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Future of Communication-LIFI (Light Fidelity): A Review

Hilal Ahmad Shah[1], Inzimam Ul Hassan[2], Inam Ul Haq[3]
[1,2,3]*Assistant professor, Department of computer science and Engineering, Chandigarh University, India*
Email: hilalshah9832@gmail.com,inzimamulhassan@gmail.com,mirinam525@gmail.com

**Corresponding Author: joemark.ablian@gmail.com*

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Abstract: The internet has revolutionized the world, with its use in coffee shops, offices, and homes. However, internet speed remains a major issue. Communication, supported by information and communication technology (ICT), has made the world more connected. Everyone, including businesses, institutions, organizations, and entrepreneurs, requires fast internet connectivity and a broad spectrum of channels to obtain the right information at the right time and place. This paper discusses the potential impact of Li-Fi, a future communication technology that uses visible light communication and may provide faster, more cost-effective, and robust internet connectivity of up to 500MBPS (30GBPS per minute), making it a viable alternative to Wi-Fi.

Keywords: Energy, Renewable Energy System, Literature Review

1. Introduction

The most important and demanded ICT accessories are internet services. We are currently utilising around 80% of the available data utilisation capacities, according to the Cisco Survey of the Usability of the Existing Spectrum (in 2018). Currently, we link our PCs, laptops, palmtops, and other devices to the campus' Wi-Fi network at distances of 10 to 100 metres. The topic of the current study is visible light communication, which has the potential to deliver a high data rate of up to 500 MBPS. An analysis compared WI-Fi to LI-Fi. as well as other crucial aspects of the communication process. A revolution is about to occur in the current era of digital wireless communication. The better version of WiFi is called Li-Fi (Light Fidelity). It is the newest and best invention of the twenty-first century [1]. The idea behind this equipment is that by employing LED light, whose intensity varies more quickly than the human eye can perceive it, and that intensity is caught by using a detector, the information needed for communication may be transferred. It is a type of VLC that is a part of optical wireless communications and could take the place of RF, or communication over Wi-Fi and cellular networks. According to current estimates, this new Li-Fi technology is 10,000 times quicker than many Wi-Fi installations. A new generation of extremely sensitive ultra LEDs, according to HARALD HASS, renowned as the father of Li-Fi from Edinburgh University in the United Kingdom, are at the heart of this technology. In order for the light emitting diode to become more useful for visible light communication, he stated, "My greatest vision is that light bulbs will become a component of broadband communication equipment". Since light emitting diodes (LEDs) are used for data transmission, the equipment is relatively compact. It is now referred to as the WiFi version that has been optimised. [3]

The benefit of using visible light for wireless communication instead of Wi-Fi modems and routers is that it is less expensive. With Li-Fi, LED lamps equipped with transceivers would be used to both light a space and send and receive bits of data. There can theoretically be a large number of entry points because basic light bulbs are employed. Other than RF, this technology makes use of a portion of the electromagnetic spectrum. The wonderful thing about this technology is that it allows us to encode data

in light by altering the pace at which LED bulbs flicker on and off to produce various strings and sequences of 1s and 0s. Human eyes cannot distinguish quick changes in LED intensity, therefore the output seems to be nearly constant. Advanced methods could significantly increase VLC data rates. [4]

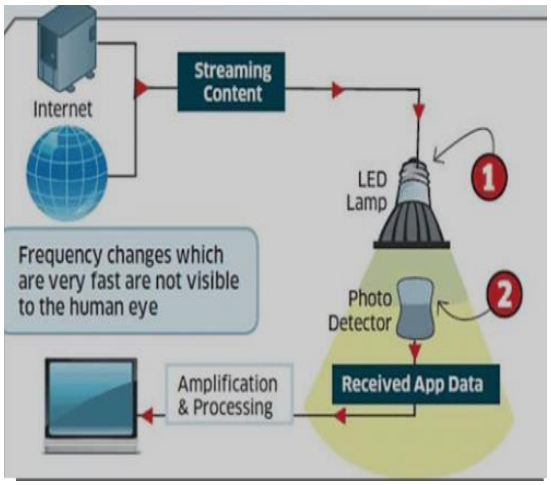

Figure 1. LIFI Technology [2]

University of Oxford and University of Edinburgh researchers are concentrating on analogous data transfer utilising arrays of LEDs, where each LED communicates a different data stream than before. Some teams are modifying light's frequency by combining red, green, and blue LED bulbs such that each frequency can convey a different data channel. He imagines a time when data transmission for computers, mobile phones, and tablets will be possible without the use of RF routers, increasing security because only those who can see the light will be able to access the data. In light of our future generations, it is possible to foresee and expand the uses of this fantastic technology to a variety of platforms, including the disciplines of education, medicine, engineering, and industry.[5]

1.1 Technical aspects of LI-FI

LI-FI (Light Fidelity) is a wireless communication technology that uses light instead of radio waves to transmit data. It works by modulating the intensity of light emitted by an LED (Light Emitting Diode) bulb, which is then received by a photodetector at the other end. This modulation is done at very high speeds, typically in the range of several megahertz to gigahertz. The process of transmitting data through LI-FI involves converting the digital data into a stream of binary digits (0s and 1s), which are then used to modulate the intensity of the light emitted by the LED. The modulated light is then transmitted through the air to the receiver, where it is detected by the photodetector and converted back into digital data.

The advantages of LI-FI over Wi-Fi are primarily due to the use of light as the communication medium. Unlike radio waves used in Wi-Fi, light waves do not penetrate through walls, which means that LI-FI is more secure and less susceptible to interference from other wireless signals. Additionally, since the visible light spectrum is much larger than the radio spectrum, LI-FI can support much higher data transfer rates. In fact, LI-FI can achieve data transfer rates of several gigabits per second, which is much faster than Wi-Fi. Another advantage of LI-FI is that it does not produce electromagnetic interference (EMI), which can interfere with other electronic devices. This makes LI-FI a good option for use in sensitive environments such as hospitals, airplanes, and submarines.

However, one of the limitations of LI-FI is that it requires a direct line-of-sight between the transmitter and receiver, which means that it cannot be used for communication between devices that are separated by obstacles such as walls or furniture. Additionally, since LI-FI relies on light, it is not suitable for use in environments with bright ambient light, as this can interfere with the signal.

2. Literature Review

The use of the visible light region of the electromagnetic spectrum to convey information is known as visible light communication (VLC),[1] and it has a history that dates back to the 1880s. The creation of Beam Caster, a LIFI wireless local network, was revealed by the Russian business Stins Coman in April 2014. Their current module has a data transfer rate of 1.25 gigabytes per second (GB/s), but they anticipate increasing it to 5 GB/s soon.A new record was set in 2014 by Mexican business Sisoft, which was able to transmit data at rates of up to 10 GB/s through a light spectrum produced by LED bulbs.

In this paper [7]A high security, electromagnetic compatibility (EMC), and high precision positioning information platform for smart phones and tablets employing LED illumination were introduced by the Japanese business Outstanding Technology in 2016. In 2016, the Indian students from Mangalore Institute of Technology and Engineering in Moodabidri, who had previously earned the

third place at the seventh annual edition of the UNISYS All India Project Competition Cloud 20/20, had successfully transmitted data using light sources. They employed three-color Triplet LiFi in their project, with each colour carrying a different data stream. The VLC applications in children's clothing and toys, as well as an indoor VLC system based on networked light bulbs, were presented by the Swiss team Disney Research. Another notable manufacturer, France's Oledcomm, introduced LiFi products to the market in 2012. They outfitted a museum in Europe and used them in retail (Leclerc) and the Paris Metro. On May 21, 2015, Carrefour implemented a LiFi system in a hypermarket in Lille with the help of Philips, enabling shoppers to find the products that are on sale.

In this paper [8]The most recent research indicates that LI-FI technology is not just for indoor use. It can be applied in a variety of ways, such as using LI-FI technology in traffic signals. The idea is that traffic signal lights will continuously disseminate road map information that any vehicle equipped with a photo detector can retrieve. A demonstration of LI-FI technology took place during the 2012 Consumer Electronics Show in Las Vegas. They communicate data using Casio smart phones by employing light with varying intensities that can be seen 10 meters away.

In this paper [9]In "smart vehicular communication system employing LI FI," Pooja Bhateley, Ratul Mohindra, and S. Balaji developed a smart vehicular communication system that uses Li Fi technology to prevent against vehicular collisions on the roadways. This project focuses on improving road safety by utilising photo sensors as the receivers and LED lamps as the transmitters in a communication system. White LEDs utilised in the head and tail lights can be used to communicate with the photo detectors successfully across short distances. Visible Light Communication (VLC) system architecture appropriate for outdoor applications was presented by Hardeep Singh and Geet Bawa . This suggested using direct sequence spread spectrum to combat interference and noise. They showed that, even in the presence of optical noise levels, it is possible to obtain communication ranges of more than 40 m for low data rate applications. They employed a VLC transceiver, which transforms electrical signals into visible light and vice versa. An encoder processes and transforms digital data into an information-carrying electrical signal. Visible light pulses travel via an optical filter on the receiver side. Following that, the signal is amplified, filtered, and transformed to digital format using an ADC.[5]

The age of wireless technology was explained by Akshata M Sonnad, Anjana Gopan, Sailakshmi N R, Divya S, and Ambika R . Every minute, there are more and more gadgets connecting to the internet. Unfortunately, this has increased network complexity, reduced wireless radio bandwidth, and raised the possibility of radio frequency interference. Therefore, the demand for novel, quick, trustworthy, error-free wireless communication methods is urgent. Light Fidelity, sometimes known as "Li-Fi," is one such technology that claims to solve the issues mentioned above. Due to the availability of high sensitivity receivers, the ability to provide wide coverage at low frequencies and line of sight communication at high frequencies, and the ability of radio/micro wave frequencies to transmit data, conventional wireless communication schemes like Wi-Fi primarily use these frequencies for data transmission. However, due to the constrained spectrum available, RF can only handle a small bandwidth. As a result, the radio spectrum is currently congested due to the growing demand for cellular data. Wireless data transfer is a field where Li-Fi has a lot of potential. It is a promising substitute for current wireless communication techniques that use radio waves as the data transport. The current technology can be improved in many different ways.

3. How Does Light Fidelity Technology works

Since LEDs run at a faster rate than 1 s, they can flicker "ON and OFF" with a frequency that is higher than the human eye can detect, giving the impression that the light source is continuous. The transfer of data using binary codes is made possible by this indiscernible flashing activity (0 & 1). Binary "1" is used to turn on an LED, while binary "0" is used to turn it off. By regulating and adjusting the pace at which LEDs flicker ON and OFF to produce various strings and series of 1s and 0s, it is feasible to encrypt data in light. The flickering binary signal is then captured by a light-sensitive device (photo detector/photo diodes) and transformed back into the original data.[10]

The phrase "Visible Light Communication" (VLC) refers to the process of wirelessly transferring information utilising brief bursts of light. Because it has the potential to compete with and possibly replace the widely used Wi-Fi technology, the word Li-Fi has received attention and is being developed quickly. The optical carrier for data transfer and illumination in the VLC is visible light between (400-800) THz / (375-780) nm. Using high-speed LEDs with sufficient multiplexing, data rates of more than 100 Mbps can be reached. The VLC data rate can be increased by parallel data transmission employing LED arrays where each

LED emits a separate data stream. The lights can be dimmed to the point that they are invisible to the human eye yet still transfer data as needed, even though they must be kept on to communicate data.[11]

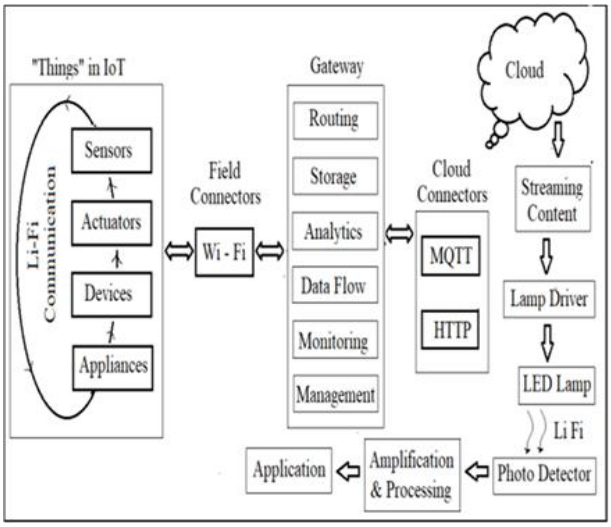

Figure 2 Architecture of LIFI[12]

The key components of this system are:
1] A multipurpose LED (acting as light source as well as source of communication)
2] A silicon photodiode (Receiving element)

4. Comparison Between Li-Fi And Wi-Fi

Li-Fi is a phrase used to describe visible light communication technology used for high-speed wireless communication. It was given this name because it is similar to Wi-Fi but uses light rather than radio waves. In a building, Wi-Fi is fantastic for providing overall wireless coverage, whereas Li-Fi is best for providing dense wireless data coverage in small spaces and for reducing radio interference. The criteria shown below compare the technological aspects of the proposed and existing wireless internet technologies.

Table 1 Comparison of the proposed and existing wireless internet technologies

S.No.	Comparison Basis	LIFI	WIFI
1	Full Form	Light Fidelity	Wireless Fidelity
2	Operations	Transmits data using bits help of light from LED bulbs.	Transmit data with help of radio waves with help of WIFI router
3	Security	Secured(cannot be hacked) as light is blocked by walls	Not secured(can be hacked)as for RF signal dry walls are transparent
4	Interference	Do not have any interference issue similar to radio waves	Has interference issue from nearby access points(routers)
5	Spectrum	The spectrum range is 10000 times than WIFI	It has radio spectrum range
6	Frequency	The frequency band is 100 times of tera Hz	The frequency band is 2.4GHz,4.9GHz and 5GHz
7	Speed	Fast speed internet (greater than 1-3.5 Gbps)	Comparitively Slow speed (54-250 Mbps)
8	Where to Use	Anywhere,where light source is present	Inside a building , typically Within a array of WLAN communications ,
9	Cost	Cheaps as LED lamps are used	Quiet expensive
10	Data transmission rate	Very high rate of data transmission due to visible light spectrum,	Transmission rate is slow as compared to LI-FI as RF is used to communicate
11	System components	Lamp drivers, LED bulbs and light detectors will from complete Li-Fi system	Routers have to be installed devices like laptops , PDAs, Desktops are called as Stations

5. Application Of Li-Fi

Applications of LiFi can be expanded in a variety of fields, including medical technology, power plants, underwater applications, and other fields where Wi-Fi technology has less potential. To transfer data and information, any street lamp can be transformed to a Li-Fi bulb. Following are a few potential uses for Li-Fi in the future:

5.1 . Internet everywhere: LEDs can be added to street lights and car headlights to enable internet connection anywhere there is a light source, including public pathways, roadways, shopping centres, etc.

5.2. Submarine ROVs: Underwater ROVs, the cherished toys of treasure hunters, use Li-Fi in one of its uses. These ROVs are powered by enormous cables, which also enable them to collect signals from their pilots above. Except when their hop is insufficiently extended to probe a space or when it becomes obstructed by something, ROVs perform admirably. They would be considerably more free to roam if their wires were cut and replaced with light, perhaps from a submerged, powerful lamp. They could communicate with one another using their headlamps, analyse data independently, and occasionally report their findings to the surface. Li-Fi also functions underwater, where Wi-Fi is entirely unreliable, creating endless possibilities for military operations.

5.3.Health care industry and medical applications: Because Wi-Fi can pass through the human body, it is detrimental to use it in hospitals and other places that provide healthcare. Wi-Fi is not allowed in operating rooms (OTs) due to its radiation impact. Tablets and personal computers (PCs) interfere with Wi-Fi signals, which disrupts the signals for monitoring devices. Li-Fi technology can be useful in both medical devices and internet connectivity. Additionally, robotic surgery and other mechanised processes can benefit from this.

*5.4 Li-F*i can be used to send data between cars and traffic lights during traffic control, improving road safety. Additionally, it can be utilised to update traffic data roughly every second, facilitating the coordination of traffic police with traffic and the capture of criminals. Traffic signals can use Li-Fi technology to communicate with the LED lights on moving vehicles, improving traffic management and accident avoidance.

5.5 Inter Vehicle Communication: LEDs are gradually replacing traditional headlights in vehicles. This raises the possibility of vehicle-to-vehicle Li-Fi connection, enabling the development of anti-collision systems and the transfer of information when driving between vehicles. Traffic signals already use LED lighting, therefore a concept of citywide traffic organisation systems has also been offered.

5.6 *Cheaper Internet on* Aircraft: Currently, passengers who fly on aeroplanes pay a significant price for access to slow internet. Wi-Fi may also interfere with an aircraft's navigation system. LiFi can be used in aeroplanes to transmit data and information. Li-Fi can easily provide high-speed internet using any light source within the aircraft, including overhead reading lamps, etc. Almost always being connected will prevent electromagnetic interference (interventions) (EMI) from damaging the flight deck's delicate radio equipment. Aircraft will be lighter as a result of less need for cabling.

5.7. Education systems: The newest technology that can provide access to high speed internet is called Li-Fi. Therefore, it can take the place of Wi-Fi in businesses and educational institutions, enabling everyone to access Li-Fi at the same speed as that offered in the area.

5.8. Smart Class: Li-Fi is used in the cutting-edge smart class technology, which is quickly becoming essential for forward-thinking educational institutions. With the aid of modern technology, educators may provide information on a variety of subjects, zoom in to highlight key aspects, and freeze and explain important points. The lecturers can capture every student's full attention in the lecture hall by using engaging animations, music, and colours. Every youngster receives visual information about what, how, when, and where everything happens, and the concepts are well grasped. Wi-Fi is currently used in smart courses, although cable LAN technology is still used to connect every computer to the server. Cables, which can be either fibre optics or twisted pair, are the physical transmission medium for wired LAN. However, wired LANs have numerous disadvantages because they necessitate drilling holes in walls, running wires via attics, fixing holes, etc. As a result, installing the equipment is expensive, time-consuming, and requires skilled experts and flexible materials for protection. Li-Fi-enabled smart courses can be used to solve these issues.

6. Advantages of Li-Fi

1. Li-Fi may achieve 1000 times the information density of Wi-Fi since visible light can be muted by light, but RF cannot because of interference.
2. The visible range of EM has a very broad spectrum of action.
3. Li-Fi makes it possible to access information securely and at a very high speed.

4. Li-Fi is a safer alternative to radio waves (RF) because these waves are susceptible to electromagnetic interference in places like mines and the petrochemical industry.
5. Because this technology doesn't deal with RF, it may easily be employed in all such locations where Bluetooth, IR, Wi-Fi, and the internet are widely used. This technology is integrated into medical appliances and in hospitals.
6. Every street lamp in the world would be a point of open data access if this technology were used.
7. It may be used to update traffic information nearly instantly, making it easy for traffic officers to manage traffic and detain violators.
8. Glow dynamic dark To enhance video contrast, the lamp output must be modulated.

7. Challenges Of Using Li-Fi

1. When in the line of sight, it can only broadcast.
2. Despite sounding like a Wi-Fi replacement, this high-speed information transfer technology has significant limitations, one of which is that light cannot pass through objects. It can be blocked and cannot pass through the walls. In the event that the light transmission is interfered with, we can effortlessly switch back to radio waves (Wi-Fi).
3. Since Li-Fi technology relies on light for transmission, the signal will be completely lost if the receiver is in any way blocked.
4. Loss of consistency and network might result from information transfer restriction from external light sources including sunshine, regular bulbs, and dense materials.
5. RF cellular systems and Wi-Fi are still necessary. A light bulb that transmits information to a swiftly moving object or that makes data available in a faraway location where there are walls, trees, and other obstructions is impossible.
6. Despite the lower cost of employing LED, the requirement by Li-Fi will increase costs as this technology requires a continual supply of illumination, requiring the LED to be on throughout the day.

8. Conclusion

Every bulb may be utilised as a Wi-Fi hotspot to transmit wireless data with the advancement of technology and its use for industrial usage, and we would be moving toward a cleaner, greener, safer, and brighter future. Li-Fi is a notion that is now generating a lot of interest, not least because it might provide a true and highly effective replacement for radio-based wireless. As more people and their numerous devices access wireless internet, it can transport data at a greater rate while also being far less expensive than WI-FI. Getting a dependable, high-speed signal is getting harder and more challenging as the airways get more congested. This may address difficulties like the lack of radio frequency capacity and provide internet access in places where conventional radio-based wireless is prohibited, such aeroplanes and hospitals.

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