

# A Survey on Li-Fi Technology and Its Applications

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**Abstract:** *In the era of overcrowded digital communication world, Li-Fi is a new way of wireless communication that uses LED lights to transmit data wirelessly. Transmission of data is one of the most important day to day activities in the fast growing world. The current wireless networks that connect us to the Internet are very slow when multiple devices are connected. Also with the increase in the number of devices which access the Internet, the availability of fixed bandwidth makes it much more difficult to enjoy high data transfer rates and to connect a secure network. Radio Frequency (RF) has limitation in bandwidth can't support the growth in demand for high data rates and the large numbers of communication systems. Li-Fi has got a much broader spectrum for transmission compared to conventional methods of wireless communications that rely on radio waves. DR. Harald Haas a physicist, 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. Li-Fi means Light Fidelity and it is a bidirectional and wireless mode of communication using light. It uses the unused visible spectrum and reduces the load on radio spectrum. Instead of using modems, Li-Fi uses LED bulbs with transceiver. Data transmission in Li-Fi is about 100 times faster than Wi-Fi. Here, in this paper we explore the need for Li-Fi and its applications.*

**Keywords:** Wi-Fi, Radio Spectrum Li-Fi, Visible Spectrum

## 1. Introduction

In simple terms, Li-Fi can be thought of as a light-based Wi-Fi. 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. Actually 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, 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.

## 2. Literature Survey

Noof Al Abdulsalam et al; in their paper[1], title "Design and Implementation of a Vehicle to Vehicle Communication System Using Li-Fi Technology" presented the initial designs and results of a small-scale prototype of a vehicle to vehicle communication system using light fidelity (Li-Fi) technology, a new technology that was developed in the last few years, which still needs more investigations on its sustainability for outdoor vehicular networks. Vehicle to vehicle communication is the most effective solution that has been used in order to reduce vehicles' accidents. In this paper comprises mainly light-emitting diode (LED) bulbs as means of connectivity by sending data through light spectrum as an optical wireless medium for signal propagation. In fact, the usage of LED eliminates the need of complex wireless networks and protocols. Both numerical simulations using Proteus package and experimental results are also presented, which agree quite well.

Hind Bangui et al; in their paper[2], title "Smart Mobile Technologies for the City of the Future presented, the Smart City concept is gaining popularity due to involving various technologies in public places in order to satisfy the citizens' needs. However, the success of the smart city paradigm is linked to the treatment and management of the amount of real time data, which can be at the moment most effectively approached with the help of cloud platforms. In this paper, they discussing the most promising mobile cloud and data transmission technologies that are expected to make the city more "smart" and more affordable for the end-users. Hence, they also discuss Li-Fi as a future transmission of data through illumination that can enhance further the communication in a smart city as well as guarantee a wireless connectivity that meets the requirements of the citizens.

Nikshep K N, Sowmya G et al; in their paper[3], title "Voice And Data Communication Using Li-Fi" presented, the process of data communication through the visible light on the transmitter side Keypad is used as the input signal. The microcontroller receives the signal from the keypad and generates two outputs and gives that signal to the DTMF Encoder. The encoder will generate one tone and one frequency for every pressed key and this frequency is amplified by the amplifier circuits and fed into the power LED. At the receiver side light dependent resistor will receive the light signal and correspondingly generate an electrical signal proportional to it. This electrical signal is processed by a demodulator circuit (DTMF Decoder), and the output of decoder is then fed to a microcontroller and the microcontroller activates the corresponding load for the pressed key. In the process of voice communication through the visible light on the transmitter side voice is used as the input signal. This signal is converted to an electrical signal through a condenser or microphone and is amplified by the amplifier circuits and fed into the power LED. The light signal from the LED varies according to the intensity of the voice signal; At the receiver side light dependent resistor

will receive the light signal and correspondingly generate an electrical signal proportional to it. This electrical signal is processed by a demodulator circuit, which is then fed to a speaker and it produces the audio signal which was at the input of the transmitter side.

Rajan Sagotra, Reena Aggarwal et al; in their paper[4] title “Visible Light Communication “ presented, With the invention of LED (Light Emitting Diode), the idea of victimization light-weight as a communication medium has started once more. VLC uses white Light Emitting Diodes (LED), which send knowledge by flashing light-weight at speeds undetectable to the human eye. Now the light-weight they tend to use in their way of life can't solely be used for providing light-weight however conjointly for communication.. A lot of analysis is being done to create this technology out there for business use in varied fields, including web access and vehicle-to-road communication victimization traffic signal lights. From review of their literature, it became evident that work should be done to appear into the chance of planning a replacement model that would work the current infrastructure for indoor applications.

Junjie Liu et al ;in their paper[5], title “Survey of Wireless Based Indoor Localization Technologies” presented, The market of localization based service (LBS) is increasing. The acquisition of physical location is the fundamental basis for LBS. GPS, in fact commonplace for out of doors localization, does not work well in indoor setting because of the block of signals by walls and ceiling. To acquire high accurate localization in indoor setting, many techniques have been developed. The vision based localization involves camera and portable computer vision technologies that increase the value. Accelerometer primarily based mostly localization will accumulate the error created by each localization prediction. Firstly, they compare the wireless technologies that have been used for localization in recent literature. The wireless technologies are divided by the distance of coverage. They vary in frequency band and recognition which make sure their distinctive characteristics once used for indoor localization. After that, they justify the mathematical techniques live utilized in wireless based localization. Proximity primarily based technique can alone offer approximate location supported link or connect information. Triangulation can be accustomed make sure angle or distance information retrieve from the received signals from three or further beacon stations to urge user location. Fingerprint assumes the signal property in each purpose is whole completely different, the location are usually found by comparison with pre-built radio-maps. In the end of the paper, they have summarized four trends among the researches in wireless based indoor localization. Incorporating multiple mathematical methods can scale back the error and increase the accuracy.

Shivaji Kulkarni et al; in their paper[6] title “A Survey on Li-Fi Technology” presented a brief survey on new technology for data communication such as Li-Fi and advantages of Li-Fi with existing technologies.

P. Kuppusamy et al; in their paper[7] title “Survey and Challenges of Li-Fi with Comparison of Wi-Fi” presented a

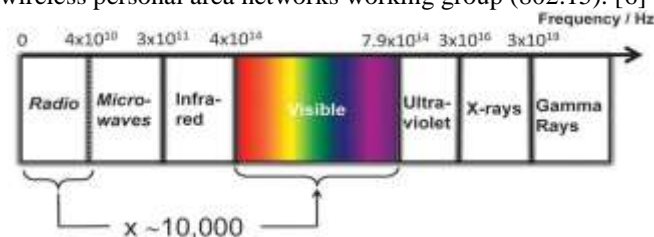
survey on Wi-Fi technology in commercial and industries and Li-Fi technology. Wi-Fi is working based on radio waves in the spectrum. These waves are very harmful to the diseased people, signal sensitive areas. Hence it could not be utilized in environments such as hospitals, scan centers, air lines etc. To overcome these limitations, Li-Fi is the technology that is developed to work in such environments. This paper is presented the study of Li-Fi technology, working principles, challenges and applications with comparison of Wi-Fi technology. The comparative study is also presented the features of both technologies. The observations show that Li-Fi performs harmless data transmission at high speed using light source.

### 3. Working

#### A) Visible light spectrum

VLC is an optical communication technology that use visible light rays, these rays locate between [400-800] THz, as optical carrier for data transmission by illumination. It uses fast pulses of light, which cannot be detected by the human eye, to transmit data. [4] [5] It includes any use of the visible light portion of the electromagnetic spectrum to transmit information.

The VLC standardization **process** is conducted within IEEE wireless personal area networks working group (802.15). [6]

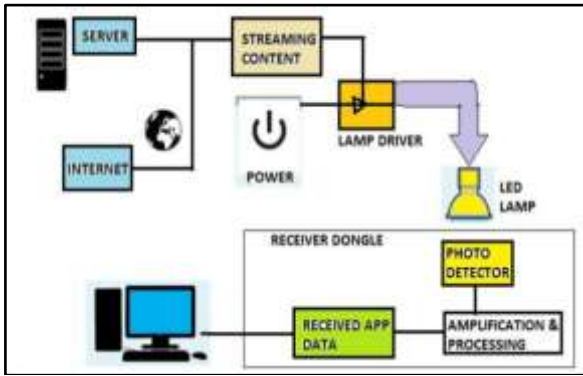


**Figure 1:** Location of visible light and RF frequencies at electromagnetic spectrum.

We can obviously see that usage the optical portion of spectrum guarantees about 10, 000 times greater bandwidth compares to the usage of the RF frequency.

#### B) Methodology

As light is present everywhere it would be very convenient if we channel this into transmitting data. This is where Li-Fi (Light Fidelity) technology comes into play. In Li-Fi, Digital data transmission takes place using LED bulbs with flickering intensity controlled by varying currents. The working is simple as shown in Fig. 2. There is a light emitter at one end. Light emitter can be simply LED. When the LED is on, a digital ‘1’ is transmitted. When the LED is off, a digital ‘0’ is transmitted. This is received by a photo detector at the other end.



**Figure 2:** Digital communication using Li-Fi

This refers to a single bit data transmission. An array of LED's can be connected so that a large amount of data transmission takes place. Speed depends on the rate of variation of LED intensity. In this manner data is encoded and transmitted. The main factors to be considered during design are –

- 1) Line of Sight (LoS).
- 2) Presence of Light.
- 3) Illumination.

#### 4. Features

##### a) Capacity:

Wireless data is transmitted through radio waves which are limited and expensive. It has a limited bandwidth, vis-à-vis Li-Fi. 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 aero- planes 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.

#### 5. Applications

Li-Fi technology has various applications as given below:

- **Smart City :** In the private or public lighting including street lamps can be utilized to endow Li-Fi hotspots and the same communications and sensor infrastructure can be consumed to monitor and control lighting and data.
- **Education:** This is the leading technology that makes better the internet accessibility speed with high bandwidth. Hence educational institutions and organizations can use this technology for internet access with fast speed for

video conference, digital tutorial downloads and online learning.

- **Mobile Connectivity:** The smart phones, tablets, laptops, and other mobile devices can interconnect directly using Li-Fi. This technology use short range links give very high data rates and also provides security.
- **Location Based Services (LBS):** The extremely accurate location-specific information services such as advertising and navigation that enables the recipient to receive appropriate, <sup>17</sup> proper information in a timely manner and location.
- **RF Spectrum Relief:** Due to additional capacity demands of cellular networks can be offloaded to Li-Fi networks where available. This is circumstantially effective on the downlink where bottlenecks tend to occur.
- **RF Avoidance:** Some people's insistence they are hypersensitive to radio frequencies and are looking for an alternative. Li-Fi is a better solution to this problem.
- **Hazardous Environments:** Li-Fi provides a safe substitute to electromagnetic interference from radio frequency communications in environments like as mines and petrochemical plants.
- **Hospital & Healthcare:** Li-Fi no release electromagnetic interference and so do not interfere with medical instruments, nor is it interfered with by MRI scanners.
- **Aviation:** This can be used to reduce weight and cabling and add flexibility to seating layouts in aircraft passenger cabins <sup>2</sup> where LED lights are beforehand deployed. In the flight entertainment (IFE) systems can also be supported and integrated with passengers' own mobile devices.
- **Disaster Management:** Li-Fi can be used as a powerful means of communication at times of disaster such as earthquake or hurricanes, for example places like subway stations and tunnels which are common dead zones for most emergency communications, don't pose obstruction for Li-Fi, so it can be used there, as emergency communication.
- **Game Consoles:** A new idea would be to put sensors on a television in order to receive information from game consoles. This would allow the unit to be placed literally somewhere within the room as long as there is a direct line of sight to the sensor.
- **Underwater Communications:** Because of strong signal absorption in water, RF uses are unsuitable. Acoustic waves have the mostly low bandwidth and disarrange marine life. Li-Fi provides a solution for short-range communications.

#### 6. Advantages of Li-Fi

- 1) Li-Fi can solve problems related to the insufficiency of radio frequency bandwidth because this technology uses Visible light spectrum that has still not been greatly utilized.
- 2) High data transmission rates of up to 10Gbps can be achieved.
- 3) Li-Fi has low implementation and maintenance costs.
- 4) Since light cannot penetrate walls, it provides privacy and security that Wi-Fi cannot.

5) It is safe for humans since light, unlike radio frequencies, cannot penetrate human body. Hence, concerns of cell mutation are mitigated.

- b) Opaque obstacles on pathways can affect data transmission.
- c) It requires a near or perfect line-of-sight to transmit data.
- d) Light waves don't penetrate through walls and so Li-Fi has a much shorter range than Wi-Fi.
- e) Natural light, sunlight and normal electric light can affect the data transmission speed.

### 7. Limitations of Li-Fi:

Some of the major limitations of Li-Fi are:

a) Internet cannot be accessed without a light source. This could limit the locations and situations in which Li-Fi could be used.

### 8. Comparison between existing Technologies

Features	Li-Fi	Wi-Fi	WiMax	Bluetooth
Full form	Light fidelity	Wireless fidelity	Worldwide Interoperability for Microwave Access	Bluetooth full from the epithet of the tenth-century king Harald "Bluetooth" Gormasson
Operation	It transmits data using light with the help of LED bulbs.	It transmits data using radio waves with the help of Wi-Fi router,	Broadband Wireless access	Anywhere at least two Bluetooth devices exist.
Interference	Do not have any interference issues similar to radio frequency waves	Will have interference issues from nearby access points (routes)	WiMAX communications pose a significant interference threat to satellite signals transmitted in the C-band frequency	Bluetooth devices interfere with other technologies
Technology	Present IrDA compliant devices	WLAN802.11a/b/g/n/ac/ad standard compliant devices	Wireless metropolitan area network(WMAN)	WPAN
Applications	Used in airlines, undersea explorations, operation theatres in the hospitals, office and home premises for data transfer and internet browsing	Used for internet browsing with the help of Wi-Fi kiosks or Wi-Fi hotpots	WiMAX serves a larger interoperable network	Bluetooth applications is huge, because we transact business and communication more with people who are close by than with those who are far away
Merits	Interference is less, it can pass through salty sea water, works in a dense region.	Interference is more, cannot pass through sea water, works in less dense region	WiMAX can be used for long range. It provides broadband connectivity up to varied ranges, around 30km.	Setting up a Bluetooth connection between two devices is quick and easy. A Bluetooth headset is compatible with any other device that supports Bluetooth.
Privacy	In Li-Fi, light blocked by the walls and hence will provide more secure data transfer	In Wi-Fi, RF signal can't be blocked by wall and hence need to employ techniques to achieve secure data transfer	WiMAX uses X.509 or PKMv2 as authentication algorithms. Mandatory-3 DES Optical-AES	Bluetooth offers several security modes and device manufactures determine which mode to include in a Bluetooth-enabled gadget.
Data transfer speed	About greater than 10Gbps	WLAN -11n offers 150Mbps, About 1-5Gbps can be achieved using WiGig/Giga-IR	Waves at bps/Hz and can peak up to 100 Mbps in a 20 MHz channel.	800Kbps
Frequency of operation	10000 times frequency spectrum of the radio	2.4GHz, 4.9GHz and 5GHz	Licensed/Unlicensed 2G to 11GHz	2.4GHz
Data density	Works in high dense environment	Works in less dense environment due to interference related issues	Works in high dense environment	Less dense
Coverage distance	About 10 meters	About 32 meters(WLAN802.11b/11g), vary based on transmit power and antenna types	Up to 40 miles	About 10 meters
System component	Lamp driver, LED bulb (lamp) and photo detector will make up complete Li-Fi system.	Requires routers to be installed, subscriber devices (laptops, PDAs, desktops) are referred as antenna	There are three main components of WiMAX network architecture: the mobile stations, an access service network and connectivity service network which is responsible for providing IP functions.	Four major components: Radio Unit(radio transceiver), Baseband Unit(flash memory & CPU), Software Stack(driver software) and Application Software(user interface)
Power consumption	Medium	Medium	High	Low
Cost price	Low	Medium	Medium	Low
Working concept	Direct Binary Data Serving	Various Topologies	Request/Grant	Master-Slave

## 9. Challenges for Li-Fi

Over some advantages this technology in facing some problems such as it requires line of sight (LoS) and receiving device would not be shift in indoors will transmit data back to transmitter. Also one important issue is interference from external light sources like sun light, normal bulbs; opaque materials in the path of transmission will cause interruption in the communication. Another disadvantage is that Li-Fi doesn't work in the dark or light can't pass through objects, so if the receiver is inadvertently blocked in any way, then the signal will immediately cut out, and the signal is easily blocked by somebody simply walking in front of the LED source.[16][21]

## 10. Conclusion

With the use of LEDs the information can be transmitted at very high rates with just the simple turning on and off of the LEDs. Hence the ongoing increase in the cellular networks, the newest technology of Li-Fi has proven to be a visible spectrum of light which is far better than the RF as it is prone to interference. This technology is not only free to use but also provides a safe and secure access.

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