American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-5, Issue-5, pp-40-47
www.ajer.org
Research Paper Open Access

Wireless Communication tends to Smart Technology Li-Fi and its comparison with Wi-Fi

M. A. Hadi[1]
[1](Department of Networks & Communication Systems, Princes Nourah University, Riyadh, KSA
Department of Computing and Electronics Systems Engineering, Cairo Higher Institute of Engineering, Computer Science and Management, New Cairo, Egypt)

ABSTRACT : *The need to find new means of wireless communication which is fast, reliable and error free, tend one germen physics, Dr. Harald Haas that is say this argument "data through illumination" that introduced a technique to cope up with this problem by sending data through an LED light bulb that varies in intensity even faster than the human eye can follow. Tend to the investing the "Li-Fi", or "Light Fidelity". Li-Fi is basically the subset of visible Light Communication (VLC), uses LED bulbs as hot-spots and provides higher data rates than Wi-Fi. It's the same idea band behind infrared remote controls but far more powerful. Li-Fi is the term some have used to label the fast and cheap wireless-Communication system, which is the optical version of Wi-Fi.*
Keywords : *Li-Fi, Wi-Fi,VLC, LED*

I. INTRODUCTION

Li-Fi basically known as "Light Fidelity" is an outcome of 21st century. The basic ideology behind this technology is that the data can be transmitted through the LED light whose intensity varies even faster than the Human-eyes. The term was coined by Harald Haasand is a form of visible light communication and a subset of optical wireless communications (OWC) and could be a complement to RF communication (Wi-Fior Cellular network), or even a replacement in contexts of data broadcasting. It is so far measured to be about 100 times faster than some Wi-Fi implementations, reaching speeds of 224 gigabits per second [1]

The disadvantage of traditional Wi-Fi routers is that multiple devices in a space can interfere with each other. Li-Fi however can use multiple lights in a room without interference. In modern times, it is called as the optimized version of Wi-Fi. The advantageous thing is the wireless communication which decreases the cost enormously. there are more and more devices coming up day-by-day the signals of Wi-Fi are being clogged up due to heavy traffic, there arised a need for an error free transmission technology. And the solution to this problem was the Li-Fi technology. [2]

With Li-Fi is possible to encode the data into the light by varying the rate at which the LED's flicker ON and OFF which is too quickly to be noticed by the human eye. Li-Fi enables devices to use their in-built stand by LED lights to transmit data.

We will offer a brief introduction and then we review some of the facts that appear why we are harry to using the Li-Fi in this days, this introduction at section I, will be explained in section II, what is the history of Li-Fi, what is meaning by Li-Fi, and its definition, also we will see how the Li-Fi does working, the General construction of Li-Fi , Basic elements, and we will present why we use the VLC in Li-Fi , all of this points present in section II. An IEEE Standard for Visible Light Communications and its classification for Li-Fi are introduced in section III with its Characteristics. In Section IV we will introduce the analytical comparison between the two types of Wireless Communication Li-Fi and Wi-Fi, following by the advantages of Li-Fi over radio waves, the challenges for Li-Fi, also we introduce why future towards Li-Fi. Section V we Will interest to show that some applications will be using the Li-Fi in the Future. By conclusion we will end this paper.

II. WHAT'S IDEA OF LI-FI

- **Li-Fi HISTORY**

Professor Harald Haas, from the University of Edinburgh in the UK, is widely recognized as the original founder of Li-Fi. He coined the term Li- Fi and is Chairman of Mobile Communications at the University of Edinburgh and co-founder of pure Li-Fi. The consortium believes it is possible to achieve more

than 10Gbps speed using this optical wireless technology also known as Li-Fi. It gets affected if line of sight is not used, the speed of data transmission will reduce or data transmission will stop. Pure Li-Fi, formerly pure VLC, is an original equipment manufacturer (OEM) firm set up to commercialize Li-Fi products for integration with existing LED-lighting systems. Philips lighting company has developed a VLC system for shoppers at stores. They have to download an app on their smartphone and then their smartphone works with the LEDs in the store. The LEDs can pinpoint where they are at in the store and give them corresponding coupons and information based on where aisle they are on and what they are looking at .[2]

- **WHAT IS Li-Fi?**

Like Wi-Fi, Li-Fi is a wireless internet connection standard. However, rather than operating on radio waves, Li-Fi operates using visible light waves. The term Li-Fi was coined by pure Li-Fi's CSO, Professor Harald Haas, and refers to light based communications technology that delivers a high-speed, bidirectional networked, mobile communications in a similar manner as Wi-Fi. Although Li-Fi can be used to off-load data from existing Wi-Fi networks, implementations may be used to provide capacity for the greater downlink demand such that existing wireless or wired network infrastructure may be used in a complementary fashion. Li-Fi is the use of the visible light portion of the electromagnetic spectrum to transmit information at very high speeds. This is in contrast to established forms of wireless communication such as Wi-Fi which use traditional radio frequency (RF) signals to transmit data. [1, 2, 3]

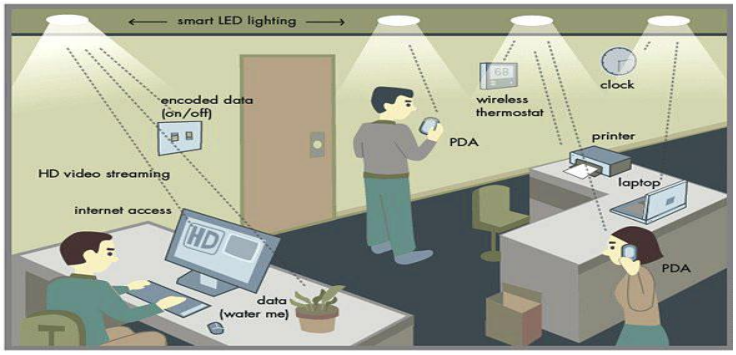

Fig.1 Li-Fi Environment

With Li-Fi, data is transmitted by modulating the intensity of the light, which is then received by a photo-sensitive detector, and the light signal is demodulated into electronic form. This modulation is performed in such a way that it is not perceptible to the human eye. Li-Fi is a category of Optical Wireless Communications (OWC). OWC includes infra-red and ultra-violet communications as well as visible light. However, Li-Fi is unique in that the same visible light energy used for illumination may also be used for communication.

The technology uses protocols similar to the RF-band 802.11 protocols, with additional standards to eliminate the impacts of interference and impacts of ambient lighting. Despite this, however, the technology cannot be deployed in outdoors in sunlight or in other odd conditions. [3]

While Li-Fi does come with the advantage of not interfering with radio signals, a lot of the benefits are overpowered by the simple fact that visible light cannot travel through walls, an essential factor which gives old-school Wi-Fi a huge advantage. This line-of-sight limitation does make the system more secure and gives better control over emissions, but it's unclear what the minimum distance for signal reception would be if clear line-of-sight is achieved. With that in mind, it is easy to imagine the signal being intercepted by someone with a telephoto lens and an optical sensor tuned appropriately. While Li-Fi was touted as a possible channel for wireless communications on airplanes, widespread adoption of onboard Wi-Fi on most US airlines makes this use case less and less pertinent. [3]

In this context, the visible light spectrum is 10,000 times bigger than the radio-wave spectrum in which all of our wireless communications take place. With our Wi-Fi networks getting ever more crowded as more and more connected devices join the fray, internet performance is only going to suffer. A completely different spectrum is one obvious solution, and that's just what Li-Fi promises to provide access to. Li-Fi is also potentially much more energy efficient than Wi-Fi, which requires costly and power-hungry masts to operate. The infrastructure for Li-Fi, meanwhile, is already partially in place, and a connection could eventually be as simple to initiate as turning on a lamp. [4]

- **HOW DOES LI-FI WORK?**

When a constant current is applied to an LED light bulb a constant stream of photons are emitted from the bulb which is observed as visible light. If the current is varied slowly the output intensity of the light dims up and down. Because LED bulbs are semi-conductor devices, the current, and hence the optical output, can be modulated at extremely high speeds which can be detected by a photo-detector device and converted back to electrical current. The intensity modulation is imperceptible to the human eye, and thus communication is just as seamless as RF. Using this technique, high speed information can be transmitted from an LED light bulb.[5]

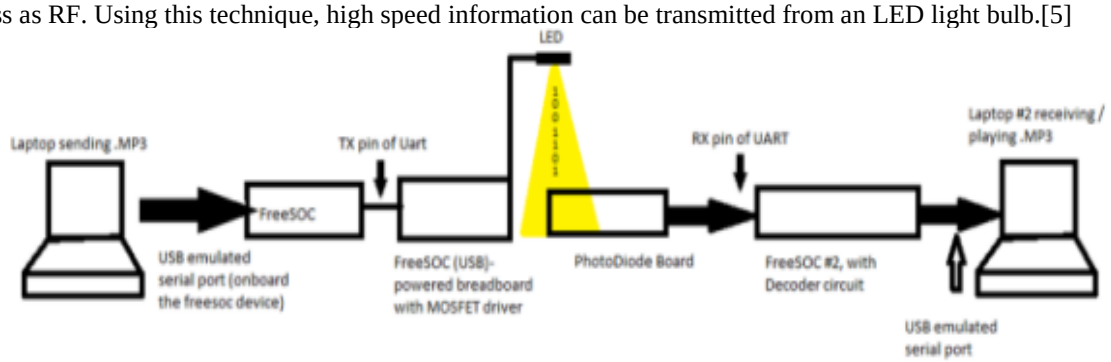

Fig 2: Block Diagram of Li-Fi System

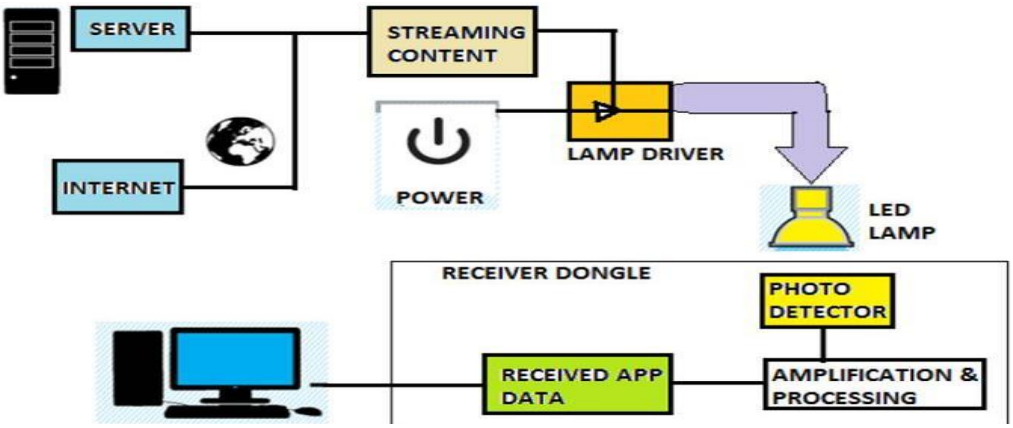

Fig. 3 Working of Li-FI

Radio frequency communication requires radio circuits, antennas and complex receivers, whereas Li-Fi is much simpler and uses direct modulation methods similar to those used in low-cost infra-red communications devices such as remote control units. Infra-red communication is limited in power due to eye safety requirements, whereas LED light bulbs have high intensities and can achieve very large data rates. Dr. Harass succeeded in 2011 creating an 800 mbps capable wireless network by using nothing more than normal red, blue, green, and white LED light bulbs, thus the idea has been around for a while and various other global teams are also exploring the advancement possibilities. Li-Fi is a wireless communication system in which light is used as a carrier signal instead of traditional radio frequency as in Wi-Fi. Li-Fi is a technology that uses light emitting diodes to transmit data wisely. Visible light communication (VLC) uses rapid pulses of light to transmit information wisely that cannot be detected by human eye.

- **LI-FI CONSTRUCTION**

The main components of Li-Fi system are as follows: [5]

a) A high brightness white LED which acts as transmission source.

b) A silicon photodiode with good response to visible light as the receiving element.

LEDs can be switched on and off to generate digital strings of different combination of 1s and 0s. To generate a new data stream, data can be encoded in the light by varying the flickering rate of the LED.

The Li-Fi System consists of 4 primary sub-assemblies:

a) Bulb

b) RF Power Amplifier circuit (PA)

d) Enclosure

c) Printed Circuit Board(PCB)

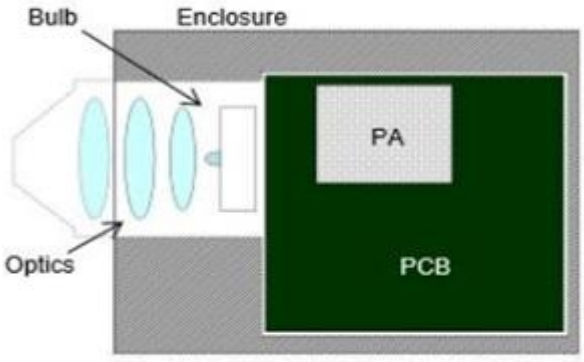

Fig. 4 Li-FI Block Diagram

The PCB : Controls the electric inputs and outputs of the lamp and houses the microcontroller used to manage different lamp functions. **An RF (Radio-Frequency)** signal is generated by the solid-state PA and is guided into an electronic 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 are contained in an aluminum **enclosure.**

Function of The Bulb: At the heart of LIFI™ is the bulb sub-assembly where a sealed bulb is embedded in a dielectric material. This design is more reliable than conventional light sources that insert degradable electrodes into the bulb. The dielectric material serves two purposes; first as a waveguide for the RF energy transmitted by the PA and second as an electric field concentrator 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.

- **WHY ONLY VLC**

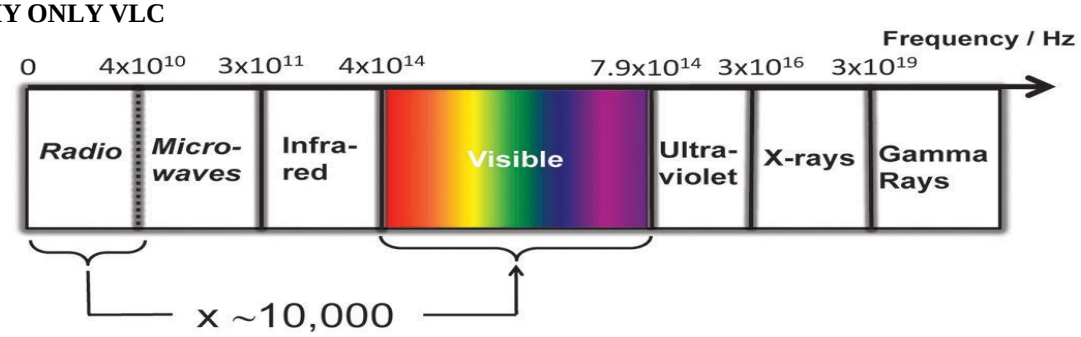

Fig. 5 Light Distribution

- Gama rays can't be used as they could be dangerous.
- X-rays 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 be used with low power.

III. An IEEE Standard for Visible Light Communications

The IEEE802.15.7 draft standard for VLC was produced few years ago. This standard covers both the physical layer (PHY) air interface and the medium-access control (MAC) [6].

The 802.15.7 draft standard is significant for our VLC community because we may now begin to develop products that will be compliant with a future international standard. It also provides a minimum benchmark for future developments. If enhancements are to be proposed to the standard, these enhancements must be based on a significant benefit over what is already written into the proposal. In the following paragraphs I will try to summarize some of the key parameters within the 802.15.7 standard. [2]

The standard is being proposed for a variety of VLC applications relating to Wireless Personal Area Networks (WPAN). The MAC currently supports three multiple access topologies; peer-to-peer, star configuration and broadcast mode. The MAC also handles physical layer management issues such as addressing, collision avoidance and data acknowledgement protocols.

- The physical layer is divided into three types; PHY I, II & III.
  - **PHY I:** is designed for outdoor, low data rate applications. It provides data rates in the range 12 – 267 kbit/s. Convolutional and Reed Solomen codes can be used for forward error correction, and OOK or VPPM are used for modulation.
  - **PHY II:** is designed for indoor operation with moderate data rates in the range 1.25 – 96 Mbit/s. Reed Solomen codes can be used for forward error correction, and OOK or VPPM are used for modulation. Note that to achieve 96 Mbit/s an optical clock rate of 120 MHz is required which most off the shelf optical devices will not support. At the more realistic clock rate of 15 MHz a data rate of 9.6 Mbit/s can be achieved.
  - **PHY III:** is designed for applications where RGB sources and detectors are available. It provides data rates in the range 12 – 96 Mbit/s. Again Reed Solomen codes can be used for forward error correction and this time CSK with 4, 8 or 16 colour constellations are used.

IV. COMPARISON BETWEEN LI-FI AND 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 due to the similarity to WI-FI, only using light instead of radio. Wi-Fi is great for general wireless coverage within buildings, and li-fi is ideal for high density wireless data coverage in confined area and for relieving radio interference issues, so the two technologies can be considered complimentary. Li-Fi features include benefits to the capacity, energy efficiency, safety and security of a wireless system with a number of key benefits over Wi-Fi but are inherently a complementary technology. [4, 5, 7, 8]

Table 1 Comparison between Li-Fi and Wi-Fi

Parameter	Li-Fi	Wi-Fi
CAPACITY	Visible light 10000 times than Radio waves	Radio waves form only a small fraction of the entire EM spectrum
EFFICIENCY	More. LEDs consume less energy and are highly efficient	Less. Radio Base Stations consume high amount of energy and most of the energy is just wasted in cooling down those stations, thus decreasing the efficiency.
AVAILABILITY	Anywhere. It can be available in airplanes, under water with the help of LED bulbs.	Limited because of the harmful effects.
SECURE	More secure because light waves cannot penetrate through walls and cannot be intercepted by anyone outside the illumination of LED i.e outside the room.	Less secure because of high penetrating power of radio waves, anyone can intercept them on the way.
Development Year	2011	1999
Speed	500Mbps, upto 10 Gbps, 100Gbps	11 Mbps
range	10 meters	20-100 meters
Parameter	**Li-Fi**	**Wi-Fi**
IEEE standard	802.15.7	802.11b
Spectrum range	10000 times than Wi-Fi (430–770 THz)	Radio spectrum range (3 Hz to 3000 GHz)
Network Topology	Point-to-point	Point-to-Multi point
Communication	Based on Visible Light Communication	Based on Radio Frequency Communication

Carrier	Information carried over Optical intensities	Information carried over electric field
Routing Device	LEDs	Access Points
Infrastructure Cost	Less	More
Interference with electronic systems	No interference.	Radio Waves do interfere.
Signal - to - Noise Ratio	Very high due to less distance between transmitter and receiver.	May be more
Beam Forming technique	10 meters	20-100 meters
Modulation	Direct Current biased Optical Orthogonal Frequency Division Multiplexing (DCO-OFDM)	Direct Sequence Spread Spectrum (DSSS)
Usage Location	Anywhere, where LED light is available like roads, homes, offices etc.	Within the WLAN range and infrastructure used.
Power Consumption	Less	More
Architecture	Atto Cell	Femto Cell
Environmental impact	Low	Medium

- **ADVANTAGES OF LI-FI OVER RADIO WAVES [9]**
  - High data transmission rates of up to 10Gbps can be archived. Potentially much faster speeds.
  - Li- Fi uses light rather than radio frequency signals so are intolerant to disturbances.
  - While travelling in planes, the VLC can be used without affecting the airline signals.
  - Security is a side benefit of using light because that Light cannot pass through walls, lot more secure.
  - This also means there's less interference between devices.
  - VLC could be used safely in aircraft without affecting airlines signals.
  - Integrated into medical devices and in hospitals as this technology doesn't deal with radio waves, so it can easily be used in all such places where Bluetooth, infrared, Wi-Fi and internet are broadly in use.
  - Like Bluetooth, Wi-Fi, infrared and internet, the VLC can also be used all locations.

- **CHALLENGES FOR LI-FI**

  Although a lot of several advantages over Wi-Fi, Li-Fi technology but still some challenges such as:

  1) Li-Fi requires line of sight.

  2) 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. [10]

  3) A major challenge is how the receiving device will transmit data back to transmitter. [11]

  4) 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. [11]

  5) There are inherent limitations with the light medium that need to be considered and overcome. For example, you wouldn't be able to use Li-Fi outdoors with strong natural light, or, presumably, in areas with lots of interfering light sources.

  6) A side effect of Li-Fi is that your power cord immediately becomes your data stream, so if you have power, you have internet [12].

- **.FUTURE TOWARDS LI-FI**

  Future can be envisioned having light as transmitting medium to our laptops, smart phones and tablets. And security wouldn't be snapped if the device can't access the data.

  Li-Fi has been in the news a bit recently, with recent tests yielding wild promises of vastly improved wireless connection speeds and an end to internet traffic congestion. New Startup Company from Talinn, called Velmenni, recently conducted a practical test of Li-Fi technology in a working office. It attained

internet connection speeds of up to 1Gbps - that's 100 times faster than bog standard Wi-Fi. Meanwhile, in laboratory conditions, it's been established that Li-Fi could theoretically reach speeds of up to 224Gbps. [4]

- **Further research in the field can look into the following issues:[13]**
  1) Driving illumination grade LEDs at high speed
  2) Increasing data rate with parallelism/arrays
  3) Achieving low complexity/low cost modulation
  4) Overcoming the line of sight constraint
  5) Achieving seamless interoperability with other networks
  6) Making Li-Fi work in environments with little or no light

V. APPLICATIONS OF LI-FI

The dramatic growth in the use of LEDs (Light Emitting Diodes) for lighting provides the opportunity to incorporate Li-Fi technology into a plethora of LED environments.

Li-Fi is particularly suitable for many popular internet "content consumption" applications such as video and audio downloads, live streaming, etc. These applications place heavy demands on the downlink bandwidth, but require minimal uplink capacity. In this way, the majority of the internet traffic is off-loaded from existing RF channels, thus also extending cellular and Wi-Fi capacities.

There are many applications for Li-Fi. These include: [3, 5, and 11]

- Street Lamps (As Free Access Points), there are billions of bulbs worldwide which just need to be replaced with LED's to transmit data.
- Traffic Lights Education Systems & traffic control applications
- Hospitals (In Few Medical Equipment's) & Healthcare
- Aircraft & Aviation
- Underwater Communications Wi-Fi does not work at where Li-Fi will work.
- Smart Lighting
- Mobile Connectivity
- Hazardous Environments
- Vehicles & Transportation
- RF Avoidance
- Location Based Services (LBS)
- Toys

VI. CONCLUSION

As a growing number of people and their many devices access wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This may solve issues such as the shortage of radio-frequency bandwidth and also allow internet where traditional radio based wireless isn't allowed.

In the future we will not only have 14 billion light bulbs, we may have 14 billion Li-Fis deployed worldwide for a cleaner, greener, and even brighter future. [14] " Now both light and radio waves can be used simultaneously to transfer data and signals.

REFERENCES

[1] Anthony Cuthbertson, "LiFi internet: First real-world usage boasts speed 100 times faster than WiFi". Retrieved 3, December 2015.

[2] http://en.wikipedia.org/wiki/Li-Fi

[3] N. Kulkarni, "Li-Fi Probably Won't Be The New Wi-Fi For Most People", Techcrunch Network, Nov. 2015, http://techcrunch.com/2015/11/29/li-fi-probably-wont-be-the-new-wi-fi-for-most-people/

[4] Jon Mundy, "What is Li-Fi and how could it make your internet 100 times faster". Trusted Reviews, 03 December 2015. http://www.trustedreviews.com/opinions/what-is-lifi

[5] S. Panda, M.Soyaib, A. Jeyasekar "Li-Fi Technology –Next Gen Data Transmission through Visible Light Communication", National Conference on Emerging Trends in Computing, Communication & Control Engineering, September, 2015. http://www.ijirset.com/upload/2015/ncet2k15/22_Li_-Fi_Modify_CSE.pdf

[6] An IEEE Standard for Visible Light Communications visiblelightcomm.com, dated April 2011. It is superfast modern internet technology.

[7] J.Rani, P. Chauhan, R. Tripathi, "Li-Fi (Light Fidelity)-The future technology In Wireless communication", International Journal of Applied Engineering Research, ISSN 0973-4562 Vol.7 No.11 (2012).

[8] S. Saini, Y. Sharma, "Li-Fi the Most Recent Innovation in Wireless Communication ", International Journal of Advanced Research in Computer Science and Software Engineering 6(2), February - 2016, pp. 347-351.

[9] D. Khandal , S. Jain, "Li-Fi (Light Fidelity): The Future Technology in Wireless Communication", International Journal of Information & Computation Technology. ISSN 0974-2239 Volume 4, Number 16 (2014), http://www. irphouse.com

[10] M. Goyal1, D. Saproo2, A. Bhagashra, "New Epoch of Wireless Communication: Light Fidelity", International Journal of Innovative Research in Computer and Communication Engineering Vol. 1, Issue 2, April 2013

[11 http://www.ispreview.co.uk/index.php/2013/01/tiny-led-lights-set-to-deliver-wifi-style-internet-communications.html, January 2013.
[12] William Connell, http://www.servondesign.co.uk/thoughts/li-fi-internet-connection-using-light-source, Oct, 2011.
[13] A. Nath , "Li-Fi Technology: Data Transmission through Visible Light ", Research gate, JULY 2015, https://www.researchgate.net/publication/279530585
[14] BEC CREW, "Li-Fi has just been tested in the real world, and it's 100 times faster than Wi-Fi", Nov. 2015, http://www.sciencealert.com/li-fi-tested-in-the-real-world-for-the-first-time-is-100-times-faster-than-wi-fi