

## INTRODUCTION TO LI-FI (LIGHT FIDELITY) TECHNOLOGY

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**Abstract:** *Li-Fi (Light Fidelity) is a bidirectional, highspeed and fully networked wireless communication technology similar to Wi-Fi. Coined by Prof. Harald Haas, Li-Fi is a subset of optical wireless communications (OWC) and can be a complement to RF communication (Wi-Fi or Cellular network), or a replacement in contexts of data broadcasting. It is so far measured to be about 100 times faster than Wi-Fi, reaching speeds of (instead of radio frequency waves) spectrum, part of optical wireless communications technology, which carries much more information, and has been proposed as a solution to the RF-bandwidth limitations. A complete solution includes an industry led standardization process.*

**Keywords:** *wireless, optical communication, Cellular Network.*

### I. INTRODUCTION

Whether you're using wireless internet in a coffee shop, stealing it from the guy next door, or competing for bandwidth at a conference, you've probably gotten frustrated at the slow speeds you face when more than one device is tapped into the network. As more and more people and their many devices access wireless internet, clogged airwaves are going to make it increasingly difficult to latch onto a reliable signal. But radio waves are just one part of the spectrum that can carry our data. What if we could use other waves to surf the internet? One German physicist, DR. Harald Haas, has come up with a solution he calls "Data Through Illumination"—taking the fiber out of fiber optics by sending data through an LED light bulb that varies in intensity faster than the human eye can follow[1]. It's the same idea behind infrared remote controls, but far more powerful. Haas says his invention, which he calls D-Light, can produce data rates faster than 10 megabits per second, which is speedier than your average broadband connection. He envisions a future where data for laptops, smart phones, and tablets is transmitted through the light in a room. And security would be a snap—if you can't see the light, you can't access the data. Li-Fi is a VLC, visible light communication, technology developed by a team of scientists including Dr Gordon Povey, Prof. Harald Haas and Dr Mostafa Afgani at the University of Edinburgh. The term Li-Fi was coined by Prof. Haas when he amazed people by streaming high-definition video from a standard LED lamp, at TED Global in July 2011. Li-Fi is now part of the Visible Light Communications (VLC) PAN IEEE 802.15.7 standard. The LiFi protocols are defined by the international standard IEEE 802.15 established in 2011 by the IEEE committee. For numerous specialists, LiFi is a major breakthrough technology for the mobile Internet community and for the connected object domain. "Li-Fi is typically implemented using white LED

light bulbs. These devices are normally used for illumination by applying a constant current through the LED. However, by fast and subtle variations of the current, the optical output can be made to vary at extremely high speeds. Unseen by the human eye, this variation is used to carry high-speed data," says Dr Povey, Product Manager of the University of Edinburgh's Li-Fi Program 'D-Light Project'. In simple terms, Li-Fi can be thought of as a light-based Wi-Fi. That is, it uses light instead of radio waves to transmit information. And instead of Wi-Fi modems, Li-Fi would use transceiver-fitted LED lamps that can light a room as well as transmit and receive information. Since simple light bulbs are used, there can technically be any number of access points. This technology uses a part of the electromagnetic spectrum that is still not greatly utilized- The Visible Spectrum. Light is in fact very much part of our lives for millions and millions of years and does not have any major ill effect. Moreover there is 10,000 times more space available in this spectrum and just counting on the bulbs in use, it also multiplies to 10,000 times more availability as an infrastructure, globally. It is possible to encode data in the light by varying the rate at which the LEDs flicker on and off to give different strings of 1s and 0s. The LED intensity is modulated so rapidly that human eyes cannot notice, so the output appears constant. More sophisticated techniques could dramatically increase VLC data rates. Teams at the University of Oxford and the University of Edinburgh are focusing on parallel data transmission using arrays 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's frequency, with each frequency encoding a different data channel. Li-Fi, as it has been dubbed, has already achieved blisteringly high speeds in the lab. Researchers at the Heinrich Hertz Institute in Berlin, Germany, have reached data rates of over 500 megabytes per second using a standard white-light LED. Haas has set up a spin-off firm to sell a consumer VLC transmitter that is due for launch next year. It is capable of transmitting data at 100 MB/s - faster than most UK broadband connections.

### II. GENESIS OF LI-FI

Harald Haas, a professor at the University of Edinburgh who began his research in the field in 2004, gave a debut demonstration of what he called a Li-Fi prototype at the TEDGlobal conference in Edinburgh on 12th July 2011. He used a table lamp with an LED bulb to transmit a video of blooming flowers that was then projected onto a screen behind him. During the event he periodically blocked the light from lamp to prove that the lamp was indeed the source of incoming data. At TEDGlobal, Haas demonstrated a data rate of transmission of around 10Mbps -- comparable to a

fairly good UK broadband connection. Two months later he achieved 123Mbps.

### III. HOW LI-FI WORKS?

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.

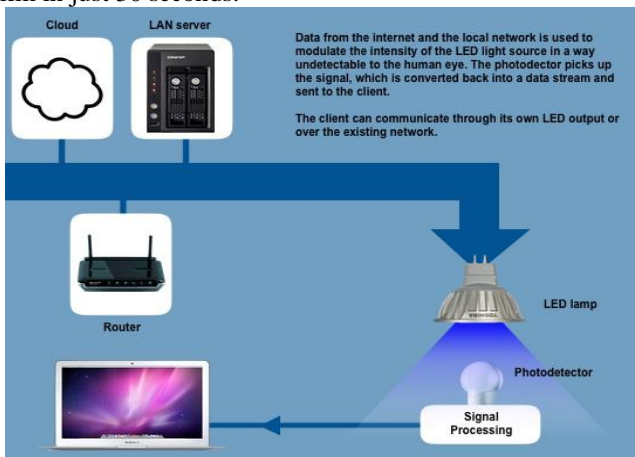


Fig. 1. Architecture of Li-Fi.

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.

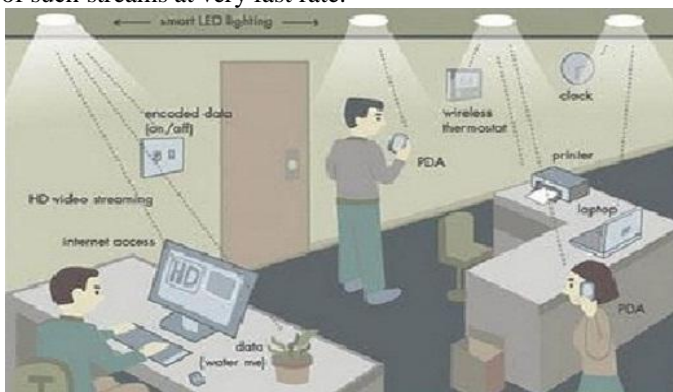


Fig.2. Li-Fi Streams.

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. The OWC technology uses light from light-emitting diodes (LEDs) as a medium to deliver networked, mobile, high-speed communication in a similar manner to Wi-Fi.[4] The Li-Fi market is projected to have a compound annual growth rate of 82% from 2013 to 2018 and to be worth over \$6 billion per year by 2018.[5] Visible light communications (VLC) works by switching the current to the LEDs off and on at a very high rate,[6] too quick to be noticed by the human eye. Although Li-Fi LEDs would have to be kept on to transmit data, they could be dimmed to below human visibility while still emitting enough light to carry data.[7] The light waves cannot penetrate walls which makes a much shorter range, though more secure from hacking, relative to Wi-Fi.[8][9] Direct line of sight isn't necessary for Li-Fi to transmit a signal; light reflected off the walls can achieve 70 Mbit/s.[10][11] Li-Fi has the advantage of being useful in electromagnetic sensitive areas such as in aircraft cabins, hospitals and nuclear power plants[citation needed]without causing electromagnetic interference.[8][9] Both Wi-Fi and Li-Fi transmit data over the electromagnetic spectrum, but whereas Wi-Fi utilizes radio waves, Li-Fi uses visible light. While the US Federal Communications Commission has warned of a potential spectrum crisis because Wi-Fi is close to full capacity, Li-Fi has almost no limitations on capacity.[12] The visible light spectrum is 10,000 times larger than the entire radio frequency spectrum.[13] Researchers have reached data rates of over 10 Gbit/s, which is much faster than typical fast broadband in 2013.[14][15] Li-Fi is expected to be ten times cheaper than Wi-Fi.[7] Short range, low reliability and high installation costs are the potential downsides.[5][6] PureLiFi demonstrated the first commercially available Li-Fi system, the Li-1st, at the 2014 Mobile World Congress in Barcelona.[16] Bg-Fi is a Li-Fi system consisting of an application for a mobile device, and a simple consumer product, like an IoT (Internet of Things) device, with color sensor, microcontroller, and embedded software. Light from the mobile device display communicates to the color sensor on the consumer product, which converts the light into digital information. Light emitting diodes enable the consumer product to communicate synchronously with the mobile device.[17][18]

### IV. CONCLUSION

Li-Fi is a new way to establish wireless communication links using the Led lightning networks. Li-Fi is transmission of data through illumination by taking the fiber out of fiber optics by sending data through a LED bulb that varies in intensity faster than the human eye can follow. Li-Fi is the term some have used to label the fast and cheap wireless-communication system, which is the optical version of Wi-Fi.

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