Li-Fi: A New Communication Mechanism

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ABSTRACT
Wireless Fidelity (Wi-Fi) is very popular today. Every place including homes, offices, colleges, other public places have hotspots to access internet through Wi-Fi. This increased number of users and thus the usage of bandwidth has lead to congestion in the radio spectrum. So, to overcome this problem of radio crisis, Light-Fidelity (Li-Fi) came into existence in 2011, which uses visible light region for data transmission. This visible part of spectrum is 10,000 times greater than the radio part being used in Wi-Fi. Li-Fi is basically the subset of Visible Light Communication (VLC), makes use of LED bulbs to transmit data using light as a medium. In other words, we can say that it uses LED bulbs as hotspots and provides higher data rates than Wi-Fi. In this paper, survey has been done on both technologies using certain common parameters and the possible research scope of this technology is elaborated.

Keywords
Li-Fi; Wi-Fi; Spectrum; VLC; LED

1. INTRODUCTION
Communication is one of the integral parts of anybody's life for exchanging information on devices in wired or wireless networks. With the introduction of new mobile devices, wireless communications have become the basic necessity of our lives. Commercially, we have Wi-Fi as the wireless communication standard. Similarly, Li-Fi (Light-fidelity) is also wireless communication system based upon Visible Light Communication with higher data rate than Wireless Fidelity (Wi-Fi). Due to increasing demand for wireless communications, Wi-Fi is facing many challenges namely- capacity, availability, efficiency and security. So, the term "Li-Fi" was introduced by Harald Hass in 2011 in TED Global talk on visible light communication, to limit these challenges faced by Wi-Fi. Li-Fi uses visible light region of the electromagnetic spectrum, transmitting data through high brightness LED bulbs. It works on simple principle- if the LED is on, you transmit a digital '1', if it's off you transmit a digital '0'. On the other hand, Wi-Fi uses radio wave region of the spectrum (Figure 1) which has very limited band as compared to number of users present and their demand for higher data rates. In order to handle more users and more data traffic, several solutions have been proposed. They can be classified into three groups: (1) improve spectrum utilization, (2) establishing heterogeneous networks (HetNet) with small cells to reuse bandwidth, (3) identify new spectrum with larger band. Basically the goal of Li-Fi is not to replace radio frequency, but rather to complement it [1].

In this paper, survey has been done for comparing both of these technologies. The paper is organised as follows: Section II presents the working of Li-Fi. Section III discusses Wi-Fi, and finally Section IV discusses the future scope of Li-Fi followed by the conclusions.

$4x10^{10}$	$3x10^{11}$	$4x10^{14}$	$7.9x10^{14}$	$3x10^{16}$	$3x10^{19}$ Freq.
Radio	Micro-waves	Infra-red	Visible	Ultra-Violet	X-rays	Gamma rays

Fig.1: Electromagnetic Spectrum

2. LIGHT FIDELITY
Li-Fi is a light-based Wi-Fi, which uses light waves instead of radio waves for data transmission. And instead of Wi-Fi modems, it uses transceiver-fitted LED lamps which can lighten a room as well as transmit and receive information.

Li-Fi is basically the subset of Visible Light communication (VLC) a data communication medium, which uses visible light between 400 THz (780 nm) and 800 THz (375 nm) as optical carrier for data transmission and illumination. Fast pulses are used for wireless transmission. Communication system components are: [3]

2.1 VLC Transmitter
It includes a high brightness white LED and a driving circuit. Flickering rate of LED bulb is very high which is not visible to human eye. This flickering of bulb is used for data transmission- if LED is ON, it transmits digital '1' and if OFF, it transmits digital '0'. The driving circuit is used to modulate the digital data over the dimming control signals of LED by passing Drive Current into the LED with appropriate DC bias [4].

2.2 VLC Receiver
It includes silicon photo diode which shows good response to visible wavelength, optical concentrator and filter and an amplifier. The optical concentrator is used to compensate for high spatial attenuation due to the beam divergence from the LEDs to illuminate large area [4]. The VLC system is vulnerable to the sunlight and other illuminations, and therefore, it is important to employ appropriate optical filter to reject unwanted DC noise components in the recovered data signal [4].

2.3 Communication Device
The mobile devices which actually want to communicate using Li-Fi or want to access data from LEDs.

2.4 Ethernet/ WLAN

This unit provides the actual data from internet.

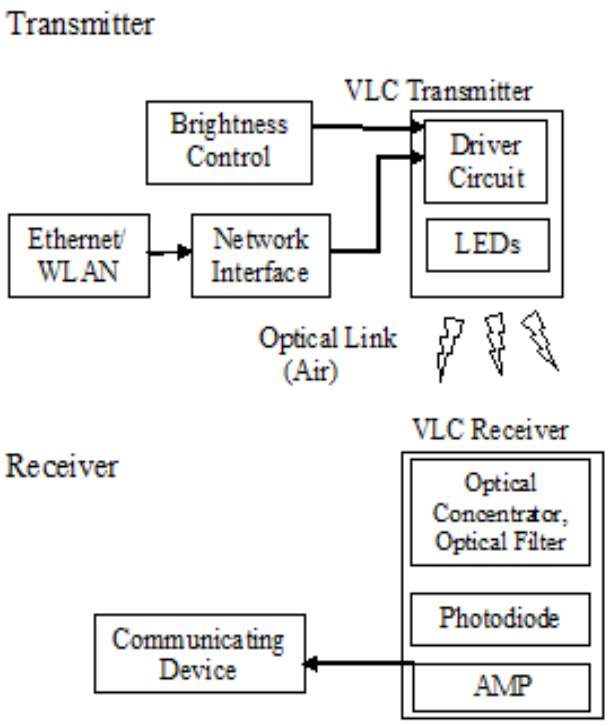

Fig.2: Block Diagram for Working of Li-Fi

The data rates provided by Li-Fi are very high. It can provide upto 500 Mbps, 10 Gbps data rates. But most recently, the researchers of Oxford University have achieved a data rate of 100 Gbps using this technology, as published in the IEEE Photonics Technology Letters in February 2015 [12].

3. WIRELESS FIDELITY

Wireless Fidelity (Wi-Fi) is the most popular wireless communication system that uses radio wave region of the spectrum having frequency in the range 0 to $4x10^4$ Hz. This system also provides high speed internet access of upto 11Mbps. It is also called WLAN and is specified by IEEE 802.11 standard.

It utilizes radio frequencies in 2.4 GHz band or 5 GHz band to transmit data, voice and video from one point to another using the radio signals as the medium. This system never works as a standalone technology but always rely on the backbone wired network (Ethernet) for getting data from the internet server. The basic architecture of Wi-Fi is further explained in the Figure 3 as shown. It consists of following components:

3.1 Wired LAN

It provides a wired connection to the internet service provider which provides internet data.

3.2 Router

It is a device which routes data in the network. It takes care of type of data to be further transmitted on the network. It also maintains the DHCP server which provides IP addresses to number of wireless devices getting attached into the network.

3.3 Web Server

It provides all services to the wired network.

3.4 Access Points

Devices which allow wireless devices to connect to wired network wirelessly. In other words, we can say APs broadcast the data in the form of wireless signals that can be accessed by devices having wireless adapter settings.

3.5 Mobile Devices

The devices who want to communicate using wi-fi. Examples- Mobile Phones, Laptops, Tablets etc.

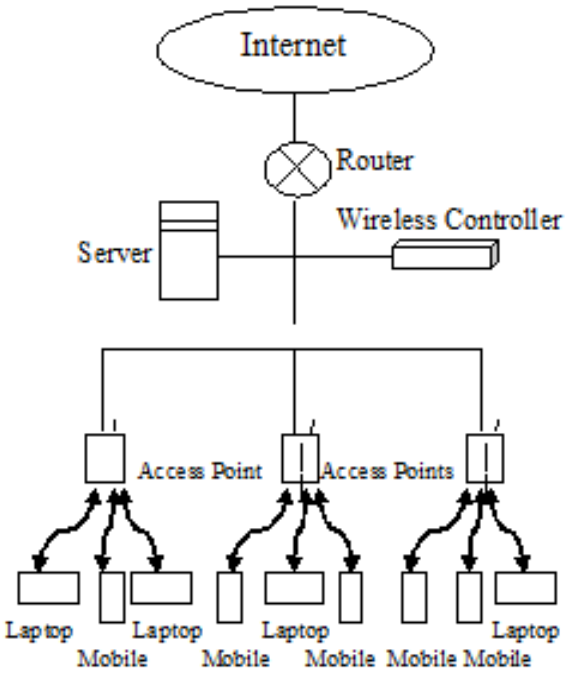

Fig.3: Architecture of Wi-Fi

4. COMPARISON OF LI-FI AND WI-FI

Both the communication systems are compared in Table.1 on the basis of various parameters available for them.

Table.1: Comparison using different parameters

S.No.	Parameters	Li-Fi	Wi-Fi
1.	Development Year	2011	1999
2.	IEEE Standard	802.15.7	802.11b (commercially)
3.	Communication	Based on Visible Light Communication	Based on Radio Frequency Communication
4.	Transmission Medium	Visible Light Waves	Radio Waves
5.	Carrier	Information carried over Optical intensities	Information carried over electric field
6.	Signal	Unipolar- real valued	Bipolar- complex valued
7.	Routing Device	LEDs	Access Points
8.	Available bandwidth	More ($4x10^{14}$ to $7.9x10^{14}$ Hz frequency band) and is 10,000 times that of Radio region.	Less (0 to $4x10^{4}$ Hz frequency band)
9.	Infrastructure Cost	Less	More
10.	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.
11.	Availability	Anywhere. It can be available in airplanes, under water with the help of LED bulbs.	Limited because of the harmful effects.
12.	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.
13.	Speed	500Mbps, upto 10 Gbps, 100Gbps [12]	11 Mbps
14.	Range	Based on the LED illumination	35 - 140 meters
15.	Network Topology	Point- to- Point	Point - to - Multipoint
16.	Interference with electronic systems	No interference	Radio Waves do interfere.
17.	Suitability	More suitable for high data rates and secure communication between a base station and mobile stations.	More suitable for APs with high coverage regions.
18.	Signal - to - Noise Ratio	Very high due to less distance between transmitter and receiver.	May be more
19.	Beam Forming technique	Optical lens is used for directional signal transmission or reception.	Multiple Antennas as well as multiple transmission path chains are used.

20.	Multipath fading	Optical channels do not suffer from fading because these channels provide spatial diversity at receiver due to large size of Photo Diode as compared to wavelength of the light waves.	Radio Frequency links suffer from the problem of fading. [1]
21.	Modulation	Direct Current biased Optical Orthogonal Frequency Division Multiplexing (DCO-OFDM)	Direct Sequence Spread Spectrum (DSSS) [1]
22.	Usage Location	Anywhere, where LED light is available like roads, homes, offices etc.	Within the WLAN range and infrastructure used.
23.	Power Consumption	Less	More
24.	Architecture	Atto Cell	Femto Cell [2]
25.	Data density	High,1000 times that of Wi-Fi	Low [11]
26.	Environmental impact	Low	Medium [11]

5. CONCLUSION AND FUTURE SCOPE

Using Li-Fi, every bulb can be used like a Wi-Fi hotspot to transmit wireless data and it will proceed towards cleaner, greener, safer and brighter wireless future. The concept of Li-Fi is a genuine and very efficient support to radio-based wireless. As the number of people and their devices accessing wireless internet increases, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. Li-Fi may solve these issues such as the shortage of radio-frequency bandwidth and also allow internet where traditional radio based wireless is not allowed such as aircraft or hospitals.

In future the work can be done for analysing the effect of interference from external light sources like sunlight and normal bulbs and how to reduce that effect.

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