A Review On LiFi : The Green WiFi

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Abstract - *Today speed of internet is a major issue and everyone be it business, institutions, organizations, entrepreneurs is thrust for getting right information at the right time and right place .This requires fast internet connectivity, technology and large spectrum of channels. Present paper reflects the Future of Communication (LI-FI) which may affect all lives. It is a technology that may provide theoretically a speed of upto 10Gbps, cost effective and more robust and useful than Wi-Fi. Li-Fi is not expected to completely replace Wi-Fi, but the two technologies could be used complementarily to create more efficient, green and future-proof access networks. The inventor of Li-Fi, Harald Haas a German physicist and professor has come up with this technology which he calls "data through illumination". It is a wireless technology that makes use of visible light in place of radio waves to transmit data at terabits per second speeds—more than 100 times the speed of Wi-Fi. This technology has immense possibilities, from public internet access through street lamps to auto-piloted cars that communicate through their headlights.*

Key Words: *Li-Fi(Light- Fidelity), Wi-Fi(Wireless- Fidelity), LED(Light Emitting Diode), VLC(Visible Light Communication),Wireless technology, LOS(Line of Sight), Photo Detector .*

1.INTRODUCTION

Li-Fi can be rightly regarded as a light based Wi-fi. The difference is that instead of wi-fi modems, transceiver-fitted LEDs lamps are used which can light a room as well as transmit and receive information. This technology uses a part of the electromagnetic spectrum that is still not greatly utilized, from the infrared through visible light and down to the ultraviolet spectrum providing a wide range of frequencies and wavelengths. Light is in fact a source of life and practically has no ill-effects. Thus li-fi proves to be the most developed technology without any sort of pollution or harms. A flickering light can unexpectedly be a great boon communication. 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 LEDs intensity is modulated so rapidly that human eyes cannot notice, so the output appears constant. Moreover, parallel data transmission using arrays of LEDs, where each LEDS transmit a different data stream is possible. Efforts are being made by using mixtures of red, green and blue LEDs to alter the light's frequency, with each frequency encoding a different data channel which is capable of transmitting of data of about 100-500 Mb/s. Presently we are utilizing the Wi-Fi services within the campus and around the 10-100 meter distances to connect our P.C's, Laptops, palmtops and P.C. notes etc. The challenges faced by Wi-Fi in today's time are

- Capacity
- Availability
- Efficiency
- Security

These drawbacks have motivated the scientists to develop a better technology which has come in the form of Li-Fi. This term was first used by Hass in 2011 in TED Global talk on visible light communication. "At the heart of this technology is a new generation of high brightness light-emitting diodes", says Harald Hass from the University of Edinburgh, UK. Later in 2012, the technology was demonstrated at the Consumer Electronics show in Las Vegas using a pair of Casio smart phones to exchange data using light of varying intensity given off from their screens, detectable at a distance of up to ten metres. Then a number of companies made efforts to overcome the drawbacks of radio waves communication by forming consortiums which believe that it is possible to achieve a data rate of more than 10 Gbps.

1.1 WORKING PRINCIPLE OF LI-FI

The working principle of li-fi was first proposed by Harald Haas from University of Edinburgh, UK, in his TED global talk on VLC. The working principle of li-fi is very simple, it is based on the transmission of digital data 0's and 1's. The logic is, if the LED is OFF, digital 0 is transmitted and if the

LED is ON, digital 1 is transmitted, which can't be detected by human eye. The LED's can be switched ON and OFF very quickly by which we can transmit data with the help of light. Generally white LED bulbs are used for implementing the concept of li-fi which is used for illumination by applying a constant current. However, the light output can be made to vary at extremely high speeds by fast variations of the current. To build up a message we are flashing the LEDs numerous times. In order to obtain data rates in the range of hundreds of mega bytes per seconds we can use array of LEDs which also helps us for parallel data transmission or we can also use combination of three basic colours LEDs red, green, blue to alter the frequency of light. The VLC (Visible Light Communication) uses visible light between 400 THz (780 nm) and 800 THz (375 nm) as the optical carrier for data transmission and for illumination.

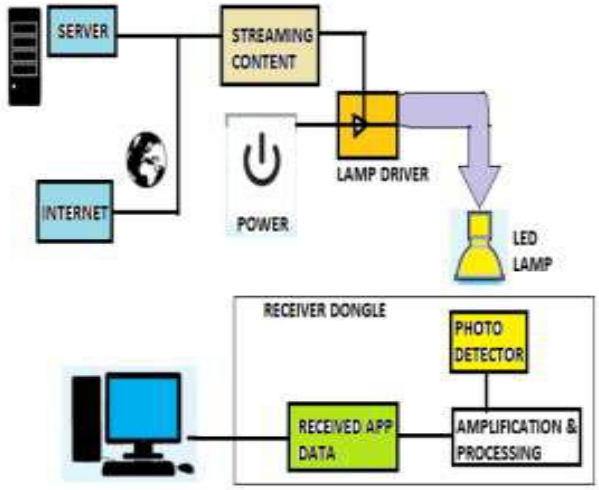


Fig 1 : Block diagram of transmitter and receiving section of li-fi.

- At one end ,all the data on the internet will be streamed to a lamp driver.
- When the LED is turned ON, the microchip converts the digital data in the form of light.
- Then the signal is received by a light sensitive device known as photo detector, which will help to convert it back into original data.
- Then it is given to the device which is connected to it.

1. 2 HOW THE BASIC LIGHT IS COVERTED INTO ELECTRICITY

- Vacuum equations, electromagnetic waves and speed of light

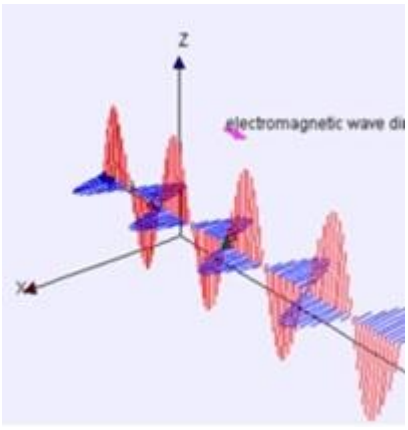


Fig 2: 3D diagram of a plane linearly polarized wave propagating from left to right.

- The above 3D diagram shows a plane linearly polarized wave propagating from left to right.
- Where $E = E_0 \sin(-\omega t + k \cdot r)$.....(a)
  $B = B_0 \sin(-\omega t + k \cdot r)$.....(b)
  Here E and B represent the electric and magnetic wave equation respectively.
- In a region, such as in a vacuum, with no charges i.e. $\rho = 0$ and no currents i.e. J = 0, Equation 1 is reduced Maxwell's equations:

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

...(1)

- Now, taking the curl (∇×) of the equations, and using the curl of the curl identity $\nabla \times (\nabla \times X) = \nabla(\nabla \cdot X) - \nabla^2 X$ we obtain the wave equations (2)

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

...(2)

Which identify

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

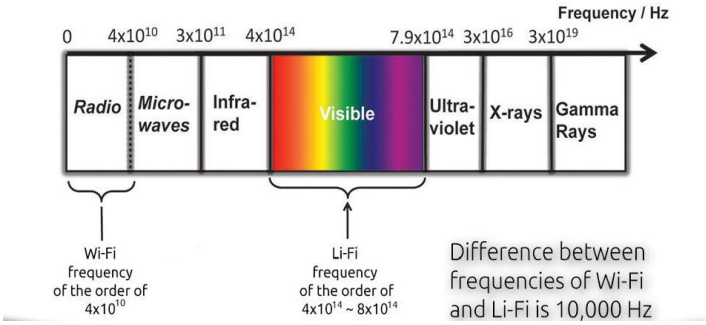
- Where C is the speed of light in free space. In materials with relative permittivity ε_r and relative permeability μ_r, the phase velocity of light becomes

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

- 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 Amperes' law. This perpetual cycle allows these waves, now known as electromagnetic radiation, to move through space at velocity *c*.

2. ADVANTAGES OF LI-FI

- Li-fi technology is based on the light sources like LED for the transmission of data. With the help of all kinds of light we can transfer the data, no matter what the part of the spectrum they belong. . That is, the light can belong to the invisible, ultraviolet or the visible part of the spectrum. Also, the speed of the communication is more than sufficient for downloading movies, games, music and all in very less time.



- **Capacity:-**The bandwidth of light is 1000 times wider than the bandwidth of radio waves. As the equipments are already available and the light sources are already installed so, it has got better capacity.
- **Efficiency:**-LED light consumes less energy and are highly efficient.
- **Cheaper:**- As the cost of the LED is less and it consumes less electricity so it is cheaper.
- **Availability:-**As light sources are present everywhere so availability is not an issue. There are billions of light bulbs worldwide, they just need to be replaced with LEDs for proper transmission of data.
- **Security:-**As light waves cannot penetrate through walls so, they cannot be intercepted or misused. They provide secure access.
- **Free band:**-It makes use of free band that doesn't need any licensing.
- **High speed:**-It provides theoretical speed of one giga byte per second.

3. APPLICATIONS OF LI-FI

The LI-FI system finds a variety of uses in many fields from access to internet by the general public using street lamps to auto-pilot cars which communicate through their headlights. Moreover, in areas such as medicine and aircrafts where WI-FI cannot be used, LI-FI is an alternative which can provide faster data access rates. Some of the applications are discussed below:

(a) Education System: LI-FI can replace WI-FI in educational institutions and provide faster internet speeds. All the people can make use of the same speed as has been designated.

(b) Medical Applications: WI-FI is not allowed in operation theatres because they can interfere with medical equipments. Moreover, their radiations pose risks for patients. LI-FI uses light and hence can be used in place of WI-FI.

(c) Internet access in aircrafts: The use of WI-FI is prohibited inside airplanes because they can interfere with the navigational systems of the plane. The users get access to very low speed internet at high rates. Thus, LI-FI is a safe alternative to WI-FI in aircrafts since it uses light and can provide faster internet access.

(d) Underwater application: Underwater ROVs (Remotely Operated Vehicles) operate from large cables that supply their power and allow them to receive signals from their pilots above. But the tether used in ROVs is not long enough to allow them to explore larger areas. If their wires were replaced with light — say from a submerged, high powered lamp — then they would be much freer to explore. They could also use their headlamps to communicate with each other, processing data autonomously and sending their findings periodically back to the surface. LI-FI can even work underwater where Wi-Fi fails completely, thereby throwing open endless opportunities for military operations.

(e) Disaster Management: In times of natural calamities such earthquakes, LI-FI can be used as a powerful means of communication since it uses light which unlike RF is not obstructed by walls or other such things.

(f) Radio broadcast: A large amount of power is required by radio masts in order to broadcast and this makes them quite inefficient. LEDs on the other hand require very low power to operate and this means that LI-FI also uses very little power.

3.1 FEW MORE APPLICATIONS

1. **Want to Live a Little Longer :**Ever since its existence, medical technology has been a couple of steps behind the wireless world. 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. Li-Li solves both problems:

lights are the most glaring fixtures in the room, And Li-Fi also has 10,000 times the spectrum of Wi-Fi.

2. **Undersea Awesomeness:** Underwater ROVs, those favourite toys of treasure seekers, operate from large cables that supply their power and allow them to receive signals from their pilots above. ROVs work great, except when the tethers isn't long enough to explore an area, or when it gets stuck on something. If their wires were cut and replaced with light — say from a submerged, high-powered lamp — then they would be much free to explore. They could also use their headlamps to communicate with each other.

3. **Smarter Airlines :**Airlines Wi-Fi, Ugh you got to be either an adventure freak or a fool to be playing around radio waves on an airplane which is a security issue and so we are requested to switch off our electrical devices during a flight. The best I've heard so far is that passengers will "soon" be offered a "high-speed like" connection on some airlines and speeds as high as 9.8 Mbps per plane. Li-Fi whereas can easily introduce that sort of speed to each passenger seat's reading light.

4. **Better and Efficient Power Plants :**Wi-Fi and many other radiation types are bad for sensitive areas like power plants. But thermal power plants need fast, inter-connected data systems to monitor things like demand, grid integrity and (in nuclear plants) core temperature. Li-Fi could offer safe (as no radiation) connectivity for these sensitive locations. Not only would this save a lot of money from the current power plant designs but the draw on a power plant's own reserves could be lessened if they haven't yet converted to LED lightning.

5. **All Information Under a StreetLight:** How about a dinner reservation on the night of your anniversary and you need internet access but struck in traffic. You just need to put your phone under a street light and book a table at your favourite restaurant. Or say an earthquake occurs and an average delhite may not know the protocols that should be followed until they pass under a street light, that is. Don't forget with Li-Fi, if there's light, you're online. Thus Li-Fi could provide cheap high-speed Web access to every street corner.

4. FUTURE ADVANCEMENTS

- A consortium called Li-Fi Consortium' was formed in October2011 by a group of companies and industry groups to promote high-speed optical wireless systems and overcome the limited amount of radio based wireless spectrum. According to the Li-Fi Consortium, it is possible to achieve more than 10 Gbps.
- Researchers at the University of Strathclyde in Scotland have begun the task of bringing high speed, ubiquitous, Li-Fi technology to market.
- Further enhancements are possible like using an array of LEDs for parallel data transmission or using mixture of red, green and blue LEDs to alter the light's frequency with each frequency encoding a different data channels. Such advancements promise a theoretical speed of 10 Gbps.

Li-Fi technology is being developed into a ubiquitous systems technology, consisting of application specific combinations of light transmitters, light receivers including solar cells, efficient computational algorithms and networking capabilities that can be deployed in a wide range of communication scenarios and in a variety of device platforms.

5. CHALLENGES OF LI-FI

Apart from many advantages over wi-fi technology, it is facing few challenges which is need to be overcome.

- For the transmission of data it requires line of sight.
- We lose access to the internet, if the light source malfunctions. For internet access we become dependent of light source.
- We have to deal with changing weather conditions ,if the apparatus is set up outdoors.
- As visible light can't penetrate through brick walls so, it can be easily blocked by somebody simply walking in front of LED source.
- A major challenge is how the receiving device will transmit the data back to transmitter.

6. CONCLUSIONS

LiFi is an emerging technology and has vast application. If this technology can be put into practical use, every bulb can be used like a wifi hotspot to transmit wireless data. This concept can be used to solve issues such as shortage of radio frequency bandwidth . Thus, this technology provides numerous benefits. By using this technology we can proceed towards a greener, safer and cleaner future. It is an advanced approach that will make our lives more technology driven in the near future. .

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