

The Future Technology: Light-Fidelity (Li-Fi)

Malvika Baury, Akshar Bhayani, Manasi Bendale and Ankit Mehta

Information Technology, Bachelor of Technology, SVKM Narsee Monjee Institute of Management Studies,
Shirpur

ABSTRACT

The new form of wireless data transmission is Li-Fi, it represents light fidelity which rose because of the approaching radio frequency range crisis. In our everyday routine, one of the most significant work is to move information from one spot to another, which is at present dependent on Wi-Fi utilizing radio waves. At such point when the quantity of gadgets associated with the Internet expands, the fixed transfer speed makes it progressively harder to transmit information easily, as the radio frequency consists of a smaller part of the spectrum for information transmission. To overcome such issues Li-Fi technology came into effect. It gives transmission of data using optical spectrum by sending information through LED light bulb. Li-Fi can be considered as a fast and efficient adjustment of Wi-Fi dependent on the idea of visible light communication (VLC) which is a medium that utilizes optical bearer for information transmission. This paper aims at one of the applications of Li-Fi and its future uses.

Keywords: Li-Fi, LED, VLC, Wi-Fi, optical spectrum.

I. INTRODUCTION

We all are depending on internet directly or not directly for the achievement of our each day requirements. It is not possible to consider an afternoon in our lives, when we aren't "connected" to the "internet". In today's situation we're sharing plenty of data so the coolest records sharing ability is needed.

In 2011, Professor Harold Haas from the University of Edinburgh inside the UK cautioned an idea about the new shape of wireless community era which is known as "Data via illumination". And to implement this he used fiber optics to ship information through LED light bulbs [1]. In Li-Fi technology, one can join the internet with the help of an LED beam in a finite range. With this era one would be capable of transmitting facts even the use of our vehicle headlights. There are various community topologies but new ones are rising, because the community spectrum is increasing. Light fidelity is an era which uses visual light for communication instead of radio waves, which is used in various conventional conversation technology. In Li-Fi generation, LED act as a medium to high-pace conversation in a comparable way as Wi-Fi. It can assist to preserve a massive amount of power with the aid of transmitting information thru light bulbs and different such lighting gadget's. Li-Fi acts as the carrier for visible light at the area of radio waves like in Wi-Fi. However, Light Fidelity bulbs are equipped with a chip that modulates the mild imperceptibly for optical information transmission [2].

It's not a new concept to use light for communication. The first efforts go back to Hertz's own epoch. In 1880, one of the telephone's pioneers, American Alexander Graham Bell, experimented with the photo-phone, a modulated light wireless system. What triumphed in Europe and North America in the nineteenth century was the optical telegraph, a network of signposts and telescopes that, for example, allowed a short message to be sent in an hour from Amsterdam to Venice. Fiber optics is now the most important part of our communications, but the revival of wireless optical communication and, more specifically, visible light communication (VLC) was seen in the 21st century [3]. Li-Fi records is transmitted by means of the LED bulbs and acquired by photoreceptors. Li-Fi's early developmental fashions had been able to one hundred fifty megabits-per-2nd (Mbps). Some business kits permitting that speed were released.

In the lab, with stronger LEDs and special generation, researchers have enabled 10 gigabits-in line with-second (Gbps). Wi-Fi may not be the maximum green manner to provide new preferred competencies including precision indoor positioning and gesture reputation. The use of seen light spectrum for high speed information exchange is allowed through the formation of the Light emitting diode (LED) which at the same

time is on the heart of the next wave of strength-green illumination. Terms at the Edinburgh University and the Oxford University are concentrating on parallel data transmission through the usage of cluster of LEDs, wherein every LED transmits a specific information circulation. In October 2011 some of agencies and enterprise businesses shaped the Li-Fi Consortium, to sell excessive pace optical remote structures and to triumph over the limited measure of radio based remote spectrum to be had by method for misusing a unique piece of the electromagnetic range. The consortium trusts its miles conceivable to harvest more than 10 Gbps, hypothetically allowing a superior quality film to be downloaded in 30 seconds.

Paris has been executed the Li-Fi innovation. There are workplaces, emergency clinics, retail locations, public road/streets lighting just as metro L Defense's Metro Station and in 2012 in Liege the Curtius gallery. The four key criteria that is utilized are: The framework can give the bi-directional correspondence, the Li-Fi can work inside a complex physical condition, congestion and safe data can be driven to cell phones, arrangement of sound informing is created to empower visitor and individuals to be guided. Later on, the work should be possible for examining the security dangers dependent on the engineering, correspondence, and execution of Li-Fi as indicated by Confidentiality, integrity and availability (CIA) Triad idea. It can also be achieved by doing experiments and analysis based on the limitations in Li-Fi technology.

Insight, a Li-Fi remote system would supplement current heterogeneous RF remote systems and would offer extensive range alleviation by permitting cell and Wi-Fi-consistency (Wi-Fi) structures to unload a gigantic piece of remote data visitors.

II. ARCHITECTURE

Architecture of Li-Fi was classified on the basis of layers. The Li-Fi layered architecture is shown in Figure 1. Li-Fi consists of three phases, e.g. Physical layer, MAC layer, and Application layer, in layered architecture. Only two norms are defined in IEEE 802.15.7. I.e. MAC and PHY layer. [4]

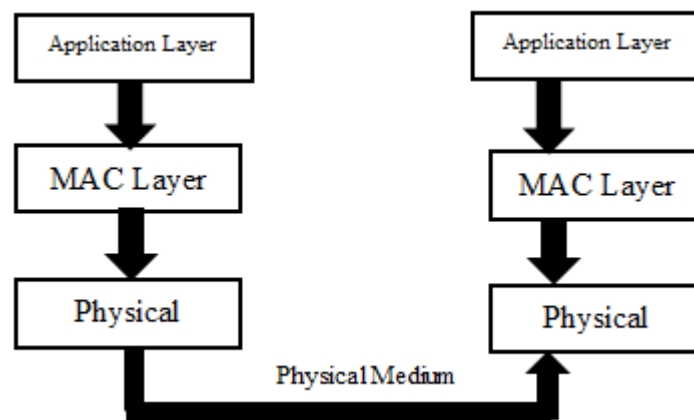


Figure 1. Li-Fi Layered Architecture

A. IEEE 802.15.7 Li-Fi Layered Architecture

1. PHYSICAL LAYER

The Physical layer is accountable to activate and deactivate the optical transceiver, for transmission and delivery, and the identification of the state of the transmission channel is either inactive or busy. There are 3 operating methods in the PHY layer and there difference is shown in Table 1 [4].

Table 1. Operation Modes PHY Layer

Modes of operation	Use	Categories	Speed
PHY Layer 1	Outdoor	Low	11.6-266 Kbps
PHY layer 2	Indoor	Average	1.2-96 Mbps
PHY Layer 3	Multiple optical transceiver	Code Shift Keying Modulation	12-96 Mbps

2. MAC LAYER

MAC layer defines three network topologies: Star, Broadcast, and Peer-to-Peer.

- A) Broadcast a machine, i.e. a coordinator sends information to multiple machines. There is a one-way communication in Broadcast Topology.
- B) In several appliances, Star Communication occurs. One of them is acting as a coordinator and used as an infrastructure for illumination.
- C) In Peer-to-Peer there are two communicating devices. One is acting as a coordinator.

B. Propagation Channel

Channel of Propagation in Li-Fi isn't equivalent to VLC. As shown by the indoor condition depicted by six various connection arrangement alludes to IR links. Transmitter and collector pass on in two establishments, for example, instance prompt or variant Line of Sight (LOS) that are necessary in the channel of propagation. These two measures rely upon the degree of directionality of the transmitter and beneficiary others rely upon the impression of the light. In the Line of Sight, the associations among the transmitter and gatherer are guided by each other. While in non-Line of Sight the light is spreading by the impression of the rooftop or diffusely reflecting the surface. Features for every rule is abbreviated in table 2. [4]

Table 2. Characteristic of IR Link

	Directed	Hybrid	Non-directed
Line of Sight	Augments control effectiveness. Minimize loss of path and ambient light noise reception.	Combines receiver and transmitter with distinct directionalities.	Transmitter and receivers are wide-angled. For mobile terminals, convenient to use.
Non line of Sight	- Reflecting light from the rooftop or some other diffuse outer surface. - Increase connection firmness and convenient way to use. Allows the connection to operate also when there is any blockade. - Referred to as diffuse connections.		

The key framework for obtaining elevated information rates is the optical Line of Sight (LOS) connection accessibility. An undirected transmission of LOS is like limiting the information rates that can be achieved. While the lighting situation may differ, to obtain a solid VLC. [5]

C. THE TOPOLOGIES OF LI-FI.

A proof-of-concept prototype VLC HetNet is built by the paper experiencing. This prototype is a concept that provides high quality service in the indoor environment using a varied spectrum. Wireless HetNet uses small-cells indoor gigabit to provide extra wireless ability. The Experiment proof-of-concept has two models like the hybrid model and the aggregated model. WiFi is used in the hybrid model to connect to the internet, but a user's downlink is linked via a Li-Fi link. While the aggregated system is linked in parallel to the user on WiFi and Li-Fi. In the hybrid system, unidirectional Li-Fi connection is used to complement the downlink to WiFi. Using bi-directional communication in the aggregated scheme, both WiFi and Li-Fi enhance the throughput and attain solid connectivity. [4]

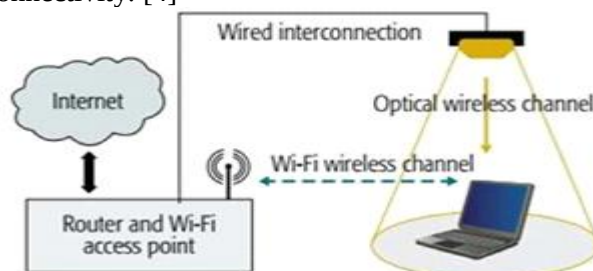


Figure 2 Hybrid system [4]

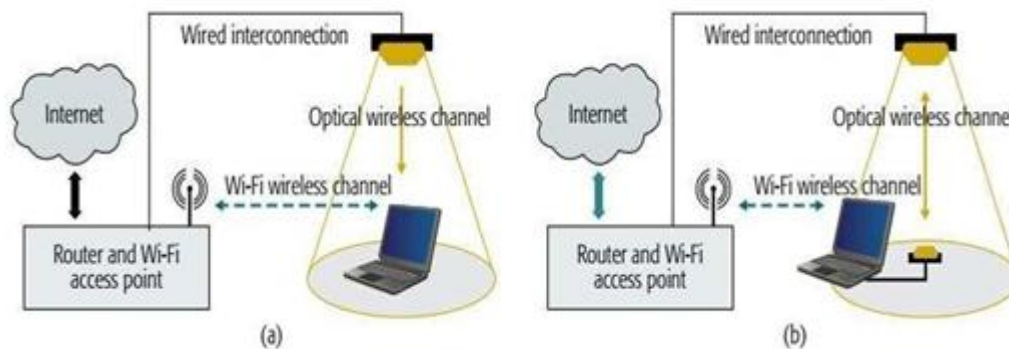


Figure 3 Aggregated system [4]

This concept's objective is to accomplish a healthy output. The throughput in the hybrid system relies only on the downlink's ability while degrading as the range increases. Consequently, the accessible reliable network communication is enhanced in the aggregation scheme. The hybrid system can also be a solution when implementing a mobile device to block the Li-Fi channel.

III. WORKING

Li-Fi works by turning LEDs on and off again, at a speed that is not obtrusive enough to be perceivable by the human eye, yet at the same time moderate enough for the recipient. Because of the tremendous measure of wavelengths that are in the noticeable light range, numerous quantities of Li-Fi channels are accessible. This implies that a lot of information can be conveyed while utilizing different channels. Li-Fi Access Point (AP) System works by using the current lighting in a structure and supplanting the regular lights, with Li-Fi AP (Access Point) LED lights. The lights would then be able to link together with an Ethernet link, which will interface them all to the principle system and perhaps control the lighting. The LED bulb will send sign to gadgets on the system and give lighting to the room. Another piece of the AP will get signals from the Li-Fi customers, making a bidirectional full-duplex association. As such Li-Fi considers two path correspondence between two Li-Fi gadgets simultaneously. Li-fi APs permits numerous gadgets to be associated with them likewise Wi-Fi APs.

When the framework begins a consistent current is linked to a LED light then from the bulb a steady stream of photons are produced, that light is called as visible light. If the current is changed gradually the yielding power of the light diminishes. For the conveyance when, LED starts sparkling, photo-detector on PC will distinguish light and get a pair of 1 or 0 [4]. The photo-detector enrolls a parallel one when the LED is on; and a twofold zero if the LED is off. Blazing LED on certain occasions will develop an information to transmit. Blazing of light is identified and then it will get information and that will be shown over the smart board with the assistance of the projector connected to the PC and smart board. Further improvements can be made in this technique, such as working with a variety of LEDs for parallel information transmission, or operating blends of red wise Wi-Fi APs.

Internet efficiency and security are the dominant problems now. Scientist Harold Haas from the UK discovered Li-Fi in 2011. The design is designed to overcome Wi-Fi's disadvantage. Wi-Fi's pace is up to 1500 Mbps, and accommodating an enormous user is not enough. [1]

Table 3. Speed and Standard of Li-Fi.

IEEE Standards	Launch Years	Rate
802.11b	1999	11Mbps
802.11a	1999	54Mbps
802.11g	2002	54Mbps
802.11n	2007	72-600Mbps
802.11ac	2013	433Mbps-1.3Gbps

Li-Fi allowing the device to use fully networked wireless communication and could provide a 100 times faster speed link than WiFi [6]. By using DMT modulation, it can achieve speeds of up to 3Gbps. Also shown in table 4 is the other speed of Li-Fi with the distinct modulation. A Scientist M.D Renzo et al using MIMO Wireless System Spatial Modulation in Li-Fi gave the transmission speed up to 10Gbps. Li-Fi's rated velocity can be greater than 3Gbps as research and development is underway. Li-Fi's rated velocity is based on the modulation's use. Doing a Li-Fi study and comparing it to Wi-Fi, Dr. P. Kuppusamy et.al found that there are several features used for comparison.

Table 4. Speed of Li-Fi with different modulations.

No.	Modulation	Speed
1	PAM	20 Mbps
2	PPM	30 Mbps
3	OOK	803 Mbps
4	CAP	1.1 Gbps
5	OFDM	2.1 Gbps
6	DMT	3.4 Gbps

Li-Fi is harder to decode or hack than Wi-Fi. The reason is that Li-Fi's coverage region is only on its illuminated region. Li-Fi's signal cannot pass through the wall. While Wi-Fi's signal can go through the wall, it can trigger information loss and information leakage vulnerabilities. VLC security problems concentrate on the aspect of the communication channel's fundamental physical features. The document also analyzes the potential for signal jamming, information snooping, alteration, and safety at the MAC level. The outcome is that VLC infrastructure is particularly vulnerable to the danger of data security. Eavesdropping is one of the safety problems in Li-Fi, an assault occurs by getting the signal from the gap between floor and door, cracking inside the ground, or partly protected windows.

IV. PROS AND CONS OF LI-FI

A. ADVANTAGES OF LI-FI

1. While Wi-Fi is predicated on the accessibility of a microwave signal, Li-Fi can speculatively turn any bulb into a system linked. Li-Fi works at frequencies much higher than Wi-Fi.
2. It can be utilized in fields with higher Radio Frequency Noise or where Radio Frequency Noise is precluded, for example, clinics and planes.
3. As far as security is concerned, Li-Fi offers more protection and security than Wi-Fi in light of the fact that the sign is effectively clouded by obscure materials and light does not enter through obstacles.
4. It has high speeds, gives link as high as 500 Mbps or 30 GB per minute, so it can be utilized in such puts where Bluetooth, infrared, Wi-Fi and web are restricted. Thus, it will be the most supportive transmitting medium.
5. It is a free band that does not need require authorization. Thus it is less expensive than Wi-Fi.
6. Wi-Fi is good for general remote inclusion while Li-Fi is perfect for high thickness inclusion in a bound locale. It is accepted that the innovation can yield a speed more than 10 Gbps, permitting a good quality movies to be downloaded in 30 seconds.
7. Hypothetical rate up to 1 Gbps: Less time and vitality utilization.
8. No more month to month broadband bills.
9. Lower power costs.
10. Lifespan of LED bulbs saves expense.

11. High fitting cost but extremely low upkeep cost.
12. It uses light as opposed to RF signals, thus it cannot bear interference.
13. It could be utilized securely in planes without having any impact on the airplane signals.
14. Wi-Fi does not work when submerged under sea except light can be operated and thus undersea inspections are great to go.
15. There are more than thousands of bulbs overall which should be supplanted with LED's to transmit information. [7]

B. LIMITATIONS OF LI-FI

1. One of the limitations of this setup is that the artificial light can't pass through barriers and other murky materials which radio waves can do. So a Li-Fi empowered end gadget will never be as quick and helpful as a Wi-Fi empowered gadget in the outdoors.
2. Likewise, another inadequacy is that it just works in direct observable pathway. All things considered, Li-Fi could develop as a help to the quickly draining data transmission of radio waves. Thus undoubtedly it will be the most preferable choice for gaining access to web in a restricted space at less expense.
3. One cannot diminish the light.
4. One needs exceptional LED.
5. The principle issue is that light does not go through articles, so if the recipient is coincidentally obstructed in any way, at that point the sign will promptly remove. In the event that the light sign is blocked, or when one have to utilize your gadget to send ones' data can switch back over to radio waves without any errors.
6. As per Harald [1], Reliability and system inclusion are the serious issues to be considered by the organizations while giving VLC administrations. Impedance from outer light sources like daylight, typical bulbs, and murky materials in the way of transmission will cause intrusion in the conveyance.
7. High establishment cost of the VLC frameworks can be supplemented by huge scale administration of VLC in spite of the fact that adopting VLC innovation will decrease further working costs like power charges, support charges and so forth. [8]

V. LI-FI OVER WI-FI

1. In Li-Fi transmitter is LED while in Wi-Fi antenna is used.
2. Li-Fi receiver is LED while antenna is used in Wi-Fi.
3. The built-in device is being researched and developed while Wi-Fi card / chip is being used in Wi-Fi.
4. The average functioning speed is above 10 Gbps (under analysis) while, the Wi-Fi functioning rate is 150-160 Mbps.
5. The frequency band is 1000 times THz and up to 2.4 GHz in Wi-Fi.
6. Its conventional notation is IEEE 802.15.xx and IEEE 802.11xx for Wi-Fi
7. All the individuals under the lamp are the target users covered here, while Wi-Fi depends on its access points.
8. Information is transmitted in bits while radio waves are used for transmission in Wi-Fi.
9. The coverage zone here is 10 meters, while Wi-Fi spans between 20 and 100 meters varying on the type of transmission capacity and antenna.
10. There are zero interference difficulties with RF waves while neighboring Access Point routers are interfered in Wi-Fi.

11. Topology carried here is point-to-point and in Wi-Fi point-to-multipoint topology is implemented.
12. Communication arises due to visible light, whilst in Wi-Fi RF based communication is carried out.
13. Li-Fi performance is better because Light Emitting Diodes consumes less amount of energy and are immensely efficient, while Wi-Fi is less efficient because more power is consumed by radio stations.
14. It is ideal for high data rates whereas Wi-Fi is suitable for Access Points with large coverage areas.
15. The SNR ratio is high but much higher in Wi-Fi.

Environmental impact is low, whereas Wi-Fi has moderate impact.

16. Consumption of energy is low and moderate in Wi-Fi. [2]

VI. APPLICATIONS

The utilization of Li-Fi is as follows:

A. MEDICAL FIELD

Coordinated into therapeutic gadgets and in medical clinics, as it should be utilized in such places where Wi-Fi, Internet, Bluetooth and Infrared are restricted. Operation Theaters don't permit Wi-Fi because of radiation concerns. Subsequently Li-Fi tackles two issues: it has more range than Wi-Fi, which in turn can be helpful for the medical data and lights are the most important installation in operation theatre, so Li-Fi can be used to accustom for getting control over medical equipment's and Web. Therefore, this is helpful for mechanical medical procedures and other computerized methods. [6]

B. UNDERWATER WORKING

Submerged remotely operated (ROV) vehicles work from large links that supplying their energy and allowing their pilots to receive signals. However, the link used in ROV's is not long enough to permit them to investigate bigger regions. Besides, their wires were supplanted with light say from a submerged, powerful light, at that point pilots will be a lot more liberated to investigate further. This way it opens scope for military usage. [8]

C. EDUCATIONAL PURPOSE

Li-Fi is the recent innovation that is capable of quickest Web access. In this way, it can supplant Wi-Fi at organizations, so that every one of the individuals can utilize Li-Fi with similar speed proposed in a specific place.

D. AIRPLANES

The travelers going in airplanes gain access to low speed web at a high rate. Moreover, Wi-Fi is not installed because it might meddle with the navigation system of the pilots. Li-Fi should be utilized for data transmission, in aircrafts. Within the aircraft, Li-Fi can readily deliver high-speed access to the internet through any light source such as perusing bulb, and so on present inside the plane. Likewise it should be utilized for oil or synthetic plants where other transmissions could be unsafe. Airplane Wi-Fi needs engaged crowd for the service of dial up on the airplane which are more costly. Li-Fi could acquaint that kind of speed with every traveler perusing light. It would be without intrusion to and from different remote flag on the board.

E. OPEN HOTSPOT

All the bulbs around the world should be supplanted with LED ones that transmit information, less expensive than Wi-Fi. In lanes for congestion control. Automobiles have LED headlights, LED backdrop illuminations, therefore one person can speak with another and forestall mishaps by communicating data. By actualizing this innovation worldwide each road light would be a free point to access data. In rush hour signals, Li-Fi should be utilized which can speak through the LED lights of the vehicles which will further help in dealing with the congestion in a superior manner so that the mishaps can be lowered. Additionally, LED vehicle lights can alert drivers when vehicles are excessively close.

F. WORK AREA

Envision ourselves strolling into a shopping center where GPS sign are inaccessible however the shopping center is outfitted with roof bulbs that make their own route of reference points. As the camera of our mobile phone naturally gets these sign, it changes our route to utilize this data to navigate us to the closest spot that we are scanning.

G. INDUSTRIAL PURPOSE

Power plants need quick, inter-related information frameworks with the goal that request, grid integrity and central temperature can be observed. Wireless connection and multiple radiating types are harmful for delicate places encompassing the power plants particularly the nuclear power plants. Li-Fi could offer protected, inexhaustible network for all these fields. This will lower the expenditure when contrasted with the actual provisions. Likewise, the stress on power plant owned resources could be reduced. It can likewise be utilized in oil plants where other transmission or frequencies will in general be perilous. [9]

VII. FUTURE SCOPE

Li-Fi offers a policy to discover the grounds of transmission of wireless information at excessive charges. If this technology is positioned into sensible use, transmission of data will be possible in safer way. The implementation of Li-Fi can go beyond imagination. In the current time, human beings can get entry to connectionless data with the LEDs mounted on the move. In many army applications, where RF based communications are not allowed and communication ought to be safe, Li-Fi can be an alternative for army automobiles. Nevertheless, given its excessive charges of information transmission and its use in a couple of fields, Li-Fi is honestly the future in Wi-Fi based communication. This concept can be advanced and can be used to transmit the information to cellular phones and computers that do not use radio waves transmission, home automation, monitoring activities and Li-Fi hotspots.

VIII. CONCLUSION

Li-Fi is an advanced wireless data distribution technique.

It is a solution to standard wireless transmission techniques that use light as an information carrier rather than traditional radio frequency like in Wi-Fi. This idea plans to fix problems like RF bandwidth shortages and tackle limitations of Wi-Fi. It responds quickly and is quicker than Wi-Fi. It enables the Web where typical radio based remote connection is not permitted, such as clinics, atomic power plants etc. Thus, this article concludes that Li-Fi is excellent for highly dense wireless information connectivity in relatively lower region and also to solve problems caused because of RF. If we introduce Li-Fi technology, every bulb could be used as a Wi-Fi hotspot that enables us to communicate information to various people at high velocity and makes it much easier to maintain our surroundings tidy, green and secure.

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