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Li-Fi (Light Fidelity)- New Era Of Wireless Communication Using LED Over Internet Of Things

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ABSTRACT

Li-Fi stands for Light-Fidelity. 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 have probably gotten frustrated at the slow speeds you face when more than one device is tapped into the network. Li-Fi technology, proposed by the German physicist—Harald Haas, provides a solution, that is transmission of "data through illumination" by sending data through an LED light bulb that varies in intensity faster than the human eye can follow. It's the same idea band 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 speeder than your average broadband connection. He envisions a future where data is transmitted through the light in a room. And security would be snap – if you can't see the light, you can't access the data. This paper focuses on developing a Li-Fi based system and analyzes its performance with respect to existing technology. It reflects the Future of Communication (LI-FI) which may affect all lives. It's a technology that may be as fast as 500MBPS(30GBPS per minute) an alternative, cost effective and more robust and useful than Wi-Fi. The Visible light communication which may be the future of Internet.

Keywords: Li-Fi, D-Light, Communication, LED.

1. INTRODUCTION

Transfer of data from one place to another is one of the most important day-to-day activities. The current wireless networks that connect us to the internet are very slow when multiple devices are connected. As the number of devices that access the internet increases, the fixed bandwidth available makes it more and more difficult to enjoy high data transfer rates and connect to a secure network. But, radio waves are just a small part of the spectrum available for data transfer. Li-Fi is transmission of data through illumination by taking the fibre out of fibre optics by sending data through an LED light bulb (shown in Fig. 1) 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. Li-Fi uses visible light instead of Gigahertz radio waves for data transfer. **Li-Fi**, as coined by Prof. Harald Haas during his TED Global talk is Bidirectional, high speed and fully networked wireless communications, like *Wi-Fi*, using visible light. Li-Fi is a subset of visible light communications (VLC) and can be a complement to RF communication (Wi-Fi or Cellular Network), or a replacement in contexts of data broadcasting.

Li-Fi comprises a wide range of frequencies and wavelengths, from the infrared through visible and down to the ultraviolet spectrum. It includes sub-gigabit and gigabit-class communication speeds for short, medium and long ranges, and unidirectional and bidirectional data transfer using line-of-sight or diffuse links, reflections and much more. It is not limited to LED or laser technologies or to a particular receiving technique.

Li-Fi is a framework for all of these providing new capabilities to current and future services, applications and end users. This brilliant idea works very simple, if the LED is on, you transmit 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. 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 eye cannot notice, so the output appears constant. More sophisticated techniques could dramatically increase VLC data rate.

Li-Fi can be the technology for the future where data for laptops, smart phones, and tablets will be transmitted through the light in a room. Security would not be an issue because if you can't see the light, you can't access the data. As a result, it can be used in high security military areas where RF communication is prone to eavesdropping.

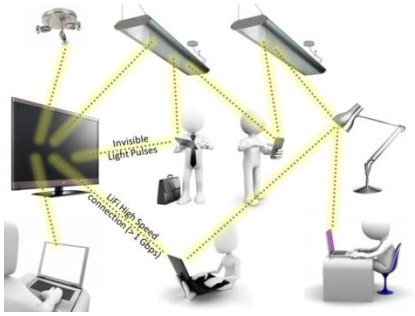


Figure 1: Li-fi technology

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 high brightness white LED which acts as transmission source.

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 sub-assemblies [10]:

1. Bulb
2. RF power amplifier circuit (PA)
3. Printed circuit board (PCB)
4. 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 centre; this controlled plasma generates an intense source of light. All of these subassemblies (shown in Fig. 2) are contained in an aluminium enclosure [10].

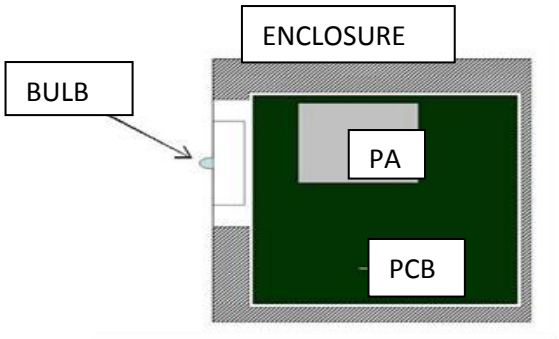


Figure 2: Construction of Li-Fi

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 [10]. Figure 3 shows the bulb sub-assembly. There are various inherent advantages of this approach which includes high brightness, excellent colour quality and high luminous efficacy of the emitter – in the range of 150 lumens 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.

DESIGN OF LI-FI

Li-Fi architecture consist numbers of LED bulbs or lamps, many wireless devices such as PDA, Mobile Phones, and laptops. Important factors we should consider while designing Li-Fi as following:

Presence of Light and Line of Sight (Los)

For better performance use fluorescent light & LED

As shown in figure 4 streaming content must have proper integration with server & internet network, so that it is easily possible to work efficiently.

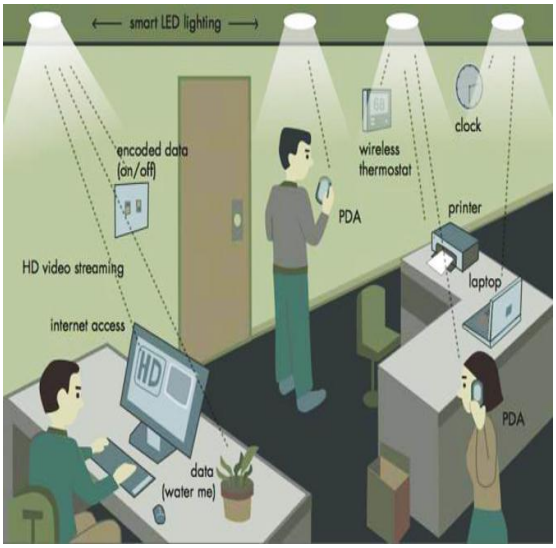


Figure 3: Design of LiFi

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 opportunities for transmitting data through light [12].

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 colours, to obtain data rates in the range of hundreds of megabits per second. The block diagram of Li-Fi system is shown in Fig. 4.

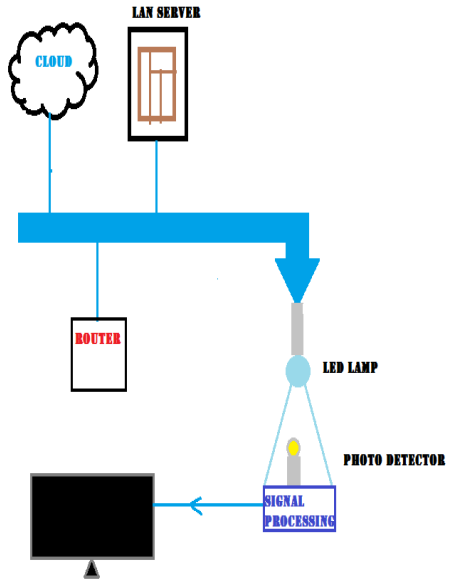


Figure 4: Li-Fi architecture

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 [13].

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. Figure 3 shows a Li-Fi system connecting devices in a room.

Many other sophisticated techniques can be used to dramatically increase VLC data rate. Teams at the University of Oxford and the University of Edinburgh are focusing on parallel data transmission using array 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 frequency encoding a different data channel.

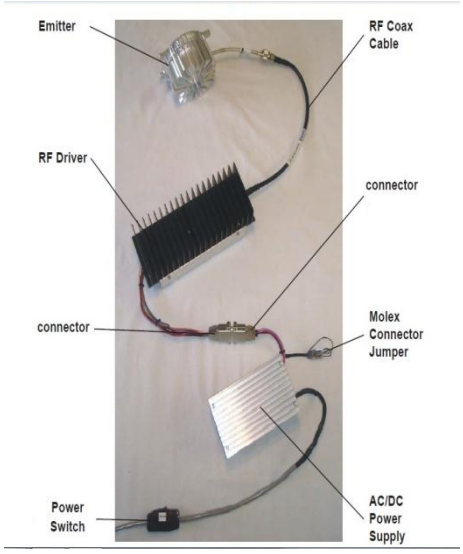


Figure 5: Li-Fi model

Visible light communication (VLC)-"A potential solution to the global wireless spectrum shortage" Li-Fi (Light Fidelity) is a fast and cheap optical version of Wi-Fi, the technology of which 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 this communication system are:

1) A high brightness white LED, Which acts as a communication source and

2) A silicon photodiode which shows good response to visible wavelength region serving as the receiving element. The LED can be switched on and off to generate digital strings of 1s and 0s.

Data can be encoded in the light to generate a new data stream by varying the flickering rate of the LED. To be clearer, by modulating the LED light with the data signal, the LED illumination can be used as a communication source. As the flickering rate is so fast, the LED output appears constant to the human eye. A data rate of greater than 100 Mbps is possible by using high speed LEDs with appropriate multiplexing techniques. VLC data rate can be increased by parallel data transmission using LED arrays where each LED transmits a different data stream. There are reasons to prefer LED as the light source in VLC. While a lot of other illumination devices like fluorescent lamp, incandescent bulb etc. are available.

COMPARISION BETWEEN Li-Fi & Wi-Fi

LI-FI is a term of one used to describe visible light communication technology applied to high speed wireless communication. It acquired this name due to the similarity to WI-FI, only using light instead of radio. WI-FI is great for general wireless coverage within buildings, and Li-Fi is ideal for high density wireless data coverage in confined area and for relieving radio interference issues, so the two technologies can be considered complimentary.

LIFI OVER WIFI

Many experts claim that Li-Fi represents the future of mobile internet due to its reduced costs and greater efficiency compared to traditional Wi-Fi.

Both Wi-Fi and Li-Fi transmit data over the electromagnetic spectrum, but whereas Wi-Fi utilizes radio waves, Li-Fi uses visible light. This is a distinct advantage in that the visible light is far more plentiful than the radio spectrum (10,000 times more in fact) and can achieve far greater data density.

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.

The research was carried out by the Ultra Parallel Visible Light Communications project, a joint venture between the universities of Oxford, Cambridge, Edinburgh, St Andrews and Strathclyde, and funded by the Engineering and Physical Sciences Research Council.

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.

And although Li-Fi bulbs would have to be kept on to transmit data, the bulbs could be dimmed to the point that they were not visible to humans and yet still functional. One draw-back is that the data receiver would have to be in sight of the transmitter-bulb as visible light does not penetrate solid materials.

The makers of Li-Fi note that this quality might actually be an advantage in some scenarios, making Li-Fi more secure than Wi-Fi with hackers unable to access unsecured internet connections from out of sight of the transmitter.

Li-Fi / Wi-Fi comparison

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

Table: LiFi and WiFi comparison

PROBLEMS IN WI-FI

The following are the basic issues with radio waves:

Capacity: Wireless data is transmitted through radio waves which are limited and expensive. It has a limited bandwidth. With the rapidly growing world and development of technologies like 3G, 4G and so on we are running out of spectrum.

Efficiency: There are 1.4 million cellular radio base stations that consume massive amount of energy. Most of the energy is used for cooling down the base station instead of transmission. Therefore efficiency of such base stations is only 5%.

Availability: Availability of radio waves is a big concern. It is not advisable to use mobile phones in aero planes and at places like petrochemical plants and petrol pumps.

Security: Radio waves can penetrate through walls. They can be intercepted. If someone has knowledge and bad intentions, they may misuse it. This causes a major security concern for Wi-Fi.

ADVANTAGES OF LI-FI

Li-Fi technology is based on LEDs or other light source for the transfer of data. The transfer of the data can be with the help of all kinds of light, no matter the part of the spectrum that they belong. That is, the light can belong to the invisible,

ultraviolet or the visible part of the spectrum. Also, the speed of the communication is more than sufficient for downloading movies, games, music and all in very less time.

Also, Li-Fi removes the limitations that have been put on the user by the Wi-Fi.

Capacity: Light has 10000 times wider bandwidth than radio waves [5]. Also, light sources are already installed. So, Li-Fi has got better capacity and also the equipments are already available.

Efficiency: Data transmission using Li-Fi is very cheap. LED lights 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 transmission of data.

Security: Light waves do not penetrate through walls. So, they can't be intercepted and misused.

APPLICATIONS OF LI-FI

There are numerous applications of this technology, from public internet access through street lamps to auto-piloted cars that communicate through their headlights.

Applications of Li-Fi can extend in areas where the Wi-Fi technology lacks its presence like medical technology, power plants and various other areas.

1. SMARTER POWER PLANTS :

Wi-Fi and many other radiation types are bad for sensitive areas. Like those surrounding power plants. But power plants need fast, inter-connected data systems to monitor things like demand, grid integrity and (in nuclear plants) core temperature. The savings from proper monitoring at a single power plant can add up to hundreds of thousands of dollars. Li-Fi could offer safe, abundant connectivity for all areas of these sensitive locations. Not only would this save money related to currently implemented solutions, but the draw on a power plant's own reserves could be lessened if they haven't yet converted to LED lighting.

2. MEDICAL APPLICATIONS:

Operation theatres (OTs) do not allow Wi-Fi due to radiation concerns. Usage of Wi-Fi at hospitals interferes with the mobile and pc which blocks the signals for monitoring equipments. So, it may be hazardous to the patient's health. To overcome this and to make OT tech savvy Li-Fi can be used to accessing internet and to control medical equipments. This can even be beneficial for robotic surgeries and other automated procedures.

3. CHEAPER INTERNET IN AIRCRAFTS:

The passengers travelling in aircrafts get access to low speed internet at a very high rate. Also Wi-Fi is not used because it may interfere with the navigational systems of the pilots. In aircrafts Li-Fi can be used for data transmission. Li-Fi can easily provide high speed internet via every light source such as overhead reading bulb, etc. present inside the airplane.

4. UNDERSEA AWESOMENESS:

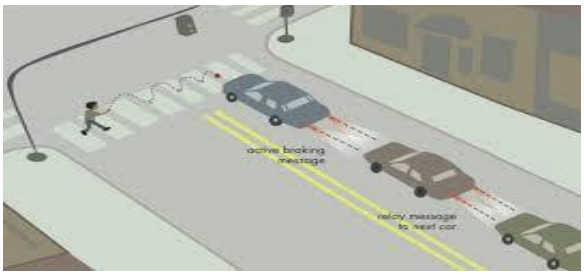
Underwater ROVs (Remotely Operated Vehicles) operate from large cables that supply their power and allow them to receive signals from their pilots above. But the tether used in ROVs is not long enough to allow them to explore larger areas. If their wires were replaced with light — say from a submerged, high-powered lamp — then they would be much freer to explore. They could also use their headlamps to communicate with each other, processing data autonomously and sending their findings periodically back to the surface [1]. Li-Fi can even work underwater where Wi-Fi fails completely, thereby throwing open endless opportunities for military operations.

5. 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.

6. TRAFFIC MANAGEMENT:

In traffic signals Li-Fi can be used which will communicate with the LED lights of the cars which can help in managing the traffic in a better manner and the accident numbers can be decreased [1]. Also, LED car lights can alert drivers when other vehicles are too close.



7. 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.

SCOPE OF LIFI IN FUTURE

This is the technology that could start to touch. Every aspect of human life within a decade”

CONCLUSION

There are surpluses of possibilities to be gouged upon in this field of technology. If this technology becomes justifiably marketed then every bulb can be used equivalent to a Wi-Fi hotspot to transmit data wirelessly. By good worth of this we can ameliorate to a greener, cleaner, safer and a resplendent future. The concept of Li-Fi is attracting a lot of eye-balls because it offers a genuine and very efficient alternative to radio based wireless. It has a bright chance to replace the traditional Wi-Fi because as an ever increasing population is using wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This concept promises to solve issues such as the shortage of radio-frequency bandwidth and boot out the disadvantages of Wi-Fi. Li-Fi is the upcoming and on growing technology acting as competent for various other developing and already invented technologies. Hence the future applications of the Li-Fi can be predicted and extended to different platforms and various walks of human life.

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