International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Study on Light-Fidelity (Li-Fi) and a Solution to Penetration Through Wall Problem

Geocey Shejy[1], Kapil Manikani[2], Jinesh Nair[3]

[1]Assistant Professor of MCA, Vivekanand Education Society's Institute of Technology, Mumbai, India

[2, 3] Student of MCA, Vivekanad Education Society's Institute of Technology, Mumbai, India

Abstract: ***There is no doubt that wireless communications play a crucial role in today's society. Information through wireless network has the most desired value. Whoever has access to wireless networks has a very powerful tool in his/her hands. One of the factors influencing the gap between the developed and developing countries is the information availability. Access to the Internet, which can be provided by wireless networks, means the access to the world's largest library but it would be great if everybody could have advantage of that. It is important not only because of the educational reasons but also for general development. Networks assuring fast and reliable exchange of data will positively affect country's production and will result in greater efficiency of people's work and these factors lead to the generation of Li-Fi.Li-Fi technology is nothing but Light-Fidelity communication systems .It is the fastest and cheapest wireless communication systems and is the optical version of the Wi-Fi. The term was first used by Harald Haas in TED Global talk. The technology works by adapting LEDs to send digital information, invisible to the naked eye. A light sensor on a device picks up the digital information sent by the LED, which enables it to be processed by a computer. It is similar to the Wi-Fi except that it uses Light waves instead of Radio waves.***

Keywords: Li-Fi Technology, Light Sensor, LED, TED Global Talk, Wireless Communication etc

1. Introduction

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 infact very much part of our lives for millions and millions of years and does not have any major ill effect.

Professor Harald Haas, from the University of Edinburgh in the UK, is widely recognised as the original founder of Li-Fi. He coined the term Li-Fi and is Chair of Mobile Communications at the University of Edinburgh and co-founder of pureLiFi. The general term visible light communication (VLC), includes any use of the visible light portion of the electromagnetic spectrum to transmit information. The D-Light project at Edinburgh's Institute for Digital Communications was funded from January 2010 to January 2012. Haas promoted this technology in his 2011 TED Global talk and helped start a company to market it. PureLi-Fi, formerly pureVLC, is an original equipment manufacturer (OEM) firm set up to commercialize Li-Fi products for integration with existing LED-lighting systems.

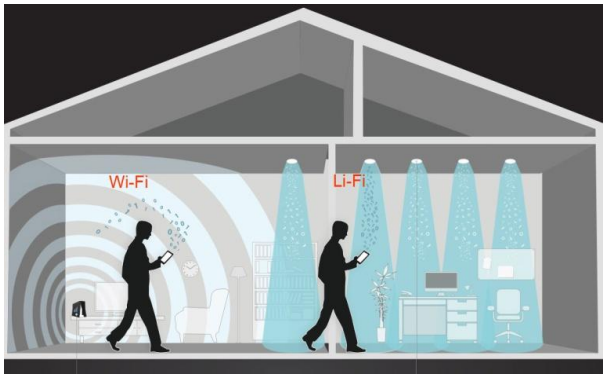

Figure 1: Diagram demonstrating the shift from Wi-Fi to Li-Fi

In October 2011, companies and industry groups formed the Li-Fi Consortium, to promote high-speed optical wireless systems and to overcome the limited amount of radio-based wireless spectrum available by exploiting a completely different part of the electromagnetic spectrum. A number of companies offer uni-directional VLC products which is not the same as Li-Fi.VLC technology was exhibited in 2012 using Li-Fi. By August 2013, data rates of over 1.6 Gbit/s were demonstrated over a single color LED. In September 2013, a press release said that Li-Fi, or VLC systems in general, do not require line-of-sight conditions. In October 2013, it was reported Chinese manufacturers were working on Li-Fi development kits. In April 2014, the Russian company Stins Coman announced the development of a Li-Fi wireless local network called BeamCaster. Their current module transfers data at 1.25 gigabytes per second but foresee boosting speeds up to 5 GB/second in the near future.

2. Comparison between Li-Fi and Wi-Fi

Table 1: Comparison between Li-Fi and Wi-Fi

S. No	*Parameter*	*Li-Fi*	*Wi-Fi*
1.	Speed	>1Gbps	150 Mbps
2.	Medium of Transfer	Uses Light Waves	Uses Radio Waves
3.	Cost	Less than Wi-Fi	More than Li-Fi
4.	Network Topology	Point to Point Topology	Star and Point to Point Topology
5.	Frequency	Hundreds of 10Hz	2.4 GHz

3. Existing System

3.1 Basic Concept

Li-Fi makes use of Visible Light Communication (VLC).VLC technology, one of the advanced optical wireless communication technologies, in which light in the visible region (375nm-780nm) is used as a medium for data transmission is more secure and achieves high data rates as compared to conventional wireless technologies like Wi-Fi, Bluetooth, Wimax etc., which use radio waves for communication. Till late 1990s infrared spectrum is used for the communication. But in the early 2000s, researches started using visible light from LEDs as the medium for communication. Initially they were able to achieve network speed about 100Kbps. With continuous developments, VLC systems can now achieve about 800Mbps data rate for short range communications.

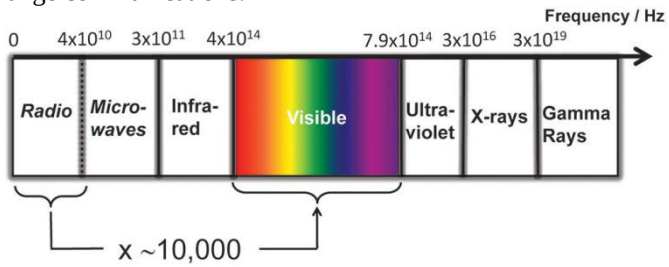

Figure 2: Light Specturm

Li-Fi signals work by switching bulbs on and off incredibly quickly – too quickly to be noticed by the human eye. This most recent breakthrough builds upon this by using tiny micro-LED bulbs to stream several lines of data in parallel.

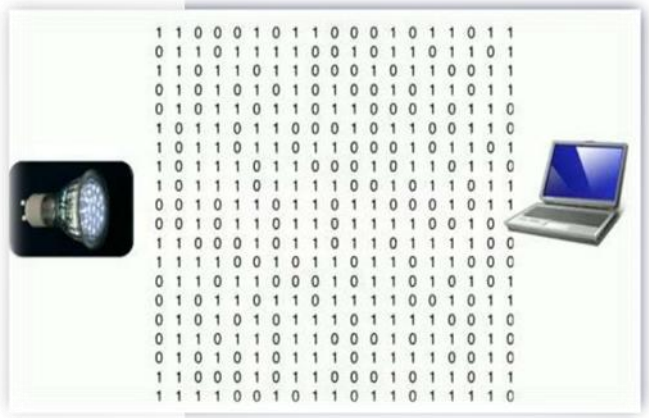

Figure 3: Transfer of Data in Li-Fi

Existing LED light bulbs could be converted to transmit Li-Fi signals with a single microchip, and the technology would also be of use in situations where radio frequencies cannot be used for fear of interfering with electronic circuitry. Li-Fi bulb could be dimmed to the point that they were not visible to humans and yet still functional.

3.2 Circuit Design

The LIFI circuit consists of 4 primary sub-assemblies:
- Bulb
- RF power amplifier circuit (PA)
- Printed circuit board (PCB)
- Enclosure

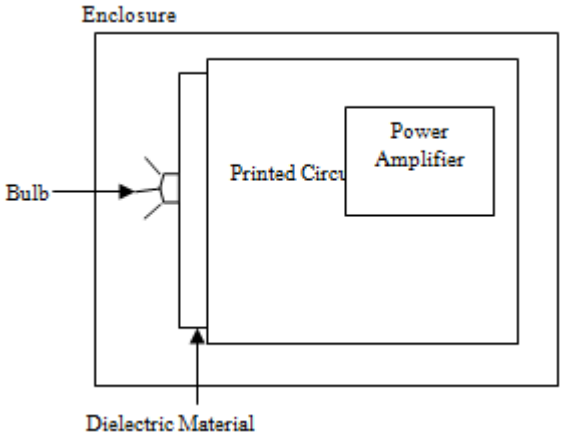

Figure 4: Circuit Diagram of Li-Fi

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

At the heart of LIFI is the bulb sub-assembly where a sealed bulb is embedded in a dielectric material. This design is more reliable than conventional light sources that insert degradable electrodes into the bulb. The dielectric material serves two purposes; first as a waveguide for the RF energy transmitted by the PA and second 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.

4. Working of the Existing System

Li-Fi is a Visible Light Communications (VLC) system for data transmission. A simple VLC system has two qualifying components: 1) at least one device with a photodiode able to receive light signals and 2) a light source equipped with a signal processing unit.

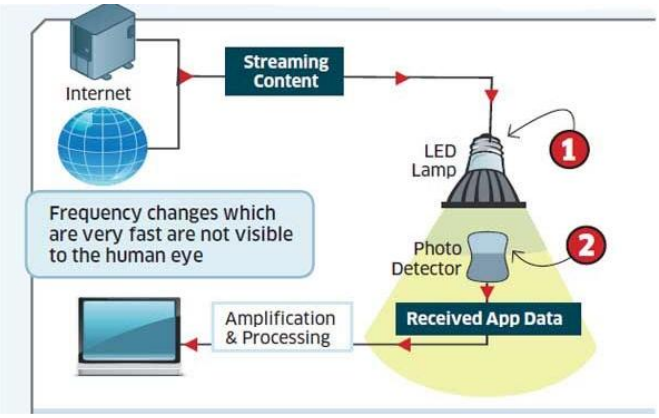

Figure 5: Diagram showing working of Li-Fi

A VLC light source could comprise of a fluorescent or light emitting diode (LED) bulb. Since a robust Li-Fi system requires extremely high rates of light output, LED bulbs are most ideal for implementing Li-Fi. LED is a semiconductor light source, which implies that LED light bulbs can amplify light intensity and switch rapidly. Therefore, LED cells can modulate thousands of signals without the human eye ever noticing. In turn, the changes in light intensity from the LED light source are interpreted and converted as electrical current by the receiving photodiode device. Once the electronic signal is demodulated, it is converted into a continuous stream of binary data comprising of audio, video, web, and application information to be consumed by any Internet-enabled device.

There is ample room for growing innovation in Li-Fi technology. Like conventional broadband and Wi-Fi, Li-Fi can also function as a bidirectional communication system. By interchanging visible light and infrared light from a photo detector, a mobile device connected to that photo detector can send data back to the light source for uplink. Also, multi-colored RGB (Red/Green/Blue) LED's at retina size could be engineered to send and receive a wider range of signals than single-colored phosphor-coated white LED's.

Few applications of Li-Fi are:

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.

5. Issues of the Existing System

The following are some of the issues of the existing system:

1) High installation charges of Visible Light Communication (VLC) devices.
2) Interference from external light sources like sun-light, normal bulbs, opaque materials.
3) Light cannot penetrate through objects such as walls and the exact explanation is described below:
   a) If there is no obstacle between LED lamp and receiver, the data is received normally on the receiver end.
   b) But if there is some kind of obstacle like wall in between the LED Lamp and receiver then there is loss of data which is explained in the diagram below

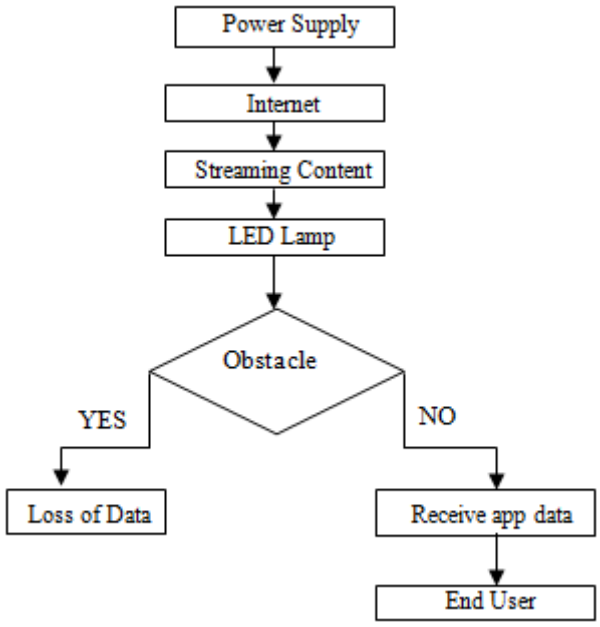

Figure 6: Flow Chart showing Issue of the Existing System

6. Proposed System

6.1 Components

Power supply: Provides the necessary electrical power to operate the transmitter.

Internet: Internet is a global system of interconnected computer networks that interchange data by packet switching using the standardized Internet Protocol Suite (TCP/IP).

Streaming Content: Streaming Content which refers to content delivered live over the Internet, requires a form of source media (e.g. a video camera, an audio interface, and screen capture software) an encoder to digitize the content, a media publisher, and a content delivery network to distribute and deliver the content.

LED Lamp: It is defines as semiconductor light source which means that LED light bulbs can amplify light intensity and switch from it rapidly.

Sensor: A sensor is a transducer whose purpose is to sense (that is, to detect) some characteristic of its environs. It detects events or changes in quantities and provides a corresponding output, generally as an electrical or optical signal.

Oscillator: Creates alternating current at the frequency on which the transmitter will transmit. The oscillator usually generates a sine wave, which is referred to as a *carrier wave.*

Modulator: Adds useful information to the carrier wave. There are two main ways to add this information. The first, called amplitude modulation or AM, makes slight increases or decreases to the intensity of the carrier wave. The second, called frequency modulation or FM, makes slight increases or decreases the frequency of the carrier wave.

Amplifier: Amplifies the modulated carrier wave to increase its power. The more powerful the amplifier, the more powerful will be the broadcast.

Antenna: Converts the amplified signal to radio waves.

Wireless Adaptors: A high-speed wireless network card that is used to access a network that is pre-installed in most of the computers, laptops and mobiles.

End User: End User can be any number of user using laptop, computer and mobile.

6.2 Working of the Proposed System

The following are the steps designed for Proposed System:

1) The first and most important thing needed for the system to work is Power Supply.
2) Internet connection is made and streaming of the content is done accordingly.
3) LED Lamp glows with the help of power supply and there is continuous transfer of 0 and 1 and when there is no obstacle the sensor receives 0 and 1. But if there is an obstacle the sensor receives only 0 signal.
4) Now, if there is continuous transfer of 0 and 1 signals the system works as a Li-Fi which has the following steps:
   a) Receiving the application data coming from the LED Lamp through sensor.
   b) Performing Amplification and Processing.
   c) Delivering the data to the end user.

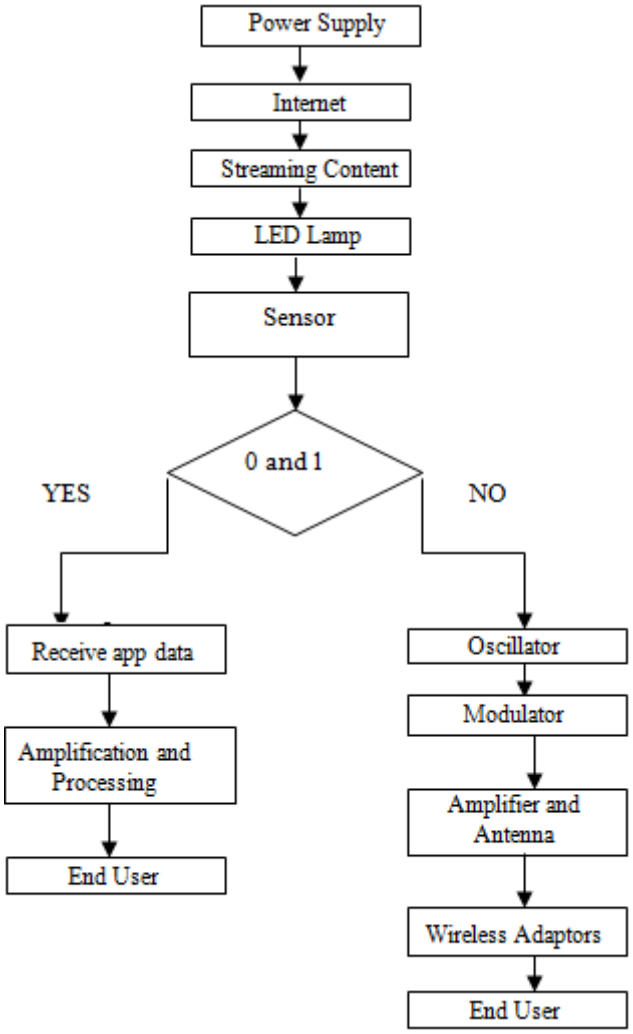

Figure 7: Flow Chart showing Proposed System

5) But, if there is only 0 signal coming from the sensor that means there is some kind of obstacle which may be wall or anything which does not allow light to transfer the system generates radio waves in the following manner:
   a) Oscillator which oscillates the current coming from the power supply into alternating current.
   b) Modulator which adds the information in the wave.
   c) Amplifier which increases the power of the transferring wave.
   d) Antenna which converts the amplified waves into radio wave.
   e) Wireless Adaptors are the receivers which receives the radio waves.
   f) Finally, the data is delivered to the end user.
6) In this way, the data can be transmitted through walls without causing any problem to the user.

7. Analysis of the Proposed System

7.1 Advantages

1) The Proposed System designed can easily penetrate through walls and the user can avail the services provided by the internet service provider without any interruption.
2) This system makes use of sensors which are not much costly and are easy to deploy.
3) This system also makes use of radio waves which can travel long distances and are cheap.
4) Radio waves can be used for almost all non written communications.
5) The Proposed System is ensures security in the following two ways:
   a) It is difficult to eavesdrop on Li-Fi signals since the signal is confined to a closely defined illumination area and will not travel through walls. Data may be directed from one device to another and the user can see where the data is going; there is no need for additional security such as pairing for RF interconnections such as Bluetooth.
   b) While using radio waves we can use encryption and decryption technique where in the user can set password and change it after periodic intervals of time so that only the authenticated user is able to access the internet.

7.2 Disadvantages

1) One of the disadvantages of the system is that as it uses radio waves they cannot transmit a lot of data simultaneously because they have low frequency.
2) In addition, continued exposure to large amounts of radio waves can cause health disorders like leukemia and cancer.
3) Though the cost of sensor and generation of radio waves is not that costly but the overall cost of the system increases.

7.3 Future Scope

1) Furthermore, a system should be developed which is less costly like by using energy saver bulbs.
2) To develop a system that will support Li-Fi in almost all mobile devices

8. Conclusion

Thus radio waves can help Li-Fi technology to overcome its few shortcomings in the following 2 ways:
1) It allows the data to penetrate through walls.
2) There is no requirement of continuous line-of-sight as is required in Li-Fi.

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