Wireless Communication using Li-Fi Technology

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Abstract

The efficiency, durability, and lifetime of light-emitting diodes (LEDs) have led to their use in a variety of applications, including general illumination, vehicle lights, sign age, and displays ,In fact, it is often predicted that LED bulbs will soon replace all traditional incandescent bulbs, as well as compact fluorescent alternatives, in general lighting applications It has long been recognized that LEDs used in such systems can be simultaneously modulated to provide a dual function of communications. Proposed applications for visible light communications (VLC) include indoor local area networks through room lighting in-flight data downlinks through airplane reading lamps intelligent transportation positioning in wireless sensor networks and underwater. We have designed a prototype LIFI system to transfer datas as well as Files. Our idea is to send data and file as serial datas using UART serial communication from one PC to another PC using VLC. So we have used the visible light communication at the transmitting end and also for reception we are using photodiodes at the receiving PC. We have deployed PIC microcontroller for toggling of the LED at the transmitting end and again for binary conversion of received stream of data into a suitable file to be recognized by the PC software. Photo diode transistor is used to recover the data from visible light and inverting amplifier is used to get the data and processed by pic controller connected to PC serial communication port as well as Android Phone using OTG cable.it can be used wherever LED light source is available.

Keywords- LiFi (Light Fidelity), WiFi (Wireless Fidelity), VLC (Visible Light Communication), LED (Light Emitting Diode), IEEE (Institute of Electrical and Electronics Engineers), RF (Radio Frequency), ALA(American Lighting Association)

I. INTRODUCTION

There are around 1.4 million cellular mast radio waves base stations deployed, with over 5 billion mobile phones. Mobile phones transmit over 600TB of data. Presently wireless communication uses radio waves. Spectrum is the one of the most essential requirement for wireless communication. With the advancement in technology and the number of users, the existing radio-wave spectrum fails to cater to this need. To resolve the issues of scalability, availability and security, we have come up with the concept of transmitting data wirelessly through light using LED‘s, which is called as Li-Fi is a latest technology that makes use of LED light which helps in the transmission of data much more faster and flexible than data that can be transmitted through Wi-Fi. LED lights are becoming widely used for homes and offices for their luminous efficacy improvement.

Visible light communication (VLC) is a new way of wireless communication using visible light. Typical transmitters used for visible light communication are visible light LEDs and receivers are photodiodes and image sensors. We present new applications which will be made possible by visible light communication technology. Location-based services are considered to be especially suitable for visible light communication applications. An indoor visible data transmission system utilizing LEDs is proposed. In this system, these devices are used not only for illuminating rooms, but also for an optical wireless communication system.

II. OVERVIEW OF LI-FI

Li-Fi stands for ‘LIGHT FIDELITY’. Li-Fi is transmission of data through illumination by taking the fiber out of fiber optics by sending data through a LED light bulb 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. Light reaches nearly everywhere so communication can also go along with light easily. Light Fidelity is a branch of optical wireless communication which is an emerging technology. By using visible light as transmission medium, Li-Fi provides wireless indoor communication. The bit rate achieved by Li-Fi cannot be achieved by Wi-Fi. Prof. Dr. Herald Haas,

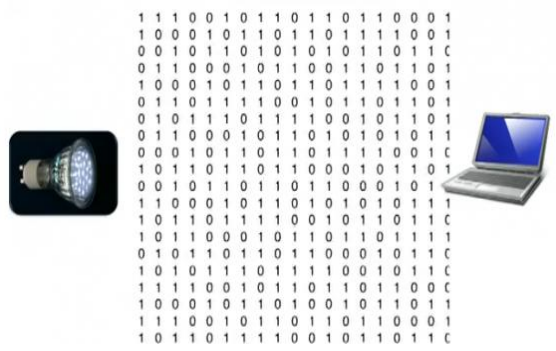

Fig. 1. Li-Fi transmission

the professor of mobile communications at the University of Edinburgh, UK, first time publically displayed the proof of Light Fidelity(Li-Fi), a method of Visible Light communication(VLC). Li-Fi is the transfer of data through light by taking fiber out of fiber optics and sending data through LED light.

Li-Fi technology 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. Wi-Fi is great for general wireless coverage within buildings, whereas Li-Fi is ideal for high density wireless data coverage in confined area and for relieving radio interference issues. Li-Fi provides better bandwidth, efficiency, availability and security than Wi-Fi and has already achieved blisteringly high speed in the lab. By leveraging the low-cost nature of LEDs and lighting units there are many opportunities to exploit this medium, from public internet access through street lamps to auto-piloted cars that communicate through their headlights. Haas envisions a future where data for laptops, smart phones, and tablets will be transmitted through the light in a room.

III. DESIGN OF LI-FI

Li-Fi architecture consists 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
- Line of Sight(Los)
- For better performance use fluorescent light & LED

As shown in figure streaming content must have proper integration with server & internet network, so that it is easily possible to work efficiently. The heart of this technology is a new generation high brightness LED'S which VISIBLE LIGHT COMMUNICATION is. These LED'S varies in intensity (that is gets on and off) so fast that a human eye cannot detect it. If LED is on , then we transmit a digital signal 1,and if the LED is off , then we transmit a digital signal 0.A controller is connected at the back side of these LED bulbs to code data to these LED's.

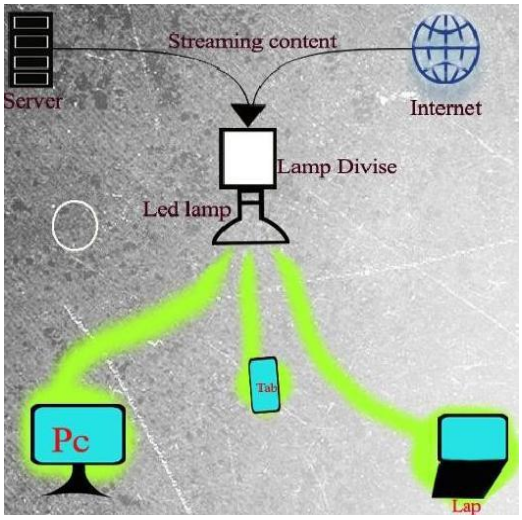

Fig 2. Architecture of Li-Fi

V. IMPLEMENTATION OF LI-FI

Li-Fi is typically implemented using white LED light bulbs at the downlink transmitter. These devices are normally used for illumination only by applying a constant current. However, by fast and subtle variations of the current, the optical output can be made to vary at extremely high speeds. This very property of optical current is used in Li-Fi setup. The operational procedure is very simple-, if the LED is on, you transmit a 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. Hence all that is required is some LEDs and a controller that code data into those LEDs. All one has to do is to vary the rate at which the LED's flicker depending upon the data we want to encode. Further enhancements can be made in this method, like using an array of LEDs for parallel data transmission, or using mixtures of red, green and blue LEDs to alter the light's frequency with each frequency encoding a different data channel. Such advancements promise a theoretical speed of 10Gbps – meaning one can download a full high-definition film in just 30 seconds.

VI. PRINCIPLE OF THE SYSTEM

The heart of this technology is a new generation high brightness LED'S which VISIBLE LIGHT COMMUNICATION. Visible light communication (VLC)-"A potential solution to the global wireless spectrum shortage" .The visible light communication is a data communication technique using visible light

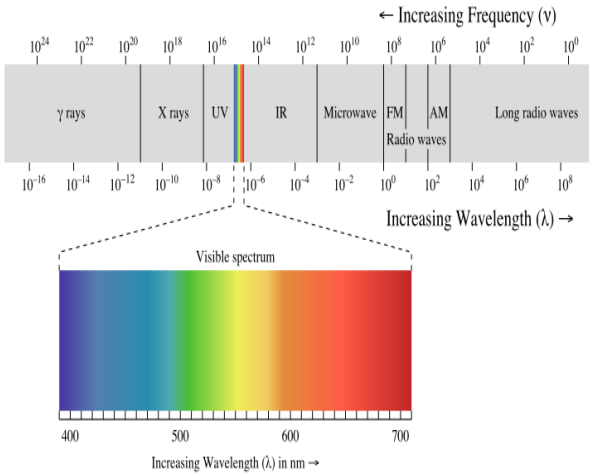

Fig 3. Electromagnetic spectrum

between 400 THz and 800 THz as an optical. As the LED light technology improves, the price of LED light is falling rapidly as shown in Figure 2 [2]. The price of a 60 Watt LED light is expected to break US

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. White LEDs have recently been used as efficient light sources replacing incandescent light bulbs and fluorescent lamps. Figure 1 shows the luminous efficacy improvement curves for LED lamps and luminaries. Currently the luminous efficacy of LED lamps and luminaries is around 100 lm/W (lumens per Watt), and expected to reach 200 lm/W around 2025, which is much higher than incandescent lamps (around 20 lm/W) and fluorescent lights (around 100 lm/W). LED lamps do not only have high luminous efficacy, but also long sustainability. LED lamps typically have a lifetime of 40,000 hours, which is 40 times longer than incandescent lamps. $10 in 2014 and US $5 in 2020. Governments in many countries are starting to ban inefficient lighting technologies such as incandescent lamps as shown in Figure. Countries such as USA, EU, Japan, China, Russia, and Brazil started to ban 100 Watt incandescent lamps by the end of 2012, and most will ban all incandescent lamps by 2016. Using increasingly popular LED lights, the visible light communication using LEDs is expected as a means for ubiquitous communication. Visible light communication (VLC) has following advantages over other competing radio communication technologies such as WiFi and cellular phone wireless communication Visible light spectrum is available for communication because the frequency above 3THz is

Visible light does not penetrate thick materials such as walls and partitions, which can be a security advantage. Visible light usually poses no health hazards to human body and eyes. Visible light also has following advantages over infrared communication technologies: Visible light can be literally visible so that human notices where the data is transmitted from. In addition, since LED lighting has recently become part of a building infrastructure, making visible light communication infrastructure is fairly easy by adding communication function to LED lighting.

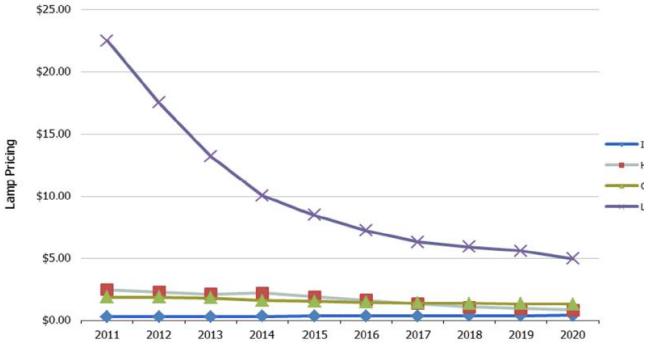

Fig 4. LED Price Trend

VII. WORKING OF LI-FI

- On one end all the data on the internet will be streamed to a lamp driver when the led is turned on the microchip converts the digital data in form of light .
- A light sensitive device (photo detector) receives the signal and converts it back into original data. This method of using rapid pulses of light to transmit information wirelessly is technically referred as Visible Light Communication .

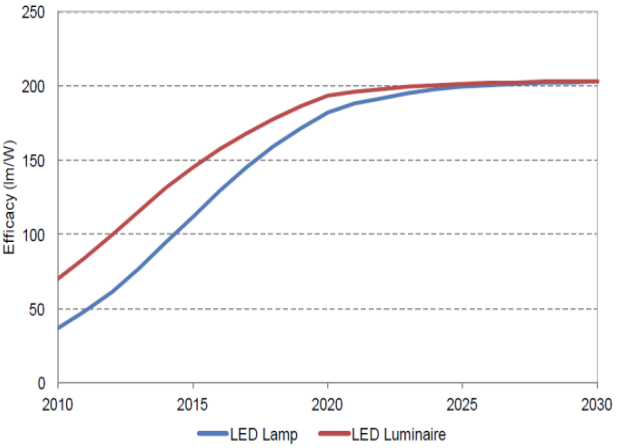

Fig 5 LED Luminous Efficiency

not currently regulated by the Radio Regulation Law. What if, all lights in your rooms will communicate each other and creates a bridge of wireless networks to provide internet access? , Li-Fi Technology would be the best optimum solution over Wi-Fi technology. it can also be used to extend wireless networks at your home, office or university for data transfer at 10 Gbps, “on the move" data transfer rate at 100 Mbps, home wireless data network with local cloud & server.

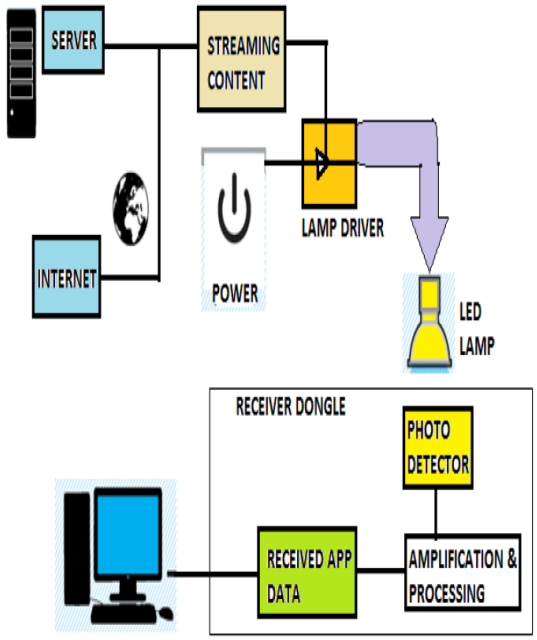

Fig 6. Working of Li-Fi

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

a) Bulb
b) RF power amplifier circuit (PA)
area with high intensity.
c) Printed circuit board (PCB)
d) Enclosure.

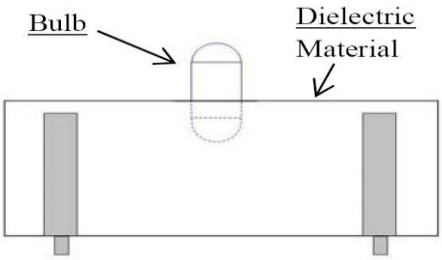

Fig 7.Bulb Assembly

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

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? LED can be switchedon 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.

VIII. INTERNAL STRUCTURE DESIGN

The ISD dimension is measured with different parameters such as the diameter and position of the LED lamp. The ISD depends on the number, size and structure of the LEDs placed in the lamp. The lamps may be in flat, circular (round tip) and movable shape. The LEDs are of different types; round tip and chip LEDs. Both types are used in the lamp for different purposes in Li-Fi technology. The round tip and circular shape LEDs are used to focus light on a fixed spot, it means that the data is transmitted through light towards a fixed point.

A. Datarate Versus size of the LED

The variations in data rate (R) with the size of LEDs are very critical in the Li-Fi technology. Different data rates can be achieved with different sizes of LEDs. The size of normal LED bulb can be reduced to micro-LED which handles millions of alterations in light intensity. A micro LED light bulb to transmit 3.5 Gbps and the data rate of more than 10 Gbps is possible. The tiny micro LED bulbs allow the stream of light to be beamed in parallel and transmitting huge amount of data in terms of Gbps. The microchip LED bulb can generate data rates up to 150 Mbps with single bulb which provide fast internet connectivity and services. Here it can be concluded that data rate (R) is inversely proportional to the size of LED ( ). The LEDs are of different sizes e.g. 5mm, 3mm, 1.8mm, 1mm, 1 m and 1nm LED. The maximum data rate can be achieved with 1 m and 1nm LED which is considered to be a pixel in size.

R is inversely proportional to size of LED

B. Datarate versus number of LEDs

The data rate can be increased with the increasing number of LEDs. The number of LEDs ( ) can be according to the available space inside the lamp. The number of LEDs can be adjusted so that it can achieve the maximum bit rate (bps).

R is directly proportional to number of LED

7.3 Datarate versus on-off switching of LEDs

The ON-OFF switching of LED light bulb can create binary data of 1s and 0s e.g. 1 for ON and 0 for OFF as shown in Fig. 8. The micro-LED handles millions of alterations in light intensity per second and faster the ON-OFF switching, transmitting large amount of data at high speed. The ON-OFFswitching of LED bulb is at a very high speed so that the human eye cannot detect the alterations. Micro-LED is capable to transmit data 1000 times faster than normal LED with faster ON-OFF switching, transmitting large amount of data at high speed.

R is directly proportional to ON OFF SWITCHING of LED

IV. 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. Using a pair of Casio smart 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. 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 . Researchers at the University of Strathclyde in Scotland have begun the task of bringing high-speed, ubiquitous, Li-Fi technology to market .

IX. 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.It shows a comparison of transfer speed of various wireless technologies and comparison of various technologies that are used for connecting to the end user. Wi- Fi currently offers high data rates.

The IEEE 802.11.n in most implementations provides up to 150Mbit/s although practically, very less speed is received. Buying light bulbs used to be much simpler: light fixtures were listed with a maximum wattage and buyers would simply purchase a corresponding bulb. Not anymore. Newer LED, CFL, and other energy efficient lighting have completely changed the values of wattage or eschew the ratings system entirely. Here's a handy guide to shine some light on how to choose the correct light bulb in this new age.

Traditionally household incandescent light bulbs were rated between 40 to 100 watts. In comparison, newer LED or CFL light bulb come equipped for as little as 5 to 15 watts. The American Lighting Association (ALA) explains quite simply why there's a discrepancy in how light bulbs are labeled for wattage 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.

INCANDESCENT (WATTS)	LUMENS	LED OR CFL (WATTS)
25	250	4 - 9
40	450	9 - 13
60	800	13 - 15
75	1110	18 - 25
100	1600	23 - 30
125	2000	22 - 40
150	2600	40 - 45

Fig 8.Comparison of Source

A. 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.

B. 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.

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.

With the advent of Li-Fi, now it is not mandatory to be in a region that is Wi-Fi enabled to have access to the internet. One can simply stand under any form of light and surf the internet as the connection is made if light is present. Figure 6 gives a description of Li-Fi along with its advantages.

C. Disadvantages of LiFi

One of the major demerits of this technology is that the artificial light cannot penetrate into walls and other opaque materials which radio waves can do. So a Li-Fi enabled end device (through its inbuilt photo-receiver) will never be as fast and handy as a Wi-Fi enabled device in the open air. Also, another shortcoming is that it only works in direct line of sight Still, Li-Fi could emerge as a boon to the rapidly depleting bandwidth of radio waves. And it will certainly be the first choice for accessing internet in a confined room at cheaper cost.

X. APPLICATIONS OF LI-FI

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

Applications of Li-Fi can extend in areas where the Wi-Fitechnology lacks its presence like medical technology, power plants and various other areas. Since Li-Fi uses just the light, it can be used safely in aircrafts and hospitals where Wi-Fi is banned because they are prone to interfere with the radio waves.

All the street lamps can be transferred to Li-Fi lamps to transfer data. As a result of it, it will be possible to access

radiation types are bad for sensitive areas surrounding the power plants. Li-Fi could offer safe, abundant connectivity for all areas of these sensitive locations. This can save money as compared to the currently implemented solutions. Also, the pressure on a power plant's own reserves could be lessened.Li-Fi can also be used in petroleum or chemical plants where other transmission or frequencies could be hazardous.

Replacement for other technologies: Li-Fi doesn't work using radio waves. So, it can be easily used in the places

internet at any public place and street.

Some of the future applications of Li-Fi are as follows:

Education systems: Li-Fi is the latest technology that can provide fastest speed internet access. So, it can replace Wi-Fi at educational institutions and at companies so that all the people can make use of Li-Fiwith the same speed intended in a particular area.

Medical Applications: Operation theatres (OTs) do not allow Wi-Fi due to radiation concerns. Usage ofWi-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.

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.

Underwater applications: 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.

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.

Applications in sensitive areas: Power plants need fast, inter-connected data systems so that demand, grid integrity and core temperature (in case of nuclear power plants) can be monitored. Wi-Fi and many other where Bluetooth, infrared, Wi-Fi, etc. are banned.

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.

XI. CONCLUSION

The world of lighting companies experiences a true revolution with the development of LED lighting devices with reduced energy consumption and a longer lifetime .

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. With so many feathers in its cap, Li-Fi has one natural shortcoming. Since light cannot penetrate opaque obstacles, this can prove to be an obvious limitation to the technology's usage. Nevertheless, given the terrific data rates and use in multiple fields Li-Fi is definitely the road ahead in wireless communication. The possibilities are numerous and can be explored further, this technology is in manufacturing process to produce every bulb to become a Wi-Fi hotspot to transmit wireless data and we will proceed towards the cleaner ,greener ,safer and brighter future without radio wave ,because radio waves create a harmful effect for living thing ,but Li-Fi is the optical wireless communication for data ,audio and video streaming in LEDs, this type of new invention can be encouraged to produce a safe and green technology. The accuracy of the proposed model has been illustrated by the simulation results generated from the proposed model and the real field measurements.

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