

Li-Fi Technology, the future of Wireless Communication

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Abstract—Li-Fi i.e. Light Fidelity is a new pathway towards high speed internet. In 2011, while speaking in TED Talks, German Physicist Harald Haas first spoke about it. It is a Visible Light Communication Technology (VLC) which uses LEDs for transmission of the data. The light is used as a medium of high-speed communication just like Wi-Fi. It is extremely useful in handling the heavy amount of data. Li-Fi will take the wireless communication to the next level by overcoming the challenges of the current Wi-Fi technology. It can be used at the places like hospitals, where radio waves can be hazardous. Another advantage of Li-Fi is, the high security of data, which makes it very useful in military operations. It will also play a vital role in the research where conditions can be life threatening for human beings.

This paper focuses mainly on its technological aspects, features, comparative study with Wi-Fi technology, implementation and new developments based on the studies done so far.

Keywords— Li-Fi, Wi-Fi, Radio Spectrum, Wireless Communication, Visible Light Communication (VLC), (Light Emitting Diodes) LEDs

I. INTRODUCTION

As the communication in today's era has become the key factor in any domain, people are seeking for more efficient ways of communication and Li-Fi is one of them. It uses LED lights to transmit data in wireless mode. The speed of the current wireless networks depends on the number of devices connected to them. It further calls for the issue of the security of the network. Unlike Radio Waves Li-Fi has got a much broader spectrum for transmission of data.

The German Physicist Herald Hass introduced this concept at "data through illumination" in his TED talks, in 2011. Hence, he and his team at University of Edinburg are known as the pioneers of this concept.

It works on Visible Light Communication (VLC). In this technology data is transferred through LED light with

modulating light intensities faster than those can be captured by human eyes, by using the Visible Spectrum as well as ultraviolet and infrared radiations. The data is transferred with the modulating frequency of light and is then received by a photo sensitive detector. This light signal is then demodulated in the form of electronic signal. Special LED bulbs are used for the illumination of the data and a photo detector is used on the other end to detect the signal. Hence, these bulbs transmit the data as well as provide the light. Its other advantage is low cost involved and low maintenance required.

It also solves the issue of Data Security as it cannot be accessed without the presence of light. This makes it fit for the use in Military Communications or any other communications which calls for high level of security. Li-Fi is already in use in the fields like Military Operations, Hospitals, Retail, Aircrafts etc. It is also extensively used by the Scuba Divers. Let us further discuss about the various aspects of Li-Fi Technology.

II. DIFFERENCE BETWEEN LI-FI AND WI-FI

The Li-Fi Technology is very new compared to the Wi-Fi Technology, which is in use since last many years. Following table briefly highlights the differences between the two technologies.

Sr. No.	Li-Fi	Wi-Fi
1	Light is used for the transmission	Radio Waves are used for the transmission
2	Technology uses IrDA Compliant Devices	Technology uses WLAN standard compliant devices
3	Is used in Hospitals, Airlines, Under Sea etc.	Is used only with the help of Wi-Fi Hotspots
4	It is more secured as light gets obstructed and then doesn't allow the information to pass ahead	Different security techniques need to be implemented to achieve the security
5	The speed achieved is up to 1Gbps	The Speed achieved is up to 150Mbps with WLAN
6	Can work in the environment with high data	Can work in the environment with low data

	density	density due to high network traffic issues
7	Network coverage is about 10 meters	Network coverage is about 32 meters
8	Component of the System: Lamp Driver, LED Bulb and Photo Detector	Component of the System: Computer and Router Installation

We can further compare both the technologies on the basis of some more technological and non-technological parameters as follows:

Parameter	Li-Fi	Wi-Fi
Speed	***	***
Range	*	**
Data Density	***	*
Security	***	**
Reliability	**	**
Power Availability	***	**
Transmitter / Receiver Power	***	**
Ecological Impact	*	**
Device to Device Connectivity	***	***
Obstacle Interface	***	*
Bill of Material	***	**
Market Maturity	*	***

*- Low, ** - Medium, *** - High

III. FUNCTIONING OF LI-FI

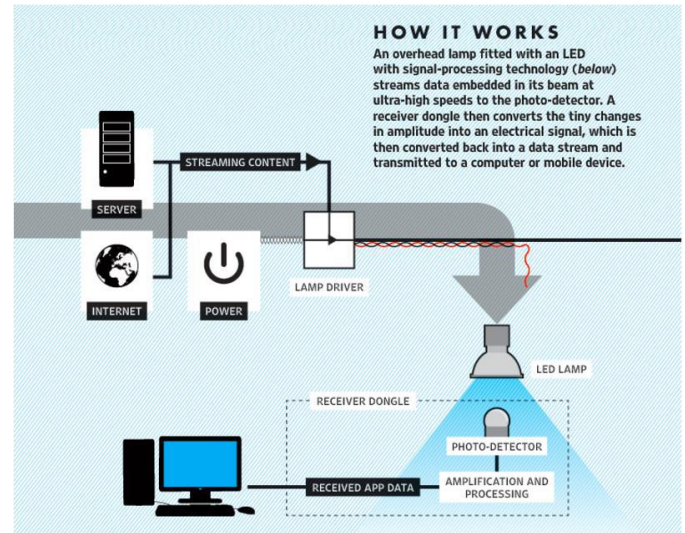
The process of Visible Light Communication (VLC) basically uses the visible light for Data Communication in Li-Fi. It requires a transmitter and a receiver. The transmission of data takes place by switching the lights ON and OFF. The transition between these ON and OFF is so fast, that the normal human eyes cannot sense it.

Harald Haas said in the explanation, "Very simple, if the LED is on, you transmit a digital 1; if it's off you transmit a 0. The LEDs can be switched on and off very quickly, which gives nice opportunities for transmitting data."(1)LED is chosen as it consumes comparatively less power than other visible light sources. Other sources like Solar Cells, LASER can be used in place of the LED.

Harald Haas said in EDINBURGH UNIVERSITY "... a solar cell has become a receiver for high speed wireless signals encoded in light, while maintaining its primary function as an energy harvesting device..."(1)Thus, the energy from solar cells on roof or translucent window glass can also be used as a receiver in Li-fi wireless communication.

Following is a structure of Li-Fi:

Transmitter:LED is used as a transmitter of the signal. The ON state of LED transmits 1 and the OFF state transmits 0. For more complex Data communication multiple LEDs or LEDs of different colours can be used.



RED LIFE APPLICATIONS OF LI-FI(2)

Receiver:As the data transmitted is in light form, it is needed to be modulated in digital signal. It is done with the help of a silicon photo diode. Following are the modulation techniques which are commonly used:

- **OFDM:** Orthogonal frequency-division multiplexing
- **OOK:** On-off keying
- **PWM:** Pulse-width modulation
- **PPM:** Pulse-position modulation
- **SIM-OFDM:** Sub-carrier Index Modulation(3)

Working of Li-Fi instrument:

As we discussed, Li-Fi technology is a wireless communication system which uses the visible light frequencies between violet (800Thz) to red (400THz). Whereas the Wi-Fi technology uses the electromagnetic spectrum. Li-Fi sends the amplitude modulated data in a standardized way. The operating speed of an LED is less than 1µS, which is much faster than what the human eye can detect. The switching of the LED is used for the transmission of the data in Binary Code. The ON state of the LED transmits 1 and OFF state transmits zero. The lamp driver shown in the figure above, drives the output intensity of the LED based on the input signal. Unlike Fiber Optics, Li-Fi protocol layers are

suitable for wireless communication over a very short distance of 10 meters. Hence it is an extremely fast and efficient way of wireless communication over a short distance.

On the receiving end, the data in the form of light signal is received and decoded for the information. It is further displayed on the device connected to the receiver. Photo detector is used here as a receiver, which registers binary '1' and '0' as per the state of the transmitting LEDs. An array with numerous LEDs can be used to transmit the data, that helps in achieving the speed of hundreds of Mbps.(4)

IV. LIMITATIONS AND CHALLENGES OF LI-FI

1. As the visible light acts as a data carrier, LI-Fi can work only in the direct source of light.
2. As light gets obstructed and cannot pass through many mediums, there should not be any barrier between sender and the receiver.
3. There should not be other sources of light as they will disrupt the signal, which is the most prominent drawback of the Li-Fi. Even sun rays are not an exception to this.
4. Infrastructure required for the implement of this mode of communication is entirely different.
5. Li-Fi can be only used in point to point communication as a high frequency (400-800 THz) used here leads to short distance coverage.
6. Li-Fi enabled devices can be installed only in limited type of places as the constant line of sight needs to be maintained between the sender and the receiver.
7. It is yet to be developed for the use on mass scale.(5)

V. MYTHS OF LI-FI TECHNOLOGY

The technology also has some myths, like:

- 1) It is 100 time faster than Wi-Fi: This is not true. The highest speed received with the current Li-Fi Standards is 7Gbps, and that of Wi-Fi is 224Mbps.
- 2) Heady files videos etc. can be downloaded within a minute or two: This is not true. Speed of Li-Fi also depends on the speed of internet and server. Currently there are no servers or internet available which can support such a high speed.(6)

VI. FUTURE SCOPE

Still, Li-Fi technology not a widely spread technology and also not much known to the people unlike Wi-Fi. It is still in

an implementation phase. It will be definitely helpful in solving the current network issues and help in overcoming the limitations of current wireless network. Radio frequencies are harmful and cannot be used at many places like hospitals etc. Radio waves are not only dangerous to the patients but can also affect readings of machines like MRI machines etc. Li-Fi can help solving this problem. Also, in the military operations which calls for the higher level of security and secrecy, RF communication cannot be used, in such cases Li-Fi could be used to transmit data. Li-Fi also provide total privacy of data, hence it is used extensively where the data secrecy is of paramount importance. RF communication underwater is not possible as water absorbs such signals and they also affect the marine life. Li-Fi can be used here effectively, though only for the transmission range will be shorter. Use of Li-Fi in traffic systems looks difficult immediately, due to the challenge of interference of the other light sources, however if it could be used through the street lamps and it would serve as Li-Fi hotspot too.(7)

Thus, Li-Fi could be used to provide a better communication in various ways. Data transmission could be more efficient and faster. It would be a great solution for the transmission of the heavy data.

VIII. CONCLUSION

The advancement in research on Li-Fi technology promises its accessibility to the common man in near future. It will be highly beneficial for the research work in life threatening areas, medical field and in military operations where secured communication is a primary need.

Though Li-Fi technology will open new avenues of communication if it successfully replaces Wi-Fi and other broad band networks, the interfering atmospheric and other sources of lights can lead to the data loss over different access points.

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