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Li-Fi (Light-Fidelity) Technology: The Future of 5G Wireless Communication

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ABSTRACT

Light Fidelity (Li-Fi) is a technology which is used for fast data communication through fast blinking of light which can't be observer by human eye. This technology is a better substitute among all the existing wireless communication. Li-Fi is a subset of Optical Wireless Communication (OWC) and RF communication which produces the data at the rate of more than 10 MHz/Sec. Li-Fi technology is the 5th generation of wireless communication technology.

Keywords : Li-Fi, OWC, VLC

I. INTRODUCTION

Light Fidelity (Li-Fi) technology is a wireless communication system based on the use of visible light between the violet (800 THz) and red (400 THz). Unlike Wi-Fi which uses the radio part of the electromagnetic spectrum, Li-Fi uses the optical spectrum i.e. Visible light part of the electromagnetic spectrum. The principle of Li-Fi is based on sending data by amplitude modulation of the light source in a well-defined and standardized way. LEDs can be switched on and off faster than the human eyes can detect since the operating speed of LEDs is less than 1 microsecond. This invisible on-off activity enables data transmission using binary codes. If the LED is on, a digital '1' is transmitted and if the LED is off, a digital '0' is transmitted. Also these LEDs can be switched on and off very quickly which gives us a very nice opportunity for transmitting data through LED lights, because there are no interfering light frequencies like that of the radio frequencies in Wi- Fi. Li-Fi is thought to be 80% more efficient, which means it can reach speeds of up to 1Gbps and even beyond. Li-Fi differs from fiber optic because the Li- Fi protocol layers are suitable for wireless communication over short distances (up to 10 meters).

This puts Li-Fi in a unique position of extremely fast wireless communication over short distances.

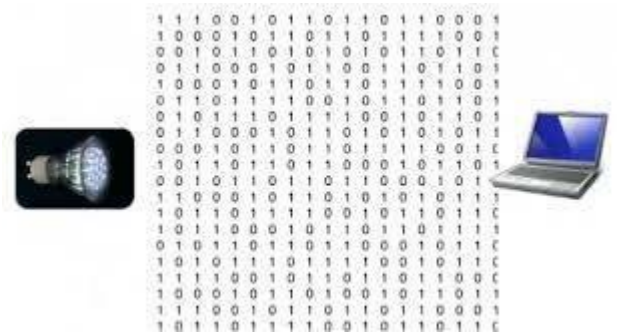

Fig 1.

II. Working of Li-Fi

The working of Li-Fi is very simple. There is a light emitter on one end i.e. an LED transmitter, and a photo detector (light sensor) on the other. The data input to the LED transmitter is encoded in to the light (technically referred to as Visible Light Communication) by varying the flickering rate at which the LEDs flicker 'on' and 'off' to generate

different strings of 1s and 0s. The on-off activity of the LED transmitter which seems to be invisible (The LED intensity is modulated so rapidly that human eye cannot notice, so the light of the LED appears constant to humans), enables data transmission in light form in accordance with the incoming binary codes: switching ON a 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.

In a typical setup, the transmitter (LED) is connected to the data network (Internet through the modem) and the receiver (photo detector/light sensor) on the receiving end receives the data as light signal and decodes the information, which is then displayed on the device connected to the receiver. The receiver (photo detector) registers a binary '1' when the transmitter (LED) is ON and a binary '0' when the transmitter (LED) is OFF. Thus flashing the LED numerous times or using an array of LEDs (perhaps of a few different colors) will eventually provide data rates in the range of hundreds of Mbps. The Li-Fi working is explained in a block diagram.

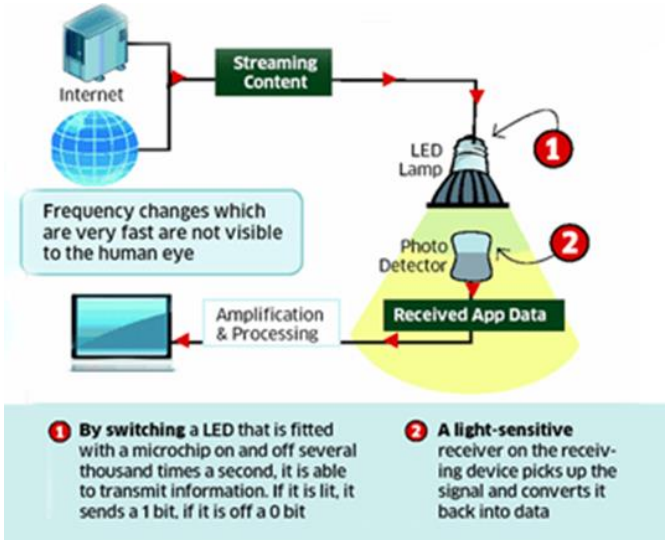

Fig.2: Block diagram of Li-Fi Sub System

Hence all that is required, is some or an array of LEDs and a controller that controls/encodes data into those LEDs. All one has to do is to vary the rate at which the LEDs flicker depending upon the data input to LEDs. Further data rate enhancements can be made in this method, by using array of the 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. Figure 3 shows working/deployment of a Li- Fi system connecting the devices in a room.

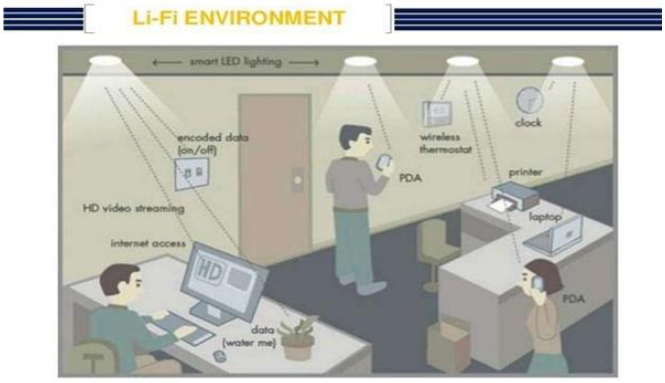

Fig 3: Li-Fi system connecting devices in a room

III. Why Visible Light Communication

The frequency spectrum that is available to us in the atmosphere consists of many wave regions like X- rays, gamma rays, u-v region, infrared region, visible light rays, radio waves, etc. Any one of the above waves can be used in the upcoming communication technologies but why the Visible Light part is chosen? The reason behind this is the easy availability and lesser harmful effects that occur due to these rays of light. VLC uses the visible light between 400 THz (780 nm) and 800 THz (375 nm) as medium which are less dangerous for high-power applications and also humans can easily perceive it and protect themselves from the harmful effects whereas the other wave regions have following disadvantages:

- ✓ Radio waves are expensive (due to spectrum charges) and less secure (due to interference and possible interception etc.).
- ✓ Gamma rays are harmful because it could be dangerous dealing with it, by the human beings

due to their proven adverse effects on human health.

- ✓ X-rays have health issues, similar to the Gamma Rays.
- ✓ Ultraviolet light can be considered for communication technology purposes at place without people, otherwise they can also be dangerous for the human body when exposed continuously.
- ✓ Infrared, due to high safety regulation, can only be used with low power.

Hence the Visible light portion (from red to blue) of the electromagnetic spectrum does not cause any harm to the people as visible rays are safe to use, provide larger bandwidth and also have a promising future in the communication field.

IV.Comparison between Li-Fi and, Wi-Fi and other Radio Communication technologies

Both Wi-Fi and Li-Fi can provide wireless Internet access to users, and both the technologies transmit data over electromagnetic spectrum. Li-Fi is a visible light communication technology useful to obtain high speed wireless communication. The difference is:

Wi-Fi technology uses radio waves for transmission, whereas Li-Fi utilizes light waves. Wi-Fi works well for general wireless coverage within building/campus/compound, and Li-Fi is ideal for high density wireless data coverage inside a confined area or room and is free from interference issues unlike the Wi-Fi. Table I shows a comparison of transfer speed of various wireless technologies. Table II shows a comparison of Li-Fi with Wi-Fi.

Table 1 : Comparison of speed of various wireless technologies

Technology	Speed
Li-Fi	~1 Gbps
Wi-Fi – IEEE 802.11n	~150 Mbps
IrDA	~4 Mbps
Bluetooth	~3 Mbps
NFC	~424 Kbps

Table 2: Comparison of Wi-Fi and Li-Fi

Parameter	Li-Fi	Wi-Fi
Spectrum Used	Visible Light	RF
Standard	IEEE 802.15.7	IEEE 802.11
Range	Based on Light Intensity (<10m)	Based on Radio propagation & interference (<300 m)
Data Transfer Rate	Very high (~1Gbps)	Low (100Mbps-1Gbps)
Power consumption	Low	High
Cost	Low	High
Bandwidth	Unlimited	Limited

V. Advantages of Li-Fi

Li-Fi, which uses visible light to transmit signals wirelessly, is an emerging technology poised to compete with Wi-Fi. Also, Li-Fi removes the limitations that have been put on the user by the Radio wave transmission such as Wi-Fi as explained above vide 4.1. Advantages of Li-Fi technology include:

i. Efficiency: Energy consumption can be minimized with the use of LED illumination which is already available in the home, offices and Mall etc. for lighting purpose. Hence the transmission of data requiring negligible additional power, which makes it very efficient in terms of costs as well as energy.
ii. High speed: Combination of low interference, high bandwidths and high- intensity output, help Li-Fi provide high data rates i.e. 1 Gbps or even beyond.
iii. Availability: Availability is not issues as light sources are present everywhere. Wherever there is a light source, there can be Internet. Light bulbs are present everywhere – in homes, offices, shops, malls

and even planes, which can be used as a medium for the data transmission.

iv. Cheaper: Li-Fi not only requires fewer components for its working, but also uses only a negligible additional power for the data transmission.

v. Security: One main advantage of Li-Fi is security. Since light cannot pass through opaque structures, Li-Fi internet is available only to the users within a confined area and cannot be intercepted and misused, outside the area under operation.

vi. Li-Fi technology has a great scope in future. The extensive growth in the use of LEDs for illumination indeed provides the opportunity to integrate the technology into a plethora of environments and applications.

VI. Limitations of Li-Fi

- ✓ Internet cannot be accessed without a light source. This could limit the locations and situations in which Li-Fi could be used.
- ✓ It requires a near or perfect line-of-sight to transmit data.
- ✓ Opaque obstacles on pathways can affect data transmission.
- ✓ Natural light, sunlight, and normal electric light can affect the data transmission speed.
- ✓ Light waves don't penetrate through walls and so Li-Fi has a much shorter range than Wi-Fi.
- ✓ High initial installation cost, if used to set up a full-fledged data network.

VII. Applications of Li-Fi

There are numerous applications of Li-Fi technology, from public Internet access through existing lighting (LED) to auto-piloted cars that communicate through their headlights (LED based). Applications of Li-Fi can extend in areas where the Wi-Fi technology lacks its presence like aircrafts and hospitals (operation theatres), power plants and various other areas, where electromagnetic (Radio) interference is of great concern for safety and security of equipments and people. Since Li-Fi uses just the light, it can be used safely in such locations or areas. In future with the Li-Fi enhancement all the street lamps can be transformed to Li-Fi connecting points to transfer data. As a result of it, it will be possible to access internet at any public place and street.

Some of the future applications of Li-Fi could be as follows:

a) Education systems: Li-Fi is the latest technology that can provide fastest speed for Internet access. So, it can augment/replace Wi-Fi at educational institutions and at companies so that the people there can make use of Li-Fi with the high speed.

b) Medical Applications: Operation theatres (OTs) do not allow Wi-Fi due to radiation concerns. Usage of Wi-Fi at hospitals interferes/blocks the signals for monitoring equipments. So, it may have hazardous effect to the patient's health, due to improper working of medical apparatus. To overcome this and to make OT tech savvy Li-Fi can be used to access internet and also to control medical equipments. This will be beneficial for conducting robotic surgeries and other automated procedures.

c) Cheaper Internet in Aircrafts: The passengers travelling in aircrafts get access to low speed Internet that too at a very high price. 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.

d) 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. Li-Fi can even work underwater where Wi-Fi fails completely, thereby throwing open endless opportunities for military underwater operations.

e) 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.

f) 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. The Radio communication interference is considered to be bad for such sensitive areas surrounding these power plants. Li-Fi can offer safe, abundant connectivity for all areas of these sensitive locations. Also, the pressure on a power plant's own reserves (power consumption for Radio communications deployments) will be lessened.

g) Traffic management: In traffic signals Li-Fi can be used to communicate with passing vehicles (through the LED lights of the cars etc) which can help in managing the traffic in a better manner resulting into smooth flow of traffic and reduction in accident numbers. Also, LED car lights can alert drivers when other vehicles are too close.

h) Mobile Connectivity: Mobiles, laptops, tablets, and other smart phones can easily connect with each other. The short-range network of Li-Fi can yield exceptionally high data rates and higher security.

i) 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.

VIII. Future Scope

As light is everywhere and free to use, there is a great scope for the use and evolution of Li-Fi technology. If this technology becomes mature, each Li-Fi bulb can be used to transmit wireless data. As the Li-Fi technology becomes popular, it will lead to a cleaner, greener, safer communications and have a bright future and environment. The concept of Li-Fi is deriving many people as it is free (require no license) and faster means of data transfer. If it evolves faster, people will use this technology more and more.

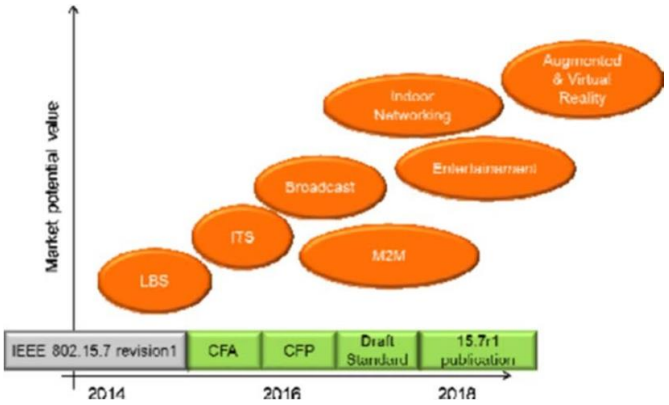

Fig 4: Li-Fi Roadmap

Currently, LBS (location Based Service) or Broadcast solution are commercially available. The next step could be a Li-Fi WLAN for B2B market with high added value on specific business cases and could grow towards mass market. In the long term, the Li-Fi could become an alternative solution to radio for wireless high data rate room connectivity and new adapted service, such as augmented or virtual reality.

IX. Conclusion

Although there's still a long way to go to make this technology a commercial success, it promises a great potential in the field of wireless internet. A significant number of researchers and companies are currently working on this concept, which promises to solve the problem of lack of radio spectrum, space and low internet connection speed. By deployment of this technology, we can migrate to greener, cleaner, safer communication networks. The very concept of Li-Fi promises to solve issues such as, shortage of radio-frequency bandwidth and eliminates the

disadvantages of Radio communication technologies. Li-Fi is the upcoming and growing technology acting as catalyst for various other developing and new inventions/technologies. Therefore, there is certainty of development of future applications of the Li-Fi which can be extended to different platforms and various walks of human life.

X. REFERENCES

[1]. http://www.warse.org/pdfs/2014/icetetssp25.pdf
[2]. http://www.onlinejournal.in/IJIRV2I6/006.pdf
[3]. http://ieeexplore.ieee.org/stamp/stamp.jsp?arnu mb er=6685753
[4]. www.oledcomm.com
[5]. https://www.ijsr.net/archive/v5i9/26051603.pdf
[6]. https://www.ijsr.net/archive/v4i12/NOV151778 .pdf
[7]. http://www.ijsrp.org/research-paper-0416/ijsrp-p5275.pdf
[8]. http://www.ijcta.com/documents/volumes/vol5i ssu e1/ijcta201 4050121.pdf
[9]. http://www.academia.edu/6996573/CSE_Study _P aper_on_._LiFi_Technology_The_latest_techno logy_ in_wireless 13.
[10]. http://www.academia.edu/6770592/Light_Fideli t y_LI-FI_- A_Comprehensive_Study_ 15.

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