A Review of Li-Fi Technology Applied to Medicine

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Abstract*– Li – Fi comes from Light – Fidelity. This technology is very modern and is becoming a theme in vogue in the telecommunications area. In 2011, Li – Fi was proposed by the German physicist Harald Haas. Unlike Wi – Fi, this technology transmits data through illumination by using a LED light bulb that varies in intensity faster than human eye can pursue. In other words, Li – Fi is a term which refers to visible light communication (VLC); technology that uses light emitting diodes (LEDs) for data transmission making it so in a wireless optical networking technology. Furthermore, Li – Fi provides high – bandwidth, efficiency and security than other technologies. In this paper, the authors discuss the technology in detail and how its advantages can be applied in the field of medicine. Basically, the idea is to improve the operation of medical equipment with the help of Li – Fi and its accelerated transmission of information.

Keywords—Li-Fi, LED, Optical Wireless, Visible Light Communication.

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I. Introduction

Harald Haas unveiled and promoted the term Li – Fi in the 2011 TED Global Conferences, demonstrating a video transmission using a LED light bulb achieving a speed of 10 Mbps.

With regular LED bulbs of red, green, blue (RGB) and white, scientists managed to create a wireless network capable of conveying data at a bandwidth of 800 Mbps, thus achieving the success in 2011 [1].

Li – Fi is a technology for the telecommunications future. Equipment, such as laptops, smart phones, and tablets would be able to transmit through the light into a room or determined area. Regarding to security, if a person cannot see the light, he/she will not be able to access data. As a result, Li – Fi can be used in high security military areas where radio frequency communication is prone to eavesdropping [2].

Such as in the military field, Li – Fi technology is applied also in medicine. Once defined this new way of transmitting information via wireless, some Li – Fi contributions in either health or communication in health centers are:

A. Wireless connectivity of large data volumes using lighting.
B. Non-interference with other devices or instruments.
C. No cabling (ECG or EEG).

Digital medical history could take advantage with transmission of more data volumes (faster access) anywhere in a hospital deployed with LED lighting, achieving transmission of biological electrical signals without errors to wireless receivers.

Nowadays, studies are underway for application of this technology in oculography, electroencephalograms (EEG), electrocardiograms (ECG), and brain connection for patients in wheelchairs.

Medical applications that operate on the basis of wireless technologies could adapt Li - Fi in a more efficient and cheaper way; it is also committed to the environment due to the fact that it does not generate harmful wavelengths for the human health and it also does not originate interference with external signals [3].

II. Working on Li-Fi

Li-Fi is an optical both faster and cheaper version of Wi-Fi. It is based on Visible Light Communication (VLC), ruled by IEEE 802.15.7, which defines seven different wavelengths for optical light communications and works with both access and physical layer [2].

Li-Fi technology uses visible light between blue color (670 THz, at 780 nm) and red color (480 THz, at 375 nm). Unlike Wi-Fi, which uses electromagnetic spectrum, Li–Fi employs optical spectrum for sending data by amplitude modulation of light sources in a well–defined and standardized mode [4].

This technology is deployed using white LED light bulbs for illumination by applying a constant current. However, at faster current variations, light output varies at high velocities. If light (LED) is ON, it conveys a digital '1', otherwise it conveys a digital '0'. LEDs can switch to modes ON and OFF to convey data, which results difficult to be detected by the human eye due to quick transitions in the process[1].

Because there are no light frequencies struggling among them (like Wi-Fi), Li-Fi is approximately eighty percent more efficient, achieving speeds of up to 1 Gigabit per second.

Sophisticated techniques can be used to increase VLC data rates. Task groups at English universities are focusing on parallel data transmission using LEDs array, where each LED transmits a different data stream. Other task groups use mixtures of red, green and blue LEDs to alter light frequency encoding different data channels [2].

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III. Designs of Li-Fi

Li-Fi architecture consists in several numbers of LED bulbs or lamps with the interconnection to several wireless devices such as mobile phones or laptops. Important factors should be considered as:

A. Light presence must be defined with line-of-sight.
B. Lamp driver with Internet access connectivity, with a switch and a LED lamp connected.
C. Use of LED bulbs for better performance.
D. Photo detector for data reception.

In addition, implementation design needs to overcome different aspects as:

- Quantity of LEDs necessary in a room.
- Quantity of diodes into the LEDs to illuminate each bulb.
- LEDs location.

IV. Li–Fi Components

A lamp driver is connected to the Internet. A switch and a LED lamp are connected to the lamp driver through a fibre optics cable. A light sensitive device, as a photo detector, receives signal processed. This device is connected to a computer's LAN port. At one end, data from the Internet will be streamed to a lamp driver when the LED is switched on the microchip to convert the digital data in light. The photo detector receives the signal and converts it back into the original data. This method that employs rapid pulses of light to convey information wirelessly is the VLC technique, previously mentioned and depicted in Fig. 1 [3][4].

V. Li – Fi Advantages and Disadvantages

Li-Fi is based either on LEDs or other light source for data transferring. Data transfer is possible with the light spectrum, no matter the segment they belong, i.e., the light can be part of different spectrum segments, such as invisible, ultraviolet or visible. Also, communication speed is enough to download movies, games, music, in lesser time. Moreover, Li-Fi removes limitations that have been put on the user by the Wi-Fi.

Advantages:

- *Capacity:* Light has 10000 times wider bandwidth than radio wavelengths. Also, light sources are already installed. So, Li-Fi has got better capacity and also the equipment is already available.
- *Efficiency:* Data transmission using Li-Fi is cheaper comparing to other technologies. LEDs consume less energy and are highly efficient.
- *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 data transmission.
- *Security:* Light wavelengths do not penetrate through walls, therefore they cannot be intercepted and misused**.**

Disadvantages:

One of the major demerits of this technology is that artificial light cannot penetrate into walls and other opaque materials which radio wavelengths can. Li-Fi enables end devices (through its inbuilt photo-receiver), but it will never be as faster and handy as Wi-Fi, which operates through the air. Another shortcoming is that Li-Fi only works in straight line of sight. Still, Li–Fi emerges as a boom to the rapidly depleting bandwidth of radio wavelengths, and it will certainly be the first choice for Internet access in a confined room at a cheaper cost [2].

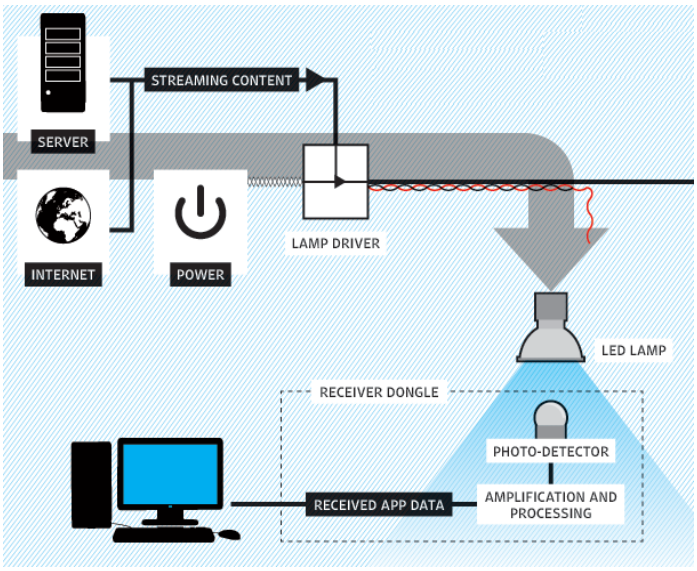

Fig 1. Li – Fi Architecture

VI. Challenges for Li – Fi

Besides from many advantages over Wi-Fi, Li–Fi technology is facing some problems such as the line of sight necessity. Receiving devices would not be shift in indoor environments. A major challenge is to figure it out how receiving devices convey data back to transmitter.

Other disadvantage is that visible light cannot penetrate

through brick walls as radio wavelengths and could be easily blocked by somebody simply walking in front of LED source [1].

VII. Medicine

An excellent idea for hospitals is the replacement of cabling for data transmission in medical equipment with the help of the light beams, making medical experiences less traumatic for patients. Elimination of cabling is one of the priorities for engineers and technical specialist in order to optimize path and spaces [3][4].

Electroencephalograms with no cabling

The first test with Li-Fi was in electroencephalograms at a distance of half a meter. It is one of the devices that cause more impression at the time of testing, but also it is one of the most complete challenges to test this technology with a view to use it in the future. This type of test signal is very weak (less than 100 millivolts) and it is necessary to amplify it before conveying it by separated channels as red, green, and blue, using different LEDs. As there is also a very high error rate in data received, researchers have resorted to colored filters to get more reliable transmissions for potential error correction.

Li-Fi tests for electrocardiograms is a choice for the future as elements control through eye movement. By removing cables, devices that allow this interaction would be better designed, plus interference with other signals of the environment would also be avoided.

Fig 2. Data exchange through Li – Fi on medical equipment [5]

Medical and Healthcare

Due to concerns over radiation, operating rooms do not allow Wi-Fi. Even though Wi-Fi is placed in several hospitals and medical centers, interferences coming from computers and mobile phones can block signals from medical and monitoring equipment. Li-Fi potentially would solve this problem, due to no electromagnetic interference is emitted by Li-Fi and thus it does not interfere with any medical instruments, e.g., magnetic resonance imaging (MRI) scanners. [5]

Other Applications in Medicine

As mentioned before, radiation due to Wi-Fi could turn in a concern, especially if medical facilities, such as operation theatres (OTs) do not allow its deployment, because of the interference with other devices, blocking signals to monitoring equipment, which becomes hazardous for patients health. To overcome it and to make OT areas savvy, Li-Fi could be deployed for Internet access to control medical equipment. The benefits focus for robotic surgeries and other automated procedures [2].

VIII. Developing Ideas

Although Li-Fi has not been developed in several countries yet, there is expected to use certain processes in different environments, such as industrial, educational or medical. Among these developed ideas is expected:

- *Education systems*: Li-Fi is the latest technology that provides faster speed Internet access, replacing Wi-Fi in educational institutions and at training companies, so people can make use of Li–Fi with the same speed intended in a particular area.

- *Traffic management:* In traffic signals, Li-Fi can approach to communicate with car's LEDs to manage traffic in a better way in order to decrease car accidents. Also, car's LEDs can alert drivers in case others get closer.

- *RF Avoidance:* Some people claim hypersensitive to radio frequencies and are looking for an alternative. Li – Fi is a good alternative to dismiss radio wavelengths.

- *Mobile Connectivity:* Laptops, smart phones, tablets and other mobile devices could interconnect directly using Li – Fi. Short range links give very high data rates and also provides transmission security.

Conclusions

The attraction to get into Li-Fi is because is a topic in vogue in the latter days. Reviewing its aspects, it turns out to be a useful invention for communications, with practical uses in several areas, for example, as the educational field. With Li-Fi,

each transmission will become faster and safer compared to wireless technologies based on radio wavelengths. Medical surgeries would be more accurate and less risky at the moment telemedicine is deployed, turning it in optimizing services from healthcare centers. Li-Fi research is still on in different fields with different applications.

Li-Fi will be adapted promptly in several regions. Typically, public policy entities only regulate services, but no technologies to be used by corporations or end users.

REFERENCES

[1] J. H. B. N. P. V. Mehta, "LI-FI Technology – A Visible Light Communication," *Electronics & Communication Engineering, Marwadi Education Foundation, Rajkot, India - ISSN: 2321-9939*, 2014.

[2] R. R. Sharma, "Li-Fi Technology," *Int.J.Computer Technology & Applications - ISSN:2229-6093*, 2014.

[3] A. P. &. S. Ladani, "Li-Fi (Light Fidelity)-The future technology In Wireless communication," *Student,CSE,FETR,Tajpore(Bardoli)*, 2015.

[4] S. M. &. M. M. Hossain, "Li - Fi Technology - The latest technology in Wireless," *Joya Das of UITS*, 2014.

[5] A. S. &. P. S. Agarwal, "Li-Fi Technology: Data Transmission through Visible Light," *International Journal of Advance Research in Computer Science and Management Studies - ISSN: 2321-7782*, 2015.