THE PAST AND FUTURE OF LI-FI

[1]Subhankar Saha*, [2]Bishanka Brata Bhowmik
[1]M.TECH student*, [2]Assistant Professor
[1]Department of Electronics & Communication Engineering,,
[1]Tripura University,Agartala, India

Abstract: Light Fidelity known as Li-Fi is going to be the new revolution in wireless communication. Where the visible light spectrum is used as the carrier for data to be transmitted. Transmission of data in a Li-Fi system is done by changing the light intensity. Li-Fi can assure us of safe and faster data communication compared to Wi-Fi. This paper describes how Li-Fi can become the future of wireless communication with the works that are going on in the present days and how our daily life light sources can be used as a source of data transmission thus giving a brief overview of Li-Fi system.

Keywords **- Li-Fi, VLC, Wi-Fi, Photodiode.**

1. INTRODUCTION

In the modern world, the number of devices is increasing day by day. Due to which demand for data transmission wirelessly is also increasing. In the case of Wi-Fi, the problem arising is less bandwidth and low speed. Where the idea of communication using light can change the future. The term Li-Fi was first introduced by Harald Haas, co-founder of pure Li-Fi, during a 2011 TEDGlobal talk in Edinburgh. Where he showed the world how he changed a simple light source into a router that transmits data through light. He used a LED lamp and using it transmitted a video wirelessly via light that was shown on a screen. The idea is to transmit data using LED wirelessly. Data transmission is the most significant activity in the modern world. While transferring tons of data, the first thing to consider is the data rate. Now the present wireless networks available connecting us to the internet are slow especially when multiple devices are connected. So when more devices access the internet at the same time, the data transfer rate reduces. This is because now only a small part of the electromagnetic spectrum is accessible for data transfer.Whereas Li-Fi uses the visible light spectrum which is around 10000 times greater than the radio frequency spectrum[1]. Also, Li-Fi is very useful in electromagnetic sensitive areas like in a nuclear power plant, hospitals without causing any electromagnetic interference.

In Li-Fi, the carrier signal used is light instead of radio frequency. Whereas Wi-Fi needs separate modems, Li-Fi uses transceivers that are fitted in the LED lamps which could light the room and also transmit and receive information.Line of sight communication is not required as lights can be reflected back to the receiver from walls[2]. Also, LED consumes less energy.

Li-Fi uses VLC technology for the transmission of data. In this technology for transmission of information rapid pulses of light is sent wirelessly. In Li-Fi technology the data is transmitted using Light Emitting Diode. The rate of transmission can be controlled by changing the intensity of the LED bulb[3]. This light intensity is so rapid that our eyes can not capture it.

2. LITERATURE REVIEW

Communication through visible light one of the burning topics nowadays and researchers are continuously working on this field. Some of the works on the field of Li-Fi communication have been listed down below.

In November 1979, Fritz R. Gfeller and URS Bapst in their paper “Wireless in-house data communication via diffuse infrared radiation”[1] proposed an idea to replace the cabling problem with wireless communication. They used diffused optical radiation (in near-infrared) to interconnect a bunch of terminals in a room to a cluster controller. Each terminal was equipped with a Light emitting diode and a photoreceiver to convert the electrical signal to light signal and the other way around. The optical radiation is scattered in the room by the walls, floor, ceiling, and other objects thus filling the entire room. So a direct line of sight communication is not essential and the data can be received by the photodiode from the wide field of view (FOV). In such a way the optical radiation by the satellite (downlink) reached every terminal in the room thus creating a broadcast channel. The uplink process is done in the same way but it requires a multi-access channel. The access to the users is given using the random access method or by polling method. Using a PCM baseband a 125Kbps link and using PSK a 64kbps link was experimentally built. With the LEDs available during that time max speed for data transmission was 100kbps and which can be increased to 1 Mbps if optical power increases, they concluded.

In 2000, Yuichi Tanaka, Shinchiro Haruyama, and Masao Nakagawa in the paper “Wireless optical transmission with white colored LED for wireless home links”[2] proposed a system which used white LEDs for the wireless home link(WHL). The idea is to use high powered LED lights as a communicating device that we use in our homes. For the indoor optical channel, they used the model given by Gfeller and Bapst. Through simulation, they also showed some results that how the field of view (FOV) and the data rates are some important factors to be considered for this model. The wider FOV increases the multipath effect, So it needs to be low for lower BER. The simulation also showed that in this system the effect of Intersymbol interference(ISI) increases when the data rate is increased.

In 2008, Masaki Y, Shinichiro H, and Masao N. in the paper "High-accuracy positioning system using visible LED lights and image sensor"[3] proposed an idea to use visible light communication to find a person's location in place of the traditional GPS system. According to their research using visible light can provide much higher accuracy to locate a user. In this proposed system three LED transmitters are used whose positions are known. These three LEDs transmit three different coordinates as data which are received by an image sensor of the receiver. Using this data the receiver can calculate the exact location of it. Using a 1000*1000 pixels image sensor they measured the location of the receiver with an accuracy of around 1.5 meters.

In 2014, Keith B. Hunter, James M. Conrad, and Andrew R. Willis in the paper "Visible light communication using a digital camera and an LED flashlight"[4] proposed an idea to create an optical communication system which had a transmitter of LED flashlight and the receiver used was a digital camera. Using image processing technique the received signal in the digital camera was processed and computed. The signal to be transmitted is converted into on/off signal using software and this sequence of on/off signal at the output of microcontroller is used to modulate the transmitter flashlight. In the receiver side a web camera and a microcomputer continuously grab the received images and then each of this image is processed via image processing techniques to determine the value of the received bit. If a camera having higher maximum FPS (Frames Per Second) is used then the transmission speed can be increased. The ambient light of the room in which the system is working is an important factor to be considered. If the room's ambient light has higher intensity compared to the intensity of the transmitted signal of the transmitter, this design won't work, they concluded.

In 2015, E. B. Adoptante, Kristine Abegail D. Cadag, and Valerie Jean R.Lualhati in the paper " Audio multicast by visible light communication for location information for the visually impaired" [5]described an idea of using the visible light communication to transmit the location data in audio format to the visually impaired peoples to guide them in an area. A central device will send the required codes to the receiver device via visible light. The system consists of three main devices one central device and two end devices as a receiver. At first, the end device transmits a request and then receive an acknowledgment from the central device. After receiving the request the central device continuously transmits data. The receiver receives the code, checks it in the look up the table and according to that the audio information from the SD card is accessed and sent to the device speaker. The communication among the central device and the end devices was successful when they were placed at a 1-meter distance and works good in both dark and bright light, they concluded.

In 2016, Pooja B, Ratul M, S. Balaji in their paper "Smart vehicular communication system using Li-Fi technology"[6] proposed an idea to use visible light communication to prevent collision between cars in roads. Communication between vehicles is the best way to avoid vehicular accidents. This can be done by using the head and tail lights of the car as the transmitter, which can be used to transmit the change of speed of the vehicle, and this data can be received by the vehicle in front or in the back of it. At the time of day when the lights are normally off, so the off time of the transmitted light is made greater than it's on time which will be changed for any change in speed, thus it looks like the LED is always OFF. And in the time of night, the on time of the LED light is made higher than the off time such that it looks like the LED is always ON. Any change in the speed the transmitting bit pattern will be changed which will be received by the following vehicle and alert signal will be displayed.

In 2017, the paper "A NOMA Scheme for Visible Light Communications using a Single Carrier Transmission"[7] proposed to use non-orthogonal multiple access scheme for the communication using light that was mainly depends on frequency domain successive interface cancellation (SIC) and single carrier transmission (SC). Compared to other multiple access technologies NOMA uses the power domain and it also uses parity check code of low density at the receiver to distinguish between users, as a result, all the users can avail the full time and frequency resources. With experimental results they showed the NOMA VLC scheme compared to OFDM shows better BER because of the lower power allocation ratio.

3. BASIC WORKING PRINCIPLE OF LI-FI

In li-fi technology, we use LED for transmitting an optical signal. The LED is turned on and off so fast that human eye cannot capture the speed. So even if the LED is changing its intensity we will not notice any kind of change and it will seem like the LED is always on. Although the fact turning on and off the LED is not totally true. The LED is never turned off. Only the brightness of the LED is changed according to the signal to be transmitted. When a '1' or "HIGH" needs to be transmitted the LED brightens up. And when a '0'or "LOW" needs to be transmitted the brightness reduces. This changing of values between highs and lows happens so fast that our normal eyes will not see any difference. In such a way information can be transmitted from the transmitter to the receiver.

The signal to be transmitted is converted into binary i.e. in the strings of highs and lows. Using a driver circuit the output of a LED light is modulated according to the input signal. Now the light of the LED will flicker according to the input signal.

In the receiver end, a very high-intensity receiver photodiode is used so that it can capture the changes in the transmitted signal. As we are working on the visible spectrum the photodiode should receive lights between 780nm to 375nm wavelengths. After amplification, the received signal can be converted into a required o/p signal.

A line of Sight communication is not required as the light signal can be received even reflected back from the walls but cannot penetrate through the walls which makes this technology more secure. Also as the human eye cannot catch the flickering of the LED during transmission this led also serves the general purpose, lighting the surroundings.

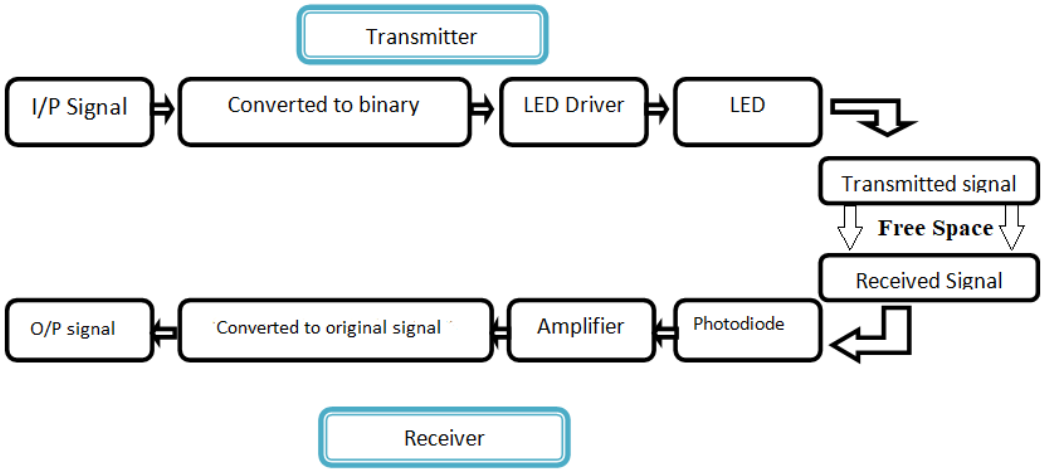

Fig 1: Block diagram of Li-Fi system

4. LI-FI COMPONENTS

4.1. Li-Fi source – LED:

In the transmitter end LED light is used to convert the electrical signal into a light signal. Choosing the appropriate light source depends on how fast the source can switch between high to low. For such reason, the fluorescent bulbs are not a good choice for the source where LED serves this purpose well. In a LED due to the change of energy, photons are generated Which are emitted in form of light. Such a design allows LEDs for frequent switching. LEDs can produce thousands of data streams throughout the whole room thus light reaches every corner of the room providing high-speed data transfer.

4.2. Li-Fi receiver – photodiode:

The photodiode is used to sense the data coming from the transmitter side thus acting as a receiver. Photodiodes convert the received light signal back to electrical signal. Choosing of the receiver photodiode in LI-FI system is the hardest part. This technology is new so there are not many photodiodes available that serves the purpose of the Li-Fi receiver. Things to be considered while selecting the photodiode are – large radiant sensitivity area, very high response time, high sensitivity between 780nm-375nm spectral bandwidth.

4.3. Communication channel:

The channel used for communication in Li-Fi system is the free space. That means the light from the transmitter travels towards the receiver photodiode through the free space thus creating a wireless communication system. Well, this free space provides the main drawback in the Li-Fi technology that is the interference coming from the other light sources which also produces visible light.

5. APPLICATIONS

Green information technology:

We have seen the adverse effects of using radio wave communication on our environment. Birds, bees and other species are at the brink of extinction. Whereas Li-Fi uses the visible light spectrum so it is totally environment-friendly.

No frequency bandwidth problem:

As Li-Fi uses the visible spectrum for communication no spectrum license is required. So no need to pay for communication and license.

Smarter Power Plants:

Places like power plants which are sensitive to radio frequency Wi-Fi cannot be used. Also, power plants need fast data transfer rate to keep track of all the equipment. Li-Fi is a good option for such places.

Communication Security:

In case of Wi-Fi radio waves can penetrate through walls so someone in the other room can have access to your data. But as Li-Fi uses light for transmission which can't penetrate through walls gives us a more secure way of communication.

Use in IOT:

Internet of things is one of the burning topic of today's world. Creating a network of devices such that they communicate with each other continuously round-the-clock and take action accordingly needs a very high-speed connectivity which Li-Fi can provide.

Indoor Communication:

Li-Fi can be the best alternative to Wi-Fi in case indoor communication. Each light sources we use for lighting the surroundings can be used as a Li-Fi modem and can provide us around 100 times more speed compared to traditional Wi-Fi. Also, indoor navigation is also possible using the Li-Fi system [9] where the location data can be sent to your devices from the light sources in the room.

In Petrochemical Industries:

Radio frequencies cannot be used in petrochemical industries due to the radioactivity of such places. As a Li-Fi system uses visible light wave for communication so it can be used here without any danger.

Vehicle communication:

It is possible to communicate between cars in the road using the headlights and backlights. Such light sources can be used as Li-Fi transceiver to transmit and receive data from the vehicles near them and thus creating a communication link. Which can even prevent accidents. [11].

Mobile Connectivity:

Using Li-Fi Laptops, Tablet, smartphones can be connected with each other[12], just like we connect them today using Wi-Fi.

6. LIMITATIONS OF LI-FI

1. Interference of external light such as sunlight, normal bulbs or any other light source, in the path of transmission, is the major problem for visible light communication[13].
2. Another huge problem is light can not travel through objects so if the receiver is covered or intercepted by the sight of transmitting light source, then the transmission will be cut out.
3. So we still need Wi-Fi as a backup plan in case of any blockage in Li-Fi.
4. Devices found nowadays are not suitable for Li-Fi system, so upgradation of devices are required.

7. FUTURE SCOPE

One thing to say that light is free to use and available everywhere so communication using visible light has a great scope in future. When this technology is evolved enough we can have each light source as a modem that will transmit Wireless data. Also, Li-Fi technology provides safer communication which will lead us to a healthier environment in the future. Further research in this field can be done on several issues like

1. Make Li-Fi work with very low light.

2. Increasing the data rate.

3. Overcome the problem of the line of sight.

4. Reducing the problem caused due to the interference of other light sources.

8. CONCLUSION

In this modern era of technology where the requirement of a higher data rate is increasing day by day, this new technology of LiFi shows some great potential. It uses the visible light spectrum for communication which provides us a very high bandwidth to work with. Also safer to use in such places where RF-based systems can't be used. Li-Fi technology has a great future and using this technology even every street light can turn into a wireless hotspot.

REFERENCES

[1]M. Mutthamma, ―A survey on Transmission of data through llumination- Li-Fi‖, International Journal of Research in Computer and Communication Technology, Vol 2, Issue 12, December- 2013.

[2]Rahul R. Sharma, Raunak and Akshay Sanganal, "Li-Fi technology", Int.J. Computer Technology & Application, Vol 5 (1), 50-154.

[3] S. Chodhary, D. Kumari, S. Goel, ―New Lighting Technology ―LI-FI‖ – A Review‖, International Conference on Advances in Engineering, Technology & Management, AETM 2013.

[4] Fritz R. Gfeller and URS Bapst "Wireless in-house data communication via diffuse infrared radiation" proceedings of the IEEE (Volume: 67, Issue:11,Nov.1979) .1474-1486.

[5] Yuichi Tanaka, Shinichirou Haruyama, and Masao Nakagawa "Wireless optical transmission with white colored LED for wireless home links" 11th IEEE International Symposium on Personal Indoor and Mobile Radio Communications. PIMRC 2000. Proceedings (Cat. No.00TH8525), **ISBN:** 0-7803-6463-5

[6] Masaki Yoshino, Shinichiro Haruyama, and Masao Nakagawa "High-accuracy positioning system using visible LED lights and image sensor" 2008 IEEE Radio and Wireless Symposium, ISSN: 2164-2958.

[7] Keith B. Hunter, James M. Conrad, and Andrew R. Willis "Visible light communication using a digital camera and an LED flashlight" IEEE SOUTHEASTCON 2014, ISSN: 1091-0050.

[8] E. B. Adoptante, Kristine Abegail D. Cadag, and Valerie Jean R.Lualhati " Audio multicast by visible light communication for location information for the visually impaired" 2015 International Conference on Humanoid, Nanotechnology, Information Technology,Communication and Control, Environment and Management (HNICEM), 9-12 Dec. 2015.

[9] Pooja Bhateley, Ratul Mohindra, S. Balaji "Smart vehicular communication system using Li-Fi technology" 2016 International Conference on Computation of Power, Energy Information and Communication (ICCPEIC), 20-21 April 2016, Chennai, India.

[10] Bangjiang Lin, Xuan Tang, Zabih Ghassemlooy, Chun Lin, Min Zhang, Zhenlei Zhou, Yi Wu, Hui Li "A NOMA scheme for visible light communications using a single carrier transmission" 2017 First South American Colloquium on Visible Light Communications (SACVLC), 13 Nov. 2017, Santiago, Chile.

[11] HumaraYaqub, Malik Misbah, Mahjabeena, Rabia Shaheen, Shahbaz Pervez "
LiFi: The Future for Indoor Wireless Data Communication" International Journal of Scientific & Engineering Research, Volume 7, Issue 10, October-2016, ISSN 2229-5518.

[12] Pooja Bhateley, Ratul Mohindra, S. Balaji "Smart vehicular communication system using Li-Fi technology" 2016 International Conference on Computation of Power, Energy Information and Communication (ICCPEIC), 20-21 April 2016, Chennai, India.

[13] Nikita Mohan Rainand , Pratiksha Laxman Poojary , Prof. Shubhangi Mahadik, "Application of Li-Fi Technology in Mobile Connectivity" International Journal of Current Trends in Engineering & Research (IJCTER) e-ISSN 2455–1392 Volume 3 Issue 4, April 2017 pp. 37 – 42

[14] Farooq Aftab "Potentials and Challenges of Light Fidelity Based Indoor Communication System" International Journal of New Computer Architectures and their Applications (IJNCAA) 6(3): 92-102 The Society of Digital Information and Wireless Communications, 2016 ISSN 2220-9085 (Online); ISSN 2412-3587 (Print)