COMMUNICATION IN LI-FI

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Abstract. Wi-Fi technology becomes more popular today. Every public spots and private offices have wi-fi because of this wireless spectrum is blocked very frequently. Due to maximum utility RF interferences are getting more common to overcome this problem light fidelity (Li-Fi) technology was introduced in the year 2011. Li-Fi is similar to other wireless communication which uses the communication medium as light. Visible light is use to transfer data between the system instead of radio signals. Li-Fi uses LED light source to transmit the data wirelessly this method is widely called as VLC (visible light communication). A stream of data transmitted in the way of pulses of light that cannot be detected by the naked eye. This paper speaks about the new VLC technology over the existing wi-fi technology and the challenges of new Li-Fi technology.

Keywords: Wireless communication, VLC technology, Li-Fi

1 Introduction

Li-Fi is a visible light communication which is used for high speed communication. The name Li-Fi is due to the similarity of the working of Wi-Fi except light source instead of radio waves. The Li-Fi technology was first proposed by Harald Hass a German physicist, number of industry groups and companies combined form the Li-Fi association to promote the high-speed wireless communication using VLC technique to overcome the shortage in spectrum distribution for the purpose of high-speed wireless communication. The technology is demonstrated for the first time in los Vegas using a pair of smart p hones up to the distance range of 10 meters. The data is sent in the way of light rays that has been generated using LED light source the intensity of the light source as been increased by reducing the amplitude of the digital data that as to be transmitted.

Light Fidelity known as Li-Fi is an outcome of twenty first century. The basic ideology behind this technology is that the data can be transmitted through LED whose intensity varies even faster than the human eye. As the transmission of the data takes place through the light emitting diodes (LEDs), the amount is comparatively small. In modern times, it is called as the optimized version of Wi-Fi. The advantageous thing is the wireless communication which decreases the cost enormously. The heart of this technology lies in the intensity and the potential of the light emitting diodes. The major reason which lead the modern man through this invention is that the confinement of Wi-Fi to comparatively small distance. As there are more and more devices coming up day-by-day the signals are being clogged up due to heavy traffic, there was a need for an error free transmission technology. And the solution to this problem was the Li-Fi technology. It has been designed in such a way that it overcomes the disadvantages that occurs during the usage of Wi-Fi. In general terms, Li-Fi works even under water thereby causing a great benefit to the military operations.

The demonstration of this technology took place using two smartphones. The data was made to exchange between the phones using light. Even though the distance was nominal, it is sure that there would be a rapid increase in the distance of transmission. A number of companies formed a consortium called Li-Fi consortium in order to promote high-speed optical wireless systems. The members of this consortium believe that a speed of 10Gbps can be achieved in no time. If this would be possible then a high definition video would take about 30 seconds to download!

2. Literature Survey

“Wireless infrared communications”, in this proposed system, the use of infrared radiation as a medium for high-speed, short-range wireless digital communication is discussed. Visible light Communication (VLC) is used and every bulb can be used as wi-fi hotspot. It only works in line of sight. [1]

“A wireless backhaul solution using visible light communication for indoor Li-Fi attocell networks”, in this paper, a novel wireless backhaul solution is proposed for indoor Li-Fi attocell networks using VLC, which is already embedded in the Li-Fi base station (BS) units. Since the backhaul links operate in the visible light spectrum, two methods are proposed for bandwidth allocation between the access and backhaul links, namely, full frequency reuse (FR) and in-band (IB). In order to realize dual-hop transmission over the backhaul and access links, both amplify-and-forward (AF) and decode-and-forward (DF) relaying protocols are analyzed. Considering a direct current optical orthogonal frequency division multiplexing (DCO-OFDM)-based multiple access system, novel signal-to-interference-plus-noise ratio (SINR) and spectral efficiency expressions are then derived for user equipment (UE) randomly distributed in each attocell. Downlink performance of the optical attocell network is assessed in terms of the average spectral efficiency using Monte Carlo simulations. [2]

"Access Point Selection for Hybrid Li-Fi and Wi-Fi Networks", in this proposed system, two-stage APS method is proposed for hybrid Li-Fi/Wi-Fi networks. In the first stage, a fuzzy logic system is developed to determine the users that should be connected to Wi-Fi. In the second stage, the remaining users are assigned in the environment of a homogeneous Li-Fi network. This method achieves a close-to-optimal throughput at significantly reduced complexity. Heuristic and near-optimal method can achieve low computational complexity relative to numerically involved optimization techniques required to solve complex problems such as resource allocation in wireless networks. Other sources of light may interfere with signals. [3]

"Introduction to indoor networking concepts and challenges in LiFi", a seamless integration of LiFi into existing wireless networks to form heterogeneous networks across the optical and RF domains and discuss implications and solutions in terms of load balancing is proposed. Any potential interferer can estimate the interference it would cause based on the received BB signal power. Vast amount of unlicensed spectrum in infrared and visible light domain. [4]

"Achievable Data Rate of Coordinated Multi-Point Transmission for Visible Light Communications" studies the sum data rate that a Visible Light Communication (VLC) system with multiple users can achieve when phosphor-converted white LED panels are used to provide illumination and communication simultaneously. Three different transmission schemes based on Asymmetrically Clipped Optical Orthogonal Frequency Division Multiplexing (ACO-OFDM) are considered to allocate the communication resources in each transmission point: Frequency Reuse (FR) Joint Transmission Coordinated Multi-Point (JT-CoMP), and a Hybrid combination of them. Phosphor-converted white LED panels are used to provide illumination and communication simultaneously Energy efficient Uniform application of phosphor in manufacturing process is more difficult to control. When the transmission points apply FR, strong inter-cell interference results in high variability of the achievable data rate at different locations. [5]

The USA's company, Qualcomm presented in 2016 its developed Lumicast project, a positioning system based on VLC. This technology is able to support a broad range of
indoor positioning applications in commercial, office and industrial settings, and has been adopted by leading players in the LED lighting ecosystem such as Acuity Brands [6].

"Li-Fi: Data Transmission through illumination", this paper proposed a public lighting system that can be used to provide LiFi hotspots and monitoring lighting and data can be used to the same communications and sensor infrastructure. [7]

"3.4 Gbit/s visible optical wireless transmission based on RGB LED", in this paper, a gigabit-class indoor visible light communication system was developed using commercially available RGB White LED and exploiting an optimized DMT modulation. A data rate of 1.5 Gbit/s with single channel and 3.4 Gbit/s by implementing WDM transmission at standard illumination levels. In both experiments, the resulting bit error ratios were below the FEC limit. These values are among the highest ever achieved in VLC systems.[8]

Recent studies have demonstrated data rates of 14 Gbps for LiFi using three off-the-shelf RGB laser diodes. In the paper "Beyond 100-Gb/s Indoor Wide Field-of-View Optical Wireless Communications", an indoor optical bidirectional wireless link with an aggregate capacity over 100 Gb/s is designed. The link operates over ~3 m range at 224 Gb/s (6 x 37.4 Gb/s) and 112 Gb/s (3 x 37.4 Gb/s) with a wide field of view (FOV) of 60° and 36°, respectively. This was the first demonstration of a wireless link of this type with a FOV that offers practical room-scale coverage.[9]

"Implementation of Li-Fi based home automation system", this paper presents an implementation of Li-Fi based home automation system prototype. This system was developed to verify the effect of LED types on VLC transmission. LED is used to transmit the data input information to the receiver LDR through visible light communication. The result demonstrates that the color types of LED has an effect on transmission distance and the voltage of LED is proportional to the distance. It was noted that Red LED has better performance compared to others.[10]

"Implementation of A Simple Li-Fi Based System", this paper deals with the implementation of the most basic Li-Fi based system to transfer data from one computer to another. The main components of this communication system are high brightness LED which acts as a communication source and silicon photodiode serving as the receiving element. The data from the sender is converted into intermediate data representation, i.e. byte format and is then converted into light signals which are then emitted by the transmitter. The light signal is received by the photodiode at the receiver side. The reverse process takes place at the destination computer to retrieve the data back from the received light.[11]

"Toward Designing a Li-Fi-Based Hierarchical IoT Architecture", this paper presents an extensive survey of the previous studies and projects conducted on the technology, besides multiple leading companies working on the manufacture of Li-Fi-compatible products. In addition, a Li-Fi-based IoT architecture is proposed in this paper, which relies on the collection of data from multiple environments, where Li-Fi is installed. Li-Fi-generated data are analyzed and processed to make intelligent decisions to enhance services in many sectors. [12]

3. Methodology

Li-Fi is typically implemented using white LED light bulbs at the downlink transmitter. These devices are normally used for illumination only by applying a constant current. However, by fast and subtle variations of the current, the optical output can be made to vary at extremely high speeds. This very property of optical current is used in Li-Fi setup.

This project has three functionalities which include transmitting an image, transmitting audio and control the device using Li-Fi.

The hardware components required for the setup are:

- Solar panel
- Power LED
- 3.5 mm jack
- Speaker
- Mp3 player
- Audio amplifier
- Arduino board
- 4-channel relay.
- LCD 16x2
- Li-fi transmitter and receiver
- USB to UART

- Arduino IDE
- MATLAB 2014a
- Flash Magic

3.1. Device control by Li-Fi

The figures 3.1 and 3.2 represent the transmitter and receiver for device control respectively. The components used are Arduino UNO, LCD display, keyboard, Li-Fi transmitter module, Li-Fi receiver module and power supply. Arduino code will be written using Arduino IDE, where we write interfacing program for LCD, keypad and serial transmission of data using Li-Fi transmitter module to transmit the data using visible light, this is transmitter part. In the receiver part, the microcontroller is programmed to receive the Li-Fi data through Li-Fi receiver and display on LCD or to activate the relays used to switch on or off the loads. At the transmission side we type some words and at the receiving end the same letters typed will be received and will be displayed on the LCD.

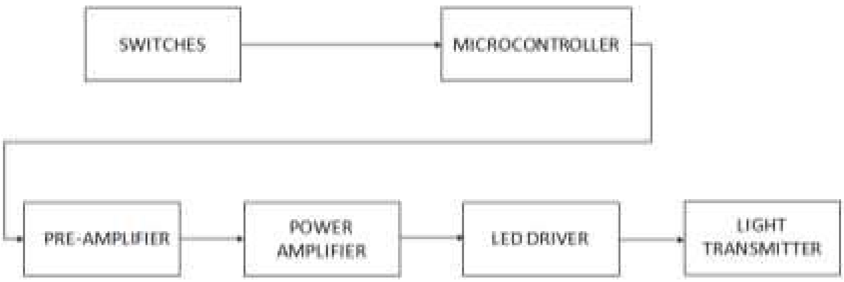

Fig 3.1. Transmitter for device control

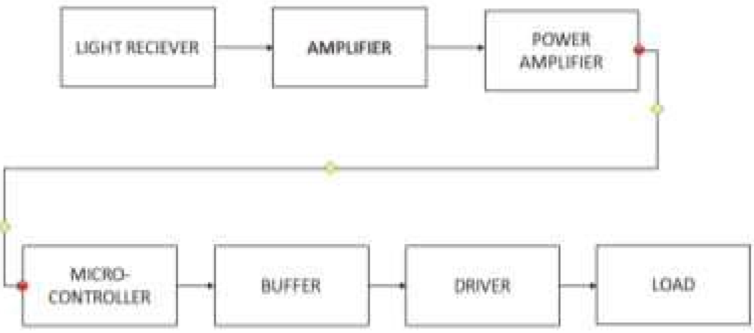

Fig 3.2. Receiver for device control

3.2. Audio transfer using Li-Fi

The components used for transmission part of audio transfer include an mp3 player, 3.5 mm jack, power supply, led/ laser light. On receiver side, a solar panel, audio amplifier, speaker and power supply are used.
The figures 3.3 and 3.4 represent the transmitter and receiver for audio transfer.

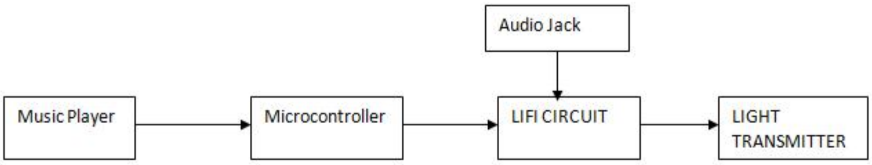

Fig 3.3. Transmitter of audio

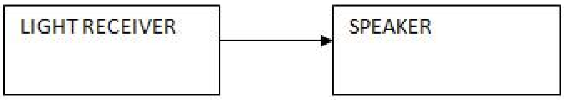

Fig 3.4. Receiver of audio

When we play music on MP3 player the music will be transmitted through led or laser. At the receiving end as the light falls on solar panel the voltage generated from photo voltaic cells will be amplified using audio amplifier and the output is given to the speaker and the played song on transmitter part will be played on speaker at the receiver end through speaker.

3.3. Image transfer using Li-Fi

Here we connect li-fi transmitter and receiver to two PCs with MATLAB with UART.
The figures 3.5 and 3.6 represent the transmitter and receiver for image transfer.

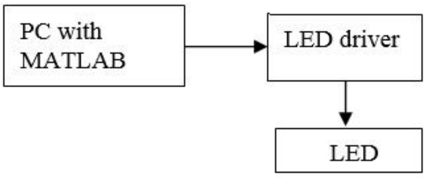

Fig 3.5. Transmitter for image transfer

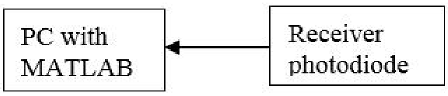

Fig 3.6. Receiver for image transfer

We take an image and we will convert that image data to serial or sequential data using MATLAB and transfer it to li-fi transmitter through UART and that data will be communicated to receiver through li-fi transmitter module.
The data which we receive from li-fi receiver module will be taken serially on another PC and that data is reconstructed as per the size of the image and will be displayed. For this process we use image processing tool box to obtain the outcome.

5. Applications and future works

There is a wide necessity for data transfer and by the end of the day every field involves the use of technologies. One such technology is Li-Fi which can have its applications extended in areas where the Wi-Fi technology lack its presence like medical technology, power plants and various other areas where Li-Fi proved it excellence of the undersea exploration.

The module we designed can be used for broadcasting internet to close by devices like that of hotspot technology, but in optical terms with added advantage of it being more fast and secure unlike in Wi-Fi where even the WPS networks are not hack proof whereas amalgamation of Li-Fi plus Wi-Fi systems provide new features, such as enhanced security in Optical-Small Cells(O-SC) and improved indoor positioning. It could be a faster alternative for thumb or flash drives. Instead of copying data from system to flash drive then to another system, we can get rid of the middle link (i.e. flash drive) which would further increase the overall speed of transmission. This system could be embodied in the PC as an additional connectivity technology, thus creating an ecosystem which will give rise to multitude of gadgets using this technology. We are also working on a way to make the existing devices like smart phones work with this technology with no additional hardware requirement, by using mobile device's camera and flash as receiver and transmitter respectively, we are calling it LiFi-Direct, which will lead to faster data sharing from device to device.

6. Conclusion

Li-Fi is the upcoming and on growing technology acting as competent for various other developing and already invented technologies. Since light is the major source for transmission in this technology it is very advantageous and implementable in various fields that can't be done with the Wi-Fi and other technologies. Hence the future applications of the Li-Fi can be predicted and extended to different platforms like education fields, medical field, industrial areas and many other fields. The possibilities are numerous and can be explored further. If this technology can be put into practical use, every bulb can be used something like a Wi-Fi hotspot to transmit wireless data and we will proceed towards the cleaner, Greener, Safer and Brighter future. Currently, the Acoustic waves are used for the purpose of underwater communication. Now we are implementing Li-Fi as an IoT for underwater communication. When the photo detector receives the signal, it sends to sink. Later the results can be exported to cloud. We have received the details via mobile application.

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