Review on Li-Fi: an advancement in wireless network communication with the application of solar power

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Abstract. Light Fidelity, commonly referred to as Li-Fi is a technology that was introduced by a German physicist called Herald Hass. This technology in its own uniqueness considers the use of light (Light Emitting Diode, LED to be specific) as its medium of delivering high speed communication that complies with standard IEEE 802.15.7 bidirectional communication standard. This optical means of communications is also known as visible light communication. It is safer when compared with Wi-Fi network. This paper will focus on Li-Fi applications, comparison with existing technologies like Wi-Fi and the inclusion of an alternative source of power i.e., solar power, as a means of effectively optimizing on the availability and accessibility of the benefits in places where erratic or total power outage is a common trend.
Keywords: Li-Fi, solar power, Visible Light Communication (VLC), Wi-Fi

1. Introduction

Light Fidelity, which is uniquely referred to as Li-Fi is a technology that was introduced first by a German Physicist called Herald Hass from the University of Edinburg. It is a Visible Light Communication (VLC) that deals with the use of LED as light source for the transmission of data at high speed. Due to the ever increasing demand, which optimally will be on the rise for wireless data communication, compelled the wireless communication industry to respond to this challenge by considering the radio spectrum above 10 GHz (mm-wave communication) since the available radio spectrum that is below 10 GHz (cm-wave communication), has become increasingly insufficient as a result of massive data being generated daily [1]. The technology provided by Li-Fi comes with much larger spectrum for transmission when it is compared with the conventional methods that employ wireless communications that rely on radio waves. The working principle that guides this technology is that data can be transferred through the use of LED light by varying light intensities faster than what the human eyes is able to perceive. The Visible Spectrum, which is a part of the electromagnetic spectrum that is not greatly used is what Li-Fi technology employs.

Because Li-Fi as a technology on its own is already a great discovery, to have data transfer rate that is comparable to fibre optics makes this new technology a major issue and an area that is worth further research. Imagine having a light source, that provides not only networking facilities but also provides illumination with data transfer at astonishing speeds [2]. The possibilities provided by Li-Fi are comparably endless, and there are greater potentials yet ahead as more researches are conducted. Soon, Li-Fi will become an everyday technology. Hence the importance of introducing or adding solar power

to its operation becomes a welcome and a desirable need. This is promising, considering the low energy consumption level of LED related devices under which LI-Fi is categorized.

Presently, researches have shown that Light Fidelity Li-Fi is gaining more ground in the area of high speed data transmission. For example data transmission speed is over 500 megabytes per second [3]. In data transmission, the consideration of Speed and security is a major issue. Data that are transmitted with the use of Wi-Fi are susceptible to security challenges since it can penetrate through walls easily and because of this reason hackers are able to access documents which ordinarily they are not given access to. Li-Fi on the other hand due to its characteristic nature does not penetrate walls and so provides more security when compared to Wi-Fi [4]. The major component that makes up Li-Fi communication is the white LED, which acts as a communication source and a silicon photodiode which shows good response to visible light. A data rate of greater than 100Mbps is possible by the high speed LEDs.

1.1 HISTORY AND WORKING PRINCIPLE

The idea of Li-Fi was first put forward and used by Professor Harald Haas from University of Edinburgh, United Kingdom. This was done at the TED global talk in 2011. Li-Fi technology was given a place of "one of 50 best inventions of 2011" on TED world site on the internet [5]. The very first project that gives explanation of the idea of Li-Fi was the D-Light project, which stands for "data through illumination" [6]. In October 2011, industries players formed the Li-Fi consortium, whose aim is to propagate the awareness of high-speed optical wireless systems and with it conquer the limited amount of space available for radio-based wireless spectrum by exploiting a completely different part of the electromagnetic spectrum. [6].

The principle of operation of Li-Fi technology is implemented by using white LED light bulbs for illumination powered by constant current. In order to achieve data transmission, the LED bulb is subjected to very fast variations of the current at extremely high speeds. This switches on and off such that the human eyes cannot detect thereby producing digital signal of '1'for the LED in 'on' state, or a signal of '0' for the LED in 'off' state [**2**]. In order to be able to send and receive data, some LEDs and a controller that codes data into those LEDs and for receiving data, an Image Sensor, and a Photodiode which is used as a detector, are needed to makes up the basic components requirement as shown in Figure 1. The LED bulb is designed to have a micro-chip whose work is to process the data received. Figure 2 shows summary of the working principle of a Li-Fi system. To transmit data therefore, a single LED or multi LED maybe required. On the side of the receiver, a photo detector is installed, which convert the light signal into electric signals which is delivered to the device connected to it. A voltage regulator and level shifter circuits are needed on both sides to convert or maintain a stabilized voltage level between the transmitter and receiver [7].

Figure 1: Basic component requirement [6]

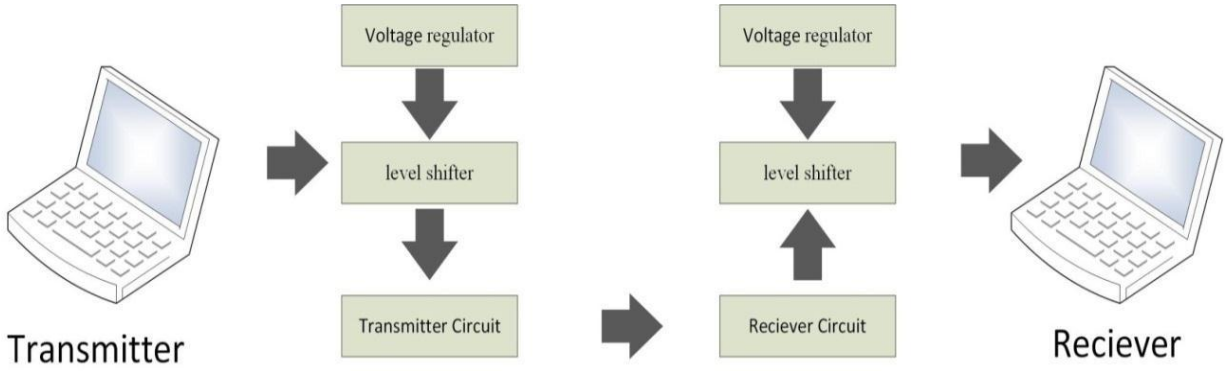

Figure 2: Li-Fi Principle of operation [6]

2. LI-FI APPLICATIONS

The usefulness of LI-Fi technology is now advancing into several fields of human endeavours. A few of the areas are as discussed in the next subsections.

2.1. Hospital

Theatre where surgical work are carried out do not permit the use of Wi-Fi because of its inherent radiation and the interferences it can cause to monitoring equipment like Magnetic Resonance Imaging (MRI) scanners during its use. This challenge is solved with the use of Li-Fi owing to the fact that light is one of the most glaring fixtures in the surgical room. Moreover, Li-Fi has 10,000 times the spectrum of Wi-Fi [2,8,9].

Figure 3: The working principle of the Li-Fi [6].

2.2. Smart Street Lighting

These days, majority of street lights are LED based, thus deviating from the usual high pressure lamps. These LED lamps easily find application by their conversion to Li-Fi hotspots that serves both as light source and for data transfer in communication [4].

Figure 4: Smart lighting with Li-Fi [6].

2.3. Mobile Device Communication

The mode of communication has been made much easier by the introduction of mobile devices. These smart mobile devices easily communicate electronically with Li-Fi technology to provide very impressive data transfer with high security [2,4].

2.4. Education

The application of Li-Fi technology in learning is very promising. It affords both the instructor and the student a base to communicate on an individual platform. It therefore makes it very easy to progressively monitor individual student [13]. And because of its unique features the download of tutorials and other materials for learning becomes easy.

2.5. High Risk Environments

Places like petrochemical plants, power plants etc., will find the technology of Li-Fi as a safe haven from the application of Wi-Fi that uses radio wave for communication in high risk areas because of their high inflammable tendencies.

Figure 5: The use of Li-Fi in power plant [6, 10].

2.6. Aviation

Li-Fi can find application in the aviation sector especially in the cabin and at the control tower where the need to avoid interference while using radio frequency related devices on-board the cabin is of very great importance [4, 7, 9, and 10].

Figure 6: Li-Fi in air plane [6].

2.7. Deep water Communications

In order to overcome the challenge of signal strength reduction in deep water communication, the technology of Li-Fi provides a way out for an effective under water communications [4, 9, and 10].

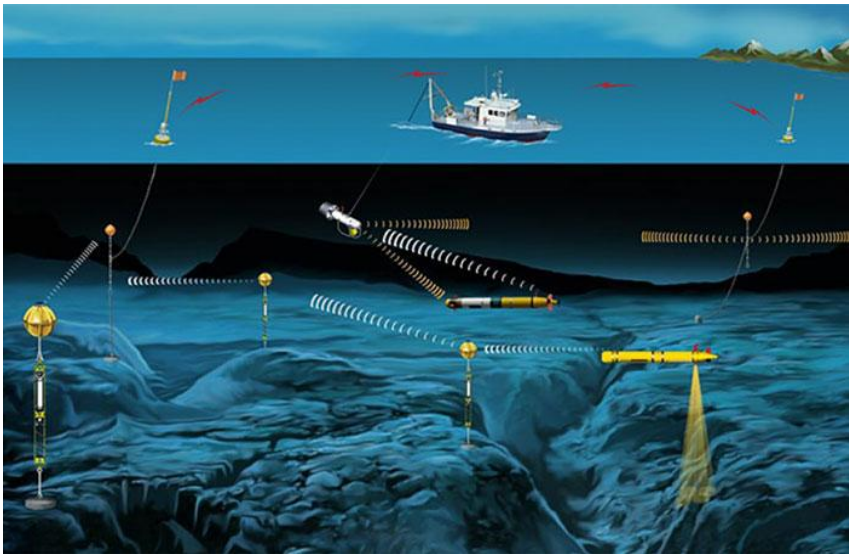

Figure 7: Application of Li-Fi in deep water [6].

3. COMPARING LI-FI AND WI-FI

Table 1 shows compared features between Li-Fi and Wi-Fi in tabular form. A close look at the table is suggestive of the importance that Li-Fi can provide high benefit in transfer of data in terms of cost,

speed and safety of data. This section is meant to show only the basic difference that exist between the use of Li-Fi, and Wi-Fi network [11].

Table1. Comparing Light Fidelity (Li-Fi) and Wi-Fi

Features	Li-Fi	Wi-Fi
Identification	Popularly called Li-Fi	Generally referred to as Wi-Fi
Mode of operation	Data transmission in Li-Fi is achieved using light from LED bulbs.	Data transmission in Wi-Fi is achieved using radio waves.
Possible Interference	Do not have any observed possible interference as with Wi-Fi	There are cases of interference from close by similar devices
Operating Frequency of the technology	Made up very wide spectrum. Above 100Ghz.	Low when compared with Li-Fi
Distance coverage	It is known to cover about 10 meters	Have potential to cover about 32 meters (WLAN 802.11b/11g), vary based on transmission power and antenna type
Hard ware System requirement	1. LED Lamp driver, 2. LED bulb 3. Photo detector, ete., will make up complete Li-Fi system.	Requires 1. Routers. 2. Installed subscriber devices like (laptops, PDAs, desktops) as stations.

4. THE PLACE OF SOLAR POWER IN LI-FI TECHNOLOGY

Availability and accessibility of power is a vital factor for optimum performance of any known technology. Solar power is readily available and it is a renewable source of energy [16,17]. Every known technology is aimed at being able to perform given task more efficiently. Hence availability of power and the ease of accessibility cannot be compromised when such new technology like Li-Fi will

need to be deployed to developing world where erratic power supply and total power outage is an issue that is being contended with [15,17].

4.1 THE LI-FI/SOLAR POWER COMPONENTS

The desire is that the system will be purely direct current (DC) based configuration. Hence the need for a power inverter may not be necessary except for cases that may uniquely require the inclusion of an inverter system. The component that will make up the system will include; 12 or 24 V deep cycle battery(ies) – to be determined by the system requirement, Solar charge controller, DC combiner box, Inverter (optional), Solar cell modules – system size to determine number of panels (solar cell modules) and Li-Fi system configuration. Figure 8 shows block diagram of a proposed arrangement for the implementation of solar power with Li-Fi system.

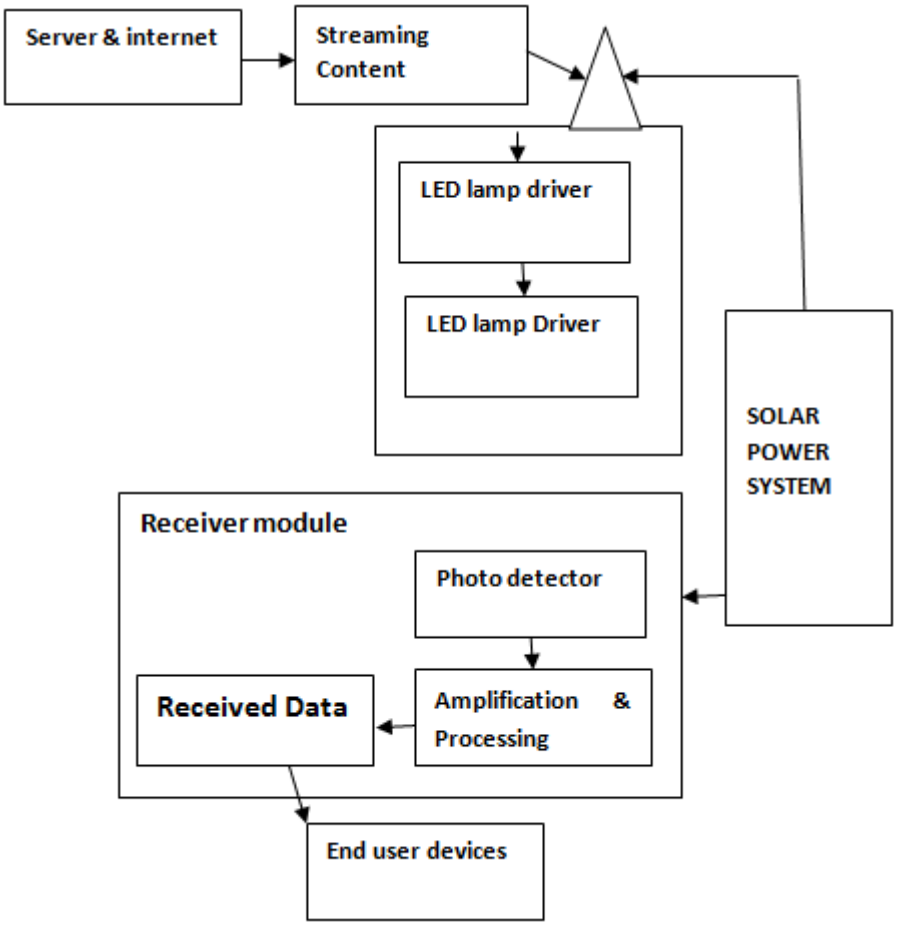

Figure 8: Block diagram of a proposed arrangement for the implementation of solar power with Li-Fi system.

4.2 CHALLENGES OF LI-FI

Li-Fi though new compared with Wi-Fi, its great prospect is not without some challenges. Such challenges are listed below. Research works are on towards overcoming these challenges. Overcoming them will further give Li-Fi more edge above Wi-Fi.

- Effective data transmission will require that both transmitter and receiver are appropriately placed in same line of sight.
- Access to the internet is lost, whenever there is a disruption with the light source. This makes internet access to be dependent of light source.

- Since visible light cannot penetrate brick walls, simply walking in front of LED source can disrupt connectivity between transmitter and receiver.
- Dealing with the effect of changing weather conditions is a concern if the system is meant to operate outdoors.

5. CONCLUSION

The need to communicate and doing it in a most friendly, safe and convenient way is on the increase daily. Huge amount of data is generated continuously, and this results in the gradual reduction of available space on the electromagnetic spectrum upon which the Wi-Fi network depends. Solving this challenge opens up the Li-Fi technology that has greater space provided by the visible light spectrum and capable of producing data transfer rate greater than 10Mbps that is faster than any average broadband connection [1,12]. The inclusion of solar power system will make the technology available and accessible in places where erratic power supply and regular total power outage is a concern.

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