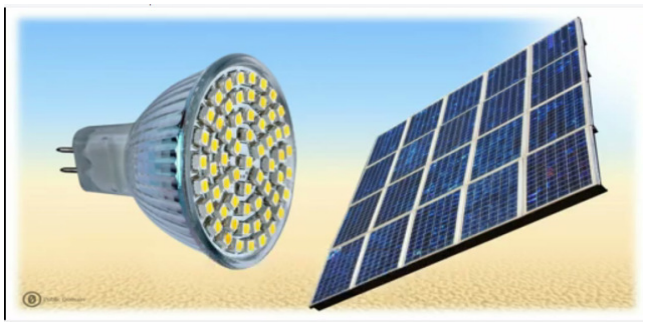

Fig 1: LED bulb and receiver panel used to perform this experiment.

Research and development team going on at University of Oxford and the University of Edinburgh are focusing at transmitting data parallel using array of LED's, where each LED in the array transmits a different data stream. Other groups use a mixture of different frequencies if LED's so as to alter the light frequency. Li-Fi, as it has been dubbed, has already attained a very high speed in the lab.

Researchers at the Heinrich Hertz Institute in Berlin, Germany, data transmission rates of over 500 Mbps are achieved using a standard white-light LED. Haas has set up a spin-off firm to sell a consumer VLC transmitter that will be launch next year. It is capable of transmitting data at 150 MB/s - faster than most UK broadband connections. Li-Fi needs LED bulbs similar to those which many of the energy-conscious house and offices are currently using. However the difference between both is that the Li-Fi bulbs are outfitted with a chip that modulates the light gradually for optical data transmission. Using Li-Fi, data is

transmitted by the LED bulbs and photoreceptors receive the data.

Li-Fi's early developmental models were capable of transmitting data up to 150Mbps. Some commercial kits enabling a speed of 150Mbps have been released in different part of world. In the lab, with robust LEDs and unique technology, researchers have enabled 10 Gbps speed of data transferring, which is faster than IEEE standard of 802.11.

2. Technology Details

Li-Fi is typically actualized using LED light bulbs at the downlink transmitter. This device can be illuminated only if we apply constant current. However, by brisk and subtle variations of current, the optical output can be varied at extremely high speed. This property of optical current is used in Li-Fi setup. This optical wireless communication technology uses LED's as a medium to deliver data packets to different devices like mobiles, tablets etc. at a very high speed in a similar manner to Wi-Fi. The Li-Fi market is projected to have a compound annual growth rate of 82% from 2013 to 2018.

Li-Fi works on a very simple procedure, if the LED is OFF then you are transmitting a digital 0, and if it's ON, you are transmitting digital 1. These array of LED's can be switched ON and OFF very quickly, so as to obtain a data packet consisting 1's and 0's which can be transmitted to different devices. Hence we require some LED's and a controller that will code data on these LED's. All one has to do is to vary the rate at which the LED's gleam depending upon the data we want to encode.

Further enhancement can be done by using arrays of LED's for parallel data transmission, or by using LED's of primary colors i.e. red, green and blue to obtain different light frequency with each frequency encoding at different data channel. This enhancement has researched and developed and founded to give out a theoretical speed of 10-12Gbps. It has also been found that this enhancement sends a single data stream of bits at a rate of 20,000B.P/S. Now actually when we will use an array of LED's the speed will be multiplied drastically.

Light is inherently safe and can be used everywhere, especially in places where RF communication cannot b used, like in aircrafts, mines, hospitals etc. so VLC not only has the potential to solve the problem of lack of spectrum space, but can also enable remote areas where RF cannot reach or are not recommended to use. The spectrum of visible light is still unused and can be utilized for communication at a very high speed.

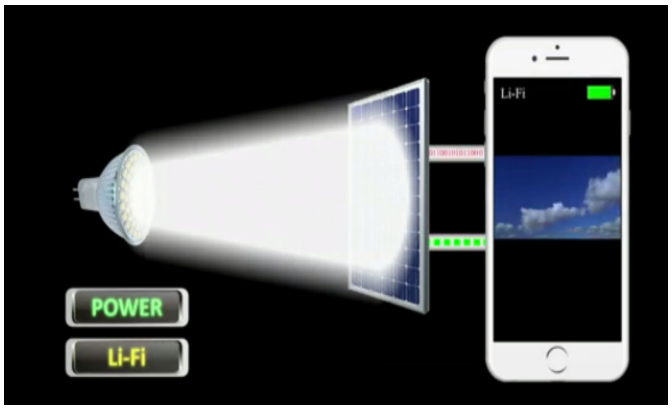

Fig 2: Data Transmission through LIFI

3. Block Diagram

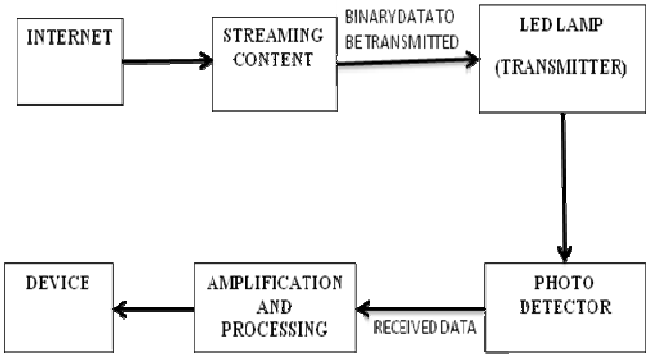

Fig 3: Block diagram of Data Transmission and Receiving through LIFI

4. Advantages

a) Unlike Wi-Fi uses radio frequency spectrum, Li-Fi uses visible light spectrum which is yet not been greatly utilized.

b) Li-Fi overcomes the problem of interference of signal in radio frequency due to wide range of light wave frequency spectrum.

c) Li-Fi required low utilization and maintenance cost.

d) Since light waves are impenetrable, it gives more privacy, security and surveillance than Wi-Fi.

e) Light wave is harmless for human body, unlike radio frequencies which passes through human body, resulting in damage of DNA which cannot be repaired, and generate errors in the process of replication.

5. Limitations

a) Li-Fi works only when light emissions travelling in a straight line between the transmitter and receiver, i.e. there is direct line of sight (LOS).
b) Light waves are impenetrable i.e. it cannot passed through walls.
c) Intensity of the light cannot reduce or decrease while transmitting the data.
d) Li-Fi is a unidirectional device i.e. which can be used for downlink or broadcast only.
e) Li-Fi uses very high frequency and hence limits its use for shorter distance and point to point communications only.
f) Also to use Li-Fi networks, we need to keep light source ON.

6. Applications

a) RF Spectrum Relief: Li-Fi networks will prove effective for unburdening the excess capacity demands of cellular networks. Li-Fi uses light spectrum hence a wide, unused spectrum is available for high speed transmission.
b) Smart Lighting: Private or public lighting including street lights which uses LED's for illumination can be used to provide Li-Fi hotspots and the same communications and sensor framework can be used to monitor and control lighting and data.
c) Mobile Connectivity: Li-Fi interconnects laptops, smart phones, tablets and other mobile devices. Short range links give very high data rates and also provides security.
d) Hazardous Environments: Li-Fi provides a safe alternative to electromagnetic interference caused due to RF spectrum communications in environments such as mines and petrochemical industries.
e) Health related instruments: Li-Fi emits no electromagnetic interference and so does not interfere with medical instruments, nor is it interfered with by MRI scanners.
f) Underwater Communications: Water has a strong tendency to absorb signals and hence RF use seems impractical. But on the other hand acoustic waves have extremely low bandwidth and disturb marine life. Therefore is the best alternative for RF signals.
g) Vehicles & Transportation: LED's for headlight and tail-lights are used as the new substitute for ordinary fluorescent bulbs. Street lamps, signage and traffic signals are also moving to LED. Here Li-Fi can be used for vehicle-to-vehicle communication. This can be applied for road safety and for reducing numbers of accidents.
h) RF Avoidance: Li-Fi does not cause any harm to people using it. RF signals when come in contact with human body generates errors in DNA.
i) Location Based Services (LBS): Highly accurate location and some specific information services such as navigation that enables the recipient to receive appropriate, pertinent information in a timely manner and location.
j) Aviation: Li-Fi can be used to reduce weight and cabling and add flexibility in aircraft passenger cabins where LED lights are already in use. In-flight entertainment (IFE) systems can also be supported and integrated with passengers' own mobile devices.

7. Conclusion

The future holds the unrevealed answer as the possibilities are huge and if this technology is brought into practice every light emitting devices would be like a Wi-Fi device and transmitting signals, this will lead towards a better, safer, cleaner and greener world. This concept allure a great deals of research as increasing number of devices are using the Wi-Fi, airwaves are said to be encumbered making it difficult to be reliable high speed data transmitting signal. This will immensely solve the problem and allow internet to places where traditional wireless signals are banned such as aircraft. The transmission cost is low with high speed of data transfer which increases the speed of communication with reliable way.

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