A Comparative Study and Analysis on Li-Fi and Wi-Fi

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ABSTRACT
Li-Fi also called as Light Fidelity is a new technology that uses light source i.e. light emitting diodes that can be used for high speed communication. It is a better alternative as compared to Wi-Fi technology. It is a safer, greener and cheaper technology as it does not have any radio waves or any other type of waves. The founder of this technology is Professor Herald Hass. This technology provides better capacity, security, and availability as compared to Wi-Fi. The concept flickers so fast that it cannot be detected by human eyes and thus transfers the data using on-off state.

Keywords
Li-Fi (Light Fidelity), Wi-Fi (Wireless Fidelity), VLC, LED, RF.

1. INTRODUCTION
Users are acquainted with Wi-Fi (Wireless Fidelity), which uses 2.4-5GHz RF to provide wireless Internet access around the offices, schools, homes and even in public places. But like most technologies, it has its restrictions. While Wi-Fi can cover an entire place, its bandwidth is restricted to 50-100 megabits per second (Mbps) [2]. The speed of Wi-Fi is good, but insufficient for transfer large files such as HD movies, music collections and video games. Being dependent upon the cloud or media servers to store all the files, such as music, movies, pictures and games, the more bandwidth and speed will be needed. Therefore Radio Frequency-based technologies such as Wi-Fi are not the ideal way. Wi-Fi may not be the most effective way to deliver desired capabilities such as gesture recognition and precision indoor positioning.

From the University of Edinburgh in the UK, Professor Herald Haas the founder of Light Fidelity. "Data through Illumination" i.e Li-Fi - taking the fiber out of fiber optics by sending data through an LED light bulb that differs in intensity faster than the human eye can follow [5, 9]. By August 2013, data rates over 1.6 Gbps were exposed over a single color LED. September 2013, a press release said that Li-Fi, or Visible Light Communication systems generally, do not require line of sight conditions [9]. Li-Fi is now a part of Visible Light Communication (VLC) PAN IEEE 802.15.7 standard.

Optical wireless technologies are at times also called as visible light communication (VLC) and more recently referred to as Li-Fi (Light Fidelity), that offer an entirely new model in wireless technologies in terms of communication speed, usability and flexibility[2]. Li-Fi acquired this name due to resemblance to Wi-Fi, using light instead of radio waves. The challenges that Wi-Fi faced in today's time such as availability, capacity, security and efficiency which is the most leading reason which drove researchers and scientists to develop a new way of wireless connectivity. Light waves cannot penetrate walls which makes the range shorter, and more secure from hacking, compared to Wi-Fi. Li-Fi can produce data rates faster than 10Mbps which is speedier that any average broadband connection. As compared to radio waves, light is naturally safe and can be used in areas where RF is often considered problematic such as hospitals or aircraft cabins.

The technology was demonstrated in Las Vegas at the 2012 Consumer Electronics show using a pair of Casio smart phones to exchange data using light of variable intensity given off from their screens, evident at a distance of up to ten meters.

2. LITERATURE SURVEY
LiFi Integrated to Power-lines for Smart Illumination cum Communication paper describes about Li-Fi is a new technology for short range wireless technology to provide connectivity within localized network environment. This technology provides a THz visible light communication (VLC) which sends the data by flashing the light at speeds undetectable to human eyes. The LED lights used in Li-Fi are cheap, durable, and secure and provide good performance. VLC is free of any health concerns, as it uses eco-friendly green technology rather than microwaves, which can cause harm to human body. If PLC is combined with VLC, there would be more benefit and the use of Li-Fi for wireless connection to devices by a simple plug-and-play technique.

The VLC systems use LED to send data by flashing light at speeds undetected to human eyes. LEDs are more advantageous than the existing fluorescent tubes. The visible light occupies unregulated and unlicensed THz spectrum since it does not cause or suffer from any electromagnetic interference, whereas interference is common using Wi-Fi or any other RF systems. VLC is free from any health concerns, as it uses eco-friendly green technology rather than microwaves, which can cause harm to human body.

There are 4 parts in the hybrid system. They are layer framework, composition of integrated system, channel model and modulation scheme. The layer framework is divided into PHY layer and MAC layer. The Li-Fi is built on composition of VLC and PLC. PLC transmitter excludes amplification and driving circuitry is added to the LED transmitter parts. The signal that comes through the power-line is received through the exclusive PLC module chip and is converted into signal form by a transconductance (TCA) amplifier. The powerline channel does not represent an AWGN, but it includes a superposition of five noise types:

1. colored background noise
2. narrowband noise
3. periodic impulsive noise asynchronous to the main frequency
4. periodic impulsive noise synchronous to the main frequency
5. asynchronous impulsive noise.

The modulation scheme used is 16QAM.

A survey on Transmission of data through illumination - Li-Fi paper talks about Wi-Fi is the most used technology by everyone, but there is an emerging technology Li-Fi, which refers to apparent light communication systems that uses light from light-emitting diodes (LEDs) as a standard to deliver mobile, networked, high-speed communication in a similar manner as Wi-Fi. Visible light communications (VLC) indicates by switching bulbs on and off within nanoseconds, which is too rapid for the human eye to notice. Although Li-Fi bulbs would have to be kept on to transmit data, the bulbs could be dimmed to the point that they were not visible to humans and yet still functional. Direct line of sight is not necessary for Li-Fi to send signal and light reflected off of the walls can accomplish 70 Mbps. There are approximately 19 billion bulbs worldwide, which just need to be replaced with LED so that it would allow data transmission.

The data transmission in Li-Fi is done by turning the LED blubs on-off so fast that it cannot be detected by human eyes. Switching on and LED is a logical '1', switching it off is a logical '0'. A light sensitive device receives the signal and converts it back into original data. Li-Fi is fast and cheap as compared to Wi-Fi.

Speed and security is a major concern while transmitting data. Data transmitted through Wi-Fi are susceptible to hackers as it penetrates through walls easily. Li-Fi on the other hand do not penetrate walls and so provides more security. The main component of Li-Fi communication is the white LED, which acts as a communication source and a silicon photodiode which shows good response to visible light. A data rate of greater than 100Mbps is possible by the high speed LEDs.

Data Transmission through LI-FI:

- VLC can be used safely in aircrafts.
- Integrated into medical devices and in hospitals as this technology does not deal with radio waves, so it can easily be used in such places where Bluetooth, infrared, Wi-Fi and internet are banned.
- As light does not penetrate walls it provides better security.
- Wi-Fi does not work under water, which is possible using Li-Fi.
- Every street lamp would be a free access points for this technology.
- This technology will solve the issue of shortage of radio frequency bandwidth.

3. PRINCIPLE AND WORKING

The heart of Li-fi technology is high brightness LED's. These Light Emitting Diodes can be switched on and off very quickly which gives you the opportunities for transmitting data since operating speed of an LED is less than 1µs. The Visible light communication is a data communications medium using visible light between 400 THz (780 nm) and 800 THz (375 nm) as optical carrier for data transmission and illumination [2].

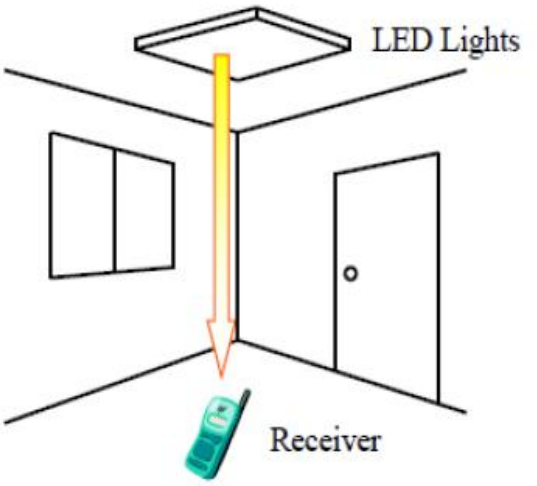

Fig 1: Typical example of Visible light communication: Use of LED illumination as a transmitter

The importance of using VLC is that frequency above 3THz is not regulated by radio regulating laws.

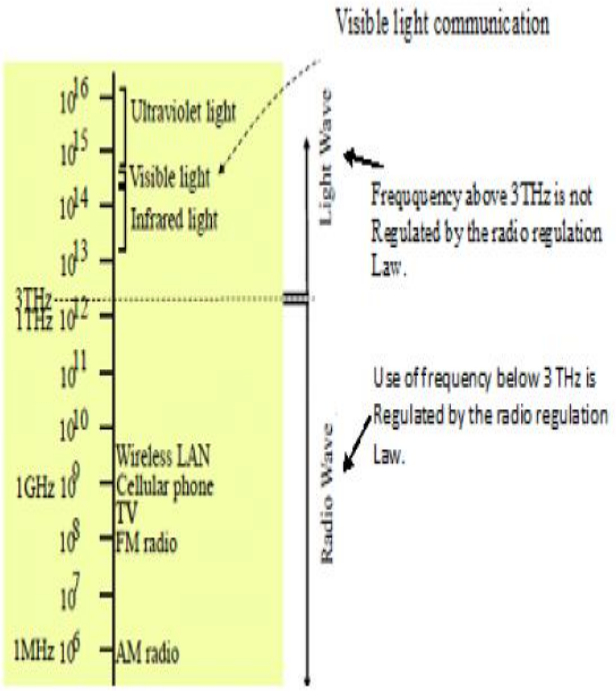

Fig 2: Spectrum of radio and light waves

The LIFI product consists of 4 primary sub-assemblies:

- Bulb
- RF power amplifier circuit (PA)
- Printed circuit board (PCB)
- Enclosure

- The PCB controls the electrical inputs and outputs of the lamp and houses the microcontroller used to manage different lamp functions. An Radio Frequency signal is generated by the solid-state PA and is guided into an electric field about the bulb. The high concentration of energy in the electric field vaporizes the contents of the bulb to a plasma state at the bulb's center; this controlled plasma generates an intense source of light. All of these subassemblies are contained in an aluminum

enclosure [8]. The dielectric material serves two purposes; first as a waveguide for the RF energy transmitted by the PA and second as an electric field concentrator that focuses energy in the bulb. The energy from the electric field rapidly heats the material in the bulb to a plasma state that emits light of high intensity and full spectrum.

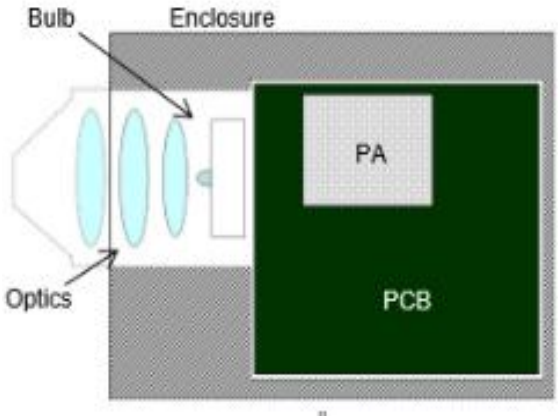

Fig 3: Li-Fi Block diagram

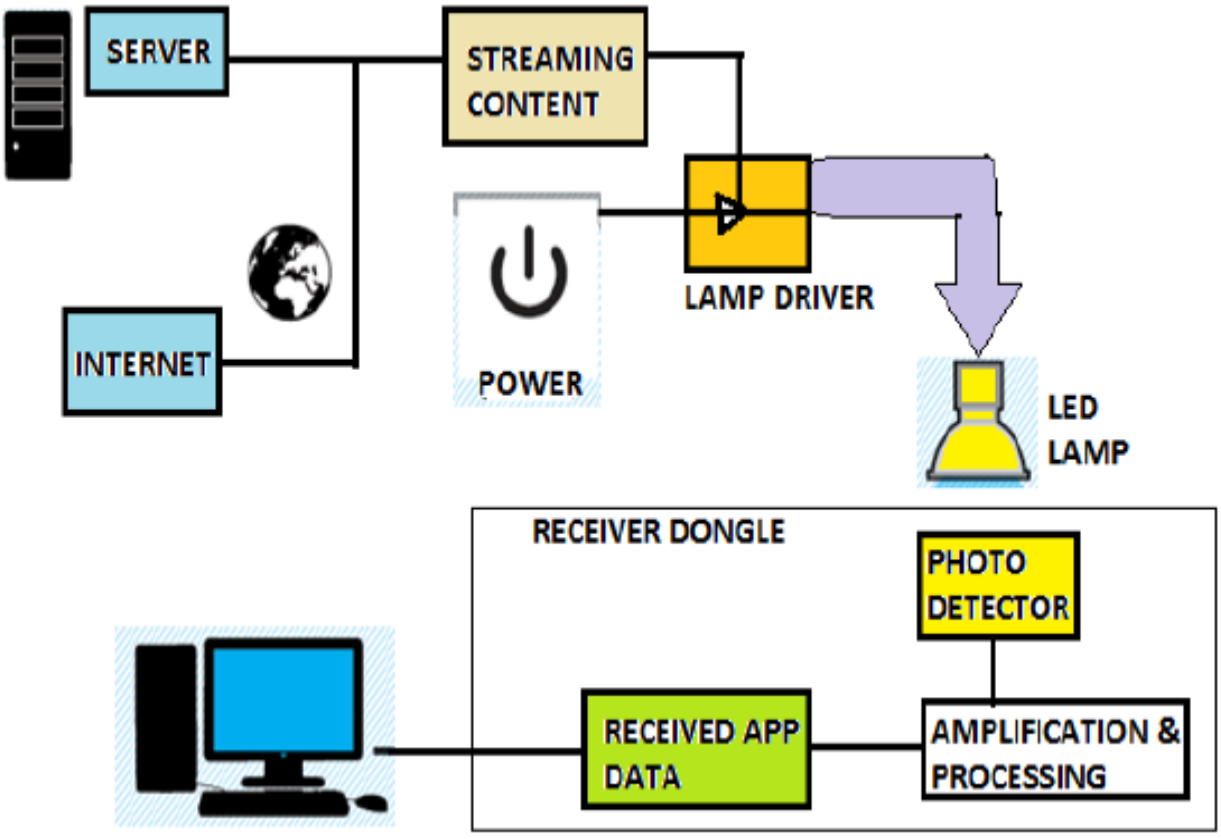

Fig 4: Working of Li-Fi

The operational procedure is very simple, if the LED is on, you transmit a digital 1, if it's off you transmit a 0. It requires some LEDs and a controller that code data into those LEDs. It is required to vary the rate at which the LED's flicker depending upon the data that is to be encoded. Further enhancements can be made in this method, like using an array of LEDs for parallel data transmission, or using mixtures of red, green and blue LEDs to alter the light's frequency with each frequency encoding a different data channel [2]. Such advancements promise a theoretical speed of 10 Gbps – meaning one can download a full high-definition film in just 30 seconds. For a section head and a subsection head together (such as Section 3 and subsection 3.1), use no additional space above the subsection head.

4. COMPARATIVE STUDY / SUMMARY

Wi-Fi is a generic term used for Wireless Fidelity i.e. IEEE 802.11 communication standard, which is commonly used to connect devices to each other, to the internet and to wired networks. When Wi-Fi enabled device encounters a hotspot the device can then connect to that network wirelessly [8]. A single access point can support upto 30 users and can function within a range of 100-150 feet indoors and upto 300 feet outdoors [6].

Table 1: Comparison between Li-Fi and Wi-Fi

Sr. No.	Parameters	Wireless Technologies	
		Light Fidelity	**Wireless Fidelity**
1.	Speed for data transfer	Faster transfer speed (>1Gbps)	Data transfer speed (150Mbps)
2.	Medium through which data transfer occurs	Use Light as carrier	Use Radio spectrum
3.	Spectrum Range	Visible light spectrum has 10,000 times 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 it 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	2.4GHz

Li-Fi on the other hand, is a VLC, visible light communication technology. Li-Fi is typically implemented using white LED light bulbs. These devices are normally used for illumination by applying a constant current through the LED [1]. Li-Fi is typically implemented using white LED light bulbs at the downlink transmitter. These devices are normally used for illumination only by applying a constant current. However, by fast and subtle variations of the current, the optical output can be made to vary at extremely high speeds [3].

Both these technologies are used for the data connection but there are some drawbacks of Wi-Fi which can be reduced by the emerging technology that is Li-Fi. In simple terms Li-Fi can be thought of as a light based Wi-Fi. It uses light instead of radio waves. And instead of Wi-Fi modems, Li-Fi would use transceiver-fitted LED lamps that can light the room as well as transmit and receive information [3].

The below table also contains the current wireless technologies that can be used for transferring data between devices today, i.e. Wi-Fi, Bluetooth and IrDA. Only Wi-Fi currently offers very high data rates. The IEEE 802.11.n in most implementations provides up to 150Mbit/s but during implementation the speed even drops further.

Table 2: Comparison between current and future wireless technology

Technology	Speed
Wi-Fi – IEEE 802.11.n	150Mbps
Bluetooth	3Mbps
IrDA	4Mbps
Wireless (Future)	
WiGig	2Gbps
Giga-IR	1Gbps
Li-Fi	>1Gbps

5. HOW IS IT DIFFERENT?

The four major challenges/limitations which the current wireless system faces are easily handled by this technology. Capacity, the first challenge, is very limited as compared to the visible light spectrum (ratio of 1:10000) and therefore no shortage of the ever increasing demand of wireless spectrum. Availability, being the second issue is solved as light is easily accessible as compared to Wi-Fi [8]. For example in hospitals and airplanes radio waves cause interference and hence avoided. Efficiency is the issue of utmost concern as the radio cellular base stations consume a lot of energy and mostly to cool them rather to transmit data and therefore only operational up to 5% efficiency, on the other hand LEDs are highly efficient and energy consumption is never a problem [8]. Security, an issue which can't be neglected is a snap-if you can't see the light you can't access the data while radio waves which can penetrate through walls make it prone to breach the security protocols.

6. APPLICATIONS AREAS of Li-Fi

i. **Live a Little Longer:** Operating rooms do not allow Wi-Fi due to radiation, and there is also that a whole lack of dedicated spectrum. Due to Wi-Fi interference from cell phones and computers causes signal blocking from monitoring equipment. Li-Fi solves both problems: lights are the most glaring fixtures in the room; And Li-Fi also has 10,000 times the spectrum of Wi-Fi [7].

Fig 6.1: Light inside an operation theatre

ii. **Undersea Awesomeness:** Underwater Remotely Operated Vehicles, operate from large cables that supply their power and allow them to receive signals from their pilots above. ROVs work great, except when the tethers aren't long enough to explore an area, or when it gets stuck on something.

If their wires were cut and replaced with light — say from a submerged, high-powered lamp — then they would be much free to explore. They could also use their headlamps to communicate with each other [7].

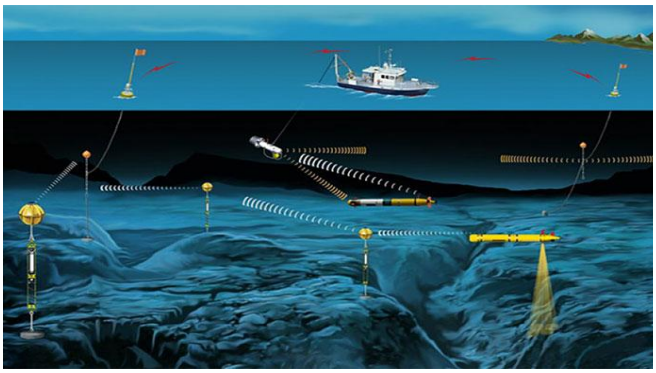

Fig 6.2: Underwater communication

iii. **Smarter Airlines:** At flight there is a problem of accessing internet, as the whole airways communication is performed on the basis of radio waves. To overcome this drawback Li-Fi is introduced. Li-Fi can provide that speed to every passenger seat's reading light.

Fig 6.3: Li-Fi potential inside an airplane

iv. **Better and Efficient Power Plants:** Wi-Fi and many other radiation types are bad for sensitive areas like power plants. On contrast, thermal power plants need fast inter-connected data systems to monitor things like demand, grid integrity and (in nuclear plants) core temperature. In such situations Li-Fi would provide access with no radiation. This would help to save money as these power plants have ample of light source which can be converted to supply communication access [7].

Fig 6.4: Power plant lights

v. **All Information under a Street Light:** You plan for a trip and find that you are out of your data pack or your Wi-Fi isn't working. You will just need a street light or any light source to book you plan. Thus Li-Fi could provide cheap high-speed Web access to every street corner [7].

Fig 6.5: Li-Fi potential under a street light

vi. **Green information technology:** Li-Fi can be called as Green information technology as it does not effect on the birds, human body's etc., like the radio waves or any other communication waves. It does not have any side effect on any living thing.

vii. **Free From Frequency Bandwidth Problem:** There is no problem with the frequency of the Li-Fi as it uses light for communication. Also it does not require any bandwidth so it does not need to pay anything for license.

viii. **Multi User Communication:** Li-Fi provides the broadcasting that would help share numerous things at a single instance.

ix. **It Could Keep You Informed and Save Lives:** For example, if there is any disaster as soon as the vehicle passes through a street light it would get a intimation and also the safety precautions that most of us are unaware of. This would also help at subways or tunnels as well as emergency zones where communication is a must. At such places street lights would provide a high speed web access at cheap cost.

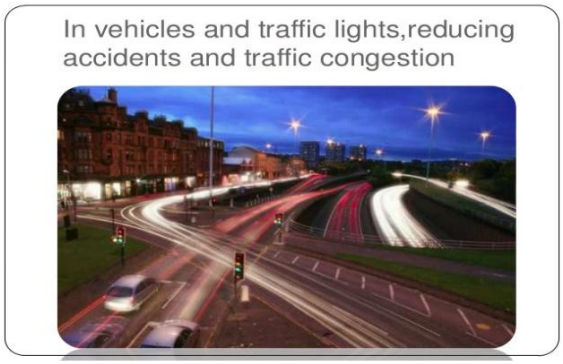

Fig 6.6. Reduce accidents using Li-Fi

7. CONCLUSION

The possibilities are numerous and can be explored further. Researchers are developing micron sized LED which are able to flicker on & off around 1000 times quicker than larger LED. They offer faster data transfers and take up less space so as to save space or add more LED's to further boost the channel of communication. Also 1000 micron sized LED can fit into area required by 1sq. mm large single LED. A 1 sq.mm sized array of micron sized LED's could therefore communicate 1000×1000 (i.e. a million) times as much information as a single 1mm LED [2]. If this technology can be implemented practically then all the bulbs can be used as Wi-Fi hotspots to transmit data without the use of wire, as well as it will allow for safer, cleaner and better future. The new Li-Fi technology is being studied and trying to put in practice as it would offer a great deal of efficient substitute to wire as well as radio wave technology. With the increase in the population and the advent of the many devices that access wireless internet, the Wi-Fi also can be termed as airwaves are becoming progressively clogged thus resulting into difficulty to get a better and reliable speed signal. This would solve the problems like the shortage of radio-frequency bandwidth and allow internet to be used in places and situations where it cannot be used currently like the hospitals or aircrafts.

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