The Future Technology LiFi

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Abstract— The LiFi is standing for the Light-Fidelity. This paper objective is to study and describe the LiFi technology. The development of the wireless communication leads to advance research in LiFi technology. The important standard for LiFi technology is IEEE 802.15.7 for VLC. LiFi provides high bandwidth, better efficiency, more security and availability than WiFi.
Key words: LiFi, WiFi, LED, VLC, CRN, EM (Electromagnetic)

I. INTRODUCTION

The LiFi technology invented by the by the German physicist Prof. Harald Haas in the year 2011. He proposed the LiFi technology, provides data transmission through the beam of light by sending data through a Light Emitting Diode (LED) that varies in intensity faster than the human eye can catch. Because of increasing demand in the wireless data communication. The available radio spectrum below or up to 10GHz nowadays become insufficient. The wireless communication industries have responded to this challenge by taking into consideration the radio spectrum above 10GHz. However, higher frequencies (f), means that the path loss (L), increases according to the Friis free space equation ($L \propto f^2$) [1]. As transmission of data from the one place to another is one of the major activities day-to-day, in present days the current wireless networks that connect us to the internet are slow if in that networks multiple devices connected. And the solution to this problem is by the use of LiFi. LiFi technology provides data transmission through the light beam by sending data through LED (shown in Fig. 1).

Fig.1: LiFi LED Bulb

A. Why Need LIFI?

- LiFi Technology is based on all various kinds of light.
- In the worlds light is present everywhere, and there are many bulbs, the only thing is to replace by LED's for the data transmission.
- Light has 10000 times wider bandwidth than radio waves [4] that proves better capacity.
- Light cannot penetrate the walls, which provides the security.
- LiFi is very cheaper for data transmission purpose.
- WiFi cannot be use under water. But, LiFi can be, light can be used under the water.
- By using LiFi technology, every street light anywhere would be free data hotspot.

II. LIFI SYSTEM CONSTRUCTION

LiFi is fast and cheap optical version of WiFi. The LiFi technology is based on Visible Light Communication (VLC). VLC technology is a medium for data communication, uses light (visible light) between 400THz to 900THz, as it is predefined (see Table.1), as the optical carrier for the transmission of data. LiFi uses pulses of light to transmit data over wireless networks. The main components of LiFi systems are:

- High brightness white LED, which acts as the transmission source.
- A good silicon photodiode, as a receiving element.

By using LiFi, it is possible to get the high speed of 100Mbps and more with the help of various multiplexing techniques. The LiFi emitter system consists of 4 primary subassemblies:

1) Bulb
2) RF power amplifier circuit (PA)
3) Printed Circuit Board (PCB)
4) Enclosure

III. HOW LIFI DOES WORKS?

The LiFi technology is based on the Visible Light Communication (VLC) system, uses light for the transmission of data. As the Intensity and Speed of the light is very high, and the transmission of the data is also high. How LiFi is works is very simple. The LED is fitted on the one end and on another end there is photo detector or photo sensor is fitted. When LED is turned ON the photo sensor detected the binary 1 and if LED turns OFF the photo sensor detected binary 0. To make any message, the LED flashes number of times, or use an Array of LED of perhaps a few different colours to obtain data rules in the range of hundreds of megabits per seconds [2]. The data is being received and has been encoded into the light by vary in the flickering rate at which the LED turn ON and OFF to generate the different strings of 1s and 0s.

The source of light constantly appears because the LED can be turned ON and OFF quickly and the intensity is rapidly modulated that human eye cannot catch even though it is flickering. The bulb activity of ON-OFF which seems invisible and enables the transmission of data using the binary codes i.e. 0s and 1s, for switch ON LED it is a logical '1', and for switch OFF LED it is a logical '0'. This method of using rapid pulses of light to transmit information wirelessly is technically referred to as visible light communication (VLC) [2].

In the WiFi technology, the radio waves are be penetrate the walls, through the walls, which has become the disadvantage related to the security purpose. Because of this, anyone can misuse it. But, in the LiFi technology, the optical signals are not able to penetrate the walls, which is the security issue advantage of LiFi. This technology contains two main components: LiFi Router and LiFi room

connector. As optical signals are not able to penetrate through the walls. So, the rooms need to be connected to each other in the accounts to provide an optical wireless LAN (Local Area Network), and that is done by the using LiFi room connector. The LiFi room connector sends the data from one side of the wall to another side using the optical cable, LiFi room connector work as a replicator. For external link connection, LiFi router is used. It connects offices and it covers 20m radius with the transmission speed of 100Mbps. LiFi sends data using light with 'LiFi-Flame' prototype.
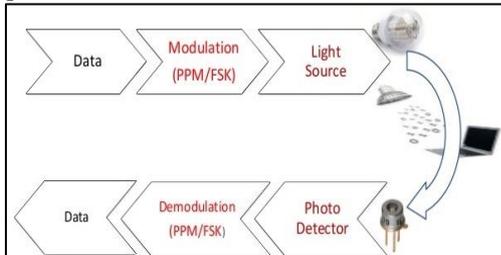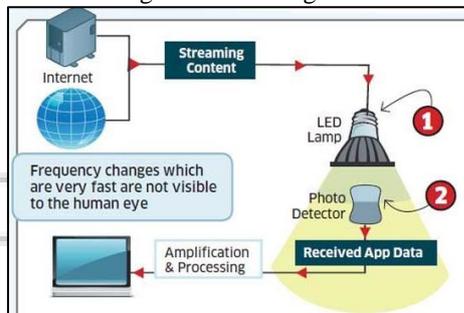

Fig. 2: Block Diagram

Fig. 3: Working of LiFi Technology [3].

Teams at the University of Oxford and the University of Edinburgh are focusing on parallel data transmission using array of LED's, where each LED transmits a different data stream. Other groups are using mixtures of red, green and blue LED's to alter the light frequency encoding a different data channel. [2, 4]

Technology	Speed	Data density
Wireless(current)		
Wi-Fi-IEEE 802.11n	150 Mbps	*
Bluetooth	3 Mbps	*
IRDA	4 Mbps	***
Wireless(future)		
WiGig	2Gbps	**
Giga-IR	1Gbps	***
Li-Fi	>1Gbps	****

Fig. 4: Comparison of various wireless technologies

IV. ARCHITECTURE OF LIFI

The world is now being transformed into digital city, street and society where many paper based traditional systems are changed to computer or Internet based systems. In other words, wherever, the mobile need the radio spectrum and that is exhausted by the exponential increase in the number of users to the wireless communication. And the bandwidth of the radio spectrum is predefined, (shown in Table.1).

Radio Wave and Microwave		Infrared	Light Wave
3	300	400	900
KHz	MHz	THz	THz

Table 1: EM spectrum for wireless communication

For solving the problem of radio spectrum, the one alternate solutions is to use cognitive radio, where the unused spectrum is being used by travelling from one frequency band to another, or within the same band. The CRN detects the spectrum holes and allocates them to the CRN users who wait for the channels [5]. However, the cognitive radio networks (CRN) doesn't produce radio spectrum, but the channels travelled from one band to another. The another alternative solution and the best solution is to use light (visible light) as a medium of communication which is known Visible Light Communication (VLC). The light waves have the frequency band of 400THz to 900THz, which is predefined but not pre-allocated, see in the above Table.1. The LiFi technology uses the VLC technology instead of using the radio spectrum. But we cannot replace existing network infrastructure by the LiFi systems. Because LiFi technology has some limitations such as LiFi uses the Line-of-Sight (LoS) propagation. Hence, there's need smart design of communication infrastructure for LiFi technology. In this paper, the architecture proposed uses two levels of communication. In the level 1, Li-Fi is used for communication and in level 2, the existing public infrastructure is used for communication [5].

The houses and the buildings communication, or inside communication are done through LiFi, and the external communication is maintained through the existing communication infrastructure. Each house and buildings have a LiFi access point (AP), which converts the light signals to the electrical signals or radio signals. And this LiFi AP connect to the public networks. On the other hand, the computers, mobiles and other devices in the houses or offices are connected to the LiFi access point (AP), either through the point-to-point (PP) communication or through the relay devices. As the light doesn't penetrate the walls, the light signals need to be reached to computers, or the other devices in multiple Hops using the relay devices (see Fig.5).
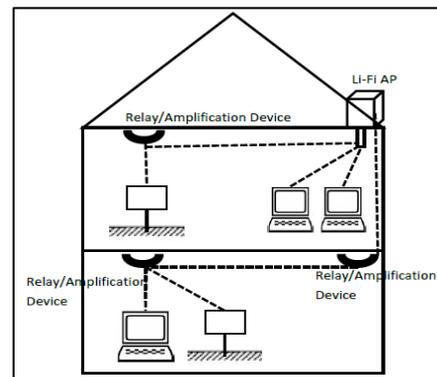

Fig. 5: Communication between LiFi AP and mobile devices [5]

The LiFi access points are connected to the traditional network by using the radio (wireless) or wired networks (see Fig.6). We assume that the AP has a special hardware to convert the light signals to either radio signals or electrical signals. The proposed architecture assumes that Li-Fi uses DAC based LED transmitter. The chip has four separate device channels [6]. Each and every channel is capable of a drive to the two LED's allowing CSK with MIMO (Multiple Input Multiple Output) systems. In addition, on the receiving end, an avalanche photo detector (APD) based receiver is placed. The Li-Fi receiver chip composed of 49 APD detectors based on 180 μm CMOS

technology [8]. The public network can be a, or may be fiber optical network, or wireless network, or wired, or the mixed of all of them. The data rate of the network is high for this kind of architectures as the data rate of Li-Fi is much higher than radio communication [9, 10].
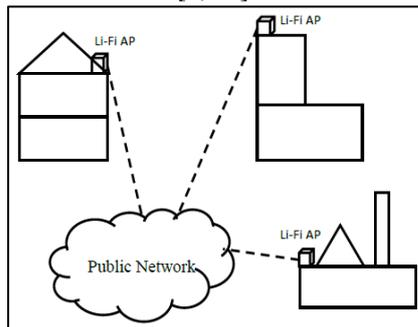

Fig. 6: Communication between LiFi AP's and Public network [5]

The another advantage of using this proposed architecture is that the huge numbers of radio channels can be saved because of the use of wireless devices. And another advantage is this it adaptability of deploying the LiFi communication system easily.
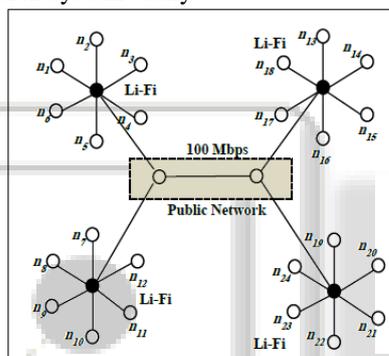

Fig. 7: Network Topology [5]

V. SIMULATION

The simulation work uses the network topology as shown in Fig. 6. In this topology, it uses Li-Fi communication system for communication at the terminal area and the public network exists in between these end points. The data transfer rate for the Li-Fi is taken as 3Gbps and the public networks as 100Mbps. For the purpose of comparison, we have taken the same network topology and data transfer rates except that the Li-Fi is replaced with WLAN (IEEE 802.11b) for which the data rate is 11Mbps.

VI. DISADVANTAGE OF LIFI

The LiFi one of the major disadvantages is that the light cannot penetrate through the walls, and other opaque materials. LiFi is not able to work in direct line of sight.

VII. APPLICATIONS OF LIFI

1) LiFi never harm living thing whereas radio waves affect the human body, birds and plants.
2) LiFi technology is useful in nuclear sector, airlines, power plants, and etc.
3) LiFi technology provides smart way to manage traffics.
4) It is applicable to GPS usage [12].

VIII. CONCLUSION

In this paper, we have surveyed the LiFi technology. LiFi technology is very advanced to WiFi as for wider bandwidth, quick response time and faster than WiFi. In the world every light can be replaced by the LED's and would acts as data hotspot. As it is very cheap everyone can be facilitated, and as it fast everyone can access easily. The problem of radio frequency bandwidth shortage can be solve by using this technique.

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