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A Review On Data Transmission Through Illumination

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Abstract- Li-Fi is a new wireless technology which provides the connectivity within localized network environment. The main principle of this technology is we can transmit the data using light illumination by using light emitting diodes where radio frequency is media in Wi-Fi and LED bulb light intensity is faster than human eye can follow. One germen phycist-Prof Harald Haas an expert in optical wireless communications at the University of Edinburgh, he demonstrated how an LED bulb equipped with signal processing technology could stream a high-definition video to a computer. By using this technology a 1 watt LED light bulb would be enough to provide net connectivity to four computers. This technology termed as "light fidelity". This technology allows us to transfer data more securely with higher data rates. This technology is still under research and further exploitation could lead to wide applications.

Keywords –Wireless, Li-Fi, Wi-Fi, LED, VLC.

I. INTRODUCTION

These days Wi-Fi is widely used in all the areas such as offices, homes, colleges, hotels. Due to this radio frequency is getting blocked gradually; simultaneously usage of wireless data is increasing exponentially every year. Each person is interested to use wireless data but the capacity is going down.

Wireless radio frequencies are increasing, complexities are rising and RF interferences keep on growing. In turn to overcome this difficulty in future, light fidelity (Li-Fi) technology came into existence since year 2011[1]. This technology is a wireless communication system in which light is used as a carrier signal instead of conventional RF. Li-Fi is a technology that uses light emitting diodes to transmit information. Visible light communication (VLC) uses rapid pulses of light to transmit information wirelessly that cannot be detected by human. This paper will focus on principle, working of Li-Fi technology and advantages over Wi-Fi technology. Li-Fi can transfer data at rates faster than 10 megabits per second which is speedier than your average broadband connection [2].

II. PRINCIPLE OF LI-FI

The Li-Fi technology operates under the principle that light can be used to carry signals as an alternative to traditional radio frequencies; it keeps serving as long as there is no obstruction of any type, between the Light source and a device. Li-Fi technology is high intensity Light emitting diodes. Light emitting diodes can be switched on and off quickly, than the human eye can detect, causing the light to be become visible continuously. This faster on off activity enables a kind of data transmission using binary codes. Switching on LED and it is a logical '1', switching it off is a logical '0'[3].It is possible to encode data in the light by varying the rate at which LED's flicker on and off to give different strings of 1s and 0s. Modulation is so fast that human being doesn't notice. A light sensitive device (photo detector) receives the signal and converts it back into original data. This technique of using quick pulses of light to transmit information wirelessly is technically referred as Visible Light Communication (VLC) though its potential to compete with conventional Wi-Fi has inspired the popular characteristics Li Fi[2] .

Li-Fi is a fast and economical edition of Wi-Fi, which is based on visible light communication (VLC). This VLC 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. Visible light is not harmful to vision [3]. Typical example of visible light communication is given below.

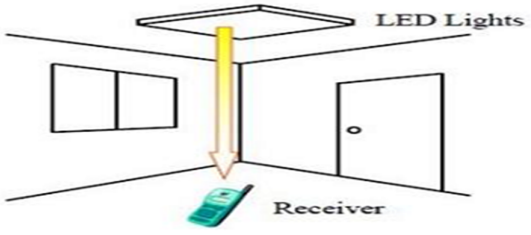

Fig 1: Typical Example of Visible light communication

III. DATA TRANSMISSION THROUGH LI-FI

Since Wi-Fi hotspot and cloud computing are rapidly increasing reliable signal is bound to suffer. Speed and security are also most important concern. They are open to hackers as it penetrates through walls easily. LI-FI is said to overcome this problems. This new technology is similar to infrared remote controls which send data through an LED light bulb that varies in intensity faster than the human eye can see. In future we can see that data for pc, tablets, laptops, smart phones and transmitted through the light in a room.

Li-Fi uses fast pulses of light to send out information wirelessly. The main element of this communication system is a high brightness LED, Which act as a communication source and a silicon photodiode which shows good response to visible wavelength region serving as the receiving element. LEDs can be switch on and off to make digital strings of 1s and 0s. Data can be encoded into light to generate a new data stream by varying the flickering rate of the LED. By modulating the LED light with the data signal, the LED light can be used as a communication source.

Working of Li-fi is, as shown in fig 2. The data gathered from internet or any other source is encoded by lamp driver which is connected to LED lamp (or array of LED's) [4].

A. The required data on the internet will be streamed to a lamp driver when the led is turned on; the microchip controller converts the digital data in form of light through LEDs.

B. A light sensitive device (photo detector) receives the signal and converts it back into original data. Then this data send it to destination.

A data rate greater than 100 Mbps is achievable by using high speed LEDs with proper multiplexing techniques. Data rate can be increased by parallel data transmission using LED arrays where each LED transmits a unlike data stream. There are reasons to choose LED as the light source in VLC while a lot of other illumination devices such as incandescent bulb, fluorescent lamb etc. are available. LI-FI technology uses semiconductor LED light bulb that rapidly develops binary signals which can be manipulated to send data by tiny changes in amplitude. Using this recent technology 10000 to 20000 bits per second of data can be transmitted at the same time in parallel using a single signal processing technology and special modulation [2].

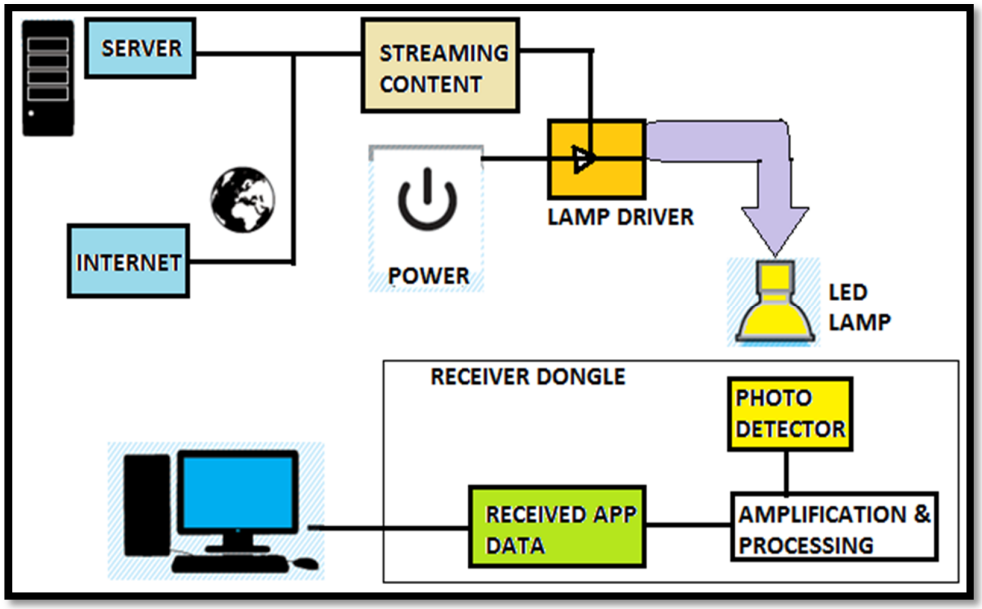

Fig 2: Data transmission using LI-FI

IV. COMMUNICATION WITH VLC

For any communication the two basic parts are sender and receiver. In VLC, a LED bulb is used as sender. The photo diode is used as a receiver to detect this signal. The fig.3 shows open system interconnection (OSI) model for VLC. The vital layers in VLC OSI model is Physical Layer (PHY) and Data Link Layer (DLL). These are important for sending and receiving the light signal. The Media Access Control (MAC) and PHY layers are same for both transmitter and receiver part [4].

A. The Physical Layer

In VLC this layer functions same as in the OSI model. It defines the electrical and physical specifications of hardware used. The communication on Physical layer is done with small units of data called as packets. According to the data rates the physical layer is categorized as,

PHY 1: It is low data rate (12 to 267 kbps) physical layer It is used for outdoor operation.

PHY 2: It have moderate data rate of 1.25 to 96 Mbps. It is used for indoor applications.

PHY 3: It is with high data rate of 12 to 96 Mbps. It is used for lightning sources and detectors.

The modulation formats used for PHY 1 and PHY 2 are On off Keying (OOK) and (Variable PPM) VPPM. In case of OOK modulation logic 0 is denoted as 01 and logic 1 by 10. This is to avoid illumination gap in case of continuous line of logic 0[5].

B. The Data Link Layer

This layer uses the services of physical layer to send and receive data bits over communication channel. According to the architecture used in IEEE 802.15.7 project this layer is divided into two sub-layers as an Optical Wireless Logic Link Control (OWLLC) and Optical Wireless Media Access Control (OWMAC).

Optical Wireless LLC: It confirms and controls the logical links between devices on a network. With DLL it allows the interconnection of other technologies and provides services to network layer.

Optical Wireless MAC: The media of communication may be simplex, half duplex or full duplex, OWMAC confirms the control over it. With the use of OWMAC protocol working terminals and connected devices are controlled [4].

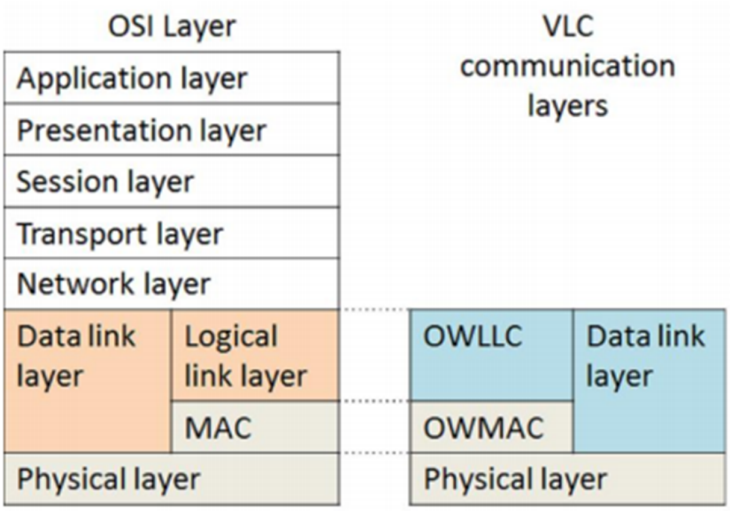

Fig. 3 OSI reference model for VLC communication

V. DIFFERENCE BETWEEN Li-Fi & Wi-Fi

Li-Fi is a term of one used to describe visible light communication technology applied to high speed wireless communication. It acquired this name by reason of the similarity to Wi-Fi, only using light instead of radio .Wi-Fi is great for general wireless coverage inside buildings, and Li-Fi is for high density wireless coverage in confined area and for relieving radio interference issues. Therefore this two technologies can be considered complimentary [3].

Li-Fi can only work when your device can detect the light being emitted by the Li-Fi router i.e. it will only work if you're in the same area the light is being emitted. Li-Fi is also way faster; the latest Wi-Fi standard, 801.11ac, has a highest possible speed of about 867 Megabits per second for a typical handheld. Li-Fi can reach speed up to 3.5Gbit/s per color – meaning a typical Red-Green-Blue (RGB) LED can emit speeds up to 10.5Gbit/s – more than 10 times faster than the latest Wi-Fi technology. These technology speeds offer a lot of prospective for wireless connectivity [6].

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

S.NO.	PARAMETERS	WIRELESS TECHNOLOGIES	
		LIGHT FIEDILITY	WIRELESS FIEDILITY
1	Speed for data transfer	Faster transfer speed(>1Gbps)	Data transfer speed(150 Mbps)
2	Medium through which data transfers occurs	Use light as a carrier	Used radio spectrum
3	Spectrum range	Visible light spectrum has 10,000 time large spectrum in comparison to radio frequency.	RF spectrum range is less than visible light spectrum.
4	Cost	Cheaper than Wi-Fi because free band doesn't need license and it use light.	Costly in comparison to Li-fi because it uses radio spectrum.
5	Power consumption	It consumes less power	It consumes high power
6	Standard	IEEE 802.15	IEEE 802.11
7	Security	It is highly secure	It is less secure than Lifi
8	Operating frequency	Hundreds of Tera Hz	2.4 GHz to 5 GHz

VI. ADVANTAGES OF LI-FI

A. Li-Fi can solve problems related to the shortage of RF bandwidth because this technology uses Visible light spectrum that has still not been greatly utilized.
B. High data transmission rates of upto 10Gbps can be achieved.
C. Since light cannot go through walls, it provides privacy and security that Wi-Fi can't.
D. Li-Fi has low implementation and repairing expenditure. Longevity of LED bulb: saves money
E. It is safe for humans as light, not like radio frequencies, cannot penetrate human body. Hence, concerns of cell transformation are mitigated.
F. LED lighting is already efficient and the data transmission requires negligible additional power.

VII. LIMITATIONS OF LI-FI

A. The main problem is that light can't go through objects, so if the receiver is by mistake blocked in any way, then the signal will instantly cut out.
B. Reliability and network coverage are the major issues to be considered by the companies while providing VLC services. Interference from outside light sources such as sunlight, normal bulbs; and opaque materials in the path of transmission will cause interruption in the communication.
C. High setting up cost of the VLC systems can be complemented by large-scale implementation of VLC though Adopting VLC technology will reduce further operating costs like electricity charges, maintenance charges etc[7].

VIII. APPLICATIONS

A. *Hospitals*: This technology can be implemented in hospitals where usage of Wi-Fi is unsafe, as it may interfere with gadgets in the area and block the signals.
B. *Road Safety and Traffic Management*: Li-Fi can be used for communication between the LED lights of vehicles so as to avoid collision. It can also be implemented in the traffic lights for vehicle to roadside communication to update vehicular traffic information.
C. *Smart Lighting*: Any private or public lighting including street lamps can be used to provide Li-Fi hotspots. This has a two-in-one benefit of lighting as well as wireless communication and data transfer.
D. *Underwater Communication***:** Use of radio frequencies (RF) for underwater communication is impractical due to strong

signal absorption. Li-Fi can be employed in such cases for underwater communication.

E. Harmful Environments: Li-Fi is a safe alternative to RF communication in environments such as mines and petrochemical plants which are susceptible to electromagnetic interferences [8].

IX. FUTURE SCOPE

Li-Fi provides a platform to explore the grounds of transmission of wireless data at high rates. If this technology is put into practical use, each light bulb can be used as a Wi-Fi hotspot to transmit data in safer manner. The applications of Li-Fi are beyond imagination at the moment. With this improved technology, people can access wireless data with the LED's installed on the go at very high rates. It solves the problem of shortage of radio frequency bandwidth. In a variety of military applications, where RF based communications are not allowed, Li-Fi could be a viable alternative to securely pass data at high rates to other military vehicles [9]. Also LEDs can be used effectively to carry out VLC in many hospital applications where RF based communications could be potentially dangerous. Since light cannot penetrate through walls, it could be a limitation to this technology. Nevertheless, given its high rates of data transmission and applications in multiple fields, Li-Fi is definitely the future in wireless communication.

X. CONCLUSION

Li-Fi is the enhanced technology in the field of wireless data transmission. It is a alternative technology to conventional methods of wireless communications that instead of traditional radio frequency as in Wi-Fi use light as a data carrier. This concept promises to solve issues such as the shortage of radio-frequency bandwidth and overcome the disadvantages of Wi-Fi. Li-Fi allow internet where traditional radio based wireless isn't allowed such as hospitals, atomic power plants etc. If this technology is put into practical use, every LED can be used as a Wi-Fi hotspot to transmit data. This can lead us to a safer and ecofriendly future.

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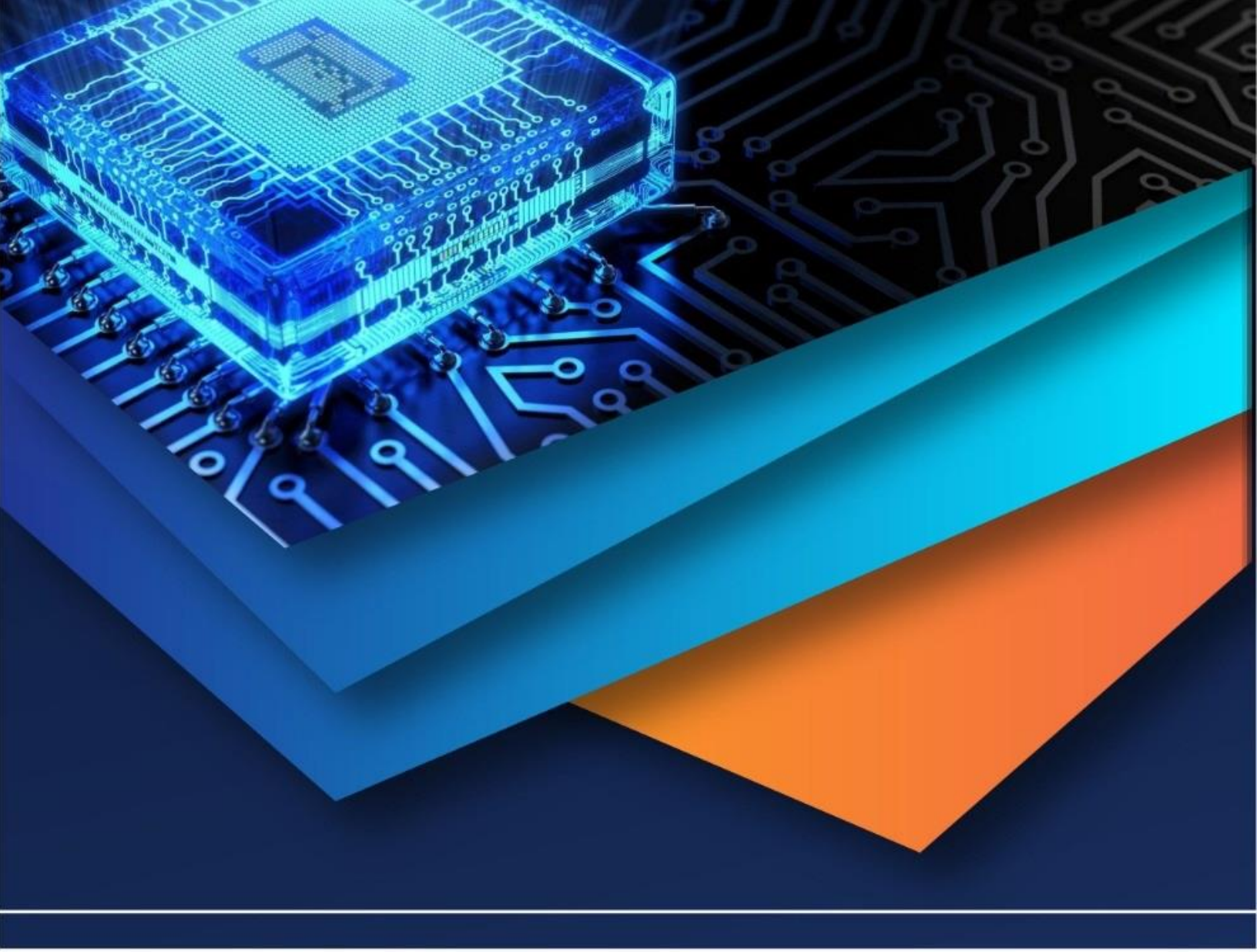

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