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Boon to Optical Wireless Technology- LiFi

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***Abstract*—In this globalised world where time is money, anyone would get frustrated if work is not completed in time. Now-a-days most of work is software oriented or based on new technologies and the internet. In such case if network is shared or tapped the speed lessens and reliability decreases. One of germen physicist named Herald Haas came up with a solution he calls "data through illumination" –taking the fibber out of fiber optic by sending data through an LED light bulb that varies in intensity faster than the human eye can follow.**

The paper focuses on description of development of Light fidelity (LiFi) an optical wireless technology, its current use in communication field and future technological trends LiFi promises to revolutionize wireless communication.

Keywords*— *LiFi, OWC, OFDM, VLC, Attocell, Femtocell.

I. INTRODUCTION

Li-Fi-term use to label the fast and cheap wireless-communication system, which is the optical version of Wi-Fi (which was first used in context by Herald Haas in his TED Global talk on Visible Light Communication). He demonstrated

that optical wireless communication (OWC) can provide the larger data transmission rate up to 3.5Gbps with single color incoherent. Harald Hass have vision that LIFI can provide data rate speed up to 10 Gbps in upcoming time.

Most of commercial and defense sector using RF spectrum between 0 - 10GHz with but license free visible light spectrum is 10,000 times greater than entire RF spectrum up to 30GHz.LIFI is optical technology so that it cannot produce harmful electromagnetic radiation. It can simply be implemented as if LED is on data is transmitted or else not. That is in logical language we can say LED ON- Logic 1 or binary 1 or else its LED OFF- Logic 0.They can be easily operated on switched. Researchers at the Heinrich Hertz Institute in Berlin, Germany, have reached data rates of over 500 megabytes per second using a standard white-light LED which is remarkable. The technology was demonstrated at the 2012 Consumer Electronics Show in Las Vegas using a pair of Casio smart phones to exchange data using light of varying intensity given off from their screens, detectable at a distance of up to 10m. Number of companies and industry groups formed the Li-Fi Consortium in October 2012, to promote high-speed optical wireless system as compared to radio based wireless systems. It is technology developed by a team of scientists including Dr Gordon Povey, Prof. Harald Haas and Dr Mostafa Afgani at the University of Edinburgh.

This paper contains three sections in which first section is Introduction of LiFi. In the second section consists how the LIFI works with technical terms. Last section provides various applications of LIFI and an alternative to RF based wireless technologies.

II. PRINCIPLE

Principle of LIFI is Visible Light Communication (VLC). VLC uses light in the range of 400 THz and 800 THz as optical carrier for data transmission and illumination. Fast switching LED source produces the illumination that can send the parallel binary data stream towards photo detector which is a receiver. LIFI provides "ATTO-CELLULAR" communication system which serves multiple mobile users at the same time with multiple accessing techniques, allowing them to move around inside room/premises while seamlessly

connecting to the network. LIFI is an unique technology that is based on light and is non line of sight type. As data communication is in form of binary bits for high efficiency it is modulated and various multiplexing schemes are used for data transmission. Modulation techniques as pulse-position modulation (PPM), on-off keying (OOK), pulse-width modulation (PWM) and unipolar M-ary pulse-amplitude modulation (M-PAM) can be used. However these modulation schemes suffered from undesired effects of inter symbol

Interference (ISI) due to the non-flat frequency response of the OWC channel, thus are not implemented. To overcome this a efficient technique called orthogonal frequency division multiplexing (OFDM) is used or required.

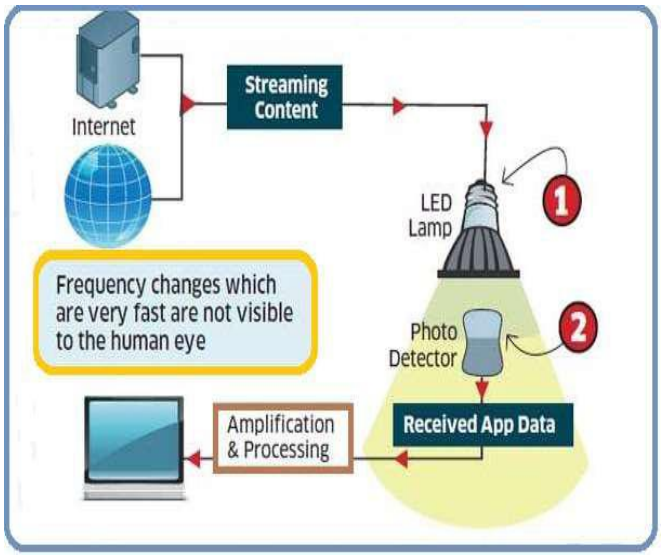


Figure 1. Operation of LiFi under localized network, which can provide internet access to personal computer.

OFDM is a form of signal modulation which divides high data rate modulating stream by placing them onto many slowly modulated narrowband that are closely spaced subcarrier ultimately making system less sensitive to frequency selective fading. .In below figure 2 there are seven sub-carriers for each individual channel. Because the symbol rate increases as the channel bandwidth increases, this implementation allows for a greater data throughput.

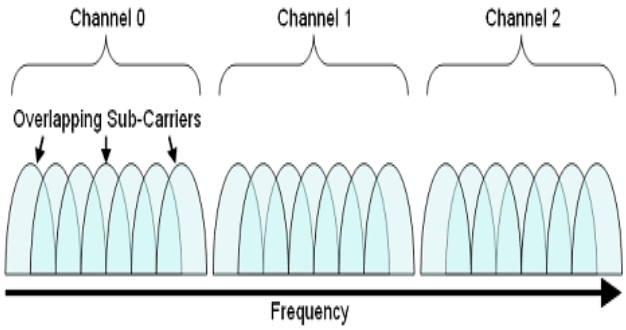


Figure 2 OFDM spectrum

A. *ATTOCELL*

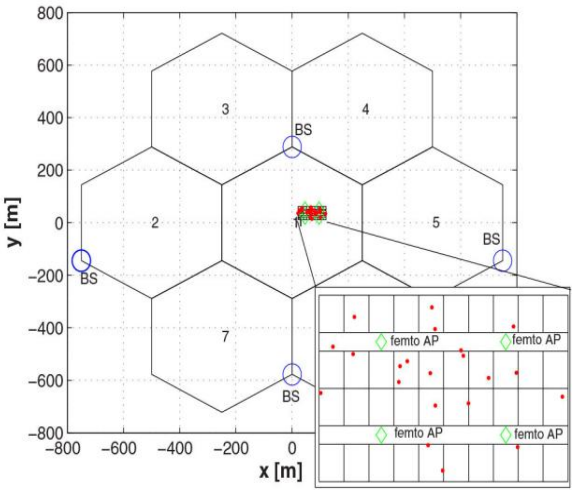


Figure 3. Simulation of a three-floor office building surrounded by seven macrocell base stations using the long-term evolution (LTE) standard. Floor loss (FL) is 17dB, internal wall loss is 12dB and external wall loss is 20dB. Users are randomly distributed in the building. Femto AP: Femtocell access point. BS: Base station.

Optical attocells are smaller cells which are analogues to femtocells in RF communications. Attocellular communication system that can provide multi-user network which can be operated under fast switching light bulb. Attocell network operated on MIMO (multiple input, multiple output) gains in both the optical and RF domains for energy-efficient indoor wireless communications. The optical attocell network is used with both RF and Optical signals as it provide low interference. A single room can be served by multiple optical attocells, with each covering an area of 1–10m^2.

The simulation of three floor office building shows result that ratios of the area spectral efficiency ASEs attained for the attocell and femtocell networks for a varying number of femtocells per floor. The ASE gain of the attocell network is higher for smaller rooms. This is because the femtocell network suffers from additional wall losses, whereas the attocell network benefits from complete interference protection by walls, which do not allow light to propagate through them.

According to research work conducted by Harald Hass, the maximum gain in ASE is about 920 for 4 femtocells per floor, which suggests that using optical attocells could achieve another three orders of magnitude improvement in spectral efficiency. Optical attocell network with an ASE of 1.2 bit/s/Hz/m^2 and a 10MHz bandwidth in a 12.5m^2 room would allow users to share on average a total of 150Mbps from attocell network. Piggy-backing the communication functionality on energy-efficient room lighting makes this a very energy-efficient method of wireless communication.

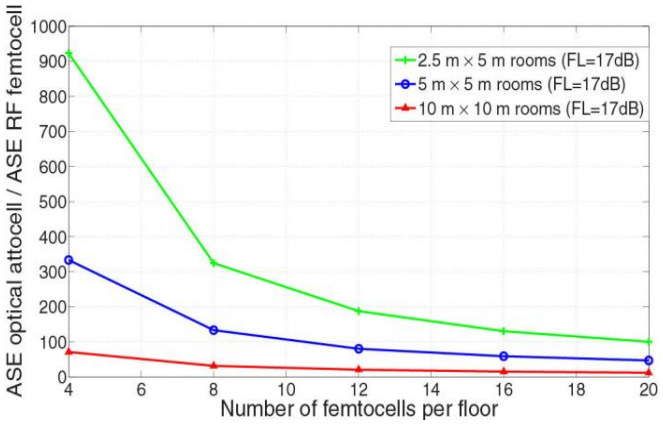


Figure 4. The area spectral efficiency (ASE) of the attocell network is divided by the ASE of the femtocell network. Results from different room sizes are shown.

B. Advantages

Li-Fi technology is based on light source for the transfer of data. The transfer of the data can be with the help of all kinds of light, no matter the part of the spectrum that they belong. That is, the light can belong to the invisible, ultraviolet or the visible part of the spectrum. Also, Li-Fi removes the limitations that have been put on the user by the Wi-Fi.

a) **Speed:** Speed of communication is very fast.

b) **Efficiency**: Highly efficient technology.

c) **Availability**: Light source present everywhere so availability is not an issue.

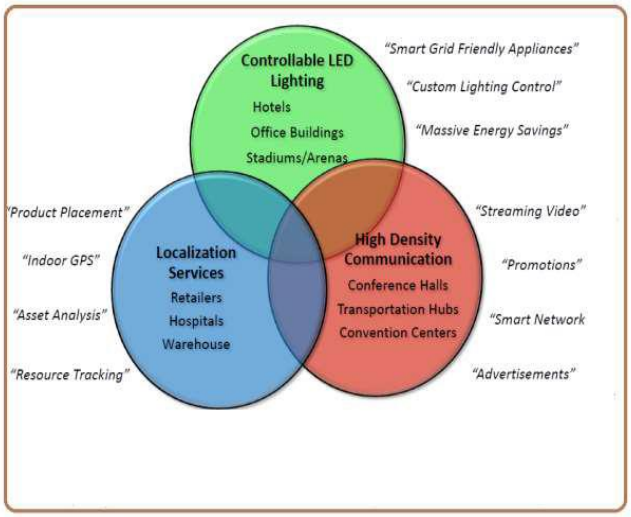
d) **Capacity**: Light sources are already installed having wider bandwidth. Thus Li-Fi has greater capacity.

e) **Security**: Light waves are not like RF waves that penetrate walls, So High security.

C. LIMITATIONS OF LI-FI

Li-Fi technology is not without drawbacks. As there is Inability of light to penetrate solid surfaces, so transmitter and receiver need to be aligned in order to establish a peer to peer connection. Service Providers while providing VLC services has to consider major issues like reliability and availability of system. Companies also need to consider how to maintain coverage area of network. The communication can be restricted due to the Interferences coming from different sources for example sun light, normal bulbs and any non-transparent materials in the path of transmission. VLC system has high Initial Installation cost but when it is implemented at large scale area it can accommodate us by its less operating cost like electricity bills ,less operational staff and limited maintenance charges as compare to RF system. One of the major demerits of this technology is that the artificial light cannot penetrate into walls and other opaque materials which radio waves can do. So a Li-Fi enabled end device (through its inbuilt photo-receiver) will never be as fast and handy as a Wi-Fi enabled device in the open air. Also, another shortcoming is that it only works in direct line of sight. Still, Li-Fi could emerge as a boon to the rapidly depleting bandwidth of radio waves. And it will certainly be the first choice for accessing internet in a confined room at cheaper cost.

III. APPLICATIONS



1. It can have applications at schools, hospitals where Street lamps could be used as a LiFi hotspot.
2. Intelligent transport system in vehicles. Real time traffic information provided by street lamps.
3. Radio frequency signal cannot propagate under water there is optical signal preferred that can provide efficient transmission in under sea projects.
4. Automation in household systems for energy handling purposes.
5. LiFi also has biomedical applications where real time medical information of patient can be sent to physician over internet.
6. Interactive systems.
7. Petrochemical elements are very sensitive to electromagnetic vibration by using LiFi technology it provides more safety to petrochemical plants.

IV. FUTURE OF LIFI TECHNOLOGY IN WIRELESS COMMUNICATION

Most of us are familiar with Wi-Fi (Wireless Fidelity), which uses 2.4-5GHz RF to deliver wireless Internet access around our homes, schools, offices and in public places. We have become quite dependent upon this nearly ubiquitous service. But like most technologies, it has its limitations. While Wi-Fi can cover an entire house, its bandwidth is typically limited to 50-100 megabits per second (Mbps). This is a good match to the speed of most current Internet services, but insufficient for moving large data files like HDTV movies, music libraries and video games. The more we become dependent upon 'the cloud' or our own 'media servers' to store all of our files, including movies, music, pictures and games, the more we will want bandwidth and speed. Therefore RF-based technologies such as today's Wi-Fi are not the optimal way. In addition, Wi-Fi may not be the most efficient way to provide new desired capabilities such as precision indoor positioning and gesture recognition. Optical wireless technologies sometimes called visible light communication (VLC) and more recently referred to as Li-Fi (Light Fidelity) on the other hand, offer an entirely new paradigm in wireless technologies in terms of communication speed, flexibility and usability.Li-Fi is transmission of data through illumination by taking the fiber out of fiber optics by sending data through a LED light bulb that varies in intensity faster than the human eye can follow. 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. It is possible to encode data in the light by varying the rate at which the LEDs flicker on and off to give different strings of 1s and 0s.The LED intensity is modulated so rapidly that human eye cannot notice, so the output appears constant. More sophisticated techniques could dramatically increase VLC data rate.

V. CONCLUSION

Li-Fi concept is currently attracting a great deal of interest, not least because it may offer a genuine and very efficient alternative to radio-based wireless systems and can prove a revolution in wireless systems in upcoming years. There are numerous possibilities that can be explored further. When this technology put into practical use, every bulb can be used something like a Wi-Fi hotspot to transmit wireless data and will proceed toward the cleaner, greener, safer and brighter future.

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