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1.Abstract :

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've probably gotten frustrated at the slow speeds you face when more than one device is tapped into the network. As more and more people and their many devices access wireless internet, clogged airwaves are going to make it increasingly difficult to latch onto a reliable signal. But radio waves are just one part of the spectrum that can carry our data. What if we could use other waves to surf the internet? One German physicist,DR. Harald Haas, has come up with a solution he calls "Data Through Illumination"—taking the fiber out of fiber optics by sending data through an LED light bulb that varies in intensity faster than the human eye can follow. It's the same idea 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 speedier than your average broadband connection. He envisions a future where data for laptops, smartphones, and tablets is transmitted through the light in a room. And security would be a snap—if you can't see the light, you can't access the data.

Li-Fi is a VLC, visible light communication, technology developed by a team of scientists including Dr Gordon Povey, Prof. Harald Haas and Dr Mostafa Afgani at the University of Edinburgh. The term Li-Fi was coined by Prof. Haas when he amazed people by streaming high-definition video from a standard LED lamp, at TED Global in July 2011. Li-Fi is now part of the Visible Light Communications (VLC) PAN IEEE 802.15.7 standard. "Li-Fi is typically implemented using white LED light bulbs. These devices are normally used for illumination by applying a constant current through the LED. However, by fast and subtle variations of the current, the optical output can be made to vary at extremely high speeds. Unseen by the human eye, this variation is used to carry high-speed data," says Dr Povey, , Product Manager of the University of Edinburgh's Li-Fi Program 'D-Light Project'.

2.Introduction To Li-Fi Technology :

LiFi 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. The term was first used in this context by Harald Haas in his TED Global talk on Visible Light Communication. “At the heart of this technology is a new generation of high brightness light-emitting diodes”, says Harald Haas from the University of Edinburgh, UK,”Very simply, if the LED is on, you transmit a digital 1, if it’s off you transmit a 0,”Haas says, “They can be switched on and off very quickly, which gives nice opportunities for transmitted data.”

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 in fact very much part of our lives for millions and millions of years and does not have any major ill effect. Moreover there is 10,000 times more space available in this spectrum and just counting on the bulbs in use, it also multiplies to 10,000 times more availability as an infrastructure, globally.

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 eyes cannot notice, so the output appears constant.

More sophisticated techniques could dramatically increase VLC data rates. Teams at the University of Oxford and the University of Edinburgh are focusing on parallel data transmission using arrays 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's frequency, with each frequency encoding a different data channel.

Li-Fi, as it has been dubbed, has already achieved blisteringly high speeds in the lab. Researchers at the Heinrich Hertz Institute in Berlin, Germany, have reached data rates of over 500 megabytes per second using a standard white-light LED. The technology was demonstrated at the 2012 Consumer Electronics Show in Las Vegas using a pair of Casio smart phones to exchange data using light of varying intensity given off from their screens, detectable at a distance of up to ten metres.

Haas has set up a spin-off firm to sell a consumer VLC transmitter that is due for launch next year. It is capable of transmitting data at 100 MB/s - faster than most UK broadband connections.

In October 2011 a number of 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. The consortium believes it is possible to achieve more than 10 Gbps, theoretically allowing a high-definition film to be downloaded in 30 seconds

3.Genesis of Li-Fi:

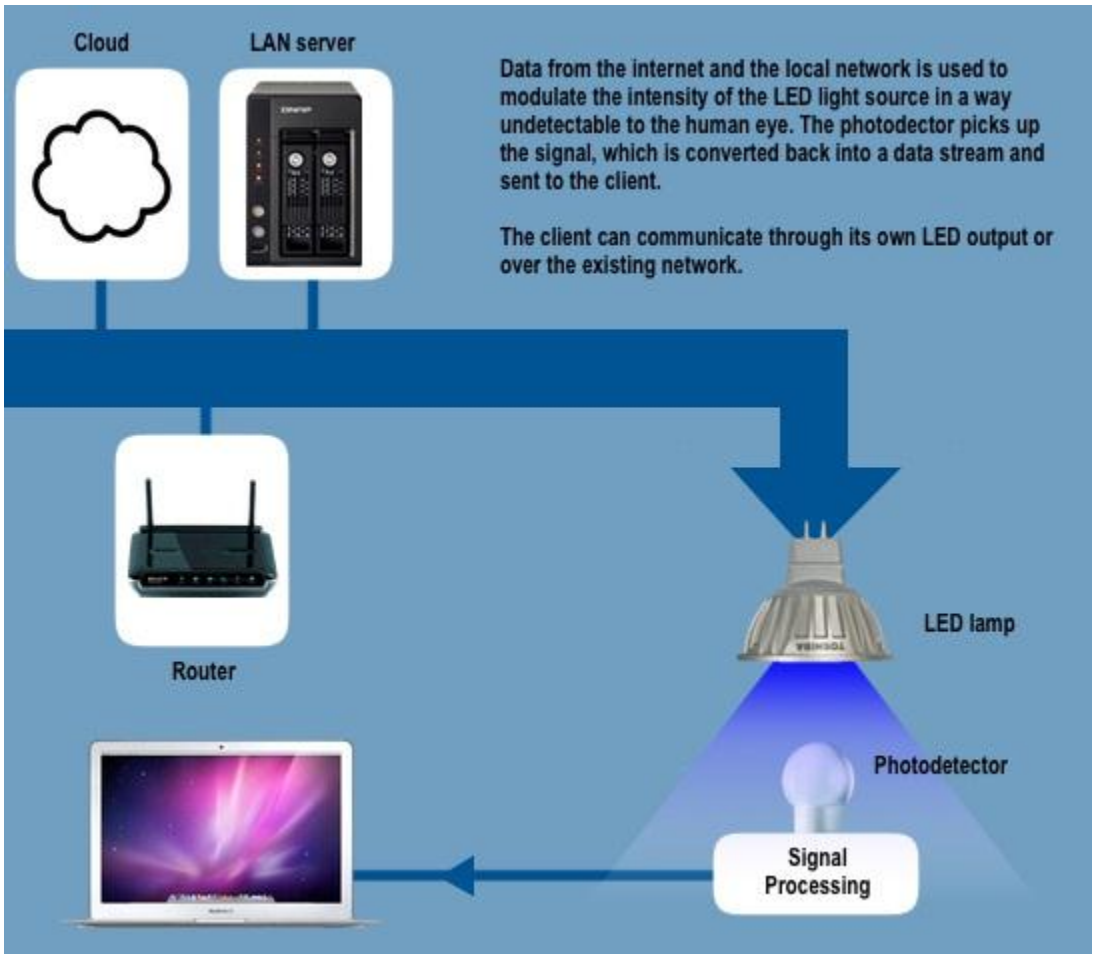
Harald Haas, a professor at the University of Edinburgh who began his research in the field in 2004, gave a debut demonstration of what he called a Li-Fi prototype at the TEDGlobal conference in Edinburgh on 12th July 2011. He used a table lamp with an LED bulb to transmit a video of blooming flowers that was then projected onto a screen behind him. During the event he periodically blocked the light from lamp to prove that the lamp was indeed the source of incoming data. At TEDGlobal, Haas demonstrated a data rate of transmission of around 10Mbps -- comparable to a fairly good UK broadband connection. Two months later he achieved 123Mbps.

Back in 2011 German scientists succeeded in creating an800Mbps (Megabits per second) capable wireless network by using nothing more than normal red, blue, green and white LED light bulbs (here), thus the idea has been around for awhile and various other global teams are also exploring the possibilities.

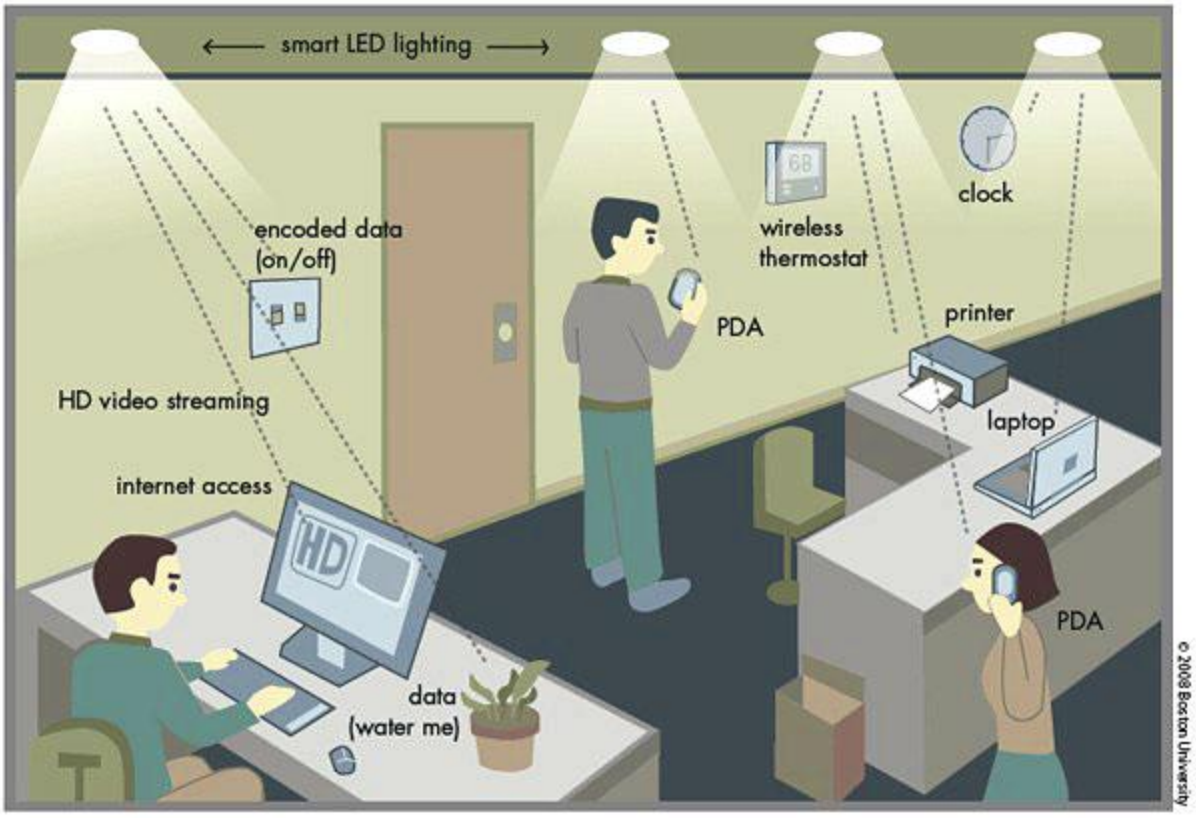
4.How Li-Fi Works?

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 10 Gbps – meaning one can download a full high-definition film in just 30 seconds.



To further get a grasp of Li-Fi consider an IR remote.(fig 3.3). It sends a single data stream of bits at the rate of 10,000-20,000 bps. Now replace the IR LED with a Light Box containing a large LED array. This system, fig 3.4, is capable of sending thousands of such streams at very fast rate.

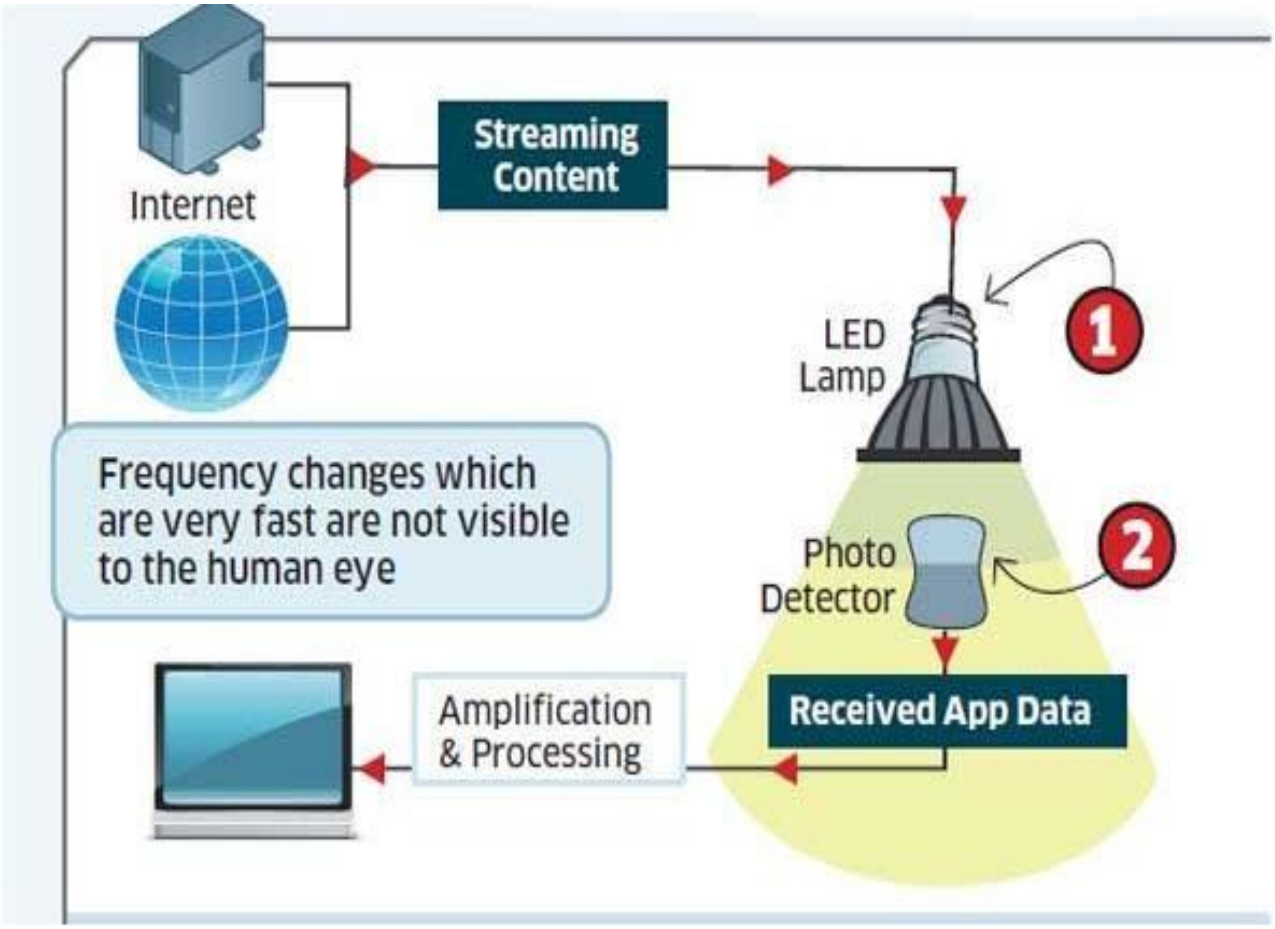


Light is inherently safe and can be used in places where radio frequency communication is often deemed problematic, such as in aircraft cabins or hospitals. So visible light communication not only has the potential to solve the problem of lack of spectrum space, but can also enable novel application. The visible light spectrum is unused, it's not regulated, and can be used for communication at very high speed.

4.1Visible light communication (VLC)-"A potential solution to the global wireless spectrum shortage"

LiFi (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 thiscommunication 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 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.



4.2 Technology Brief

How LI-FI Light Sources Work:

- **Introduction:**

LI-FI is a new class of high intensity light source of solid state design bringing clean lighting solutions to general and specialty lighting. With energy efficiency, long useful lifetime, full spectrum and dimming, LI-FI lighting applications work better compared to conventional approaches. This technology brief describes the general construction of LI-FI lighting systems and the basic technology building blocks behind their function.

- **Li-Fi Construction:**

The LIFI™ product consists of 4 primary sub-assemblies:

• Bulb
• RF power amplifier circuit (PA)
• Printed circuit board (PCB)
• Enclosure

- 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.

- **Function Of The Bulb:**

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.

- **Summary:**

The design and construction of the LIFI™ light source enable efficiency, long stable life, full spectrum intensity that is digitally controlled and easy to use.

5.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.

COMPARISON BETWEEN LI-FI VS. WI-FI

S. No.	Parameters	Wireless Technologies	
		Light Fidelity	Wireless Fidelity
1.	Speed for data transfer	Faster transfer speed (>1 Gbps)	Data Transfer speed (150 Mbps)
2.	Medium through which data transfers occurs	Used Light as a carrier	Used Radio spectrum
3.	Spectrum Range	Visible light spectrum has 10,000 time broad spectrum in comparison to radio frequency	Radio frequency spectrum range is less than visible light spectrum.
4.	Cost	Cheaper than Wi-Fi because free band doesn't need license and it uses light.	Expensive in comparison to Li-Fi because its uses radio spectrum.
5.	Network topology	Point to point	Point to point
6.	Operating frequency	Hundreds of Tera Hz	2.4 GHz

The below table also contains the current wireless technologies that can be used for transferring data between devices today, i.e. Wi-Fi, Bluetooth and IrDA. Only Wi-Fi currently offers very

high data rates. The IEEE 802.11.n in most implementations provides up to 150Mbit/s (in theory the standard can go to 600Mbit/s) although in practice you receive considerably less than this. Note that one out of three of these is an optical technology.

Technology	Speed	Data Density
Wi-Fi – IEEE 802.11n	**150 Mbps**	*
Bluetooth	**3 Mbps**	*
IrDA	**4 Mbps**	***
Wireless (future)		
WiGig	**2 Gbps**	**
Giga-IR	**1 Gbps**	***
Li-Fi	**>1Gbps**	****

Table 1.Comparison between current and future wireless technology

5.1 How it is different?

Li-Fi technology is based on LEDs 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 internet is incredibly high and you can download movies, games, music etc in just a few minutes with the help of this technology. Also, the technology removes limitations that have been put on the user by the Wi-Fi. You no more need to be in a region that is Wi-Fi enabled to have access to the internet. You can simply stand under any form of light and surf the internet as the connection is made in case of any light presence. There cannot be anything better than this technology.

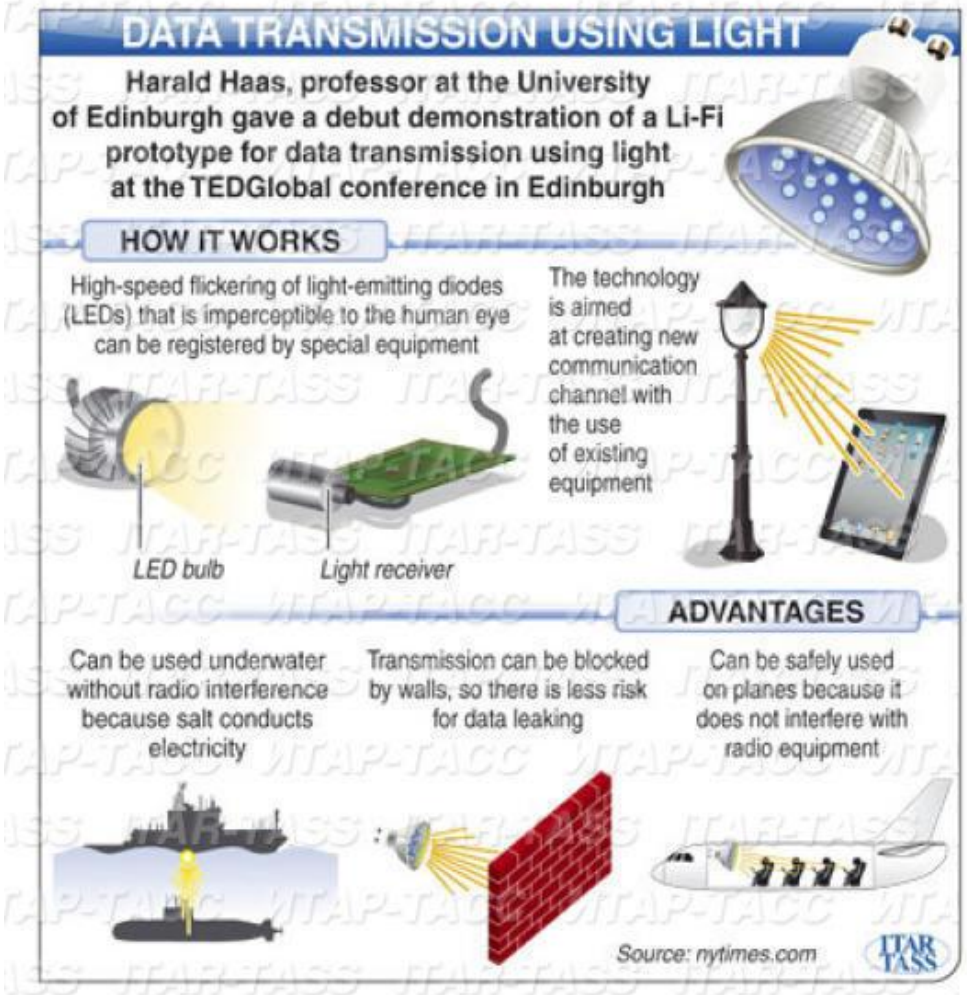


Fig :- representing the data transfer using light and advantages

6.Application Areas Of Li-Fi Technology

6.1Airways:

Whenever we travel through airways we face the problem in communication media ,because the whole airways communication are performed on the basis of radio waves.To overcomes this drawback on radioways ,**li-fi** is introduce.

6.2 You Might Just Live Longer :

For a long time, medical technology has lagged behind the rest of the wireless world. Operating rooms do not allow Wi-Fi over radiation concerns, and there is also that whole lack of dedicated spectrum. While Wi-Fi is in place in many hospitals, interference from cell phones and computers can block signals from monitoring equipment. Li-Fi solves both problems: lights are not only allowed in operating rooms, but tend to be the most glaring (pun intended) fixtures in the room. And, as Haas mentions in his TED Talk**,** Li-Fi has 10,000 times the spectrum of Wi-Fi, so maybe we can, I dunno, delegate red light to priority medical data. Code Red!

6.3Green information technology:

Green information technology means that unlike radiowaves and other communication waves affects on the birds , human bodys etc. Li-Fi never gives such side effects on any living thing.

6.4 Free From Frequency Bandwidth Problem:

Li-fi is an communication media in the form of light ,so no matter about the frequency bandwidth problem . It does not require the any bandwidth spectrum i.e. we don't need to pay any amount for communication and licence.

6.5 Increase Communication Safety:

Due to visual light communication , the node or any terminal attach to our network is visible to the host of network .

6.6 Multi User Communication:

Li-Fi supports the broadcasting of network , it helps to share multiple thing at a single instance called broadcasting.

6.7 Lightings Points Used as Hotspot:

Any lightings device is performed as a hotspot it means that the light device like car lights, ceiling lights , street lamps etc area able to spread internet connectivity using visual light communication. Which helps us to low cost architecture for hotspot. Hotspot is an limited region in which some amount of device can access the internet connectivity .

Fig :Shows every street lamps acting as a Li-Fi Hotspot.

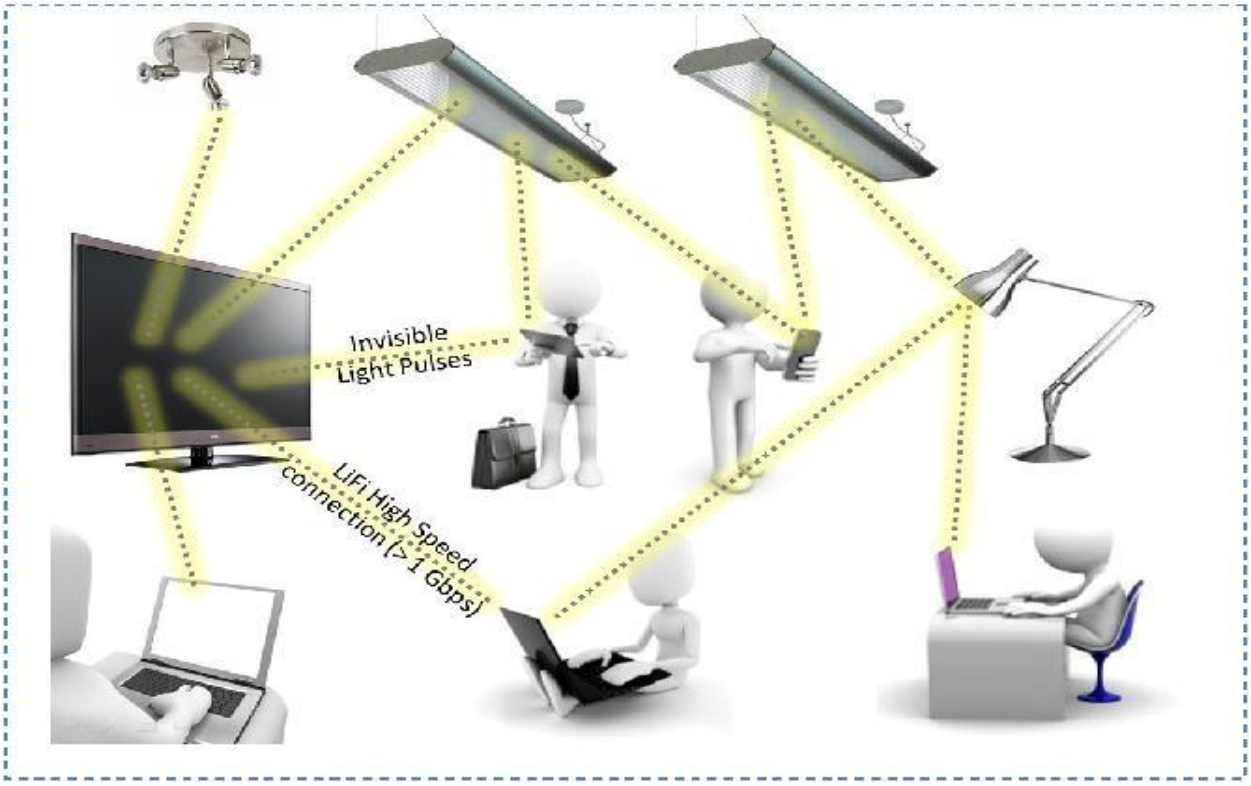


Fig :Shows every light emmiting device acting as a Li-Fi Hotspot

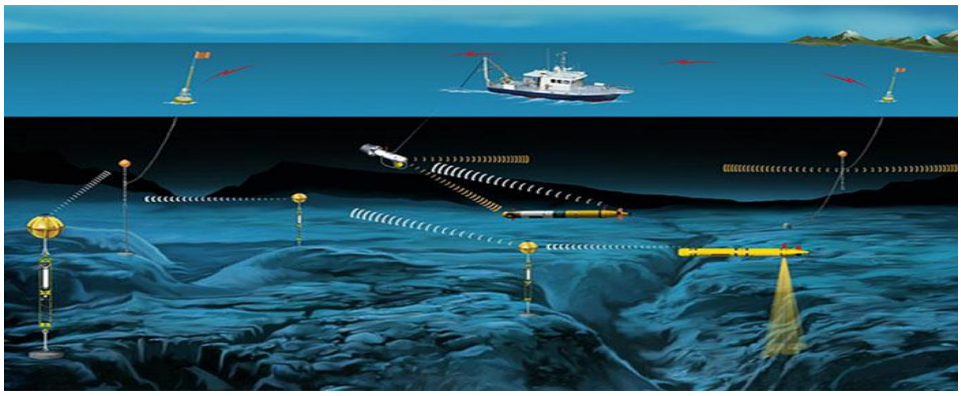
6.8 Smarter Power Plants:

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.

6.9 Undersea Awesomeness:

Underwater ROVs, those favourite toys of treasure seekersand James Cameron, operate from large cables that supplytheir power and allow them to receive signals from their pilotsabove. ROVs work great, except when the tether isn't longenough to explore an area, or when it gets stuck on something.If their wires were cut and replaced with light — say from asubmerged, high-powered lamp — then they would be muchfreer to explore. They could also use their headlamps tocommunicate with each other, processing data autonomouslyand referring findings periodically back to the surface, all the while obtaining their next batch of orders.



6.10. It Could Keep You Informed and Save Lives :

Say there's an earthquake in New York. Or a hurricane. Take your pick — it's a wacky city. The average New Yorker may not know what the protocols are for those kinds of disasters. Until they pass under a street light, that is. Remember, with Li-Fi, if there's light, you're online. Subway stations and tunnels, common dead zones for most emergency communications, pose no obstruction. Plus, in times less stressing cities could opt to provide cheap high-speed Web access to every street corner.

7. Uses in various areas:

Can be used in plases where it is difficult to lay optical fiber like hospitals.In operation theatre Li-Fi can be used for modern medical instruments.In traffic signals Li-Fi can be used which will communicate with the cars and other vehicles and accidents can be decreased.Thousands and millions of street lamps can be transferred to Li-Fi lamps to transfer data.In aircrafts Li-Fi can be used for data transmission. It can be used in petroleum or chemical plants where other frequencies can be harmful.

8. Challenges For Li-Fi :

Apart from many advantages over Wi-Fi, Li-Fi technology is facing some challenges. Li-Fi requires line of sight.When set up outdoors, the apparatus would need to deal with ever changing conditions. Indoors, one would not be able to shift the receiving device. A

major challenge facing Li-Fi is how the receiving device will transmit back totransmitter. One more disadvantage is that visible light can't penetrate through brick walls as radio waves and is easily blocked by somebody simply walking in front of LED source . A side effect of Li-Fi is that your power cord immediately becomes your data stream, so if you have power, you have internet .

9. Conclusion :

The possibilities are numerous and can be explored further. If his technology can be put into practical use, every bulb can be used something like a Wi-Fi hotspot to transmit wireless data and we will proceed toward the cleaner, greener, safer and brighter future. The concept of Li-Fi is currently attracting a great deal of interest, not least because it may offer a genuine and very efficient alternative to radio-based wireless. As a growing number of people and their many devices access wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This may solve issues such as the shortage of radio-frequency bandwidth and also allow internet where traditional radio based wireless isn't allowed such as aircraft or hospitals. One of the short coming show ever is that it only work in direct line of sight.

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