ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 5, Issue 3, March 2017

A Study on Li-Fi Technology and Challenges in Connecting Devices

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ABSTRACT: Li-Fi is an acronym which refers to Light-fidelity. It refers to light based communication technology i.e)Visible Light communication(VLC). It delivers a high-speed, Bidirectional networked mobile communication in a similar manner as Wi-Fi. Li-Fi is a category of Optimal Wireless Communication(OWC). Harald Hass coined the term Li-Fi in his TED(Technology Entertainment and Design)a Global Talk. Li-Fi is an exciting breakthrough in 5G Visible Light communication system and the future of wireless internet access. Light-emitting diode(LED) bulbs transmit data when they are switched on and off so rapidly in nanoseconds that it is not visible to human eye but it is focused on photo detector which coverts the on-off state into binary digital data. Li-Fi is zero interference allowing connectivity even in areas where Wi-Fi isn't accepted. Li-Fi works on three modes i)Star topology, ii)Peer to peer topology, iii) Broadcast communication. Li-Fi has more capacity in terms of bandwidth in visible region. It has gained a huge popularity within a short period of time.

KEYWORDS: Li-Fi (Light Fidelity), VLC(Visible Light Communication), Wi-Fi(Wireless fidelity),OWC(Optimal Wireless Communication), LED(Light Emitting Diode)

I. INTRODUCTION

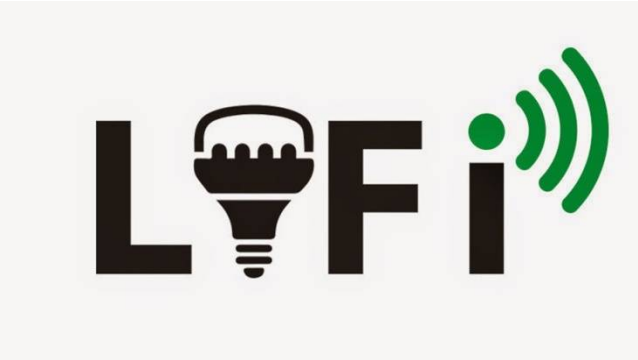

Fig: 1 Light Fidility

Li-Fi (Light Fidelity) the future technology in wireless technology. In simple terms Li-Fi can be thought of as a light-based Wi-Fi. That is, it uses light instead of radio waves to transmit information. And instead of Wi-Fi modems, Li-Fi would use transceiver-fitted LED lamps that can light a room as well as transmit and receive information. Since simple lights bulbs are used , there can technically be any number of access points. This technology uses a part of the electromagnetic spectrum that is still not greatly utilized- The Visible

This technology uses a part of the electromagnetic spectrum that is still not greatly utilized- The Visible Spectrum. Light is in fact very much part of our lives for millions and millions of years and does not have any major ill effect. Moreover there is 10,000 times more space available in this spectrum and just counting on the bulbs in use, it also multiplies to 10,000 times more availability as an infrastructure, globally. Visible Light Communication(VLC) works

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by switching the current to the LED s off and on at a very high rate, too quick to be noticed by the human eye. Although Li-Fi LEDs would have to be kept on to transmit data, they could be dimmed to below human visibility while still emitting enough light to carry data. The light waves cannot penetrate walls which makes a much shorter range, though more secure from hacking, relative to Wi-Fi Direct line of sight is not necessary for Li-Fi to transmit a signal, light reflected off the walls can achieve 70 Mbit/s.

II. HISTORY OF LI-FI

The technology underpinning Li-Fi was pioneered by German Physicist Harald Hass at University of Edinburgh in UK. Haas coined the term Li-Fi in 2011 in the context of a talk presenting the new technology at the TED(Technology Entertainment and Design) Global Conference. The word quickly entered common parlance as an instantly recognizable alternative to Wi-Fi. Both terms are examples of abbreviations linguists sometimes describe as clipped forms(i.e. Wi-Fi=wireless fidelity, Li-Fi= light fidelity). Haas's research project, originally known as D-light (short for Data Light), is now set to launch a prototype Li-Fi application under the name of newly-formed company VLC(Visible Light Communication) Ltd., which was setup to commercialize the technology. The Li-Fi technology can be used for various purposes, it matters the data transmission through LEDs thus all the screens which illuminate light can be served as a platform for data communication. The screen of the mobile phone, television, bulbs can act as a source of light. On the other hand, the receiving platform, the photo detector can be replaced by a camera in mobile phone for scanning and retrieving data. Its other applications are Li-Fi for desktops, smartcard Li-Fi, Li-Fi for schools, hospitals, Li-Fi in cities, smart guides, museums, hotels, fairgrounds, events indoor and LBS(Location-based Services), access control and identification crisis, malls, airport and dangerous environments like thermal power plants.

III. WHAT IS LI-FI AND ITS FUTURE

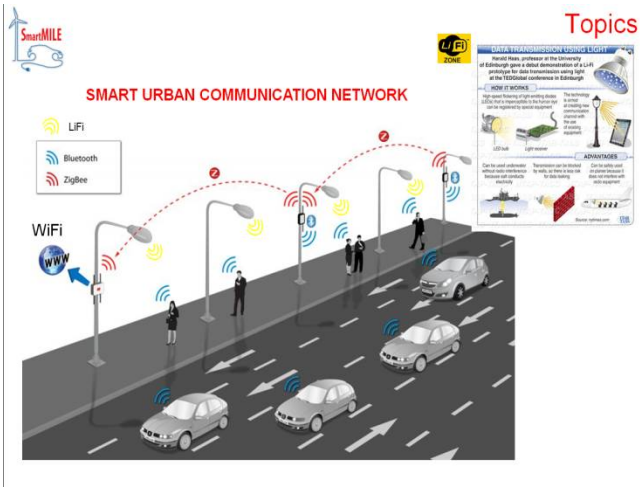

Fig:2 Smart urban communication network

It's impossible to avoid Wi-Fi in today's world. It's , your neighbours have it, it's free in coffee shops, and essential for mobile Internet via smartphones. We all know Wi-Fi but what is *Li-Fi?*

Secure, localized, safe and incredibly fast, Li-Fi is here and set to increasingly shape our working and domestic lives in the future, because we will be running out of radio frequency spectrum. Li-Fi, like Wi-Fi, enables electronic devices like computers, laptops and smartphones to wirelessly connect to the Internet. Even though Wi-Fi was also originally intended for such de vices, it is widely used today to connect all sorts of things. Li-Fi uses the light waves from LED light bulbs— that are rapidly replacing incandescent light bulbs for their energy savings and durability — to transmit for their energy savings and so it provides illumination and

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wireless data communications at the same time and with the same device. As Li-Fi becomes more commercialized, it will be an era of incredible business opportunities, such as allowing telecom service providers to reach out to a wider customer base. We can look forward to broader accessibility with Li-Fi Cloud. Smartphones will soon be able to download traffic information from traffic lights or a program guide from a television. This is the tip of the iceberg. In the future, shops will transmit advertisements to your phone as you pass by and bus schedule changes will be transmitted to a screen at the stop. Smarter home appliances that talk machine-to-machine (M2M) are already being extensively researched, where LED lights on electronics function as Li-Fi access points. In fact, the Li-Fi industry is set to become a $6 billion industry by 2018.

IV. WORKING

The functioning of new Li-Fi technology is just simple. You will have a light source at one end like a LED and a photo detector (Light Sensor) on the other end. A VLC light source could comprise of a fluorescent or light emitting diode (LED) bulb. Since a robust Li-Fi system requires extremely high rates of light output, LED bulbs are most ideal for implementing Li-Fi. LED is a semiconductor light source, which implies that LED light bulbs can amplify light intensity and switch rapidly. Therefore, LED cells can modulate thousands of signals without the humaneye ever noticing. In turn, the changes in light intensity from the LED light source are interpreted and converted as electrical current by the receiving photodiode device.

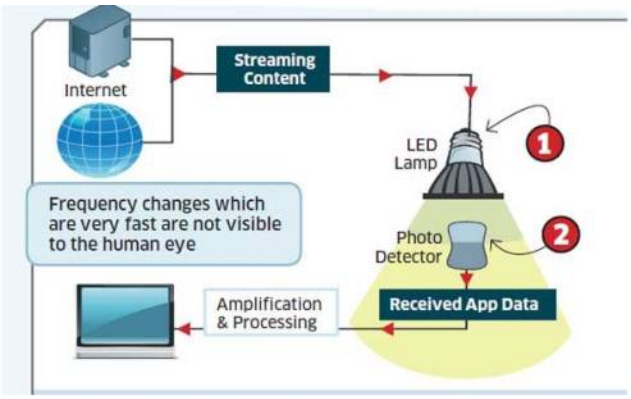

Fig: 3 Working of Li-Fi

Once the electrical signal is demodulated, it is converted into a continuous stream of binary data comprising of audio, video, web, and application information to be consumed by any Internet-enabled device.There is ample room for growing innovation in Li-Fi technology. Like conventional broadband and Wi-Fi, Li-Fi can also function as a bidirectional communication system. By interchanging visible light and infrared light from a photo detector, a mobile device connected to that photo detector can send data back to the light source for uplink. Also, multi-coloured RGB (Red/Green/Blue) LED's at retina size could be engineered to send and receive a wider range of signals than single-coloured phosphor-coated white LED's.

V. MODULATION TECHNIQUE USED IN LI-FI

Since LI-FI uses visible light for sending data, it is necessary to modulate the data into a signal which can be transmitted. These signals consist of light pulses. Some of the common modulation techniques used in LI-FI are discussed below:

(a) OFDM: Orthogonal frequency-division multiplexing (OFDM) is a method of encoding digital data on multiple carrier frequencies. OFDM is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method. A large number of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data streams or channels. Each sub-carrier is modulated with a conventional modulation

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scheme (such as quadrature amplitude modulation or phaseshift keying) at a low symbol rate, maintaining total data rates similar to conventional *single-carrier* modulation schemes in the same bandwidth.

(b) OOK: On-off keying (OOK) denotes the simplest form of amplitude-shift keying (ASK) modulation that represents digital data as the presence or absence of a carrier wave. In its simplest form, the presence of a carrier for a specific duration represents a binary one, while its absence for the same duration represents a binary zero. Some more so phisticated schemes vary these durations to convey additional information. It is analogous to unipolar encoding line code. It is very easy to generate and decode but is not very optimal in terms of illumination control and data throughput.

(c) PWM: Pulse-Width Modulation (PWM) is a technique used to encode a message into a pulsing signal. Although this modulation technique can be used to encode information for transmission, its main use is To allow the control of the power supplied to electrical devices, especially to inertial loads such as motors. Pulse Width Modulation(PWM) transmits the data by encoding the data into the duration of the pulses. More than one bit of data can be conveyed within each pulse.

(d) PPM: Pulse-position modulation (PPM) is a form of signal modulation in which M message bits are encoded by transmitting a single pulse in one of possible required time-shifts. This is repeated every T seconds, such that the transmitted bit rate is bits per second. It is primarily useful for optical Communications systems, where there tends to be little or no multipath interference.

(e) SIM-OFDM: Sub-carrier Index Modulation OFDM is a technique which adds an additional dimension to the two dimensional amplitude/phase modulation technique i.e., Amplitude Shift Keying (ASK) and Quadrature Amplitude Modulation (QAM). SIM uses the sub-carrier index to convey information to the receiver. Unlike the traditional OFDM technique, the SIM-OFDM technique splits the serial bit stream into two bit sub-streams of the same length.

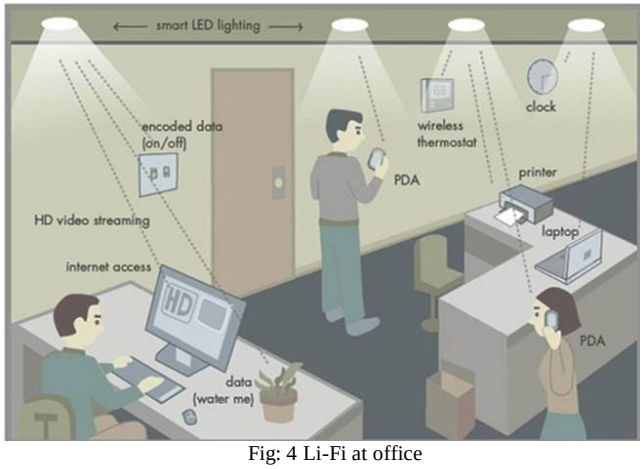

Fig: 4 Li-Fi at office

VI. APPLICATIONS

Li-Fi applications are varied as a result of its key features, such as directional lighting, energy efficiency, intrinsic security, high data rate capability, signal blocking by walls and integrated networking capability. Each light fixture in the application environment becomes a separate data channel. These channels can supply different data into each separate pool of light, delivered at the full rated download speed for that channel.

- Security

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- Dense urban environments
- Cellular communication
- EMI sensitive environments
- Augmented reality
- Localised
- Underwater communication
- Safety environments
- Intelligent
- Connectivity
- Sensitive data
- Indoor

VII. CHALLENGES OF LI-FI

Although there are a lot of advantages of Li-Fi, there are still certain challenges which need to be overcome.

- LI-FI requires Line of Sight.
- If the apparatus is set up outdoors, it would need to deal with changing weather conditions.
- If the apparatus is set up indoors, one would not be able to shift the receiver.
- The problem of how the receiver will transmit back to the transmitter still persists.
- Light waves can easily be blocked and cannot penetrate thick walls like the radio waves can.
- We become dependent on the light source for internet access. If the light source malfunctions, we lose access to the internet.

VIII. LI-FI VS WI-FI

Main Difference – Wifi vs Lifi

The main difference between Wifi and Lifi is, Wifi uses radio waves in order to transmit data at a slower data rate whereas Lifi uses visible light in order to transmit data at a much faster rate. Lifi is a groundbreaking technology which has been introduced recently in wireless communication. Through this technology, the bulbs at homes, offices and streets will not only be able to light and illuminate the environment but will also be able to transmit data wirelessly at high speed. Let us take a closer look at Wifi and Lifi and see what both of these technologies have to offer.

The following table shows the comparison between Li-Fi and Wi-Fi technologies

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Feature / Parameter	Li-Fi	Wi-Fi
Technology	IrDA compliant devices	WLAN 802.11a/b/g/n/ac/ad standard
Operating Frequecny	10,000 times frquency spectrum of radio	2.4 GHz , 4.9 GHz and 5 GHz
Coverage	Around 10 meters	Around 32 meters and varies on power /antennae type
Data Density	Works in high dense environment	Works in less dense environment
Privacy	Light is blocked by walls , hence more secured.	RF signal cant be blocked by walls , hence less secured
Data Tranfer Speed	Faster transfer speed (>1 Gbps)	Slower transfer speed (150 Mbps)
Midium of Data Tranfer	Light as the carrier	Radio spectrum is carrier
Spectrum Range	Light has spectrum 10000 times broader than radio frequency	Radio frequency spectrum is much less than light spectrum
Cost	Cheaper than Wifi due to – 1 – No license required for light band 2 – Lower installation cost	Cheaper than Wifi due to – 1 – License required for radio band 2 – Higher installation cost
Ecological impact	Low	Medium
Market Maturity	Low	High
System components	Lamp driver, LED bulb (lamp) and photo detector will make up complete LiFi system.	requires routers to be installed, subscriber devices(laptops ,PDAs,desktops) are referred as stations
Applications	Used in airlines, undersea explorations, operation theaters in the hospitals, office and home premises for data transfer and internet browsing	Used for internet browsing with the help of wifi kiosks or wifi hotspots
Merits(advantages)	Interference is less, can pass through salty sea water, works in densy region	Interference is more, can not pass through sea water, works in less densy region

Table 1. Li-Wi Vs Wi-Fi

IX. DISADVANTAGES

- Light can't pass through objects
- High installation cost of the VLC systems
- Interferences from external light sources like sun,light,normal bulbs,opaque materials.
- Internet cannot be used without a light source. This could limit the locations and situations in which Li-Fi could be used.
- Because it uses visible light, and light cannot penetrate walls, the signal's range is limited by physical barriers.
- Other sources of light may interfere with the signal. One of the biggest potential drawbacks is the interception of signals outdoors. Sunlight will interfere the signals, resulting in interrupted Internet.
- A whole new infrastructure for Li-Fi would need to be constructed.

X. CONCLUTION

Li-Fi will make our lives more technology driven in the near future. With its magic of light it can make our world greener,safer,cleaner and moreover a brighter place to live. Every bulb can be used something like a Wi-Fi hotspot to transmit wireless data. It is currently attracting a great deal of internet, not least because it may offer a genuine and efficient alternative to radio based wireless. It can solve issues such as the shortage of radio-frequency bandwidth and als allow internet where traditional radio based wireless is not allowed such as aircraft or hospitals. As there is growth in population and their devices access wireless internet, the air waves are becoming increasingly clogged, making it more and more and difficult to get a reliable, high-speed signal. So Li-Fi has a bright future.

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