

Li-Fi: Ultra Fast light based Wireless Data Transmission

Aarti H. Dharmani (Author)¹, Tushar D. D. Prabhu (Author)²

¹Thakur College of Engineering and Technology Masters of Engineering in Electronics & Telecommunications. Mumbai, INDIA.

²Thakur College of Engineering and Technology Masters of Engineering in Electronics & Telecommunications. Mumbai, INDIA.

Corresponding Author: Aarti H. Dharmani

Abstract— In the present time, Wi-Fi is the most drifting area. As web customers are increasing consistently, there is an enormous load on radio range that leads to congestion. To show signs of improvement in data transfer, capacity and speed, another innovation Li-Fi has progressed. Li-Fi stands for Light Fidelity. It is a bidirectional and remote method for communication utilizing light. It utilizes the unused visible range and decreases the load on radio frequency range. Li-Fi can just be used instead of Wi-Fi with light used as the medium as opposed to radio waves. Here, information is transmitted utilizing light whose frequency differs quicker than human eye to catch. Rather than utilizing modems, Li-Fi utilizes LED bulbs with handset. Information transmission in Li-Fi is around 100 times speedier than Wi-Fi. Here, in this paper we discuss the requirement for Li-Fi. Li-Fi is a type of optical remote innovation that utilizes light as the medium to transmit information in the visible range (Visible Light Communication {VLC}). The Li-Fi with which one can browse new sites in a matter of seconds and which makes it profoundly secure is discussed.

Keywords—Wi-Fi, Li-Fi, VLC (Visible Light Communication)

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I. INTRODUCTION

Wi-Fi innovation is being utilized by the general population as last mile arrangement however there are a few downsides like:

- a) Low information rate.
- b) Interference.
- c) Limited number of channels.

To conquer these impediments another innovation is created named Li-Fi. It remains for Light Fidelity. Li-Fi is a rising innovation which is an improved form of Wi-Fi yet Li-Fi communication take place at a very high speed using visible light. The idea of Li-Fi was extricated from visible light communication, the word Li-Fi was first time utilized by Harald Hass from University of Edin-burgh, UK in his TED Global talk on VLC. The idea was clarified by Hass in straightforward and refined words he said "exceptionally basic, if LED is ON, you exchange a digit 1 and if it's off you transmit a 0. The LEDs can be turned OFF and ON rapidly which gives us the chance to transmit information at a rapid rate". It incorporates an extensive variety of frequencies and wavelengths, from the infrared through visible light and down to the bright range. It covers gigabit and sub-gigabit class for short, medium and long range correspondence rates and information exchange for unidirectional or bidirectional utilizing observable pathway or diffuse connection, reflections and substantially more components. It isn't limited to

LED, LASER or a specific accepting strategy. Li-Fi is a structure for these giving new capabilities to present and future administrations, applications and end clients. To do as such, one just needs a variety of LEDs and a controlling circuit that can balance information into those LEDs. To overcome the impediments of wired range, various industry gatherings and companies formed Li-Fi consortium in 2011 to promote Visible Light Communication.

II. DISTINGUISHED ISSUE

A. Congestion in radio frequency spectrum

Remote availability—including Wi-Fi—is subject to the presence of unlicensed radio frequency spectrum. Provisioned by the FCC, unlicensed range are frequencies put aside for break even with circumstance overall population use, rather than being held for military purposes or sold to private or business interests. Regardless of at first being seen by the FCC and business licensees alike as "garbage bands," unlicensed spectrum has turned into the dear of advancement, and its open designation has yielded numerous monetary advantages and mechanical additions. Without unlicensed range, there would be no Wi-Fi particulars and no Internet of Things, the system of physical items implanted with network. Be that as it may, with taking off measures of versatile movement and a blast in IoT gadgets, existing unlicensed groups are getting to be noticeably congested. Furthermore, if these unlicensed groups

wind up plainly depleted, future advancements may actually be swarmed out.

B. Shortcomings of radio wave shortcomings

In spite of the fact that Radio Frequency Spectrum is prevalent and most generally utilized as a part of the present time, it surely has a few issues with its use.

The following are the basic issues with radio waves:

- a) 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 radio spectrum.
- b) Energy Efficiency: There are a large number of 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 radio base stations is very low.
- c) Availability: Availability of radio waves is a big concern. Further, Radio waves are not advisable to be used in aeroplanes and at places where radio interference may cause undesirable/catastrophic result.
- d) 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.

C. Alternative solution

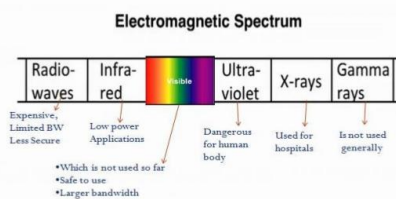


Figure 1

In Figure 1, the utilization of every spectrum and its related impacts are mentioned:

- a) Radio Frequency Spectrum: Issues identified with Radio waves, as seen before, isn't just costly yet additionally has a restricted data transmission alongside it being less secure.
- b) Infrared Spectrum: Infrared, due to eye safety regulation, must be utilized with low power.
- c) Ultraviolet Spectrum: Ultraviolet light is useful for place without individuals, however generally hazardous for the human body
- d) X-Rays: It is used in hospitals.

III. ARCHITECTURE OF LI-FI

Li-Fi which can be the eventual fate of information correspondence seems, by all accounts, to be a quick and cheap optical adaptation of Wi-Fi. Being a Visible Light Communication (VLC), Li-Fi utilizes visible light of electromagnetic range between

400 THz and 800 THz as optical carrier for information transmission and brightening. It utilizes fast pulses of light to transmit data in remote medium. The fundamental segments of an essential Li-Fi framework may contain the accompanying:

- a) A high brilliance white LED which goes about as transmission source.
- b) A silicon photodiode with great reaction to visible light as the receiving component.

Switching the LEDs on and off can influence them to generate advanced strings with various blends of 1s and 0s. To generate another information stream, information can be encoded in the light by shifting the flickering rate of the LED. Along these lines, the LEDs function as a sender by regulating the light with the information flag. The LED output seems consistent to the human since they are made to glimmer at a marvelous speed (a large number of times each second) and it's unthinkable for human eye to identify this frequency. Communication rate more than 100 Mbps can be accomplished by utilizing rapid LEDs with the assistance of different multiplexing procedures. What's more, this VLC information rate can be additionally expanded to as high as 10 Gbps by means of parallel information transmission utilizing a variety of LED lights with each LED transmitting an alternate information stream.

The Li-Fi transmitter system comprises of four primary subassemblies as shown in Figure 2:

- a) Bulb.
- b) RF Power Amplifier Circuit.
- c) Printed Circuit Board.
- d) Enclosure.

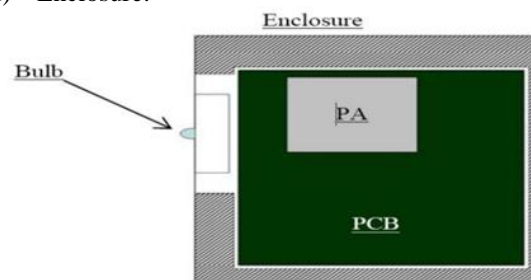


FIGURE 2

The Printed circuit board (PCB) controls the electrical inputs and outputs of the light and houses the microcontroller used to oversee diverse light capacities. A Radio Frequency (RF) flag is produced by the Power Amplifier and is coordinated into the electric field of the bulb. Because of the high

centralization of energy in the electric field, the contents of the bulb will get vaporized into a plasma state at the bulb's center. Furthermore, this controlled plasma thus will deliver an intense source of light. These subassemblies are contained in an aluminum walled enclosure.

D. Li-Fi- Bulb Sub Assembly

The bulb sub-assembly (Figure 3) is the main part of the Li-Fi emitter. It comprises of a fixed bulb inserted in a dielectric material which fulfills two needs: one, it goes about as a waveguide for the RF energy transmitted by the PA (Power Amplifier) and two, it goes about as an electric field concentrator that focuses the energy into the bulb. The gathered energy from the electric field quickly warms the material in the bulb to a plasma express that transmits light of high power of Visible light range. Figure 3 shows the sub-assembly of the bulb. There are various inherent advantages of this approach which includes high brightness, excellent color quality and high luminous efficacy of the emitter – in the range of 150 lumens per watt or greater.

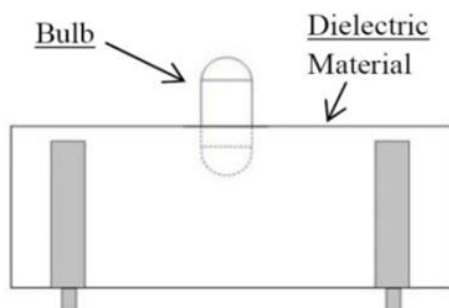


FIGURE 3

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. Moreover, the special mix of high temperature plasma and carefully controlled strong state gadgets brings about a monetarily created group of lights versatile in bundles from 3,000 to more than 100,000 lumens.

Vital components that ought to be considered while outlining Li-Fi are as per the following:

- a) Presence of Light
- b) Line of Sight (LOS)
- c) For better performance use fluorescent light & LED.

E. Working

Li-Fi depends on VLC (Visible Light Communication). VLC optical carrier for information transmission and brightening utilizes 400 THz (780nm) and 800THz (375nm). As said over a surge of 0's and 1's can be produced by turning LEDs ON and OFF and information encoding is conceivable in

LEDs by the controller. At the recipient end a photodiode distinguishes the flickering of LEDs and concentrates a succession of 0's and 1's. This process takes place in nanoseconds which isn't recognized by human eye. Human eye can just watch the persistent light. So the issue of security settle in light of the fact that no one can see the information stream, however just visible light. Li-Fi is believed to be 80% more proficient, which implies it can achieve rates of up to 1Gbps and even beyond. Li-Fi contrasts from fiber optic in light of the fact that the Li-Fi convention layers are appropriate for remote correspondence over short separations (up to 10 meters). This puts Li-Fi in a novel position of amazingly quick remote correspondence over short separations. In Figure 4 a total Li-Fi framework is appeared. Information stream coming from web or any server can be changed over into light flags by the assistance of a converter. Then a LED lamp transmits information utilizing noticeable light. At the beneficiary end a photo detector is put which recognize the light originating from blinking LEDs and change over it into an electrical flag which is enhanced and afterward the flag is prepared to use by the particular gadget. To accomplish high information rates photo detector ought to be extremely exact.

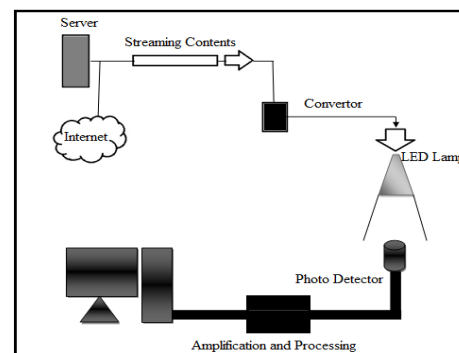


FIGURE 4

Data rate upgrades can be made in this strategy, by utilizing array of the LEDs for parallel information transmission, or utilizing blends of red, green and blue LEDs to adjust the light's frequency, with every frequency encoding an alternate data channel.

IV. COMPARISION BETWEEN TECHNOLOGIES

This examination is critical in light of the fact that by this examination we will have a reasonable thought of productivity of Li-Fi over different innovations. In Table 1 correlation in the shape of information rates is given.

TABLE 1

Innovation	Data Rates
Wi-Fi – IEEE 802.11n	150 Mbps
Bluetooth	3Mbps
Li-Fi	>1Gbps

Information rates of various current remote innovations

The table contains the present remote innovations for the exchanging of information between various gadgets, i.e. Wi-Fi, Bluetooth and IrDA. Be that as it may, right now just Wi-Fi manages high information rates. The IEEE 802.11n standard for the most part executions conveys up to 150Mbit/s hypothetically however in down to earth it can go to 600Mbit/s. In current remote there are two optical advances which are IrDA and Li-Fi.

F. Comparison with Wi-fi

Figure 5 shows the progress of media transmission from LTE to Wi-Fi to Li-Fi (in distant future). Li-Fi can be thought of as a light based Wi-Fi. That is, it uses light instead of radio range to transmit information. As opposed to Wi-Fi modems, Li-Fi would use transceiver - fitted LED lights that can light a room and transmit and get information. Wi-Fi is mind blowing for general remote extension inside buildings and Li-Fi is ideal for high thickness remote data scope in bound zone and for reducing radio obstruction issues.

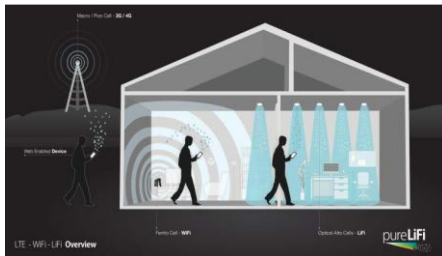


FIGURE 5

Sr. No.	Parameters	Wireless Technologies	
		Li-Fi	Wi-Fi
1.	Speed for data Transfer	Faster transfer speed (>1 Gbps)	Data transfer speed (150 Mbps)
2.	Medium through which data transfer 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 uses light.	Expensive in comparison to Li-Fi because it uses radio spectrum.
5.	Network Topology	Point to point	Point to point
6.	Operating Frequency	Hundreds of Tera Hz.	2.4 Ghz (Single Band) 2.4 Ghz & 5 Ghz (Dual Band)

TABLE 2 Comparison Table

V. STANDARDIZATION

The Visible Light Communication intrigue gathering, affirmed by the IEEE, with its standardization endorsed in 2011 as IEEE 802.15.7. This standardization determines VLC comprising of mobile-to-mobile (M2M), fixed to-mobile (F2M) and infrastructure-to-mobile (I2M) communications. The fundamental motivation behind VLC standard is to center around medium-run communications for smart frameworks at low-speed and on short-range mobile to mobile and fixed to mobile correspondences at high speeds to exchange data. Data rates are upheld up to 1 Gbps utilizing different tweak plans. IEEE 802.15.7 characterizes physical layer (PHY) and media get to control (MAC) layer for VLC/Li-Fi. The MAC layer supports 3 multi-access innovations: peer-to-peer, star configuration and broadcast mode. It likewise handles physical layer administration issues, for example, addressing, collision and data acknowledgement protocols. The physical layer is separated into 3 writes: PHY I, II, III and utilize a blend of various adjustment plans.

The PHY I was built up for open air application and works from 11.67 kbps to 267.6 kbps.

The PHY II layer licenses achieving information rates from 1.25 Mbit/s to 96 Mbit/s.

The PHY III is utilized for some, emissions sources with a specific adjustment technique called color shift keying (CSK). PHY III can convey rates from 12 Mbit/s to 96 Mbit/s.

The modulation formats perceived for PHY I and PHY II are on-off keying (OOK) and variable pulse position modulation (VPPM). The Manchester coding utilized for the PHY I and PHY II layers incorporates the clock inside the transmitted information with a rationale 0 as an OOK image "01" and a rationale 1 with an OOK image "10", all with a DC part. The DC segment keeps away from light termination if there should be an occurrence of an extended 0's. There are additionally two Japanese principles for VLC organizing (JEITA CP-1221 and CP-1222).

VI. ADVANTAGES OF LI-FI

Li-Fi, which utilizes visible light to transmit signals wirelessly, is a developing innovation ready to rival Wi-Fi. Additionally, Li-Fi expels the constraints that have been put on the client by the Radio wave transmission, for example, Wi-Fi as clarified above wide Advantages of Li-Fi innovation include:

- a) Efficiency: Energy utilization can be limited with the manipulation of LED light which is as of now accessible in the home, workplaces and Mall and so forth for lighting purpose. Henceforth the transmission of information requiring negligible additional power, which makes it exceptionally productive as far as expenses and also energy.

- b) High speed: Blend of low interference, high transmission capacities and high-potency output, help Li-Fi give high information rates i.e. 1 Gbps or even beyond.
- c) Availability: Accessibility is not an issue as light sources are available all over the place. Wherever there is a light source, there can be Internet. Lights are available all around – in homes, workplaces, shops, shopping centers and even planes, which can be utilized as a medium for the information transmission.
- d) Cheaper: Li-Fi requires less components for its working, as well as negligible additional power for the data transmission.
- e) Security: One fundamental advantage of Li-Fi is security. Since light can't go through opaque structures, Li-Fi internet is accessible just to the clients inside a restricted territory and can't be captured outside the region under activity.
- f) Li-Fi innovation has an incredible scope in future. The broad development in the use of LEDs for illumination surely gives the chance to incorporate the innovation into a plenty of situations and applications.

VII. DIS-ADVANTAGES OF LI-FI

- a) A portion of the real constraints of Li-Fi are:
- b) Internet cannot be easily accessed without a light source. This could restrain the areas and circumstances in which Li-Fi could be utilized.
- c) It requires a close or perfect line of sight to transmit information.
- d) Opaque impediments on pathways can influence information transmission.
- e) Natural light, daylight, and typical electric light can influence the information transmission speed
- f) Light waves don't penetrate through walls thus Li-Fi has a considerably shorter range than Wi-Fi
- g) High starting establishment cost, if used to set up a undeniable information network. However it is yet to be produced for mass scale appropriation. One of the major limitations of Li-Fi.
- h)

VIII. APPLICATIONS OF LI-FI

There are various applications of Li-Fi innovation, from open Internet access through existing lighting (LED) to auto-steered cars that impart through their headlights (LED based). Uses of Li-Fi can reach out in territories where the Wi-Fi innovation does not have its essence like air ships and hospitals (operation theaters), power plants and different zones, where electromagnetic (Radio) interference is of great worry for safety and security of supplies and individuals. Since Li-Fi utilizes only the light, it can be utilized securely in such areas or territories. In future with the Li-Fi improvement all the road lights can be changed to Li-Fi associating focuses to exchange data.

Because of it, it will be possible to get to internet at any open place and road.

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

Education frameworks: Li-Fi is the most recent innovation that can give fastest speed to Internet access. Along these lines, it can augment/replace Wi-Fi at educational institutions and at organizations so the general population there can make use of Li-Fi with high speed.

a) Medical Applications: Operation theaters (OTs) don't permit Wi-Fi because of radiation concerns. Use of Wi-Fi at doctor's facilities interference/obstructs the signs for observing types of gear. In this way, it might have risky impact to the patient's health, because of inappropriate working of medicinal device. To overcome this and to influence OT tech savvy Li-Fi can be utilized to get to internet and furthermore to control medicinal apparatus. This will be helpful for directing mechanical surgeries and other computerized methods.

b) Cheaper Internet in Aircrafts: The travelers going in airplanes access low speed Internet that too at a high cost. Additionally Wi-Fi is not used because it may interfere with the navigational systems of the pilots. In flying machines Li-Fi can be utilized for information transmission. Li-Fi can without much of a stretch give rapid Internet via every light source such as overhead reading bulb, etc. present inside the airplane.

c) Underwater applications: Underwater ROVs (Remotely Operated Vehicles) work from extensive links that supply their energy and enable them to get signals from their pilots above. In any case, the tether utilized as a part of ROVs isn't sufficiently long to enable them to investigate bigger territories. In the event that their wires were replaced with light — say from a submerged, powerful light — then they would be substantially more liberated to investigate. They could likewise utilize their headlamps to speak with each other, handling information independently and sending their discoveries occasionally back to the surface. Li-Fi can even work submerged where Wi-Fi fails completely, in this way throwing unlimited open doors for military submerged tasks.

d) Disaster administration: Li-Fi can be utilized as intense methods for correspondence in the midst of calamity, for example, earthquake or hurricanes. The normal individuals may not know the conventions during such catastrophes. Subway stations and tunnels, common dead zones for most emergency communications, pose no obstruction for Li-Fi.

e) Applications in sensitive zones: Power plants require quick, inter-connected data systems with

the goal that demand, grid integrity and core temperature (in the event of atomic power plants) can be observed. The Radio communication obstruction is thought to be awful for such sensitive territories encompassing these power plants. Li-Fi can offer protected, plenteous connectivity for all regions of these sensitive areas. Additionally, the pressure on a power plant's own reserves (power consumption for Radio communications deployments) will be lessened.

- f) Traffic administration: In rush hour gridlock signals Li-Fi can be utilized to speak with passing vehicles (through the LED lights of the cars and so forth) which can help in dealing with traffic in a superior way coming about into smooth flow of traffic and reduction in accident numbers. Additionally, LED car lights can alarm drivers when different vehicles are excessively close.
- g) Mobile Connectivity: Mobiles, workstations, tablets, and other advanced cells can without much of a stretch associate with each other. The short-extend system of Li-Fi can yield outstandingly high information rates and higher security.
- h) Replacement for different advancements: Li-Fi doesn't work utilizing radio waves. In this way, it can be effectively utilized at those spots where Bluetooth, infrared, Wi-Fi, and so forth are prohibited.

IX. CONCLUSION

Li-Fi is one of the developing innovations which utilize noticeable light range for correspondence. Presently now – a - days Li-Fi is being utilized as last

mile arrangement which gives high information rate by coordinate availability utilizing viewable pathway. Any client associated with the Li-Fi source when moves, May loose network when there is any snag between versatile client and source. To defeat this issue two unique answers for two distinct situations are expressed.

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