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LiFi – Communication through Visible Light

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Abstract— LiFi stands for Light Fidelity. It is a technology proposed by German Physicist Harald Haas in 2011 which allows wireless communication by sending data using visible light (LED Bulbs) which varies in intensity faster than a human eye can detect. Nowadays many people are using internet to accomplish their task through wired or wireless network. As number of users get increased in wireless network, speed decreases proportionally. Though WiFi gives us speed up to 150mbps as per IEEE 802.11n, it is still insufficient to accommodate number of desired users. Li-Fi gets a place here by providing better bandwidth, efficiency, availability and security than WiFi and has already achieved high speeds in the lab. In this paper, we will discuss the technology in detail and also how WiFi can be replaced by LiFi. WiFi is useful for general wireless coverage within buildings while LiFi is ideal for high density wireless data coverage in confined areas where there are no obstacles.

***Keywords*— VLC; LED; Light Fidelity; LiFi; 5G**

I. INTRODUCTION

Professor Harald Haas, the Chair of Mobile Communications at the University of Edinburgh, is recognized as the founder of Li-Fi. He coined the term Li-Fi and is the co-founder of pureLiFi. He gave a demonstration of a Li-Fi prototype at the TED Global conference in Edinburgh on 12th July 2011. He used a table lamp with an LED bulb to transmit a video of a blooming flower that was then projected onto a screen. During the talk, he periodically blocked the light from the lamp with his hand to show that the lamp was indeed the source of the video data. Li-Fi can be regarded as light-based Wi-Fi, i.e. instead of radio waves it uses light to transmit data. In place of Wi-Fi modems, Li-Fi would use transceivers fitted with LED lamps that could light a room as well as transmit and receive information. It makes use of the visible portion of the electromagnetic spectrum which is underutilized. Li-Fi can be considered better than Wi-Fi because there are some limitations in Wi-Fi. Wi-Fi uses 2.4 – 5 GHz radio frequencies to deliver wireless internet access and its bandwidth is limited to 50-100 Mbps. With the increase in the number of Wi-Fi hotspots and volume of Wi-Fi traffic, the reliability of signals is bound to suffer. Security and speed are also important concerns. Wi-Fi communication is vulnerable to hackers as it penetrates easily through walls. In his TED talk, Professor Haas highlighted the following key problems of Wi-Fi that need to be overcome in the near future:

a) Capacity: The radio waves used by Wi-Fi to transmit data are limited as well as expensive. With the development of 3G and 4G technologies, the amount of available spectrum is running out.

b) Efficiency: There are 1.4 million cellular radio masts worldwide. These masts consume massive amounts of energy, most of which is used for cooling the station rather than transmission of radio waves. In fact, the efficiency of such stations is only 5%.

c) Availability: Radio waves cannot be used in all environments, particularly in airplanes, chemical and power plants and in hospitals.

d) Security: Radio waves can penetrate through walls. This leads to many security concerns as they can be easily intercepted.

Li-Fi addresses the aforementioned issues with Wi-Fi as follows:

a) Capacity: The visible light spectrum is 10,000 times wider than the spectrum of radio waves. Additionally, the light sources are already installed. Hence Li-Fi has greater bandwidth and equipment which is already available.

b) Efficiency: LED lights consume less energy and are highly efficient.

c) Availability: Light sources are present in all corners of the world. Hence, availability is not an issue. The billions of light bulbs worldwide need only be replaced by LEDs.

d) Security: Light of course does not penetrate through walls and thus data transmission using light waves is more secure.

II. WORKING OF LI-FI

Li-Fi is typically implemented using white LED light bulbs at the downlink transmitter. These devices are normally used for illumination only by applying a constant current. However, by fast and subtle variations of the current, the optical output can be made to vary at extremely high speeds. This very property of optical current is used in Li-Fi setup. 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 depending upon the data we want to encode. Further enhancements can be made in this method, like using an array of LEDs for parallel data transmission, or using mixtures of red, green and blue LEDs to alter the light's frequency with each frequency encoding a different data channel. Such advancements promise a theoretical speed of 10 Gbps – meaning one can download a full high-definition film in just 30 seconds.

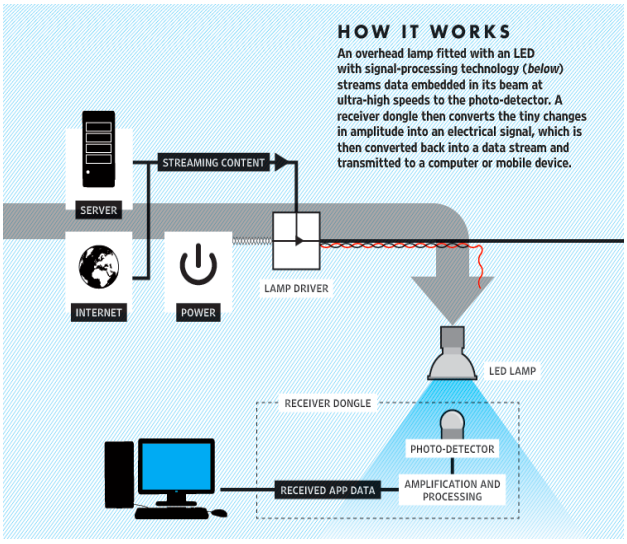

Figure 1: Working of Li-Fi

To further get a grasp of Li-Fi consider an IR remote. It sends a single data stream of bits at the rate of 10,000-20,000 bps. Now replace the IR LED with a Light Box containing a large LED array. This system is capable of sending thousands of such streams at very fast rate. Light is inherently safe and can be used in places where radio frequency communication is often deemed problematic, such as in aircraft cabins or hospitals. So visible light communication not only has the potential to solve the problem of lack of spectrum space, but can also enable novel application. The visible light spectrum is unused, it's not regulated, and can be used for communication at very high speeds.

III. APPLICATIONS OF LI-FI

The dramatic growth in the use of LEDs (Light Emitting Diodes) for lighting provides the opportunity to incorporate Li-Fi technology into a plethora of LED environments.

Li-Fi is particularly suitable for many popular internet "content consumption" applications such as video and audio downloads, live streaming, etc.

These applications place heavy demands on the downlink bandwidth, but require minimal uplink capacity. In this way, the majority of the internet traffic is off-loaded from existing RF channels, thus also extending cellular and Wi-Fi capacities.

There are many applications for Li-Fi. These include:

- **RF Spectrum Relief:** Excess capacity demands of cellular networks can be off-loaded to Li-Fi networks where available. This is especially effective on the downlink where bottlenecks tend to occur.
- **Smart Lighting:** Any private or public lighting including street lamps can be used to provide Li-Fi hotspots and the same communications and sensor infrastructure can be used to monitor and control lighting and data.
- **Mobile Connectivity:** Laptops, smart phones, tablets and other mobile devices can interconnect directly using Li-Fi. Short range links give very high data rates and also provides security.
- **Hazardous Environments:** Li-Fi provides a safe alternative to electromagnetic interference from radio frequency communications in environments such as mines and petrochemical plants.
- **Hospital & Healthcare:** Li-Fi emits no electromagnetic interference and so does not interfere with medical instruments, nor is it interfered with by MRI scanners.
- **Aviation:** Li-Fi can be used to reduce weight and cabling and add flexibility to seating layouts in aircraft passenger cabins where LED lights are already deployed. In-flight entertainment (IFE) systems can also be supported and integrated with passengers' own mobile devices.
- **Underwater Communications:** Due to strong signal absorption in water, RF use is impractical. Acoustic waves have extremely low bandwidth and disturb marine life. Li-Fi provides a solution for short-range communications.
- **Vehicles & Transportation:** LED headlights and tail-lights are being introduced. Street lamps, signage and traffic signals are also moving to LED. This can be used for vehicle-to-vehicle and vehicle-to-roadside communications. This can be applied for road safety and traffic management.
- **RF Avoidance:** Some people claim they are hypersensitive to radio frequencies and are looking for an alternative. Li-Fi is a good solution to this problem.
- **Location Based Services (LBS):** Highly accurate location-specific information services such as advertising and navigation that enables the recipient to receive appropriate, pertinent information in a timely manner and location.
- **Toys:** Many toys incorporate LED lights and these can be used to enable extremely low-cost communication between interactive toys.

IV. ADVANTAGES AND DISADVANTAGES

Advantages of LI-FI

- Li-Fi can solve problems related to the insufficiency of radio frequency bandwidth because this technology uses
- Visible light spectrum that has still not been greatly utilized.
- High data transmission rates of up to 10Gbps can be achieved.
- Since light cannot penetrate walls, it provides privacy and security that Wi-Fi cannot.
- Li-Fi has low implementation and maintenance costs.
- It is safe for humans since light, unlike radio frequencies, cannot penetrate human body. Hence, concerns of cell mutation are mitigated.

Disadvantage of LI-FI

- Light can't pass through objects.
- A major challenge facing Li-Fi is how the receiving device will transmit back to transmitter.
- High installation cost of the VLC systems.
- Interferences from external light sources like sun, light, normal bulbs, opaque materials.

CONCLUSION

The possibilities are numerous and can be explored further. If his technology can be put into practical use, every bulb can be used something like a Wi-Fi hotspot to transmit wireless data and we will proceed toward the cleaner, greener, safer and brighter future. The concept of Li-Fi is currently attracting a great deal of interest, not least because it may offer a genuine and very efficient alternative to radio-based wireless. As a growing number of people and their many devices access wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This may solve issues such as the shortage of radio-frequency bandwidth and also allow internet where traditional radio based wireless isn't allowed such as aircraft or hospitals. One of the shortcomings however is that it only work in direct line of sight.

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