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LI-FI: A REVOLUTION IN WIRELESS COMMUNICATION

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***Abstract*— It can be observed that the use of internet has increased world-wide and everyone is looking for the internet with high speed. By the making use of wireless fidelity it is difficult to achieve that. The WI-FI is also has limitations like capacity, availability, efficiency and security. In order to make these issues possible, the LI-FI is introduced by inventor Harald Hass. The internet with very high speed is achieved by making use of LI-FI. The basic concept regarding LI-FI is the LED lamp can act as base station for communication. In order to transmit the data through LED's its intensity is modulated at very high speed so that the high speed data transmission is achieved. The modulation scheme used is special modulation called as Orthogonal Frequency Division Multiplexing (OFDM). Present paper focuses on new technology invented and demonstrated in year 2011 by Harald Hass. This paper also focused on the principle of working of LI-FI. The modulation scheme OFDM adopted is also discussed. Present paper deals with the visible light communication which can provide a wide and fast data rate of around 500 MBPS.**

Index Terms— LI-FI, LED, OFDM, WI-FI

I. INTRODUCTION

There are 1.4 million cellular radio masts deployed worldwide today which are base stations. Also more than 5 billion of these devices are cellular mobile phones. With these mobile phones, it can be transmitted more than 600 terabytes of data every month. Wireless communication today has become a necessary need like electricity and water. It is used every day in private as well as business lives.

Recently there is increased interest in visible light communication systems. Several applications make use of High brightness LEDs. Soon around next decade it is expected that they might replace conventional lighting sources. Furthermore, there is high bandwidth of optical free space communication systems using LED technology compared to radio frequency based solutions.

Cisco Survey shows the results of the use of the existing spectrum, which is about 80% of the existing capabilities of the data utilization. Presently we use Wi-Fi services within the campus, around the 10-100 meter distances to connect our P.C., Laptops etc. Present paper deals with the visible light communication which can provide a wide and fast data rate of around 500MBPS.

II. LITERATURE SURVEY

Harald Haas et. al. presented a work titled "Visible Light Communication Using OFDM" in 2006 IEEE. The authors focused on LI- FI modulation scheme [1]. The authors discussed about the wireless communication by the use of Light Emitting Diodes (LED's) having high intensity. The main aspect they focused on was about modulation of intensity by means of Orthogonal Frequency Division Multiplexing (OFDM). They further discussed about drawbacks regarding radio frequency (RF) transmission systems because of non-linearity of the power amplifier. They also commented about the method of reduction in the error by OFDM. Also they threw light on design of system, comprising of transmitter, receiver and Optical channel receiver along with the optical interface. The authors verified that the theoretical and the experimental results are in good agreement. It is probable for an LED to cover a distance of up to one meter. They lastly came to the conclusion that performance of system is eventually reliant on the environment. Shifting the system bandwidth to a higher frequency can easily mitigate the interference observed from the fluorescent lighting system. Improvement in further system performance with coding, is achieved by means of a faster DSP, a higher number of subcarriers, a larger FFT/IFFT, better data, or any combination of these factors is possible.

Dobroslav Tsonev and Harald Haas presented their work on "Light Fidelity (Li-Fi): Towards All-Optical Networking". Their work directed at state at which the demonstration of optical wireless communication (OWC) has now reached where it is a feasible and matured solution to this fundamental problem. Their work describes all important technologies which are essential to recognize the optical cellular communication systems discussed here as networks of optical attocell [2]. Optical attocells is the succeeding phase in the development towards ever smaller cells. It is a most noteworthy progression which is contribution to the developments in network spectral efficiencies in RF wireless networks. They mainly focused on important aspects of Light Fidelity as multiple access, signal modulation, cellular network, uplink and LI-FI autocell.

III. MOTIVATION

There is an exponential growth in the demands for wireless data rates. More than 6 Exabyte's of data is expected to be sent globally alone this year in 2015. There is insufficiency in RF spectrum for growing demands. It is desirable for a new physical domain for Wireless Communications. For emerging spectrum problem, optical wireless communication is a potential solution.

Various issues exist in the use of Wi-Fi communication. One of the issues is capacity. We transmit wireless data by using electromagnetic waves, in particular radio waves which are limited, scares and expensive; and we only have a certain range of it. This limitation that doesn't cope with the demand of wireless data transmissions and number of bytes of data which are transmitted every month. Another problem is efficiency. There are 1.4 million cellular radio masts, or base stations, which consumes a lot of energy. Most of the energy is not used to transmit the radio waves, but to cool the base stations. The efficiency of such a base station is only at five percent. Next issue is availability. We have to switch off our cellular devices during flights, hospitals, for security reasons. Radio waves penetrate through walls. They can be intercepted and used. Thus these are the main four issues.

IV. WORKING PRINCIPLE

An LED is semiconductor. It's an electronic device. It has a very nice acute property. Its intensity can be modulated at very high speeds, and it can be switched off at very high speeds. By making use of this fundamental basic property high speed wireless communication using LED light is achieved.

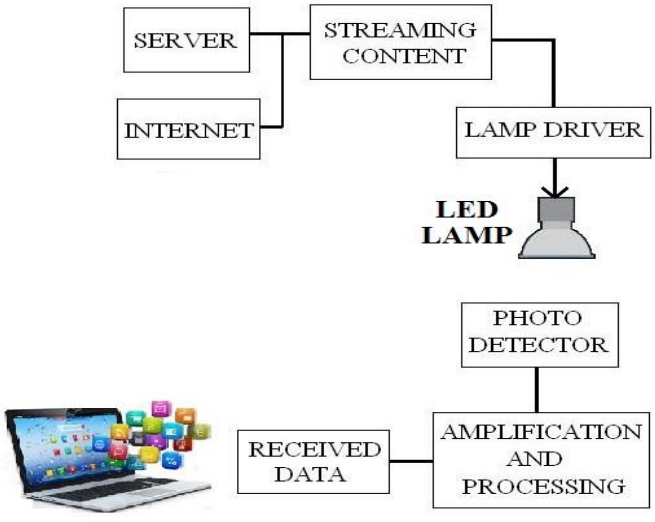

Fig1. Working of Li-Fi system

The above diagram shows the working scenario of LI-FI. This consists of a server and internet which is the basic parts required for communication. The data is then modulated by means of lamp driver and streaming content. The modulated signal is given to the LED lamp. The LED lamp transmits the data in the form of light. The data transmission is possible due to the property of LED's. Which is nothing but the intensity of LED can be modulated at very high speed. The intensity modulation is nothing but switching ON and OFF LED at very high speed.

The modulation scheme adopted for communication is orthogonal frequency division multiplexing

OFDM: Orthogonal Frequency Division Multiplexing is a signal modulation method which splits a stream of high data rate modulation and placing them onto numerous slower modulated narrowband close-spaced subcarriers. Thus, it is less sensitive to frequency selective fading.

A. What is OFDM? - The concept

OFDM is a multicarrier modulation system. Many narrowly spaced modulated carriers are contained in an OFDM signal. When the type of modulation like voice, data, etc. is applied to a carrier, the sidebands extend out on either side. For successfully demodulating the data, it is essential for a receiver to be able to receive the entire signal. Thus, when signals are transmitted adjacent to each other they need be spaced so that the receiver can distinct them using a filter along with a guard band between them. This is not the case with OFDM. The sidebands can still be received without the interference that might be expected although they overlap from each carrier because they are orthogonal to each another. Because of carrier spacing equal to the reciprocal of the symbol period, this is achieved.

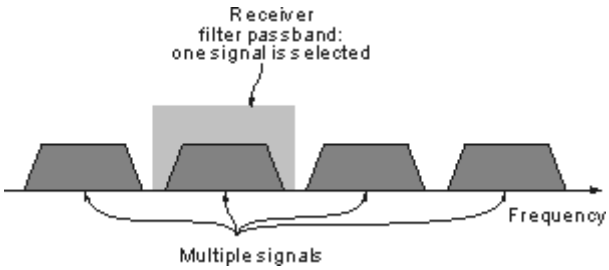

Fig2. Traditional view to receive signals for carrying modulation.

It is essential to take a look at the receiver to see how OFDM works. It perform as a panel of demodulators, translating each carrier down to DC. Integration of the resulting signal is done over the symbol period to restore the data from that carrier. It also demodulates the other carriers as well. The carrier spacing is equal to the reciprocal of the symbol period explains that a whole number of cycles will exist in the symbol period and their input will sum up to zero. In other words there is no interference contribution.

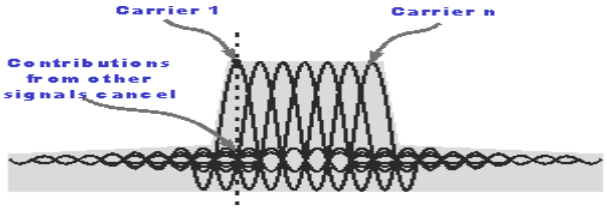

Fig3. OFDM Spectrum

Linearity is one requirement of the OFDM transmitting and receiving systems. Interference will be caused between the carriers of inter-modulation distortion because of any non-linearity. Unwanted signals will be introduced causing interference and spoil the orthogonality of the transmission. The high peak to average ratio of multi-carrier systems (as OFDM) requires the RF final amplifier on the output of the transmitter to be able to handle the peaks in terms of the equipment to be used whilst the average power is much lower which leads to inefficiency.

V. METHODOLOGY

A. *Spectrum Analysis*

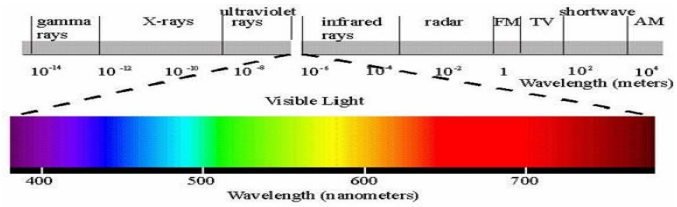

Fig4. Electromagnetic Spectrum

Out of the entire electromagnetic spectrum, we have gamma rays which are dangerous, X-rays which are helpful at the hospitals, ultra-violet light dangerous for the human body, Infrared, due to eye safety regulations, can be only used with low power. Radio waves have issues mentioned earlier. In the middle, we have the visible light spectrum. Thus it's inherently safe to use. Sir Haralt has compared it to entire light spectrum. He compared the radio waves spectrum size with the size of visible light spectrum. We have 10,000 times more visible light spectrum compared to radio waves spectrum. We have 1.4 million expensively deployed, inefficient cellular radio base stations. If it is multiplied by 10,000 we get 10 billion, but 14 billion light bulbs are already installed. We already have the infrastructure; we can use them for communications. We have to replace these inefficient incandescent light bulbs, florescent lights, with LED light bulbs.

B. *Comparison With Communication used in Television Remote Control*

Remote controls used in television have an infrared LED. Basically we switch on the LED by pressing button on remote control, and if it's off, we switch it off. And it creates a simple, low speed data stream in 10,000-20,000 bits per second, which is not high speed data transmission.

Fig5. Data Transmission between television and remote

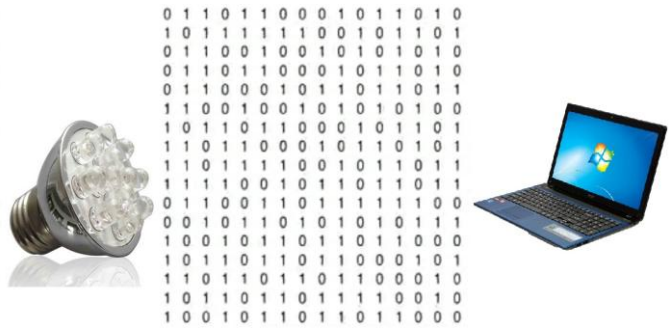

Fig6. Data transmission between LED and laptop

VI. SYSTEM OVERVIEW

As communication is taking place then this system has transmitter and receiver. At the transmitter side the LED is placed and at the receiver side receiver is placed. A small chip is placed at the receiver side so that it can sense the subtle change in the intensity of the light. Though the light from other sources is coming to the receiver that light is having constant intensity. But the Receiver is designed in such a way that it can notice the subtle changes in the intensity of LED light and respond to that changes.

If the LED is on a digit 1 is transmitted, and when it is off, 0 is transmitted. The procedure of switching the LED's on and off is done very quickly. The flicker have to be varied depending upon the data to be encoded. Further enhancements like using an array of LEDs for parallel data transmission, can be made in this method. Also, by using mixtures of red, green and blue LED's to alter the light's frequency with each frequency encoding a different data channel can also be done. Such advancements promise a theoretical speed of 10Gbps. Fast data rates and depleting bandwidths worldwide and safety are the only reasons that give this technology an upper hand. This technology works even underwater, whereas Wi-Fi is incapable to do so. Thus, proving it useful for many applications in defense areas.

There's a new technology available which can meet the need of ever-increasing demand for high-speed wireless connectivity. Light waves replace Radio waves for data transmission which is being called Li-Fi. LED's can be switched ON/OFF at a speed which human eye cannot detect. This causes the LED to appear to be in ON state continuously. Thus a flickering light is turned out to be advantageous making it possible to use visible light for

wireless data transmission. LEDs are found in street lamps, traffic signals, vehicle head and brake lights, wireless remote control appliances etc. can be used for high speed data transmission.

VII. Advantages and Applications

Speed up to 500mbps to 30GB per minute, beneath the ocean is some of the advantages of Li-Fi. Along with these, as it does not deal with the radio frequency, it can be safely used in petrochemical plants, hospitals, aircrafts etc.

The infrastructure for Li-Fi is already present as there are presently 19 billion bulbs placed in the world today. This just requires its replacement with the LED's. As light does not pass through walls, it is secure to use as far as security is concerned. This method can also be adopted in case of traffic collision of vehicles. The LED based headlights and backlights can be installed in the vehicles to avoid accident as they will be able to cover more distance exchanging information. By application of this work, every street light can turn into a free access point. The problem of shortage of RF bandwidth can be solved by Li-Fi.

VIII. Conclusion

By using the Light-Fidelity concept the high speed data transmission and reception can be achieved. It can be observed that LI-FI is cheaper than WI-FI since we have large number of light bulbs already deployed all we need to replace those bulbs by LED bulbs.

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