

# APPLICATIONS, CHALLENGES AND FUTURE OF LiFi

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**Abstract**— This paper aims to show that Li-Fi now reached at a state, where it can be considered as a reliable wireless communication solution for the future technologies. Currently the Internet can be accessed using Wi-Fi, but it has its limitations too. It is sufficient for current Internet services, but insufficient with IoT and cloud-based services. In the upcoming decade, hard drives will be obsolete and everything will be on cloud. Modern Web applications i.e., 4K & 8K videos, games and high-resolution photos etc. require fast bandwidth. Li-Fi opens a reliable door for the end users to access the future technology-based services at high speed.

**Keywords**— Li-Fi; Areas of applications; Challenges of Li-Fi; Li-Fi Hybrid Network

## I. INTRODUCTION

According to the Cisco Annual Internet Report (2018-2023) number of devices connected with the IP network will be more than thrice the population of human beings by the year 2023. To put the facts in perspective, there will be 29.3 billion devices connected with the Internet by the year 2023 [1]. By the year 2022, mobile data traffic accounts for an estimated total of 71% IP traffic and 80% of projected mobile IP traffic will happen indoors [2]. This increase in demand for more better short range wireless communication combined with the surge in use of smartphones, tablets, and IoT [3] [4] [5] collectively with the 5G network requires improved networking infrastructure in order to meet the growing future communication needs [2] [6]. The latest Wi-Fi standard of IEEE 802.11ay offers 300 Gbps transfer rate at 60 GHz band [7]. In this current decade the avalanche of data traffic will make it progressively challenging for Radio Frequency (RF) to cater the communicational needs as per Harald Haas in [8]. Professor Harald Haas is credited for coining the term and the first public demonstration of Li-Fi in action during his talk at TEDGlobal in July 2011 [8] [9] [10]. Li-Fi simply uses visible light spectrum instead of RF to send 0s and 1s from sender to receiver [11]. Li-Fi technology has already grabbed \$70 million in 2019 and is estimated to reach \$105 million in current decade as reported by Global Market Insights [12]. The key reasons for humans to reduce their reliance on Radio Waves (RW) are Capacity, Availability, Efficiency and Security [8] [10]. In the Electromagnetic Spectrum the ratio of RW to Visible Light Spectrum is 1:10,000 as shown in Figure 1 [13]. In simple words we have ten thousand times more room in Li-Fi than Wi-Fi and unlike RF, light spectrum is free of interference, which makes it environment friendly and power efficient [8] [14]. This process is not visible to the human eye because of its speed.

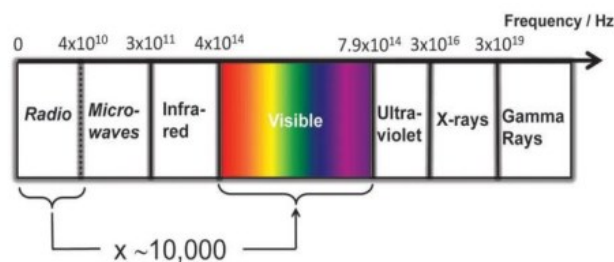


Figure 1. Ratio of RF to visible light spectrum

#### A. *What is Li-Fi?*

Professor Herald Haas introduced the term Li-Fi during TED Global in July 2011 [8] [9] [10]. Li-Fi is a form of optical wireless communication, in which light waves are used to deliver data along with lamination. It uses the visible light portion of the electromagnetic spectrum instead of radio technology [15]. It transmits data through LED without using any cable. Binary numbers 1 and/or 0 are used to switch on and off respectively and the LED controller will handle the data encoding. At the user end photo diodes will encrypt the data, which is in the form of 0's and 1's [11] [13] [15]. According to [16] Li-Fi can offer a whopping speed of 224 gigabytes per second and that with a common LED that we commonly use in homes and offices and it makes Li-Fi hundred time faster than Wi-Fi.

#### B. *How does Li-Fi work?*

The IEEE 802.15.7 standard for short-range Optical Wireless Communication (OWC) is paving way for standardization of Li-Fi [17]. Li-Fi system has two components: Light source with a signal-processing unit and on the other end a photo detector. LED is used to stream data to the photo detector by its beam. A receiver dongle then converts the tiny changes in amplitude into an electric signal, which is then converted back into a data stream and transmitted to a computer device. This process is not visible to the human eye [17] [18].

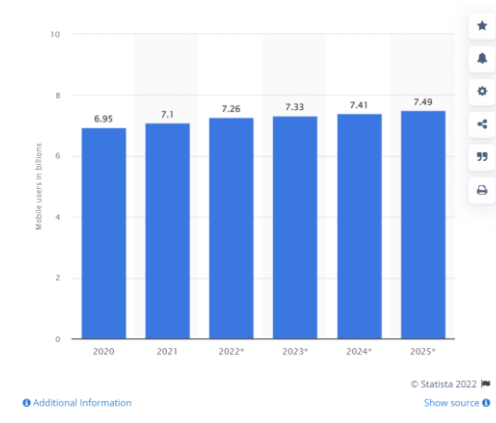
This paper consists of five sections: Section 2, will talk about areas of applications of Li-Fi; section 3 will discussed the challenges of Li-Fi; section 4 will proposed Solution and finally paper will conclude with Conclusion in section 5.

## II. AREAS OF APPLICATIONS

The Light Emitting Diodes (LEDs) technology is not only commonly used homes and offices, but it is also energy efficient. With the help modulating circuits data can be transferred at the high rates, i.e., not visible to human eye, along with communication and the illumination aspect of LEDs that is called visible light communication (VLC) [19]. The applications of Li-Fi are virtually infinite, Li-Fi can be implemented at any place where LEDs are used. Previously hazardous places where Wi-Fi usage is not permitted due to RF interference can now enjoy wireless communication due to nature of light spectrum. To name a few, areas like manufacturing plants, hospitals, oil fields, nuclear power plants, airplanes, prisons, and fighter jets can now benefit from wireless communication due to Li-Fi [19] [20]. Following are the main areas of Li-Fi applications:

#### A. *Smart Devices*

According to the statista [21], the number of smartphone user is expected to increase from 7.26 billion in the year 2022 to 7.49 billion by the year 2025 as shown in Figure 2 [21] [22]. Almost every second person in the world is using at least one or two smart devices [23]. Li-Fi is ideal for smart devices because it offers high data rates and is more secure as compared to Wi-Fi. Short range Li-Fi system to share data between smart devices instead of using Bluetooth or Wi-Fi is feasible for home-based media centers or small offices. A practical demonstration was done by [24] using an android application Luximetro and camera of a smartphone to transfer and received light signals at a short range. Similarly, another work [25] uses flash light of a smartphone to send data and Arduino Uno to receive data. The scale of the work in [24] can be raise to form a multimedia system.



**Figure 2. Smartphone users in billions**

### B. Charging Smart Devices & Vehicles

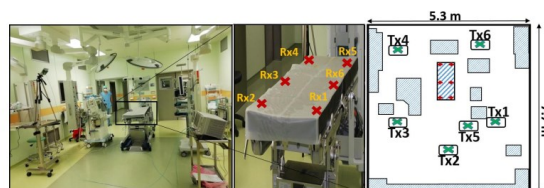
Using Li-Fi, we can also charge our smart devices, by embedding a thin crystal layer into the display that will act like a solar photovoltaic cell. The job of photovoltaic cell is to convert the light into electrical power [26]. Due to interference free nature of Li-Fi, it is suitable medium for transmission of Wireless Power Transfer (WPT) in vehicular ad hoc networks [27].

### C. Industrial Application

Li-Fi can be used in industrial environment to achieve low-latency wireless communication such as connecting head mounted cameras of an industrial robot to a cloud [28]. Researchers in their work [29] demonstrated an enhanced Li-Fi positioning system that offers enhanced accuracy, reliable, improved productivity and secure wireless communication medium to fulfill the future needs of Industry 4.0.

### D. Healthcare

It is a common observation that people admitted in hospitals requires continuous monitoring of human vitals signs: body temperature, heart rate, blood pressure, and breathing rate. Suitability of li-Fi in hospital environment is due to its non-interference with RF based medical equipment such as MRI [30] [31]. In [30], researchers presented practical vitals monitoring system based on life that offers accepting only the required signals, filtering noise, and 100% accuracy of received signals along with the patient mobility. The proposed prototype uses a Fiber Bragg Grating (FBG) sensor carried by a patient and Li-Fi receiver may be installed in ceiling of room for wireless transfer of vital signs of patient to cloud [32] [33], central monitoring unit or anywhere hospital administration deems suitable. In work [34], the researchers examined the implementation of Li-Fi in a typical neurosurgery operation room of a hospital. Researcher examined various locations for transmitter and receiver for best wireless communication using Li-Fi as shown in Figure 3 [34].



**Figure 3. Li-Fi based prototype for a neurosurgery room**

### E. Aviation

The use of LEDs technology can be witness in every walk of life and aviation industry is not an exception. On average there are 2 to 3 hundred LEDs in an airplane. With small tweak of economical circuitry these LEDs can be used as a network switch. Lodge of an airplane usually have a large set of LEDs and that can offer many times

faster wireless connectivity to the passengers than Wi-Fi and that without worrying about Electromagnetic Interference (EMI). With the proposed system in [35], people in flight can enjoy browsing, calls, and in-flight theater as shown in the Figure 4 [35]. EMI can occur with the use Wi-Fi technology during flights. However, Li-Fi technology can be used for in-flight communication to avoid EMI with aircraft equipment such as radar [36] and solely this feature makes Li-Fi suitable for use in military aviation as well.



**Figure 4. Li-Fi based in-flight gaming setup**

#### *F. Green Environments*

One of the key reasons for the popularity of LED technology is its energy efficacy. LED in contrast with fluorescent tube consume very less power. LED consume about 10% of energy as compared with fluorescent tube and offers more lifespan. The on state of an LED is simply considered as sending 1 and off state of a led is communicating 0 in a binary number system. The more data is transferred the less LED is in on state which results in further decreases in power consumption [37]. Researchers in [38], argues that Li-Fi not only consume less power in comparison with Wi-Fi, but also offers improved security, better range, and minimal effects on environment. As Li-Fi uses light spectrum and common household and office equipment for communication, it is suitable for future smart cities and green cities. In larger perspective Li-Fi can contribute in decreasing the use of fossil fuels as it is about 24 times better in performance and energy consumption ratio [38].

#### *G. Underwater Applications*

Typical underwater robots communicate with operator on surface through wired fiber-optic or shielded ethernet cables and both of them are inclined to faults [39]. Radio waves do not travel well in water due to signal attenuation. Li-Fi technology is appropriate solution to enhance underwater communication. Underwater communication using RF is not completely impossible, but the used technology relay on Very Low Frequency (VLF) radio waves that falls in the range of 3-30KHz. In simple words VLF renders broadcast over long distance but meager bandwidth [40]. Researcher in [40], proposed an Unmanned Underwater Vehicle (UUV), with LightByte modems, using point-point communication that is able to communicate at the speed of 5.8 KB per second which is sufficient to control UUV with a wireless joystick. Secure Connectivity. Figure 5 shows the waterproof LightByte (Li-Fi) modems [39].



**Figure 5. Waterproof LightByte (Li-Fi) modems**

### III. CHALLENGES OF LI-FI

Besides several useful applications of Li-Fi in all walks of life, there are still limitations to this emerging technology. Following are the currently main challenges of Li-Fi [10] [11]:

#### A. Limited Coverage

Despite its benefits, we cannot enjoy this technology easily everywhere because it cannot travel through walls, which is one of the major drawbacks. If you move from one place to another, you need the LED bulb in that place too.

#### B. Light Dependency

Li-Fi is dependent on the light. We cannot access the Internet in case of light failure.

#### C. Additional Hardware

A Li-Fi supported lighting system and Li-Fi enabled devices are required for the Li-Fi.

#### D. Atmospheric Instability

If a Li-Fi lighting system is installed outdoors, it needs to be compatible with extreme weather conditions.

#### E. Light Pollution

Light intensity needs to be enhanced for longer distance communication, which may create an impact on human health. How can these challenges be overcome? The next section will propose solutions towards these challenges.

### IV. PROPOSED SOLUTION

Wi-Fi is a reliable way to access indoor Internet, but in buildings with different kinds of walls can reduce the signal strength. Weak signals will create an impact on the speed. If multiple users are sharing the 1 connection than it will also cause the slow connectivity. By Li-Fi/Wi-Fi hybrid network solution one can provide reliable speed and connectivity.

Li-Fi offers 10,000 times better bandwidth than Wi-Fi and Wi-Fi range is better than Li-Fi [41]. Users can choose Li-Fi for good bandwidth and speed. As a user will be in limited coverage, the device can automatically select Wi-Fi. If people are using Li-Fi then load on Wi-Fi will be reduced and the people who are on Wi-Fi can also experience a better service. It will significantly improve the user Internet experience [6].

As shown in Figure 6, tablet and mobile users are provided data access via Li-Fi, while laptop and desktop computer data are provided data by Wi-F while another mobile user using Wi-Fi for uplink and downlink for Li-Fi. This heterogeneous approach can free RF resources to serve users being more mobile or outside the Li-Fi coverage area [6]. More highly mobile users will be able to fall back on the broader coverage of the Wi-Fi

network. Such network is solution for security cordon environments, where authorized personals can access the Internet by Li-Fi. It will also give more parental control; parents can easily manage the time their children spend online.

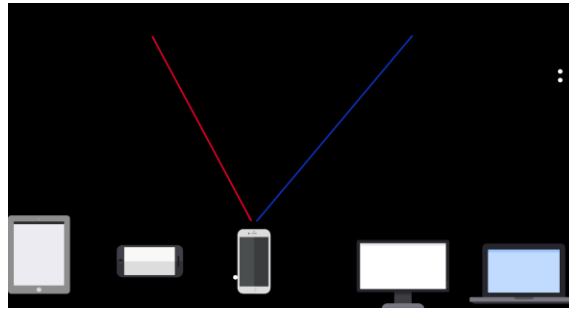


Figure 6. The proposed Li-Wi Fi Heterogeneous Network

## V. CONCLUSION

This paper is based on the analysis of emerging technology Li-Fi. Wi-Fi limitation motivates the use of Li-Fi. This ecofriendly solution is more efficient and cost effective as compare to Wi-Fi. It can be used to charge smart devices, road communication, deployed in hospital without causing EMI, offers wireless connectivity to previously hazardous places, such as nuclear power plants as well as to provide secure Internet access to authorize people. Limited coverage's, light dependency, additional hardware, light pollution and atmospheric instability are the current challenges of Li-Fi. These challenges can be resolved by a Li-Fi/Wi-Fi hybrid network, which will improve the user Internet experience and source utilization and create new horizon in the Internet connectivity and parallely promote the green environment.

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