



**INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH
TECHNOLOGY**

**INCREDIBLE INNOVATION IN VISIBLE LIGHT COMMUNICATION- LIGHT
FIDELITY (LI-FI)**

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ABSTRACT

Light Fidelity (Li-Fi), high speed communication and networking variant of Visible Light Communication (VLC), aims to utilize a vast amount of unused electromagnetic spectrum in the visible light region. It provides a transmission of data through illumination by sending data through an LED light bulb that varies in intensity faster than the human eye can follow. Li-Fi provides a better bandwidth, efficiency, availability and security than the existing technology (Wi-Fi). By using visible light as transmission medium, it provides wireless indoor communication of achieved bit rate of 10Gbps. As there are more and more devices coming up day-by-day the signals are being clogged up due to heavy traffic, there arise a error free transmission and the solution to this problem was the Li-Fi technology.

KEYWORDS: Li-Fi, VLC, LED, Wi-Fi, bit rate.

INTRODUCTION

Li-Fi is a Visible Light Communication (VLC) technique which is used for high speed communication systems. This technology was first proposed by Harald Hass a German physicist, number of industry groups and companies combined to form a Li-Fi association to promote the high speed wireless communication using Visible Light Communication (VLC) technique to overcome the shortage in spectrum distribution for the purpose of high speed wireless communication [2]. "At the heart of this technology is a new generation of high brightness light-emitting diodes (LED)" says Harald Haas from the University of Edinburgh, UK, "simply if the LED is ON, you transmit a digital 1, if it's OFF you transmit a 0," Haas says, "They can be switched ON and OFF very quickly, which gives nice opportunities for transmitted data."



Fig -1: Li-Fi LED bulbs

It is possible to encode data in the light by varying the rate at which the LEDs flicker ON and OFF to give different strings of 1s and 0s. The LED intensity is modulated so rapidly that human eye cannot notice, so the output appears

constant. More sophisticated techniques could dramatically increase VLC data Rate [1]. Li-Fi was implemented through white LED bulbs only but teams at the University of Oxford and the University of Edinburgh are focusing on parallel data transmission by using multiple LEDs or array of LEDs, where each LED transmits a different stream of data. Mixtures of red, blue, green LEDs are also used by some groups to encode different data channels by altering the light frequencies.

NETWORK EVOLUTION

The shifts in social paradigm can trigger diversified communication technologies. Therefore, technical “seeds” must be fostered to meet these needs. This entails building an infrastructure for communication technologies for users.

We can observe significant developments in transmission systems, in which the characteristics of technological “seeds” in optical transmission, wireless transmission, Bluetooth, Zig-Bee, Wi-Fi, Wi-Max, Gi-Fi and now Li-Fi meet these requirements. Furthermore, it is expected that the communication network infrastructure will evolve towards greater reliability and contain more intelligent functions by modification of the Network Evolution.

Bluetooth is a wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz) from fixed and mobile devices, building PANs. The IEEE standardized of Bluetooth is **802.15.1**. ZigBee is a specification for a suite of high-level communication protocols used to create personal area networks built from small, low-power digital radios. ZigBee is based on an **IEEE 802.15.4** standard. Though its low power consumption limits transmission distances to 10–100 meters line-of-sight, depending on power output and environmental characteristics.

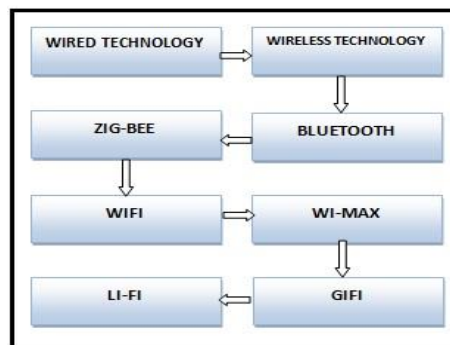


Fig -2: Network Evolution

Wi-Fi is a local area wireless technology that allows an electronic device to participate in computer networking using 2.4 GHz UHF and 5 GHz SHF ISM bands. The IEEE standardized of Wi-Fi is **802.11**. Many devices can use Wi-Fi, e.g. personal computers, video-games consoles, smart phones, digital cameras and digital audio players.

Worldwide Interoperability for Microwave Access (Wi-MAX) is the common name associated to the IEEE **802.16a** standards. These standards are issued by the IEEE 802.16 subgroup that originally covered the Wireless Local Loop (WLL) technologies with radio spectrum from 10 to 66 GHz. Recently, specifications were extended below 10GHz. Harmonize standards and certify interoperability between equipment from different vendors. Standardized Interoperable solutions will result in mass volume and bring down costs, promote and establish a brand for the technology. Wi-Fi style access will be limited to a 4 to 6 mile radius (perhaps 25 square miles or 65 square km of coverage, which is similar in range to a cell-phone zone). Through the stronger line-of sight antennas, the Wi-MAX transmitting station would send data to Wi-MAX enabled computers or routers set up within the transmitter’s 30 mile radius (3,600 square miles or 9,300 square km of coverage). This is what allows Wi-MAX to achieve its maximum range.

Li-Fi is a Wireless Personal Area Network (WPAN) , it uses IEEE 802.11 Protocols and also uses a Visible Light Communication instead of Radio Frequency(RF) Waves with a larger frequency band of THz range.

WORKING PRINCIPLE OF LI-FI

Li-Fi is implemented by using a light bulb at the downlink transmitter. Normally the light bulb glows at a constant current supply however fast and subtle variations in current can be made to produce the optical outputs. The operation procedure is very simple, if the LED is ON, it transmit a digit **1**, if it OFF, it transmit a digit **0**. The LED can be switched ON and OFF very quickly hence providing a nice opportunities to transmit data. Hence all that is required some LED and a controller that code data into those LEDs flicker depending upon the data we want to encode.

Mixtures of red, green and blue LEDs to alter the light’s frequency with each frequency encoding a different data channel. Such advancements promise a theoretical speed of 10 Gbps.

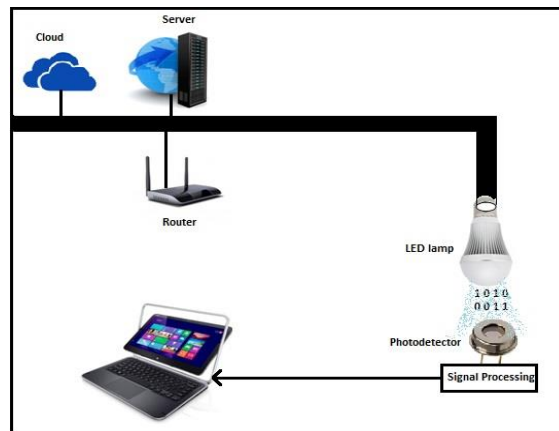


Fig -3: Working of Li-Fi system

The components used in the Li-Fi communication purposes are Led lights or florescent light source and the photo detector. The light intensity of the LED and florescent bulb can be controlled by regulating the current applied to the light source. The usage of florescent lamps will help in generating the 10mb/s speed of data transfer but led light source provides the transmission speed of 500mb/s which is more faster response than that of florescent light so LED lights are preferred to perform the visual light communication[2].

VISIBLE LIGHT COMMUNICATION

Visible light communication (VLC) is a data communications medium which uses visible light between 400 and 800 THz (780–375 nm). VLC is a subset of optical wireless communications technologies.

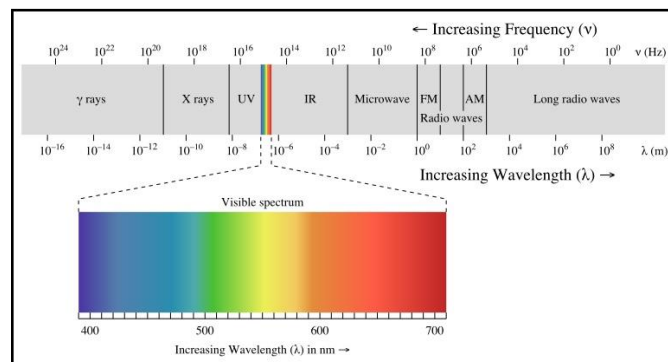


Fig -4: Electromagnetic Spectrum

The technology uses fluorescent lamps (ordinary lamps, not special communications devices) to transmit signals at 10 kbps, or LEDs for up to 500 Mbps. Low rate data transmissions at 1 and 2 kilometers (0.6 and 1.2 m) were demonstrated[3]. Although the use of light in order to transmit data can be limited in comparison to radio waves, there is a great amount of possibilities that can be developed due to this technology. In essence, a single pixel of a monitor could transmit a single channel of information to a source. Although this technology is still in its infant stages, the usefulness of this Li-Fi technology has implications of great amount.

COMPARISON OF WI-FI Vs GI-FI Vs LI-FI

Table-1: Comparison of various Technology

PARAMETERS	WI-FI	GI-FI	LI-FI
IEEE Standard	802.11	802.15.3C	802.11(VLC)
Development Started	1990	2004	1990
Primary Devices	Notebooks, Desktop Computers	Mobile phones, Home devices, Industrial Automation	Smart Phone ,Laptops
Medium Used	RF	RF	Light as Carrier
Speed	150 Mbps	5 Gbps	>10 Gbps
Operating Frequency	2.4 GHz	60 GHz	Hundreds of THz

CHALLENGES IN LI-FI

Li-Fi needs line of sight transmission limit. It cannot penetrate any obstacles so even a person stand between the receiver and the light source can stop the function of Li-Fi system which results in failure of system. An important challenge is how to transmit the data from reception side to transition side or vice-versa [2]. When the Li-Fi system is placed outdoor then the system should face the changes in climatic conditions and in indoor the receiving device cannot be shifted around the places.

The four major challenges which the current wireless system faces are easily handled by this technology. **Capacity**, the first challenge, as we know is very limited as compared to the visible light spectrum 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. **Efficiency**, is the issue of at most 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 and on the other hand LEDs are highly efficient and energy consumption is not a problem. **Security**, an issue which can't be neglected is a snap-if you can't see the light and you can't access the data while radio waves can penetrate through the walls makes it prone to breach the security protocols [6].

APPLICATION OF LI-FI

Office Security Environment

In a meeting room environment, the access area of each channel is the width of the light pool, and can be accessed by multiple users. Each user can receive higher data rates than would be the case for an equivalent Wi-Fi channel. In the Wi-Fi case, each user or group of users directly competes for access to bandwidth. The net result is that the more connections there are, the slower the download speeds are for all. By contrast, in the case of Li-Fi, with its greater number of available access points, each pool of light provides full channel data rates with fewer simultaneous users.

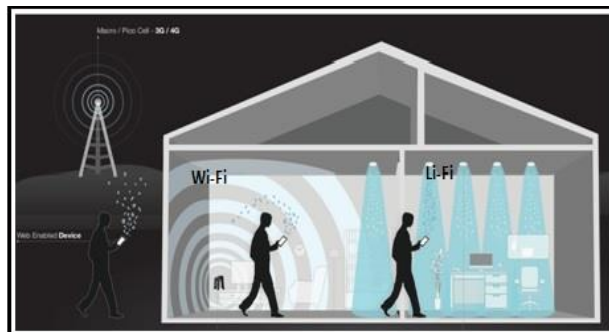


Fig -5: Office Environment

The overall net benefit to each user is up to 1000 time's greater speeds. In addition, and in contrast to radio waves, the light does not pass through the walls [5]. Therefore, with minimal precautions to avoid leakage from windows.

Hospital & Healthcare:

Li-Fi emits no electromagnetic interference and so does not interfere with medical instruments, nor is it interfered with by MRI scanners[4].



Fig -6: Li-Fi Inside an Operation Theatre

Operating rooms do not allow Wi-Fi due to radiation concerns, 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.

EMI Sensitive Environments

Li-Fi can be used to reduce weight and cabling and add flexibility to seating layouts in aircraft passenger cabins where LED lights are already deployed. In-flight entertainment (IFE) systems can also be supported and integrated with passengers' own mobile devices [4]. On aircraft, Li-Fi enabled lighting which allows high data rate connectivity for each passenger. It will allow connectivity at all times without creating the electromagnetic interference (EMI) with sensitive radio equipment on the flight deck. The reduction in cabling requirement also means a lighter aircraft[5].



Fig -7: Li-Fi in Aircraft

Inter Vehicle Communication

Car headlights and tail lights are steadily being replaced with LED versions. This offers the prospect of car-to-car communication over Li-Fi, allowing development of anti-collision systems and exchange of information on driving conditions between vehicles.

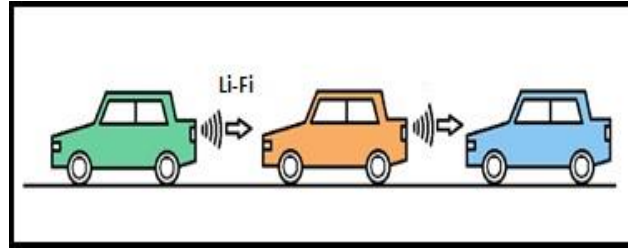


Fig -8: Inter Vehicle Communication

Traffic lights already use LED lighting, so that there is also the prospect offered of city wide traffic management systems.

Underwater communication

Radio waves are quickly absorbed in water, thereby preventing underwater radio communications, but light can penetrate for large distances. Therefore, Li-Fi can enable communication from diver to diver, diver to mini-sub, diver to drilling rig, etc [5].

CONCLUSION

This Li-Fi technology combines spectral efficiency with power efficiency and allows very high speed data communications to be reliably achieved using LED lighting infrastructure as the transmission channel. The concept of Li-Fi is currently attracting a great deal of interest because it offers a genuine and very efficient alternative to radio based wireless. It solves issues such as shortage of radio frequency bandwidth. This new Visible Light Communication (VLC) technology has grown in practical application like Smartphone, Laptops. In future we will not have 14 billion light bulbs, we may have 14 billion Li-Fi's deployed worldwide for a cleaner, greener and even a brighter future.

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