

# Comprehensive Review on Light Fidelity

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## ABSTRACT

Light fidelity technology transmits the wireless internet by light emitting diode. Utilizing a various segment of the visible spectrum from radio frequency. There are different technologies which are already introduced for transmitting and receiving data without help of wired medium, e.g. Wi-max, Bluetooth, Wi-Fi etc. Working of these technologies are based on radio waves which are very harmful for the human environment and health. Li-Fi can be used in aircrafts, scan centers, hospitals, without harming the human society. Li-Fi is more advance and it is having high speed as comparable with other technologies. In Li-Fi, the intensity of light is very high so that human eye can easily capture and follows it. In this paper, we discuss the comparison of light fidelity with other wireless schemes, advantages, applications and problems associated with Li-Fi.

**Keywords:** Light Fidelity, Visible Light Communication, radio waves, Wi-max, bluetooth.

## I. INTRODUCTION

In a current scenario, communication is the basic need of a common man. People can do communication with both wired and wireless medium according to the requirement. Some time ago, people use internet just for data sharing, communication, gaining knowledge, social activities and education but nowadays, people having interest in transmitting the data safely and efficiently using good bandwidth and low cost or we can say that, All the things are dependent on internet technology; it is very difficult for people to survive without internet.

Wireless Fidelity (Wi-Fi), Wi-max, and Bluetooth are the technologies which people are using these days. These all technologies are based on IEEE standards.

Wi-Fi is based on 802.11 IEEE standards. This technology is a combination of microwave and radio wave frequencies. Wi-Fi another name is WLAN [16]. This technology changed the mind of common people and also through wireless technology people can share their views and data one place to another place with 2.4 to 5 GHz frequency band [3]. Wi-Fi technology can be very easily found in the computers and internet access device such as, routers, and cable modems. People are using this technology for various applications like, internet telephony, watching movies online, music streaming and gaming extracts [16]. Approximately 204.1 million people are using smart phones in all over world. Researchers say that they are using 600 terabytes of data in every month [3]. As we all know that everything has pros and cons so Wi-Fi also have some limitations for example, it can cover only 100 meters of distance, capacity of channels is limited and less security.

To overcome Wi-Fi challenges professor Harald Haas introduce a new technology in his TED global talk on visible light communication in 2011 from university of Edinburgh in the United Kingdom, the name of this technology is Light Fidelity (Li-Fi). In accordance with Hass, high data rates (more than 10Mb/s) can be produced by using D-Light (referred by him) that are fastest than Wi-Fi [5]. As we all know

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that human is impossible without light, they need light while surviving good life style. If the data transmission is possible through light than nothing can be outperform with that technology that is why Professor Harald Haas gave an idea called “data through illumination” [8]. In his idea, he used fiber optics to send and receive data through light emitting diode bulbs or tubes. LED spectrums are varying in intensity faster so that human eye can follow it. The researchers said that, Li-Fi is a technology which has high speed of communication, also it is bidirectional, and with this it can be in a form of Visible Light Communication (VLC). VLC has spectrum wavelength from 380 nm to 750nm [8]. In this spectrum, researchers are using bulbs, if the bulbs are in on position then we can send and receive data, if bulbs are in switch is off then it stops sending and receiving data. In addition, Li-Fi put great effect in automation industry. In this industry, it can be implemented in vehicle to vehicle communication and in intelligent transport system.

If we compare light fidelity with wireless fidelity, then it is 100 times faster than Wi-Fi. The reaching speed of light fidelity is 224 Gbps. In this technology, researchers were applying some modulation techniques that are, PWM (Pulse Width Modulation), PPM (Pulse Position Modulation, PAM (Pulse Amplitude Modulation), and OOK that is on off keying, but these are not bandwidth efficient and these techniques may create Inter Symbol Interference (ISI) [9]. There are some better techniques which are based on digital communication and also applicable for light emitting diode system. These techniques are Digital Based Orthogonal Frequency Division Multiplexing (DCO-OFDM), Asymmetrically Clipped Optical Orthogonal Frequency Division Multiplexing (ACO-OFDM) [9].

Because we are using light emitting diode in light fidelity so this is directly connected with the optical frequency. This optical frequency may be suffered from attenuation and that attenuation may be much higher than micrometer waves in the environment of wireless. From this process, the reflective energy might be low just because of Optical Wireless Communication (OWC) and VLC [6]. But these things are limited for point to point links in indoor where the Line of Sight (LOS) comes into picture. In addition, some limitations of light fidelity are line of sight blocking and non-uniform spatial distribution of data rates, caused by Co-Channel Interference (CCI) have initially been studied in [6]. Li-Fi has enough advantages than disadvantages like; more secure than wireless fidelity and it can be easily installed. The data can be easily transferred with light as shown in figure 1 [1].

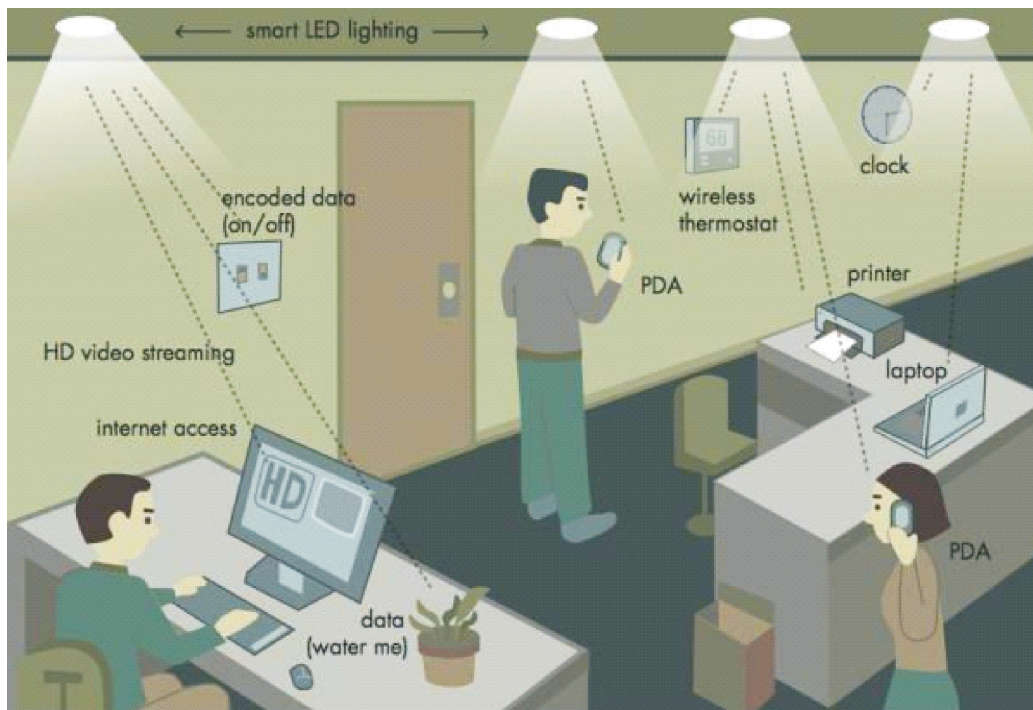


Figure 1: Li-Fi data transferring [1, 2]

## II. PRINCIPLE AND ARCHITECTURE OF LIGHT FIDELITY

Light is the prime requirement of everyone. To take advantages from light engineers introduced light fidelity. So, we can say that Li-Fi is based on the visible light communication which requires present light, server, internet, power, lamp driver, LED bulb, photo detector and desktop are the main components which are used by Dr. Hass in Li-fi as shown in figure 2. Researchers are using light bulb which conserves a big scale of electricity by data transmitting and receiving through light emitting diode bulbs and other equipment of light. Light cannot be crossed through the hard things, such as wood, steel, walls and these kind of other materials [14]. The transmitter and receiver is applied on the LED bulbs and current is flowing in the light emitting diode at very high speed [13]. Engineers are using digital coding or binary coding for sending and receiving the information. If the LED is in on mode than you transmit a digital 1 and if it is on off mode, you transmit digital 0 [2]. The procedure of on and off is very fast so we can send and receive our data at very fast rate. The procedure of using instant light pulses to send data over wireless medium is considered as Visible Light Communication (VLC), however its capability to cope up with typical Wi-Fi has stimulated the well-known features Li-Fi [17].

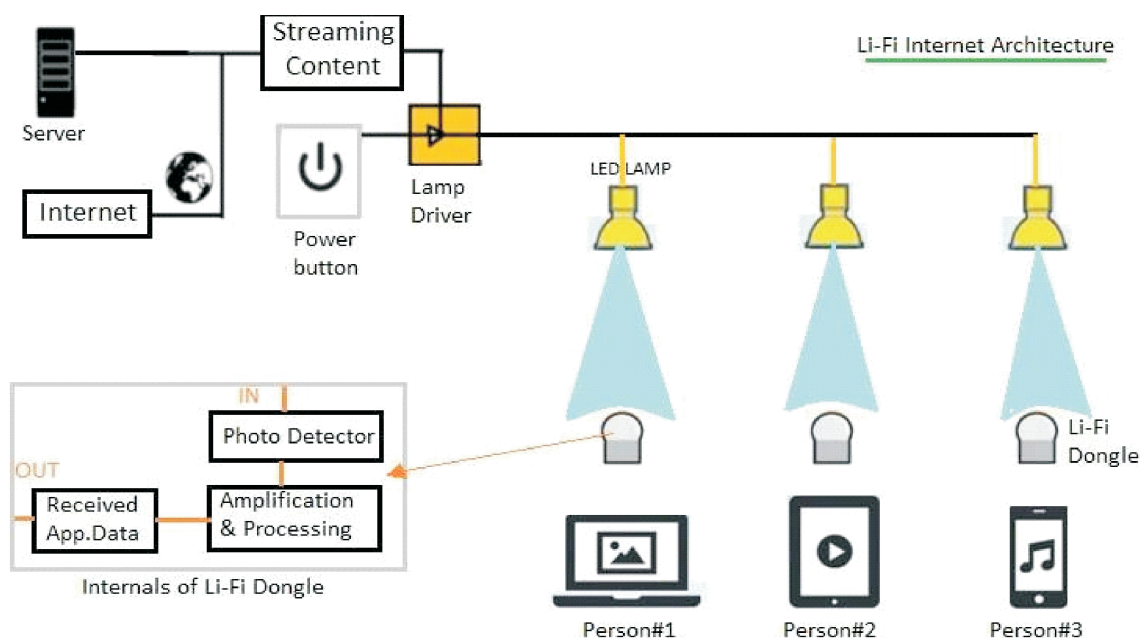


Figure 2: Working of Li-Fi [8]

## III. WORKING OF LIGHT FIDELITY

LED's functioning in Li-fi technology is not difficult. In this, a smart LED which has very good brightness, which would work as a transmitter. Li-Fi usually uses LED bulbs at the downlink transmitter. A photo detector or silicon photo detector used as a receiver. Generally, a continuous current is applied to the LED to use them. But by varying the current at a very fast rate, the optical output transmits a digital 1 that means the LED is ON, when we transmit a digital 0 that means LED is OFF, [1]. We can easily transmit data by switching the LED ON and OFF very rapidly as shown in figure 3. A collection of LEDs of some dissimilar colors is used to generate the message and to acquire data transfer rates in the range of hundreds of Mbps. Thus, we need LEDs and a controller which can code data into those LEDs in order to set up the system. Now, by varying the rate at which the LED flick, one can encode the desired data and thus transmit the data very easily [11]. 'Flickering' is continuous appearance of source of light because of fast on/off switching of LED. We may also make certain improvements to the system by using an array of LEDs for parallel data transmission and using a mixture of red, green and blue LEDs to alter the light frequency, with each frequency encoding a different data channel [17]. Theoretically, speeds of up to 10Gbps can be achieved by using such a system.

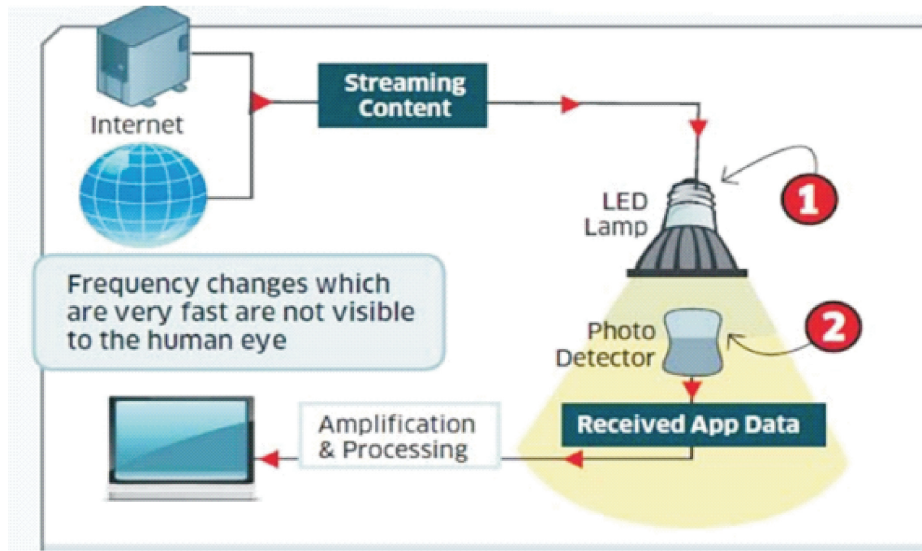


Figure 3. Block Diagram of Li-Fi system

**IV. COMPARISON OF LI-FI AND VLC**

LEDs are used by VLC to transmit data via wireless medium and data is modulated using intensity modulation (IM). At the receiver end, Photo-Diode (PD) detects the signal using the principle of Direct Detection (DD) as shown in figure 4.

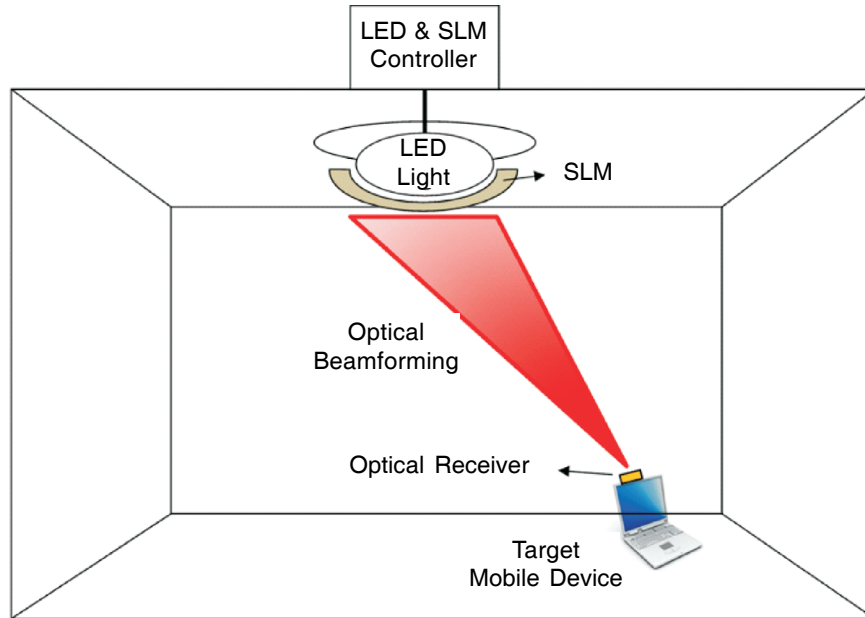


Figure 4: Visible Light Communication

Some of the parameters that are showing differences between VLC and Li-Fi are mentioned in Table 1.

**Table 1**  
**Difference between VLC and Li-Fi**

Parameter	VLC	Li-Fi
Mode	Unidirectional communication	Bidirectional communication
Spectrum used	Uses only visible light	Uses any possible light like visible and infrared
Speed	Less	High



VLC is a one-way single user point to point data communication technique whereas Li-Fi in contrast is a two-way multiuser communication, i.e. point-to-multipoint and multipoint-to-point communication. It also includes multiple access points, i.e. it enables full user mobility. Moreover, the VLC can use the visible light only whereas Li-Fi can use any of the possible light, mostly the infrared light. Hence, Li-Fi is best as compare to VLC.

#### IV. MODULATION TECHNIQUES USED BY LIGHT FIDELITY

- a) **OFDM [1] [Orthogonal Frequency Division Multiplexing]**: This scheme comes under the frequency division multiplexing that is used for digital multi carrier modulation method. A high scale number of closely spaced orthogonal sub carrier signal are to transmit data on different parallel data stream.
- b) **OOK [1] [On Off Keying]**: That is comes under the simplest form of appearance and non-appearance of carrier signal. We are using binary one to represent the appearance of a carrier for a specific duration and binary zero for non-appearance for to represent the same duration. This is called as analog to bipolar encoding line coding.
- c) **PPM [1] [Pulse Width Modulation]**: It is ability to convert a message code into pulse signal. There is time duration to convert this data into encoding pulse. Huge number of data can convey within each pulse.
- d) **SCIM [1] [Sub Carrier Index Modulation]**: In this technique, we are using two-dimension Phase / Amplitude modulation technique, first are Amplitude Shift Key modulation technique and second are Quadrature Amplitude Modulation.

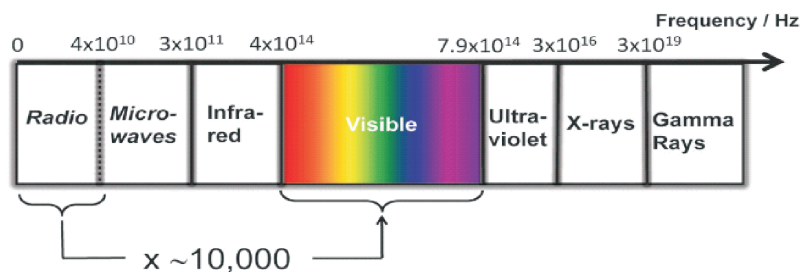


Figure 5: Li-Fi versus Wi-Fi [17]

From the Table 2. and Figure 5, we can say that Li-Fi is faster in speed with respect to Wi-Fi and also its frequency band is in THz and bandwidth of Wi-Fi is in GHz. Li-Fi is more secure with high speed, high density but less range. In Li-Fi, data is transferred using bits whereas in Wi-Fi, data is transmitted using radio waves. Because of all these benefits, Li-Fi is considered as best over Wi-Fi [17].

#### V. APPLICATIONS OF LIGHT FIDELITY

Actually light fidelity is based on light bulb or tube so; human beings are totally depending on lights. If life is totally based on light and light is used for transmitting and receive the data, there are many applications where which we are using this light fidelity. We are discussing application of light fidelity one by one.

**Medical world:** In Wi-Fi we are using radio waves which are very dangerous for human health. From these radio waves humans are suffering from heart diseases, allergy in eyes, cancer excretes. So wireless is prohibited in the hospitals special in operation theaters. But in Li-Fi we are using light so it can be used in hospitals as well as in the Operation Theaters (OTs) because it did not produce radio waves which generally harmful for the persons who are suffering from critical pain.

**Under Water Application:** Military officers are using Remotely Operated Vehicles to transceive information in under water. These remotely operation vehicles did not cover huge area but with the help of Light Emitting Diode (LED) bulbs military officers can easily take advantages from internet with high speed and from it they can cover large distance.

**Education world:** Wi-Fi is little expensive technique and having limited area and there are no visible or wired connections of Wi-Fi without landline telephones. But, with the help of Li-Fi students can take advantages from internet everywhere because light connections are already built in every area. From this the need of sharing is almost finished. In the library students can take advantages at night time with the help of light.

**Disaster Management:** Li-Fi can use powerful means of communication in the case of earthquake and natural calamities.

**Internet access in aircraft:** Wi-Fi is prohibited in the airplanes because it interfaces with the navigation system of airplanes, but with Li-Fi these is no problem for this kind of issue so we can take advantages of internet in airplanes also.

**Radio Broadcast:** A huge amount of power is required by radio to establish a broadcast. On other hand VLC require a very small power to operate the broadcast. This is used for radio broadcast because we are using data communication as well as video data communication. Variable bit rate, constant bit rate we are using in the Li-Fi.

## VI. RECENT ADVANCEMENTS AND COMPARISION OF LI-FI VS OTHER WIRELESS TECHNOLOGIES

**Li-Fi in smart cities:** In the light fidelity technology, using led light bulbs to transmit the data, with including high speed of data connections that may serve from street light, motorbike light, traffic light could be added to the emergence of smart cities. Lights are present everywhere in the smart cities and metro cities so it proved that the Li-Fi network can be used in smart cities.

**Li-Fi technology is true enables of internet of things:** The researches in the University of Edinburgh states that, the Li-Fi node could be built on strong communication and network capacities of optical wireless physical layer and internet protocol layers with a clear vision to connect things anytime and anyplace with the minimal capability and expenditure.

**Topology matters the most in the future:** Scientists and researchers published worldwide indication that future network will fast but the capacity ability could be still same. Point to point topology we are using in this for indoor application.

**Improved networking and reliable communication in a Li-fi network:** The technology of light fidelity comes with high speed, bi-directional and fully networked broadband wireless technology which may aim at offloading the exiting Wi-Fi technology.

**Light bring users superfast wireless internet:** In classrooms, cars and the shops we can use light fidelity to access the internet. If we compare Li-Fi with Wi-Fi which is 10 times better than the Wi-Fi. Because the speed of Li-Fi depends upon the light intensity if we use large bulb of LED than it can provide high speed of internet.

**Nodes of access networking technology –its inherent programmable features:** In this technique there is used number of photons that converts light signal into electrical signal. This technology also deals with five generations in smart phones. White blubs we are using in this technology.

**Table 2**  
**Comparison of Li-Fi with other Wireless Technologies [4][12][15]**

<i>Parameters</i>	<i>Bluetooth</i>	<i>Wi-Fi</i>	<i>Wi-MAX</i>	<i>Li-Fi</i>
Introduced year	1994	1998	2001	2011
IEEE Standard	802.15	802.11	802.16	802.17
Frequency band	2.4 GHz	2.4GHz-5GHz	2GHz-11GHz	10 thousands time frequency spectrum of radio
Range (covered area)	10 meters	100 meters	30 miles	Depends upon LED light intensity
Network topology	Point to point and point to multi-point	Infrastructure, ad-hoc	Mesh environment	Pear to pear indoor application.
System components	Interoperability and replacement of cable	Router, DSL, Cable, modem	Downstream-TDM, upstream-TDMA.	Lamp driver, LED bulb, and photo detector.
Modulating techniques	GFSK	DSSS	QAM	DCO-OFDM, ACO-OFDM
Network	LAN	WPANs	MAN	WPAN
Speed	25 Mbps	54 Mbps	10 Mbps	224 Gbps
Advantages	Secure at short distance, third party can't attack	Multiple user can share internet at the same time	Faster categorization, back compatibles	Interference is not there, more secure.
Disadvantages	Battery drain, security is poor, slow transferring	Security, range of 10 meters, speed.	Poor bandwidth, unreliable services and cost	Light may interfere the signal, light is necessary, LOS problem
Challenges	Speed of data transfer and security	Range and security	Quality of services	Line of sight

## VII. ADVANTAGES OF LIGHT FIDELITY

In Li-Fi we are using light rather than the radio waves which create noise in signals.

- Li-Fi we are using anywhere at any place, for example: it can be used in aircrafts without effecting airline signals.
- As far we discussed that in the hospitals the use of radio waves are prohibited but in Li-Fi we are using VLC, so it would be used in hospitals in future.
- Wi-Fi cannot be used in underwater because it can affect the sea area, but with the help of Li-Fi we can internet service in underwater as simple. Data is more secure as compare to Wi-Fi because the signal cannot be passed from the walls.
- We can take advantages from street bulb for free internet. There is no need to store radio wave frequency in Li-Fi.

## VIII. CHALLENGES OF LIGHT FIDELITY

Nothing in this World is perfect. If there are advantages of something, the disadvantages are also being there.

- These signals cannot penetrate walls. So the person needs wired bulb in that room also.
- Only works if there is direct line of sight between source and receiver.
- Used for broadcast and it is difficult to uplink.

## CONCLUSION

The Li-fi technology will be practically used sooner, with the advancement in technology and use of the internet services. Li-Fi bulbs will be used instead of other bulbs. The use of Li-fi might replace technologies dependent on radio waves. With increase in quantity of users, use of internet is growing on large scale; hence, the requirement for the bandwidth is also increasing which is making Wi-Fi insufficient. Also, the increase in network traffic will lower the internet accessing speed. Thus the use of Li-fi will might replace Wi-Fi in future, providing the high speed of data transfer. In future, transmission of data on electronic devices can be done via light using Li-Fi. The advance research of developing micron sized LED is going on which can switches between ON and OFF approx. 1000 times rapidly than big LED. It will provide data transmission with increased speed and will introduce more LED's to increase the channel communication by covering less space. It is confirmed that the Li-Fi is the future of internet. It might be possible to achieve data rates of 10Gbps, i.e. a HD movie can be downloaded in 30 seconds.

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