New Future Inventions Light Fidelity Li-Fi

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Abstract— Visible Light Communication is the wireless communication technology used in LEDs for communication and illumination. Li-Fi represents the Light Fidelity. Li-Fi allows better bandwidth, efficiency, availability and security as compare to Wi-Fi. Professor Harald Haas from the University of Edinburgh has invented the wireless technology very much like to Wi-Fi that allows data to be sent at high speeds using technology uses transmitter, receiver, modulators and demodulators for communication. Visible light communication is a new broadband transmission technology that uses standard visible light LED to transmit broadband data streams. The Li-Fi technology can be used for both dispersion of high-definition video streaming likewise two-way communication covering the whole range from internet access to video conferencing. Harlad promises a theoretical speed of Li-Fi is 10 Gbps that's meaning using this wireless technology we can download high-definition film in just 30 seconds. Li-Fi is now part of the VLC as it is implemented using LED light Bulbs. easy to access if we access in real life then it will give high speed, high security, low maintenance charge and mainly it doesn't have any side effect because it uses visible light as transmission medium.

Key words: Visible Light communication, LED, Wireless fidelity (Wi-Fi), light Fidelity (Li-Fi)

I. INTRODUCTION

The visible light communication (VLC) refers to the communication technology which utilizes the visible light source as a signal transmitter, the air as a transmission medium, and LED (Light Emitting Diode) as a signal receiving components which achieves high data rates compare to other wireless technologies like WIFI, BLUETOOTH, WI-max.

If we are using wireless internet or wireless network if one or more devices are connected to network, then bandwidth of network goes down at slow speed. To overcome this deficiency of bandwidth we can use light to transfer the data faster. The visible light communication is accomplished with LED (Light Emitting Diode). The intensity of light cannot catch by human eye. LED's are low cost and bidirectional which gives 300THz bandwidth whereas RF (Radio Frequency) gives 6GHz. It
also gives low complexity network transfer rates up to 10GB/S.

VLC = Illumination + Communication
VLC = Radio waves+ Communication

The visible light is the form in which the electromagnetic radiation with wavelengths in particular range is interrupted by human brain.

A. *Why only VLC*

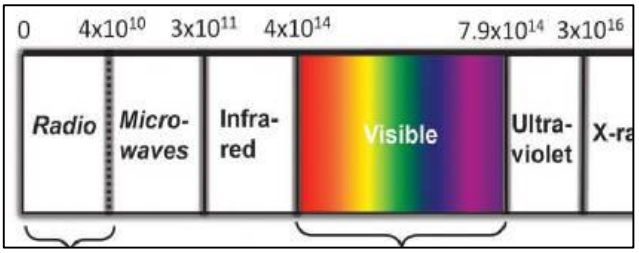

Fig. 1: Electromagnetic Spectrum [11]

Gamma Rays can't be used as they could be dangerous rays and have similar health issues.

Ultraviolet light is good for place without people, but otherwise dangerous for the human body.

Infrared, due to eye safety regulation, can only use with low power. Li-Fi is option to overcome these problems.

B. *Characteristics of Visible Light Communication*

1) *Efficiency*

LED lights consume less energy and are highly efficient. It is an inexpensive because of the use of already available visible light sources.

2) *Security*

VLC signal is defined closely to lightning area i.e. line of sight communication and other is signals cannot be transmitted through solid things like walls. So, they can't be intercepted and misused.

3) *Safety*

VLC uses light as a carrier. Light is the source of life. Hence, there has no health hazard. While in case of radio frequency, it is proved to be hazardous for all living things.

4) *Unlicensed use*

As VLC uses visible spectrum which is free. Hence, there are no licensing issues.

5) *High data rates*

VLC inherits high data rates from optical communication.

C. *Construction of Li-Fi*

The Li-Fi emitter system consists of 4 primary sub-assemblies [2]:

- Bulb
- RF power amplifier circuit (PA)
- Printed circuit board (PCB)
- Enclosure

The PCB controls the electrical inputs and outputs of the lamp and houses the micro controller used to manage different lamp functions. A RF (radio-frequency) signal is generated by the solid-state PA and is guided into an electric field about the bulb. The high concentration of energy in the electric field vaporizes the contents of the bulb to a plasma state at the bulb 's center; this controlled plasma generates an intense source of light. All of these sub-assemblies (shown in Fig. 1.2) are contained in an aluminum enclosure [2]. The bulb sub-assembly is the heart of the Li-Fi emitter. It consists of a sealed bulb which is embedded in a dielectric material. This

design is more reliable than conventional light sources that insert degradable electrodes into the bulb [3].

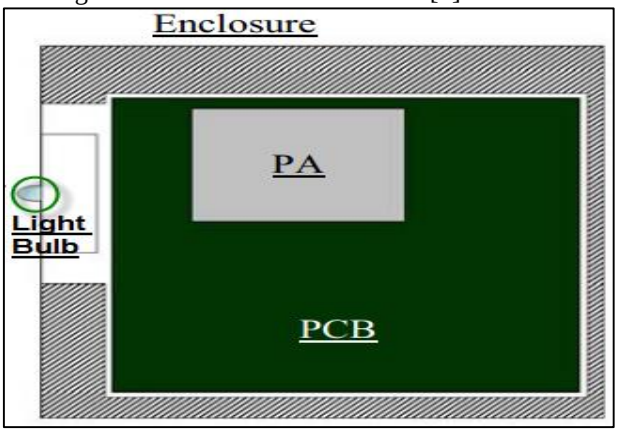

Fig. 2: Block diagram of Li-Fi sub-assemblies [2]

The dielectric material serves two purposes.It acts as a wave guide for the RF energy transmitted by the PA. It also acts as an electric field concentrate that focuses energy in the bulb. The energy from the electric field rapidly heats the material in the bulb to a plasma state that emits light of high intensity and full spectrum [2]. Figure 1.3 shows the bulb sub-assembly.

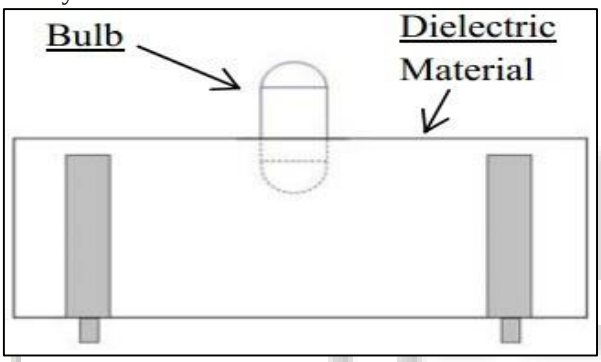

Fig. 3: Bulb sub-assembly [2]

D. How The Basic Light Is Converted into Electricity?

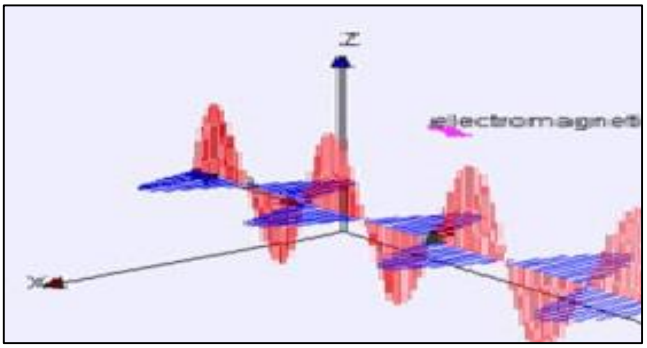

Fig. 4: Electromagnetic Waves

Figure 1.4 is a 3D diagram shows a plane linearly polarized wave propagating from left to right with the same wave equations from left to right

Where

$E = E_0 \sin(?\omega t + k\,?\,r)$ and

$B = B_0 \sin(?\omega t + k\,?\,r)$

In a region with no charges ($\rho = 0$) and no currents (J = 0), such as in a vacuum, Equation 1 is reduced Maxwell's equations:

$$\nabla \cdot \mathbf{E} = 0 \qquad \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t},$$
$$\nabla \cdot \mathbf{B} = 0 \qquad \nabla \times \mathbf{B} = \frac{1}{c^2}\frac{\partial \mathbf{E}}{\partial t}. \quad \ldots (1)$$

Taking the curl (×) of the curl equations, and using the curl of the curl identity

$\times(\times X) = (\cdot X)?^2 X$ we obtain the wave equations (2)

$$\frac{1}{c^2}\frac{\partial^2 \mathbf{E}}{\partial t^2} - \nabla^2 \mathbf{E} = 0, \quad \frac{1}{c^2}\frac{\partial^2 \mathbf{B}}{\partial t^2} - \nabla^2 \mathbf{B} = 0, \quad \ldots (2)$$

Which Identify

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 2.99792458 \times 10^8 \text{ m s}^{-1}$$

C is the speed of light in free space. In materials with relative permittivity ε_r and relative permeability μ_r, the phase velocity of light becomes

$$v_p = \frac{1}{\sqrt{\mu_0 \mu_r \varepsilon_0 \varepsilon_r}}$$

Which is usually less than *c* In addition, E and B are mutually perpendicular to each other and the direction of wave propagation, and are in phase with each other. A sinusoidal plane wave is one special solution of these equations. Maxwell's equations explain how these waves can physically propagate through space. The changing magnetic field creates a changing electric field through Faraday's law. In turn, that electric field creates a changing magnetic field through Maxwell's correction to Ampere's law. This perpetual cycle allows these waves, now known as electromagnetic radiation, to move through space at velocity *c*. [12]

Table Electromagnetic equation [12] Name Differential Equations Gauss's Law Gauss law for magnetism Maxwell faraday equation ampere's circuital law

E. Implementation of Li-Fi

Fig. 5: Real world implementation. [11]

Li-Fi is typically implemented using white LED light bulbs which are used to pass the radio waves to transmitter. These devices are normally used for illumination by applying a stable current. How it will be proceed its very simple- if the LED is on, you transmit a digital 1, it will pass the signal and if it's off you transmit a 0 then it will stop passing the signal.[5] The LED's can be switched on and off very quickly.

Example: If LED is on, and a photo detector (light sensor) on the other. The photo detector registers a binary code as one and it passes the radio waves to transmitter and when the LED is off binary code as zero it will stop proceeding.

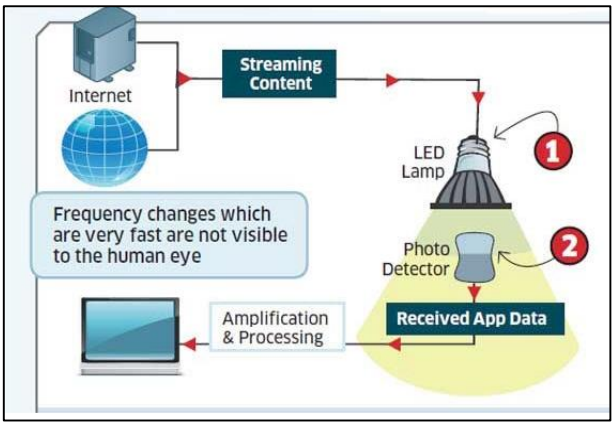

Fig. 6: Working on Li-Fi technology [11

F. Brightness of LI-FI source

The Li-Fi source has a very high amount of light emitted per second in a unit solid angle from a uniform source (light intensity). A single source with only a few millimeters in size can produce 2300 lumens of brilliant white light. In most cases, it will only need to use one light source per street light. It makes the mechanical and optical implementation of light much simpler and less expensive. [4]

II. WORKING MODEL

For Giga speed technologies, the Li-Fi Consortium defined Giga Shower, Giga Spot and Giga MIMO models. Giga Shower and Giga MIMO are used for in-house communication. There a transmitter or receiver is mounted into the ceiling. for example: a media server. Giga Shower provides unidirectional data services via several channels to multiple users with gigabit-class communication speed over several meters. This is like watching TV channels or listening to different radio stations where no up link channel is needed. In case Giga Shower is used to sell books, music or movies, the connected media server can be accessed via Wi-Fi to process payment via a mobile device. Giga Spot and Giga MIMO are optical wireless single- and multi-channel Hot Spot solutions offering bidirectional gigabit-class communication. For example: in a room, hall or shopping mall. [13]

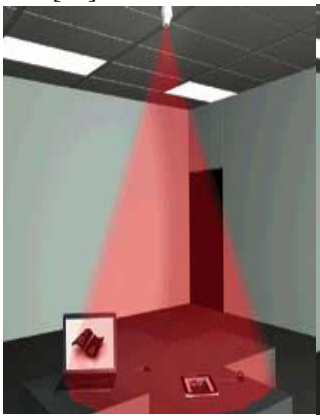

Fig. 7: Giga shower [13]

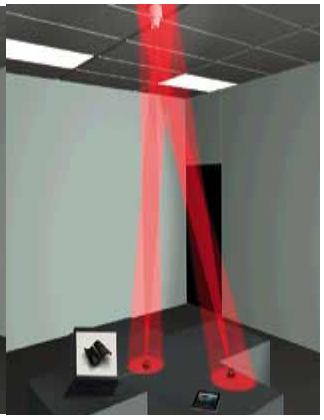

Fig. 8: Giga mimo [13]

Fig. 8: Giga spot [13]

III. COMPARISON BETWEEN IR WIFI AND LI-FI

Fig. 9: Comparison between WIFI and Li-Fi [7]

Li-Fi is the name given to describe visible light communication technology applied to obtain high speed wireless communication. It derived this name by virtue of the similarity to Wi-Fi. Wi-Fi works well for general wireless coverage within buildings, and Li-Fi is ideal for high density wireless data coverage inside a confined area or room and for relieving radio interference issues. [2]

Table I Comparison between Li-Fi vs. Wi-Fi [11]

A. Parameter IRWIFI Li-Fi

Spectrum Used IRRF Visual Light Standard IEEE 802.11IEEE 802.11 IEEE 802.15Range5 meters Not more than 150 meters Based on Light Intensity Data Transfer Rate1-5 mbps10-30 mbps>1 gbps Power Consumption Low High Low Uses Ambient light Radio waves Visible light Cost Low Low High Density Low Low High Security Less Less More than WIFI

B. How it is different?

Li-Fi technology is based on LED's for the transfer of data. The transfer of the data can be with the help of all kinds of light, no matter the part of the spectrum that they belong. That is, the light can belong to the invisible, ultraviolet or the visible part of the spectrum. [1]

You no more need to be in a region that is Wi-Fi enabled to have access to the internet. You can simply stand under any form of light and surf the internet as the connection is made in case of any light presence. There cannot be anything better than this technology.

IV. APPLICATIONS OF LI-FI

A. Healthcare

In hospitals any RF application like Wi-Fi is banned because of its hazardous effects on human health, it may affect the working of medical instruments. In this situation, Li-Fi which

uses light as medium will be best solution for communication in hospital campus.

Fig. 10: lifi in hospital

B. Defense

With established RF application it is not possible to communicate without proper instruments. As light is available everywhere, VLC communication is possible. Like RF jammer, VLC communication has no such barrier.

C. Aviation

Li-Fi can be used to reduce weight, 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.

Fig. 11: lifi on airport

D. Underwater Communications

Due to strong signal absorption in water, RF use is impractical. Acoustic waves have extremely low bandwidth and disturb marine life. Li-Fi provides solution for short-range communications. [9]

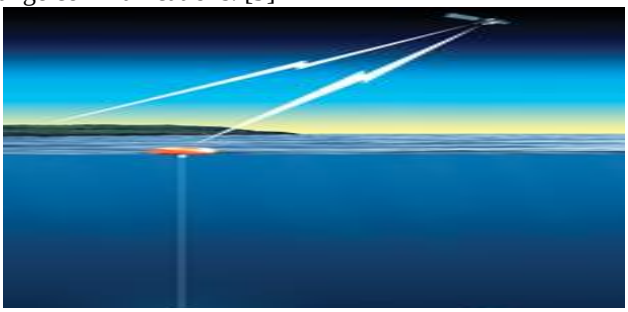

Fig. 12: Underwater communication diagram [9]

E. Vehicle & Transportation

LED headlights and tail-lights are being introduced. Street lamps, signage and traffic signals are also moving to LED. This can be used for vehicle-to-vehicle and vehicle-to-roadside communications. This can be applied for road safety and traffic management.

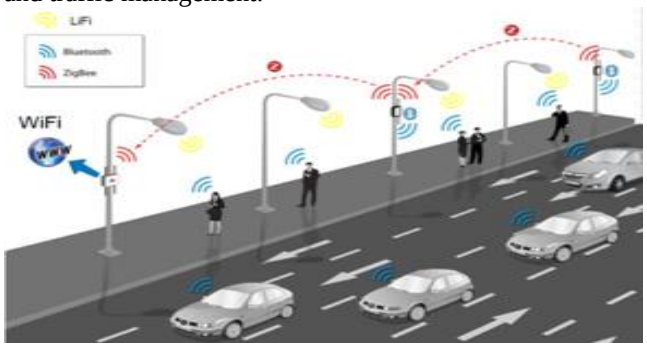

Fig. 13: Vehicle & transportation diagram [10]

F. Location Based Services(GPS)

Highly accurate location-specific information services such as advertising and navigation that enables the recipient to receive appropriate information in a timely manner and location. [9]

G. Limitation

Only works if there is direct line of sight (LOS) between the transmitter and receiver. High installation 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 etc.

V. ADVANTAGES

A free band that does not need license. High installment cost but very low maintenance cost. Cheaper than Wi-Fi. Theoretical speed up to 1 GB per second less time & energy consumption. No more monthly broadband bills. Lower electricity costs.

Longevity of LED bulb saves money. Light cannot penetrate through walls it provides privacy and security [5]. Transmission of data is fast and easy Long service life.

VI. CHALLENGE

Apart from many advantages over Wi-Fi, Li-Fi technology is facing some challenges. Li-Fi requires line of sight. When set up outdoors, the apparatus would need to deal with ever changing conditions. Indoors, one would not be able to shift the receiving device. A major challenge facing Li-Fi is how the receiving device will transmit back to transmitter. It is easily block by somebody walking in front of LED source.

One more disadvantage is that visible light can't penetrate through brick walls as radio waves and is easily blocked by somebody simply walking in front of LED source. A side effect of Li-Fi is that your power cord immediately becomes your data stream, so if you have power, you have internet [1].

VII. FUTURE ADVANCEMENTS

Traffic lights could better regulate traffic flow using data. It can also be used in hospitals and aeroplanes where radio signals are prohibited [1].

Thousands and millions of street lamps can be transferred to Li-Fi lamps to transfer data. It can be used in petroleum and chemical plants where other transmission or frequencies could be hazardous.

VIII. CONCLUSION

We presented the concept of VLC in which communication takes place by visible light signal. We explained the benefits of VLC over current RF solutions including ability, efficiency, security and safety. These benefits enable a new and wider range of VLC applications from hospital, military applications, Underwater Communications, Aviation etc. If we put this technology into practical use, every bulb can be used something like a Wi-Fi hotspot to transmit wireless data and we can proceed toward the cleaner, safer and brighter future.LC gives the advantage of a using an unregulated, unlicensed part of the electromagnetic spectrum. VLC have many challenges but apart from it is ready for implementation. It is greener, safer and brighter option for radio waves.

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