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LI-FI IS FUTURE TECHNOLOGY OF WIRELESS COMMUNICATION

SHAHID RAMZAN
STUDENT (MCA)
PUNJABI UNIVERSITY
PATIALA

MOHD. IRFAN
ASSOCIATE PROFESSOR
GOVERNMENT COLLEGE
MALERKOTLA

ABSTRACT

The purpose of the paper depicted that Light Fidelity Technology is more secure, reliable and efficient than Wi-Fi Technology. Li-Fi stands for Light-Fidelity. Li-Fi Technology, proposed by the German physicist—Harald Haas, provides transmission of data through illumination by sending data through an LED light bulb that varies in intensity faster than the human eye can follow. In this paper, the author will discuss the construction of Li-Fi, Design and working of Li-Fi, Recent advancement of Li-Fi, Comparison between Li-Fi and Wi-Fi. Further, the author will provide the advantages and application of Li-Fi in this modern era.

KEYWORDS
light fidelity, LED, wireless fidelity, radio waves, visible light communication.

INTRODUCTION

In the technology era, The new wireless communication technology Li-Fi that will be transmission data through lights .The current wireless networks that connect us to the internet are very slow when multiple device are connected. As the number of device that access the internet increase the fixed bandwidth available make its more and more difficult to enjoy high data transfer rate and connect secure a network.

Li-Fi transmission of data through illumination by taking the fibber out of fiber optic by sending data though an LED light bulb that various in intensity faster than the human eye can follow. Li-Fi comprises a wide range of frequencies and wave lengths, from the infrared through visible and down to the ultraviolet spectrum. It includes sub-gigabit and Giga bit class communication speeds for short medium and long ranges, and unidirectional and bidirectional data transfer using line of sight or sight or diffuse links, reflections and much more. 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 pure Li-Fi. 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 his TED talk, Professor Haas highlighted the following key problems of Wi-Fi that need to be overcome in the near future:

1) 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.
2) 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%.
3) Availability: Radio waves cannot be used in all environments, particularly in airplanes, chemical and power plants and in hospitals.
4) 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:

5) 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.
6) Efficiency: LED lights consume less energy and are highly efficient.
7) 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.
8) Security: Light of course does not penetrate through walls and thus data transmission using light waves is more secure.

CONSTRUCTION OF Li-Fi SYSTEM

Li-Fi is a fast and cheap optical version of Wi-Fi. It is based on Visible Light Communication (VLC). VLC is a data communication medium, which uses visible light between 400 THz (780 nm) and 800 THz (375 nm) as optical carrier for data transmission and illumination. It uses fast pulses of light to transmit information wirelessly. The main components of Li-Fi system are as follows:

a) a high brightness white LED which acts as transmission source.
b) a silicon photodiode with good response to visible light as the receiving element.

LEDs can be switched on and off to generate digital strings of different combination of 1s and 0s. To generate a new data stream, data can be encoded in the light by varying the flickering rate of the LED. The LEDs can be used as a sender or source, by modulating the LED light with the data signal. The LED output appears constant to the human eye by virtue of the fast flickering rate of the LED. Communication rate greater than 100 Mbps is possible by using high speed LEDs with the help of various multiplexing techniques. VLC data rate can be increased by parallel data transmission using an array of LEDs where each LED transmits a different data stream. The Li-Fi emitter system consists of 4 primary subassemblies [1]:

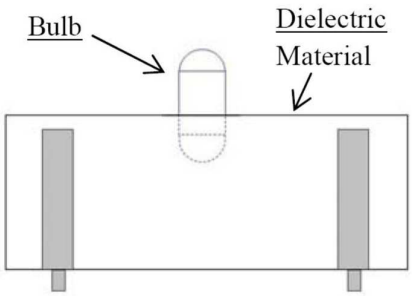
a) Bulb
b) RF power amplifier circuit (PA)
c) Printed circuit board (PCB)
d) Enclosure

The PCB controls the electrical inputs and outputs of the lamp and houses the microcontroller used to manage different lamp functions.

A RF (radio-frequency) signal is generated by the solid-state PA and is guided into an electric field about the bulb. The high concentration of energy in the electric field vaporizes the contents of the bulb to a plasma state at the bulb's center; this controlled plasma generates an intense source of light. All of these subassemblies are contained in analuminum enclosure [1]. The bulb sub-assembly is the heart of the Li-Fi emitter. It consists of a sealed bulb which is embedded in a dielectric material. This design is more reliable than conventional light sources that insert degradable electrodes into the bulb [3]. The dielectric material serves two purposes. It acts as a waveguide for the RF energy transmitted by the PA. It also acts as an electric field concentrator that focuses energy in the bulb. The energy from

the electric field rapidly heats the material in the bulb to a plasma state that emits light of high intensity and full spectrum [1]. Figure (1) shows the bulb sub-assembly.

FIGURE 1



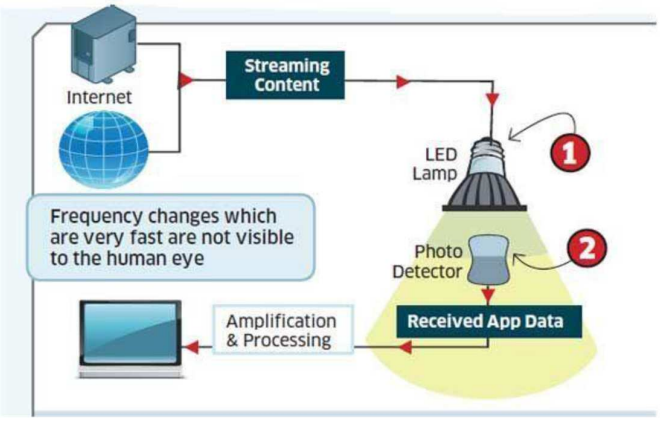
There are various inherent advantages of this approach which includes high brightness, excellent color quality and high luminous efficacy of the emitter – in the range of 150 ens per watt or greater. The structure is mechanically robust without typical degradation and failure mechanisms associated with tungsten electrodes and glass to metal seals, resulting in useful lamp life of 30,000+ hours. In addition, the unique combination of high temperature plasma and digitally controlled solid state electronics results in an economically produced family of lamps scalable in packages from 3,000 to over 100,000 lumens [2].

WORKING OF Li-Fi

A new generation of high brightness light-emitting diodes forms the core part of light fidelity technology. The logic is very simple. If the LED is on, a digital 1 is transmitted. If the LED is off, a digital 0 is transmitted.

These high brightness LEDs can be switched on and off very quickly which gives us a very nice opportunity for transmitting data through light [4]. The working of Li-Fi is very simple. There is a light emitter on one end, for example, an LED, and a photo detector (light sensor) on the other. The photo detector registers a binary one when the LED is on; and a binary zero if the LED is off. To build up a message, flash the LED numerous times or use an array of LEDs of perhaps a few different colors, to obtain data rates in the range of hundreds of megabits per second. The block diagram of Li-Fi system is shown in Fig. (2).

FIGURE 2



The data can be encoded in the light by varying the flickering rate at which the LEDs flicker on and off to generate different strings of 1s and 0s. The LED intensity is modulated so rapidly that human eye cannot notice, so the light of the LED appears constant to humans [5].

Light-emitting diodes (commonly referred to as LEDs and found in traffic and street lights, car brake lights, remote control units and countless other applications) can be switched on and off faster than the human eye can detect, causing the light source to appear to be on continuously, even though it is in fact 'flickering'. The on-off activity of the bulb which seems to be invisible enables data transmission using binary codes: switching on an LED is a logical '1', switching it off is a logical '0'. By varying the rate at which the LEDs flicker on and off, information can be encoded in the light to different combinations of 1s and 0s. This method of using rapid pulses of light to transmit information wirelessly is technically referred to as Visible Light Communication (VLC), though it is popularly called as Li-Fi because it can compete with its radio-based rival Wi-Fi.

RECENT ADVANCEMENTS IN Li-Fi

Using a standard white-light LED, researchers at the Heinrich Hertz Institute in Berlin, Germany, have reached data rates of over 500 megabytes per second [7]. Using a pair of Casio smart phones, the technology was demonstrated at the 2012 Consumer Electronics Show in Las Vegas to exchange data using light of varying intensity given off from their screens, detectable at a distance of up to ten meters [7]. A consortium called Li-Fi Consortium' was formed in October 2011 by a group of companies and industry groups to promote high-speed optical wireless systems and overcome the limited amount of radio based wireless spectrum. According to the Li- Fi Consortium, it is possible to achieve more than 10 Gbps of speed, theoretically which would allow a high-definition film to be downloaded in just 30 seconds [7]. Researchers at the University of Strathclyde in Scotland have begun the task of bringing high-speed, ubiquitous, Li-Fi technology to market [6].

COMPARISON BETWEEN Li-Fi &Wi-Fi

Li-Fi is the name given to describe visible light communication Technology applied to obtain high speed wireless communication. It derived this name by virtue of the similarity to Wi-Fi. Wi-Fi works well for general wireless coverage within buildings, and Li-Fi is ideal for high density wireless data coverage inside a confined area or room and for relieving radio interference issues.

FIGURE 3

Parameter	Li-Fi	Wi-Fi
Speed	***	***
Range	*	**
Data density	***	*
Security	***	**
Reliability	**	**
Power available	***	*
Transmit/receive power	***	**
Ecological impact	*	**
Device-to-device connectivity	***	***
Obstacle interference	***	*
Bill of materials	***	**
Market maturity	*	***

* low ** medium *** high

ADVANTAGES AND APPLICATION OF Li-Fi

A detailed discussion of its various advantages is given Below:

- A free band that does not need license.
- High installment cost but very low maintenance cost.
- Cheaper than Wi-Fi.
- Theoretical speed up to 1 GB per second: Less time & energy consumption.
- No more monthly broadband bills.
- Lower electricity costs.
- Longevity of LED bulb: saves money.
- Light doesn't penetrate through walls: secured access.

APPLICATION OF Li-Fi

(i) Medical and Healthcare-Due to concerns over radiation, operating rooms do not allow Wi-Fi and even though Wi-Fi is in place in several hospitals, interferences from computers and cell phones can block signals from medical and monitoring equipment. Li-Fi solves these problems. Lights are an essential part of operating rooms and Li-Fi can thus be used for modern medical instruments. Moreover, no electromagnetic interference is emitted by Li-Fi and thus it does not interfere with any medical instruments such as MRI scanners.

(ii) Airlines and Aviation-Wi-Fi is often prohibited in aircrafts. However, since aircrafts already contain multiple lights, thus Li-Fi can be used for data transmission.

FIGURE 4

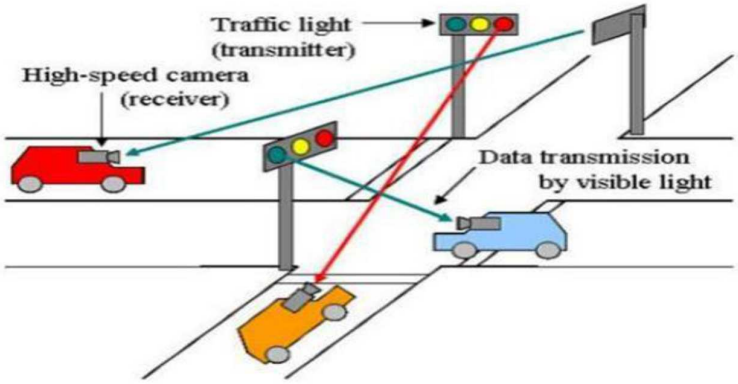
(iii) Power Plants and Hazardous Environments-Wi-Fi is not suitable for sensitive areas like power plants. However, power plants still require fast and interconnected data systems for monitoring grid intensity, demand, temperature etc. In place of Wi-Fi, Li-Fi can provide safe connectivity throughout the power plant. Li-Fi offers a safe alternative to electromagnetic interference due to radio waves in environments such as petrochemical plants and mines.(8)

FIGURE 5

(iv) Underwater Explorations and Communications-Remotely operated underwater vehicles or ROVs work well except in situations when the tether is not long enough to fully explore an underwater area or when they get stuck. If instead of the wires, light was used then the ROVs would be freer to explore. With Li-Fi, the head lamps head lamps Could also then be used to communicate with each other, data processing and reporting findings back to the surface at regular intervals, while also receiving the next batch of instructions. Radio waves cannot be used in water due to strong signal absorption. Acoustic waves have low bandwidth and disrupt marine life. Li-Fi offers a solution for conducting short-range underwater communications.

(v) Traffic-Li-Fi can be used for communications between the LED lights of cars to reduce and prevent traffic accidents. LED headlights and tail-lights are being implemented for different cars. Traffic signals, signs and street lamps are all also transitioning to LED. With these LED lights in place, Li-Fi can be used for effective vehicle-to-vehicle as well as vehicle-to-signal communications. This would of course lead to increased traffic management and safety.

FIGURE 6



(vi) Giga Speed Technology -The Li-Fi Consortium provides the fastest wireless data transfer technology presently available. Our current solutions offer effective transmission rates of up to 10 Gbps, allowing a 2 hour HDTV film to be transferred in less than 30 seconds. This can be extended to several 100 Gbps in future versions

(vii) Smart Lighting- Street lamps can in the future be used to provide Li-Fi hotspots and can also be used to control and monitor lighting and data.

(viii) Mobile Connectivity-Laptops, tablets, smart phones and various other mobile devices can interconnect with each other using Li-Fi, much like they Inter connect today using Wi-Fi. These short range links provide very high data rates as well as increased security.

(ix) Toys-Several toys consist of LED lights and these can be utilized to implement low-cost communication in order to build interactive toys.

(x) RF Spectrum Relief- Li-Fi networks can be used to relieve the radio spectrum off of excessive capacity demands of cellular networks.

(xi) RF Avoidance- Li-Fi can be used as a solution to any situation in which hypersensitivity to radio frequencies is a problem and radio waves cannot be used for communication or data transfer.

(xii) Indoor Wireless Communication- Li-Fi is very well suited for indoor wireless communication and data transmission. Li-Fi makes use of a free, unlicensed spectrum and is not affected by RF noise. Moreover, most indoor locations would have a sufficient amount of light sources and provide additional security since Li-Fi as previously discussed cannot penetrate through walls.

(xiii) Retail Analytics - Li-Fi can find wide application in retail analytics. Most retail stores consist of a rich lighting environment comprising of abundant sources of light which may be utilized for Li-Fi. Li-Fi could be used to track the behaviour of individual shoppers. Since most customers nowadays possess smartphones, Li-Fi could be used to connect to these smartphones to link up the people, product and purchasing, and thereby greatly simplify the overall shopping process.

(xiv) Casinos- Like retail stores, casinos also have rich lighting environments which could be easily harnessed for Li-Fi, which can find application in the large amount of video monitoring equipment that most casinos employ.

(xv) Hidden Communications - Li-Fi is extremely useful for applications in which communications must be hidden. These involve various military and defense based communications as well as communications in hospitals.

(xvi) Line of Sight Applications - Li-Fi can also be used in situations where line of sight makes a difference, such as in vehicle to vehicle communication as previously discussed as well as in indoor GPS systems.

(xvii) Spatial Reuse - Li-Fi can act as an alternative in regions with high density wireless communication where 500 or more users may be contending for Wi-Fi. This would lead to low access speeds for the users. Li-Fi can be used to share some of the load of Wi-Fi.

(xviii) Smart Class- Li-Fi can find application in the new smart class technology which is quickly becoming imperative for progressive schools and colleges in the world. Using this technology, teachers show the class a 2D/3D animation on a large screen. They can explain different topics, zoom in to show the important details and freeze and annotate for appropriate emphasis. Through engaging animations, colours and sounds, the teachers gain the full attention of every child in the class. Each child gets visual input on what, where, when and how anything happens and the concepts are well understood. In this technology all the computers are connected to the server using wired LAN technology. The physical transmission medium for wired LAN involves cables, either twisted pair or fiber optics.

(xix) Disaster management- Li-Fi can be used as a powerful means of communication in times of disaster such as earthquake or hurricanes. The average people may not know the protocols during such disasters. Subway stations and tunnels, common dead zones for most emergency Communications, pose no obstruction for Li-Fi [1]. Also, for normal Periods, Li-Fi bulbs could provide cheap high-speed Web access to every street corner.

(xx) Replacement for other technologies - Li-Fi doesn't work using radio waves. So, it can be easily used in the places where Bluetooth, infrared, Wi-Fi, etc. are banned.

LIMITATIONS OF Li-Fi

- The main problem is that light cannot pass through objects, so if the receiver is inadvertently blocked in any way, then the signal will immediately be cut out. If the light signal is blocked on Could switch back over to radio waves.
- High installation cost of the systems can be complemented by large-scale implementation of VLC though adopting this technology will reduce further operating costs like electricity Charges, maintenance charges etc.
- Reliability and network coverage are the major issues to be considered by the companies while providing VLC services. Interference from external light sources like sunlight, normal bulbs; and opaque materials in the path of transmission will cause interruption in the communication.

CONCLUSIONS

If LI-FI technology can be put into practical use, every bulb used to transmit a data and will lead toward the cleaner, greener, safer and brighter future. LI-FI may solve issues such as the shortage of radio-frequency bandwidth and is aimed at creating new communication channels with the use of existing equipment. Currently, the LI-FI concept is attracting a great deal of interest, because it provides an authentic and very efficient alternative to wireless device which used radio spectrum.

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