A Survey on Li Fi Technology and Internet of Things (IOT)

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ABSTRACT

Currently, Li-Fi technology is a new and relevant area of research in the field of information communications. At the end of 2015, in one of the laboratories in Estonia, a test was conducted in which it was able to obtain a very high transmission rate of 224 Gb / s in the laboratory, and during tests in offices - up to 1 GB/s was recorded. However, due to some limitations, the existing technology could only be applied in certain specialized areas. This article presents the features of this technology and strikes a comparison between the known Wi-Fi technology and the prospects of using Li-Fi for the IOT network.

Key words*:* Internet of Things , Li Fi technology , Wi Fi technology, WSN.

1. INTRODUCTION

One of the founders of Li-Fi technology is Professor Harald Haas from Edinburgh University. It was he who initiated the creation of the project D-Light and the commercial project Pure VCL [1] .He has been developing Li-Fi technology for more than a decade and is also the author of the VLC technology (Visible Light communications) on LEDs - Li-Fi technology (the abbreviation in the title is made up of the English words "light" and "fidelity" (accuracy)).

In June 2011, Dr. Harald Haas demonstrated that the LED lamp, equipped with a modulator for coding the signal, could transmit a video image of high definition (HD, an abbreviation of English words of high-definition) [2] to the computer.

Li-Fi technology can provide a reliable and a cheap way to connect to the Internet from almost anywhere with the help of special LEDs.

With funding from the British Council for Engineering and Physical Sciences (Engineering and Physical Science Research Council, Edinburgh, Oxford and Cambridge Universities), the project for the study of data transmission using ultra-parallel Visible light communications project was initiated. Microcircuit loudspeakers could create parallel light streams and, in several ways, increase the amount of data that could be transmitted per unit of time. "Imagine a shower head that directs water strictly parallel to and we, too, made the light behave in the same way, "explained Professor Harald Haas [3].

According to the IEEE 802.15.7 standard, issued in December 2012 for VLC technology, the bandwidth of Li-Fi technology was prescribed in limits of 96 Mbit / s [4]. With a micro-light tube, you could achieve a data rate of 3.5 GB/ s through each of the track colors - red, green and blue, - which together constituted white light [5]. This meant that, by folding the spectral channels, you could transfer data at a total speed of 10 Gb / s. The signal reset for the used LEDs and photodiodes was fast enough to not withstand a pause for its reliable attenuation.

Visible radiation is that part of the electromagnetic spectrum that lies between 385 THz and 790 THz. This part of the electromagnetic spectrum is 10 thousand times wider than the spectrum of radio emission. Therefore, potentially light could provide an almost unlimited bandwidth for data transmission, and has wider capabilities of VLC technologies. In order to transfer back data based on Li-Fi technology, the network required combined usage with other data transfer technologies, such as PLC (Power Line Commendations), in which data is transmitted over power wires for high-speed.

Infrared data transmission (VFIR or UFlR - Very Fast Infrared and Ultra Fast Infrared) [6]. Fig. 1 shows a local data network based on a combination of Li-Fi technology and VFIR technology for feedback, in which the Li-Fi transmitter is a photodiode 3 infrared emitter ,receiver, decoder, as well as USB-interface.

In Li-Fi technology, light from LEDs are used as an environment for delivering access to the network, mobile and high-speed transmissions. The data is transmitted by modulating light intensity at nanosecond intervals, which is too

fast to be detected by the human eye. This data is then received by the photosensitive detector. After that, the light signal is demodulated in the electron form.
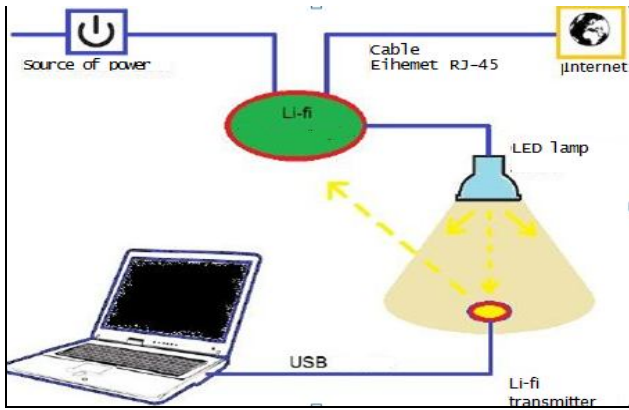

Figure. 1: Diagram representation of the local Li-Fi network.

2. LI-FI AND A COMPARISON WITH THE FAMOUS TECHNOLOGY WI-FI

The biggest difference between Li-Fi and Wi-Fi is when using Li-Fi data, it uses visible light as a communication channel (unlike radio waves in Wi-Fi). From this, in comparison with Wi-Fi, Li-Fi technology has several advantages and disadvantages.

2.1 Advantages Li Fi
First of all, now Li-Fi allows transferring data to the network at speeds up to 1 GB / s, which means 100 times faster than the speed of transfer to Wi-Fi. Even in the laboratory, you can get a high transmission speed - 224 GB / s, so you can download 20 HD movies in a flash of a second. According to Haas, Li-Fi can achieve a data transfer rate which is 100 times more than Wi-Fi. This is because Li-Fi is contained in a small area, and at that time, radio signals are spreading.
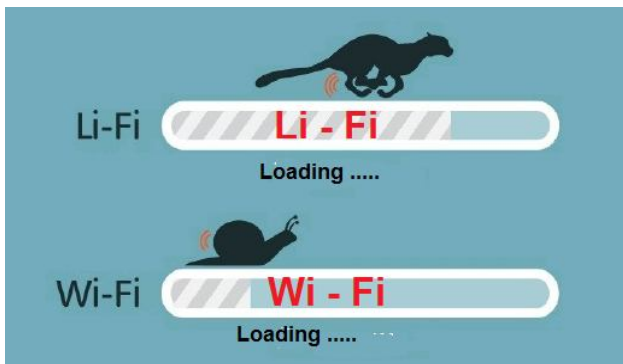

Figure 2 : The difference between the data transfer speed in Li-Fi and Wi-Fi.

In Wi-Fi networks for data transmission, it is necessary to expand the allowable frequency band, which is limited and paid, and in Li-Fi networks, the additional bandwidth will be allocated free of charge and does not require a licensing procedure, which will simplify the use of the technology of the Li-Fi.

At the same time, DFID radio frequency technologies for data transmission can cause negative effects on the human body. Despite the effects of the Li-Fi network are unknown, there are studies showing that LED light is the most convenient for the human eye [7], [26] .

Visible light does not pass through the walls, so LCV technology is potentially more reliable than traditional Wi-Fi, in terms of preserving the privacy of data transmission. Unlike radio-frequency technologies, the network radius uses Li -Fi technology which allows you to completely cover the closed target room with a signal (for example: a room, an office, a hall...) and will not go beyond it [8].

This means that it is possible to secure a high level of data confidentiality and an easier way for people to protect them from unauthorized access.

In the area of 10 Square. Meters, by using the technology of Li-Fi, the researchers of the Fraunhofer Institute of Telecine have already transmitted data at a speed of 800 Mbit / s [9] . This allows Li-Fi technology to be an excellent solution for creating and using a wireless network in a home environment.

In addition, the low price of a micro-LED lamp, combined with the power-saving capabilities, allows building a Li-Fi network to become cheaper and more energy efficient.

According to Professor Haas, another advantage of the new technology is that for an even distribution of the LED transmitter it is possible to get an internet connection much more accurately.

It is accurate and stable inside the building [10] . The drawback of the traditional Wi-Fi router always existed that with increasing distance from the transducer the signal weakens, as well as in homes and offices with an area where communication is so weak that the connection to the Internet becomes unstable or even interrupted.

2.2. Disadvantages Li Fi
Despite the fact that there are many advantages, now Li-Fi technology is still a new technology, which is at the beginning of the study. Therefore, this technology also has some drawbacks, which make it possible to prevent the use of Li-Fi in practice.

First of all, this change in infrastructure. Well-known technologies of wireless data transmission today like Wi-Fi, Bluetooth, and LTE are widely used on the basis of a solid infrastructure, and they work well and satisfy most of the users' needs. In order to become popular, Li-Fi requires a change

from-the manufacturer of the auxiliary equipment, unity in the construction of the relevant infrastructure. This process requires a lot of time and money.

As shown above, Li-Fi technology uses light for data transmission and light is transmitted directly and cannot go through obstacles, which indicates a higher vulnerability to interruptions [11] , [12] .This means that in home conditions, objects such as curtains, plants or the user ... can become obstacles to the transfer of information between the user and the Internet , as shown in Fig. 3.
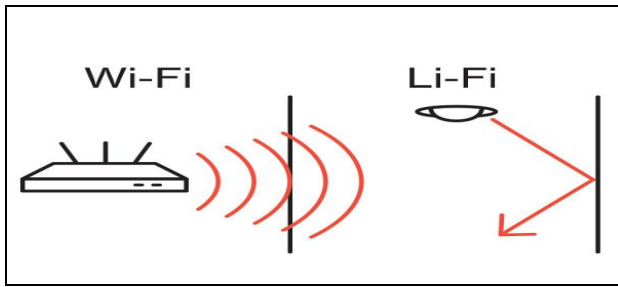
Figure. 3 : Li-Fi and Wi-fi compare to data transmission

In addition, under the condition of the existence of sunlight, or where there are mixed media for light, as in a fog computing [28], it is impossible to use Li-Fi technology. In such environments, the interference is formed, the light transmission is prevented, the light is weakened, which leads to a loss and loss of information at transfer.

Table 1:. Advantages And Disadvantages Of Li-Fi Technology

Advantages:	Disadvantages:
- high speed**.** - high level of safety**.** - low power consumption and cheap**.** - not influenced by the human body**.** -comfortable for human eyes**.**	**-**Vulnerability to interruptions**.** - you cannot use the device**.** **-** mixed media for light**.** - change in infrastructure. - range is limited and Closed .

In particular, the biggest drawback of Li-Fi technology is the problem when used in the dark. In most cases, users who want to connect to the Internet in the dark, for example, before going to bed [13]. Then the use of light to transmit information causes a feeling of disk-fort for users.

To become an uncomplicated part of life, Li-Fi technology needs to overcome existing barriers. Nevertheless, scientists say that in the future, Li-Fi cannot completely replace traditional technologies, only coexist and be used in specialized fields.

3. LITERATURE SURVEY

[14] they studied the design of Li-Fi as a new wireless technology which works in providing connectivity within a prescribed network environment. The working of this technology is very unique Because It provides transfer of data by sending information through an LED that varies in intensity so fast that the human eye cannot follow. Haas's invention, DLIGHT could produce data rates more than 10 Mb/s, which is faster than an average broadband connection. Finally, the authors have predicted the brighter future scope of this technology for using visible light as a transporter in data transfer and networking.

[4] they gave a relative study on Li-Fi. They also provided an overview of applications of Li-Fi, need of Li-Fi, future scope, design challenges for Li-Fi and also the recent developments that have taken place in Li-Fi . The authors explain Li-Fi's working and have compared Li-Fi and Wi-Fi technologies.
and also they studied the electromagnetic which frequency spectrum the visible light portion is used for exchange of information which is similar to old forms of wireless communication like Wireless- Fidelity (Wi-Fi) and Bluetooth, in which data is transferred over the wireless medium using RF signals (radio frequency). By changing the intensity of illumination like Light Emitting Diode is used as a transmitter and a photosensitive detector like Photodiodes (PD) is used for demodulation of the light signals to convert it back into electrical form as a receiver .and they explained Various features of Li-Fi have been illustrated like huge capacity of bandwidth, low cost of components, Radiation free security and different kinds of usability of this technology[30] [15] they found that in the Current times, the speed of internet is one of the major challenges that is faced by industries, businesses, several organizations, entrepreneurs, educational institutions etc. All of them are moving for getting right information in right sequence and at right place. they studied the Future of Communication (LI-FI) which may affect all lives. According to the authors, the application and advantage of Light fidelity (Li-Fi) is the ability of LED bulbs to give both illumination and communication connectivity simultaneously but only up to certain limits like walls. The authors explained the design and the working of Li-Fi technology and has compared Li-Fi's visible spectrum of light which is far better than Wi-Fi's Radio Frequencies. Disadvantage of Wi-Fi is that unlike LEDs, the information cannot be transferred at very huge range with just the turning on and off of the LED's.

[16][32] they dealted with the issues of capacity of High Bandwidth, availability of light sources and security present in Wi-Fi technology by coming up with a concept of transferring data through light using sources like LED's. And the authors further describes the design of this technology as an indoor visible data transmission system using LEDs which is applied for the purpose for lighting the rooms, as well as for creating an optical communication system. So Li-Fi technology works for solving the problem of lack of spectrum space and for a communication at very high speed. By this project, the authors

came to a conclusion that Li-Fi can be used as a very good medium for transmitting data between systems which will lead us to a cleaner, greener, safer and brighter future.

[17] they revealed the design and described the working of Li-Fi Technology and The authors compared the two technologies in the present scenario and gave its applications. Wi-Fi is used widely in each and every environment but in recent times many researches are going on Li-Fi technology. Li-Fi technology may not be so effective in order to replace old-styled radios altogether, but it could give a rapid push to the development of devices like wireless television and The authors discovered a big disadvantage of Wi-Fi is that finding the ideal position for the placement of a wireless router from where it could cover the desired area. Some of the advantages of Wi-Fi discussed by the authors are its convenience, its mobility, many clients can be given access etc [26],[27].

[11] they explained the design of Li – Fi as a completely networked wireless technology that makes usage of light waves as a substitute of radio waves to deliver data. Li – Fi works on visible light communication (VLC) or infra-red spectrum which carries much more data, and has been offered as a substitute to the Radio Frequencies-bandwidth limitations. they focused on the Li – Fi technology, its advantages and challenges over Wi – Fi. It is a disadvantage for Wi-fi that the technology is more costly and provided slower data transmission rate.

[18] they described the design of Li-Fi as a new technology that works on illumination of sources i.e. LED's that could be used for high speed data communication. they studied some advantages for Li -fi which included safer, greener and cheaper technology as it does not have any radio waves or any other type of waves and This technology provides better capacity, security, and availability as compared to Wi-Fi .also they studied The main usage of Li-Fi is faster information transfers which take up a lesser amount of space in order to add more LED's for further boosting the channel of communication. If this technology can be applied in practical life then all the light sources could be used as Wi-Fi hotspots in order to transmit data wirelessly. The authors compared Wi-Fi technology with Li-Fi technology. The authors say that Li-Fi would solve the challenges faced by Wi-Fi technology like the shortage of bandwidth and allow internet to be used in places and situations where it cannot be used currently like aircrafts .also they described the spectrum which it range, visible light spectrum has 10,000 times broad spectrum in comparison to radio frequency. In terms of cost, it is cheaper than Wi-Fi because free band doesn't need license and instead uses light.

[19] predicted that every bulb could be used as a Wi-Fi Hotspot, if this technology of Li-Fi is practically applied. This could transmit data wirelessly and at a very high speed. and they predicted to use of Li-Fi technology will be a brighter, safer, cleaner and greener future for that reasons technology is currently attracting a large number of people, because it may

offer an alternative to radio-based wireless which is much more efficient. Due to increase in the number of devices, the airwaves are becoming increasingly congested day by day, making it difficult to get a reliable, high-speed signal. One of its advantage is that this may solve issues such as the shortage of radio-frequency bandwidth and also allow internet where traditional radio based wireless isn't allowed such as aircraft or hospitals. One of its disadvantages, however is that it only work in direct line of sight. The authors have also discussed about the design and working of Li-fi System. Reduction of energy consumption, data as well as light would be done at low cost and the employments opportunities would be created at large scale. In short, this technology will change the whole picture of wireless communications in many ways. shown the below Table 2. Comparisons of surveys Li Fi .
The survey done by researchers did not mention the use of Li-Fi technology with internet of things (IOT), hence the we will focus to study on Li-Fi technology with IOT

4. LITERATURE REVIEW FOR LI -FI USES WITH IOT
[20] came up with an idea of an Automatic Billing System (ABS) which uses Li-Fi (Light Fidelity) technology which being a component of Internet of things-IOT helps in transferring data quickly through an android application that is completely free and accessible which has to be installed in mobile by which we can get the complete product details and the total amount to be paid is processed in the mobile phone itself by using IOT platform. For security purposes, the finally selected products are verified in the gate section [29] [31]. In gate section, the items placed in trolley are checked. The main objective of this paper is to avoid the long queues in supermarkets and malls. He studied IOT in context of how Li-Fi technology is useful in Speedy transmission of data
[22] described Visible Light Communication (VLC) as a technology having great potential which could be used to crack the spectrum crunch problem.
Scalable connectivity would be provided to zillions of mobile and IOT devices. He presents Dark VLC, a prototype which is a new communication primitive. The prototype encodes data into imperceptible, ultra-short light pulses and using off the shelf LEDs and low-cost photodiodes. Dark VLC(DVLC) basically broadens the applications of VLC and attempts to provide an affordable ultra-low power, always-on connectivity technology for mobile and IOT device.

Table 2 : :Comparison Literature Survey of Li Fi.

Paper Num	Design of Li-Fi	Working of Li-Fi	the future scope	Advantages and Disadvantages of LI-FI	Advantages and Disadvantages of Wi-Fi	challenges/limitations current wireless system Capacity	bandwidth limitations	Availability	Application LI-FI	Compared Li-Fi and Wi-Fi	Spectrum Range	Cost	IOT	Security	capacity	usability
[14]	√	√	√													
[13]	√	√	√	√	√	√			√	√						
[17]	√	√			√	√			√	√						
[18]	√	√		√		√	√	√	√	√	√	√		√	√	√
[19]	√	√		√					√							
[11]	√	√			√		√									
[4]	√	√						√	√	√		√		√	√	√
[16]	√	√						√	√					√	√	√

 [8] studied about the use of Li-Fi that might help in solving some bottleneck problems of data transmission in Wireless Fidelity-Wi-Fi technology. The authors have also explored the scope of this fresh technology in the years to come. This technology could use visible light as the transporters in transmission of data and networking in IOT [25]. They explained the future scope of Li-Fi technology in IOT to be very bright as it has a high Bandwidth Data Transmission

[10] studied the potential of indoor communication system based on Li-Fi. It points out the challenges faced by this indoor based Li-Fi network under the knowledge of existing research work. The study also revolves around the elements which affect the performance of indoor based li-fi network. It discovers that Li-Fi has a possibility of large scale execution and Li-Fi technology will improve as the time passes by. It attracts many designers, companies and researchers to continuously work for the practical execution of Li-Fi network for indoor communication in Internet of Things-IOT.

[23] studied the technological advantages, applications and disadvantages of Li-Fi. Li-Fi contributed in increasing performance of the Internet of things (IOT) [25]. It contributed in application of Li-fi like with the development of wireless T.V. it was made a lot easier to throw wireless signals across the house .

Table 3: :Comparison related work of Li Fi with IOT.

Paper	Bandwidth data transmission	future scope (Li Fi)	challenges with indoor based Li-Fi	Li Fi advantages and disadvantages	Li Fi Applications used	IOT (Li Fi)	decision making (Li Fi)	(DVLC)	automatic billing system (Li Fi)	(Li Fi) Speed transmission Data	load balancing	Li-Fi/RF hybrid
[8]	√	√				√						
[10]			√		√	√						
[23]	√			√	√	√						
[21]	√					√	√					
[22]						√		√				
[20]						√			√	√		
[24]	√					√					√	√

The authors also studied about the potential of High Bandwidth Data Transmission using IOT platform [24] ,[26] proposed an algorithm for the Li-Fi/RF hybrid IOT network as load balancing (LB) algorithm. The proposal was based on Evolutionary Game Theory-EGT. A significant feature of the proposal was that users by themselves selected the APs and adopted their strategies. The researchers even tried to find the speed of Bandwidth Data Transmission in IOT .Thus, EGT algorithm was compared with the old centralized algorithm, there was a reduction in computation load of the central unit (CU) when former was used. Moreover, the EGT algorithm outdid the old centralized algorithms in terms of the user satisfaction in simulation results .shown the below Table 3 related work of Li Fi with IOT.

5. PERSPECTIVE OF PRACTICAL USE OF LI-FI FOR IOT

At present, the technology of wireless optical transmission Li-Fi data is being studied for use in highly specialized areas, deployment in medical institutions and enterprises, in space shuttles and stations, on board aircraft [10] ,where production processes are associated with radio transmissions. However, scientists predict that the appearance of the Internet of Things can lead to the phenomenon of "crunch spectrum", in which radio-frequency data networks are overloaded. Using Li-Fi technology, you can avoid this problem, and transmit the signal to unlimited number of devices present in the visibility zone, as shown in Fig. 4.

It is known that the Internet of things is a concept used to describe a network in which all physical objects are equipped with built-in technologies for interaction with each other or with the external environment which can be connected to the Internet [13] through means such as means of identification,

means of measurement, means of data transmission, and means of data processing. Means of measurement play a special role and are responsible for interactions with the external environment
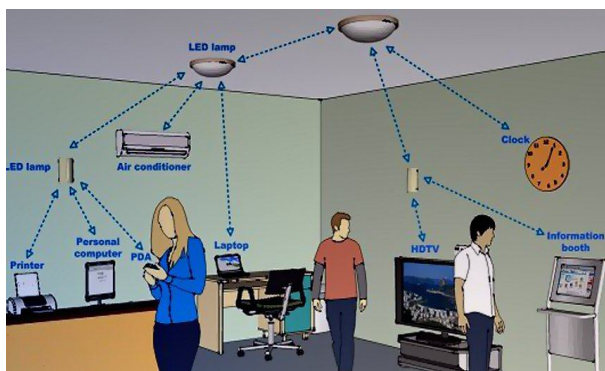

Figure. 4: Practical use of Li-Fi technology.

They also provide transformation of the external environment into an understandable kind of data for the machine, and thereby filling the computing environment with meaningful

information. A network of ethics and the most popular to date is a wireless sensor network based on Zigbee, BLOWRAN, IEEE 802.15.4, VLE ... With its advantages, Li-Fi technology can fully compete with mentioned technology, and widely be used on the Internet of Things-IOT of modern devices that are equipped with at least LED. Devices were able to connect to the network, we simply add additional set Li-Fi-transmitter. This can be seen as a great advantage in the use of Li-Fi for IOT.

Another practical application of Li-Fi in life is for the VANET (Vehicular ad hoc network) network, in which cars can communicate with each other using car headlights; and flashlights as control stations - RSU (Road Side Unit). This is shown in Fig. 5.
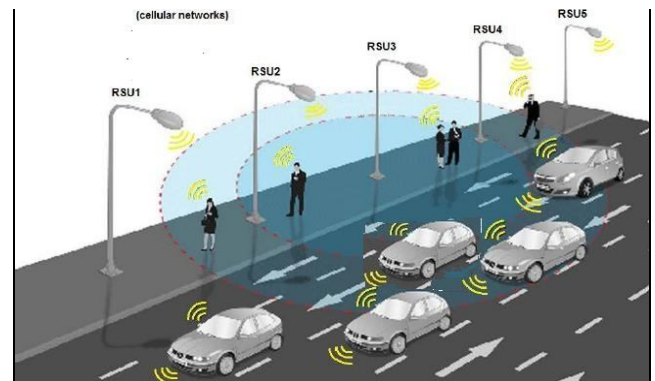

Figure. 5: The use of Li-Fi technology.

6. CONCLUSION

Today, science and technology are changing rapidly to meet the demands of a person's life. The advent of Li-Fi technology allows people to solve the problem of a limited range of radio frequencies of traditional technologies, and provides the ability to transfer data at a very high speed. Despite some limitations, Li-Fi technology is still in the research and development stage. Next time, along with the development of IOT, Li-Fi will achieve some success.

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