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EMPIRICAL STUDY AND ANALYTICAL REVIEW OF LI-FI TRANSMISSION OF DATA THROUGH ILLUMINATION

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ABSTRACT

This is a research paper on The study of Whether you're using wireless internet in a coffee shop, stealing it from the guy next door, or competing for bandwidth at a conference, you've probably gotten frustrated at the slow speeds you face when more than one device is tapped into the network. As more and more people and their many devices access wireless internet, clogged airwaves are going to make it increasingly difficult to latch onto a reliable signal. But radio waves are just one part of the spectrum that can carry our data. What if we could use other waves to surf the internet? One German physicist, DR. Harald Haas, has come up with a solution he calls "Data Through Illumination"—taking the fiber out of fiber optics by sending data through an LED light bulb that varies in intensity faster than the human eye can follow. It's the same idea behind infrared remote controls, but far more powerful. Haas says his invention, which he calls D-Light, can produce data rates faster than 10 megabits per second, which is speedier than your average broadband connection. He envisions a future where data for laptops ,smart phones, and tablets is transmitted through the light in a room. And security would be a snap—if you can't see the light, you can't access the data..

Keywords: led , light-Emitting Diode Li-Fi

I. INTRODUCTION

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. The term was first used in this context by Harald Haas in his TED Global talk on Visible Light Communication. At the heart of this technology is a new generation of high brightness light-emitting diodes, says Harald Haas from the University of Edinburgh, UK, Very simply, if the LED is on, you transmit a digital 1, if it's off you transmit a 0.Haas says ,They can be switched on and off very quickly, which gives nice opportunities for transmitted data.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. Terms at the University of Oxford and the University of Edingburgh are focusing on parallel data transmission using array

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Of LEDs, where each LED transmits a different data stream. Other group is using mixtures of red, green and blue LEDs to alter the light frequency encoding a different data channel. Li-Fi, as it has been dubbed, has already achieved blisteringly high speed in the lab. 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. 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 ten metres In October 2011 a number of companies and industry groups formed the Li-Fi Consortium, to promote high-speed optical wireless systems and to overcome the limited amount of radio based wireless spectrum available by exploiting a completely different part of the electromagnetic spectrum. The consortium believes it is possible to achieve more than 10Gbps, theoretically allowing a high-definition film to be downloaded in 30 seconds. 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) today using the IEEE802.11n standard. 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.

Figure 1. Linksys 2.4 Ghz Wireless Router

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.

II. VISIBLE LIGHT COMMUNICATION

Many people‘s first exposure to optical wireless technology was VLC. This emerging technology offers optical wireless communications by using visible light. Today, it is seen as an alternative to different RF-based communication services in wireless personal-area networks. An additional opportunity is arising by using current state-of-the-art LED lighting solutions for illumination and communication at the same time and with the same module. This can be done due to the ability to modulate LEDs at speeds far faster than the human eye can detect while still providing artificial lighting.

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Thus while LEDs will be used for illumination, their secondary duty could be to piggyback data communication onto lighting systems. This will be particularly relevant in indoor smart lighting systems, where the light is always on.

In contrast to infrared, the so called what you see is what you send feature can be used to improve the usability of transmitting data at shorter point-to-point distances between different portable or fixed devices. There, illumination can be used for beam guiding, discovery or generating an alarm for misalignment.

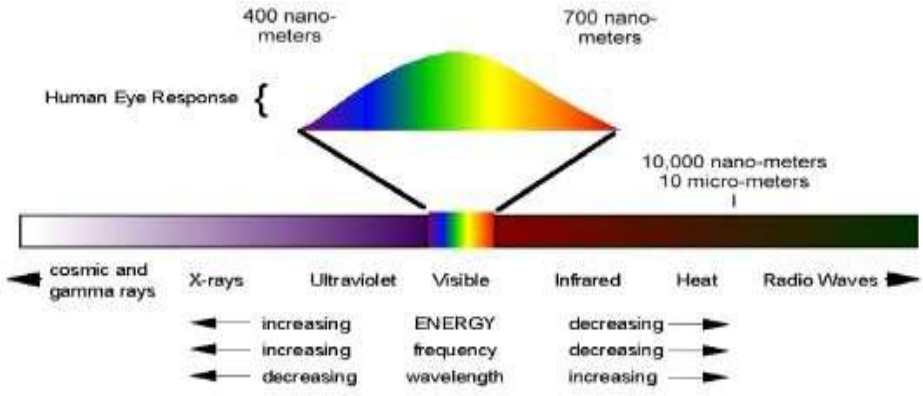

Fig 2 Electromagnetic spectrum

The premise behind VLC is that because lighting is nearly everywhere, communications can ride along for nearly free. Think of a TV remote in every LED light bulb and you'll soon realise the possibilities of this technology. One of the biggest attractions of VLC is the energy saving of LED technology. Nineteen per cent of the worldwide electricity is used for lighting. Thirty billion light bulbs are in use worldwide. Assuming that all the light bulbs are exchanged with LEDs, one billion barrels of oil could be saved every year, which again translates into energy production of 250 nuclear power plants. Driven by the progress of LED technology, visible light communication is gaining attention in research and development. The VLC Consortium (VLCC) in Japan was one of the first to introduce this technology.

After establishing a VLC interest group within the IEEE 802.15 wireless personal-area networks working group, the IEEE 802.15.7 task group was established by the industry, research institutes and universities in 2008. The final standard was approved in 2011. It specifies VLC comprising mobile-to-mobile (M2M), fixed-to-mobile (F2M) and infrastructure-to-mobile (I2M) communications. There, the focus is on low-speed, medium-range communications for intelligent traffic systems and on high-speed, short-range M2M and F2M communications to exchange, for example, multimedia data. Data rates are supported from some 100 kbps up to 100 Mbps using different modulation schemes.

Other standardization groups are working on standardized optical wireless communication (OWC) solutions using visible and infrared light. The most important groups are IrDA with its new 10 Giga-IR working group, ISO and ICSA.

2.1 Light Fidelity (Li-Fi)

VLC represents only a fraction of what appears to be a much larger movement towards optical wireless technologies in general. This larger word has been dubbed _Li-Fi' (Light Fidelity) by Dr Harald Haas of

Edinburgh University and organisations such as the Li-Fi Consortium. Li-Fi is a VLC, visible light communication, technology developed by a team of scientists including Dr Gordon Povey, Prof. Harald Haas and Dr Mostafa Afgani at the University of Edinburgh. The term Li-Fi was coined by Prof. Haas when he amazed people by streaming highdefinition video from a standard LED lamp,at TED Global in July 2011. Li-Fi is now part of the Visible Light Communications (VLC) PAN IEEE 802.15.7 standard. Li-Fi is typically implemented using white LED light bulbs. These devices are normally used for illumination by applying a constant current through the LED. However, by fast and subtle variations of the current, the optical output can be made to vary at extremely high speeds.Unseen by the human eye, this variation is used to carry high-speed data, says Dr Povey, , Product Manager of the University of Edinburgh's Li-Fi Program'D-Light Project'. Li-Fi is a short term of light fidelity. Just like the more commonly known wireless fidelity,it aims to transfer data through light. It is a technology based on LED's for the exchange of data. Data will be sent via light, all kinds of light, regardless the part of the spectrum where they belong. Li-Fi has been developed by Haas whose expertise is on the mobile communications at Edinburgh University, known as the head over heels in LED from his teenage years. In that connection, Li-Fi comprises several optical wireless technologies such as optical wireless Communication, navigation and gesture recognition applied for natural user interfaces .Thus it provides a completely new set of optical technologies and techniques to offer users add-on as well as complementary functionalities compared to well-known and established RF services. This could reach from a new user experience regarding communication speeds in the giga bit class to bridge the well-known spectrum crunch, over to precise indoor positioning or controlling video games, machines or robots with entirely new natural user interfaces. Finally, these and many more could be merged to a full-featured Li-Fi cloud providing wireless services for other future applications as well.

Li-Fi comprises a wide range of frequencies and wavelengths, from the infrared through visible and down to the ultraviolet spectrum. It includes sub-gigabit and gigabit-class communication speeds for short, medium and long ranges, and unidirectional and bidirectional data transfer using line-of-sight or diffuse links, reflections and much more. It is not limited to LED or laser technologies or to a particular receiving technique. Li-Fi is a framework for all of these providing new capabilities to current and future services, applications and end users.

Fig 3.Transfer of data through light

Within a local Li-Fi cloud several databased services are supported through a heterogeneous communication system. In an initial approach, the Li-Fi Consortium defined different types of technologies to provide secure,

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reliable and ultra-high-speed wireless communication interfaces. These technologies included giga-speed technologies, optical mobility technologies, and navigation, precision location and gesture recognition technologies.

For giga-speed technologies, the Li-Fi Consortium defined GigaDock, GigaBeam, GigaShower, GigaSpot and GigaMIMO models to address different user scenarios for wireless indoor and indoor-like data transfers. While GigaDock is a wireless docking solution including wireless charging for smartphones, tablets or notebooks, with speeds up to 10 Gbps, the GigaBeam model is a point-to-point data link for kiosk applications or portable-to-portable data exchanges. Thus a two-hour full HDTV movie (5 GB) can be transferred from one device to another within four seconds. GigaShower, GigaSpot and Giga- MIMO are the other models for in-house communication. There a transmitter or receiver is mounted into the ceiling connected to, for example, a media server. On the other side are portable or fixed devices on a desk in an office, in an operating room, in a production hall or at an airport. GigaShower provides unidirectional data services via several channels to multiple users with gigabit-class communication speed over several meters. This is like watching TV channels or listening to different radio stations where no uplink channel is needed. In case GigaShower is used to sell books, music or movies, the connected media server can be accessed via Wi-Fi to process payment via a mobile device. GigaSpot and GigaMIMO are optical wireless single- and multi-channel HotSpot solutions offering bidirectional gigabit-class communication in a room, hall or shopping mall for example.

III. SYSTEM DESIGN

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. The operational procedure is very simple-,data from the internet and local network is used to modulate the intensity of the LED light source if any undetectable to the human eye. The photo detector picks up signal, which is converted back into a data stream and sent to the client. The client can communicate through its own LED output or over the existing network. An overhead lamp fitted with an LED with signal-processing technology streams data embedded in its beam at ultra-high speeds to the photo-detector. A receiver dongle then converts the tiny changes in amplitude into an electrical signal, which is then converted back into a data stream and transmitted to a computer or mobile device.

3.1 Methods of Visible Light Communication

- Devices used for Visible Light Communication
- Communication using Image Sensors

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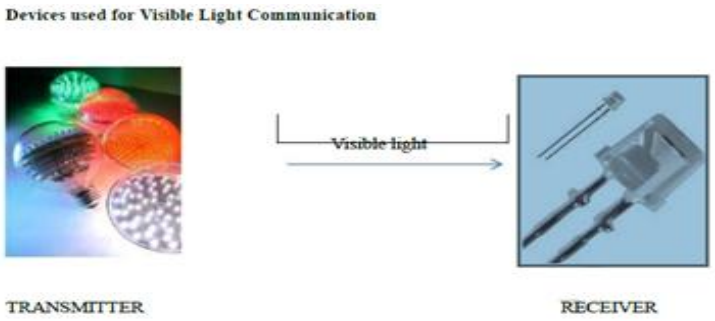

Fig 4. Communication system

3.2 Transmitter devices of visible light communication

1.>Visible Light LED

- LED light intensity is modulated by controlling its current.
- Data rate: low speed to very high speed (up to several hundred Mbps)

2.> Fluorescent Lamp

- FSK modulation of high frequency fluorescent light.
- Data rate: up to several kilo bps.

3.3 Receiver devices of visible light communication

1.>PIN diode

A PIN diode is a diode with a wide, lightly doped 'near' intrinsic semiconductor region between a p-type semiconductor and an n-type semiconductor region. The p-type and n-type regions are typically heavily doped because they are used for Ohmic contacts.

The wide intrinsic region is in contrast to an ordinary PN diode. The wide intrinsic region makes the PIN diode an inferior rectifier (one typical function of a diode), but it makes the PIN diode suitable for attenuators, fast switches, photo detectors, and high voltage power electronics applications.

2.>Avalanche photodiode

An avalanche photodiode (APD) is a highly sensitive semiconductor electronic device that exploits the photoelectric effect to convert light to electricity. APDs can be thought of as photo detectors that provide a built-in first stage of gain through avalanche multiplication. From a functional standpoint, they can be regarded as the semiconductor analog to photo multipliers .By applying a high reverse bias voltage (typically 100-200 V in silicon), APDs show an internal current gain effect (around 100) due to impact ionization (avalanche effect). However, some silicon APDs employ alternative doping and beveling techniques compared to traditional APDs that allow greater voltage to be applied (> 1500 V) before breakdown is reached and hence a greater operating gain (>1000).In general, the higher the reverse voltage the higher the gain.

3.4 Communication through image sensors

An image sensor is a device that converts an optical image into an electronic signal. It is used mostly in digital cameras, camera modules and other imaging devices. Early analog sensors were video camera tubes; most

currently used are digital charge-coupled device (CCD) or complementary metal–oxide–semiconductor (CMOS) active pixel sensors.

Very simply, if the LED is on, you transmit a digital 1, if it‘s off you transmit a 0,Haas says, ―They can be switched on and off very quickly, which gives nice opportunities for transmitted data.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. Terms at the University of Oxford and the University of Edingburgh are focusing on parallel data transmission using array of LEDs, where each LED transmits a different data stream. Other group are using mixtures of red, green and blue LEDs to alter the light frequency encoding a different data channel.Li-Fi, as it has been dubbed, has already achieved blisteringly high speed in the lab. 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. 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 ten metres.

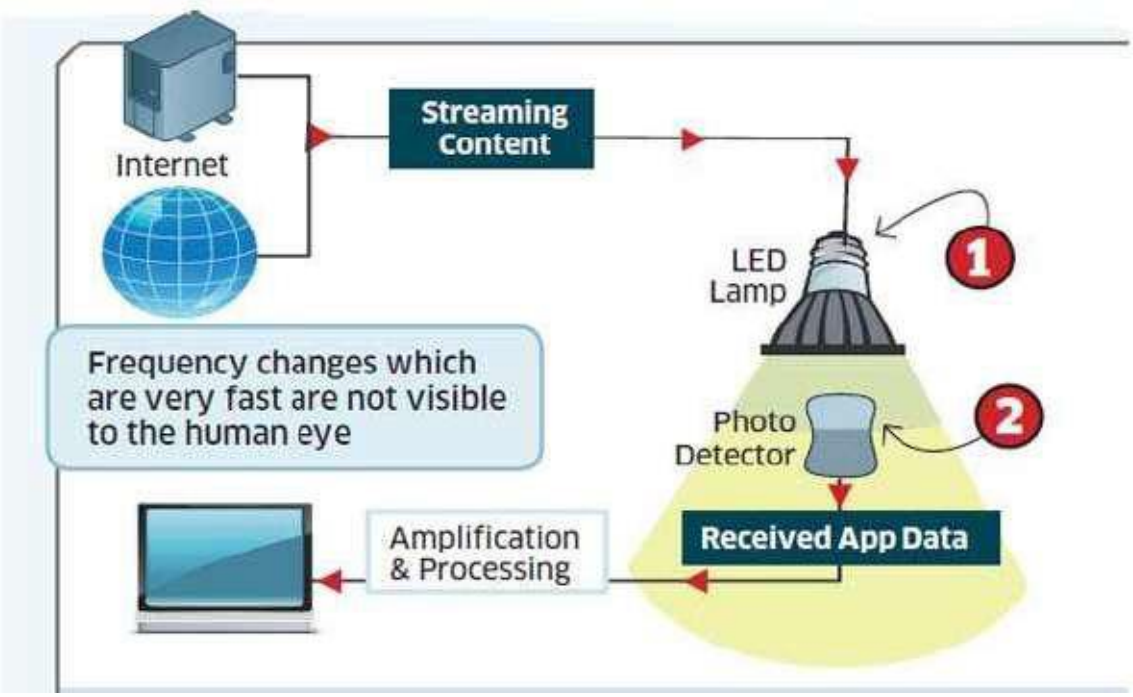

Figure 5 Working of LI-FI

So what you require at all are some LEDs and a controller that code data into those LEDs. We have to just vary the rate at which the LED‘s flicker depending upon the data we want to encode. Further enhancements can be made in this method, like using an array of LEDs for parallel data transmission, or using mixtures of red, green and blue LEDs to alter the light‘s frequency with International Journal of Applied Engineering Research, ISSN 0973-4562 Vol.7 No.11 (2012)© Research India Publications; http://www.ripublication.com/ijaer.htm each frequency encoding is a different data channel. Such advancements promise a theoretical speed of 10 Gbps – meaningyou can download a full high-definition film in just 30 seconds. Simply awesome! But blazingly fast data rates and depleting bandwidths worldwide are not the only reasons that give this technology an upper hand. Since Li-Fi uses just the light, it can be used safely in aircrafts and hospitals that are prone to interference from

radio waves. This can even work underwater where Wi-Fi fails completely, thereby throwing open endless opportunities for military operations.

Imagine only needing to hover under a street lamp to get public internet access, or downloading a movie from the lamp on your desk. There's a new technology on the block which could, quite literally as well as metaphorically, 'throw light on' how to meet the ever-increasing demand for high-speed wireless connectivity. Radio waves are replaced by light waves in a new method of data transmission which is being called Li-Fi Light-emitting diodes can be switched on and off faster than the human eye can detect, causing the light source to appear to be on continuously.

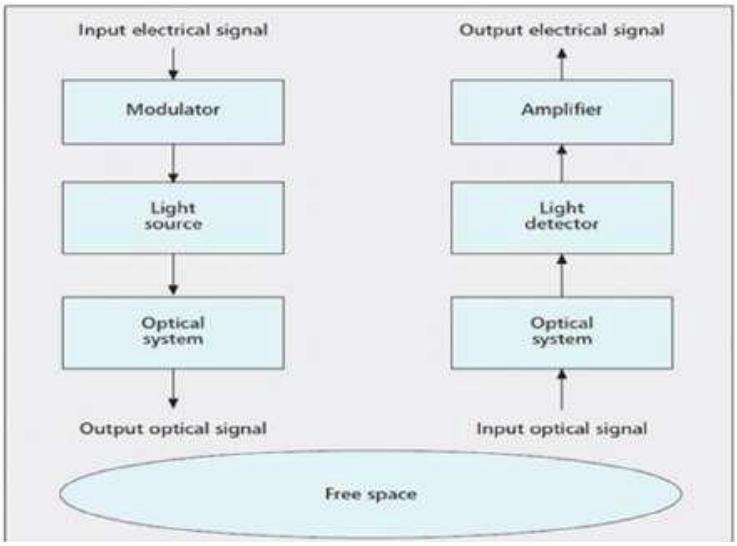

Figure 6 Block Diagram

A flickering light can be incredibly annoying, but has turned out to have its upside, being precisely what makes it possible to use light for wireless data transmission. Light-emitting diodes can be switched on and off faster than the human eye can detect, causing the light source to appear to be on continuously, even though it is in fact 'flickering'.

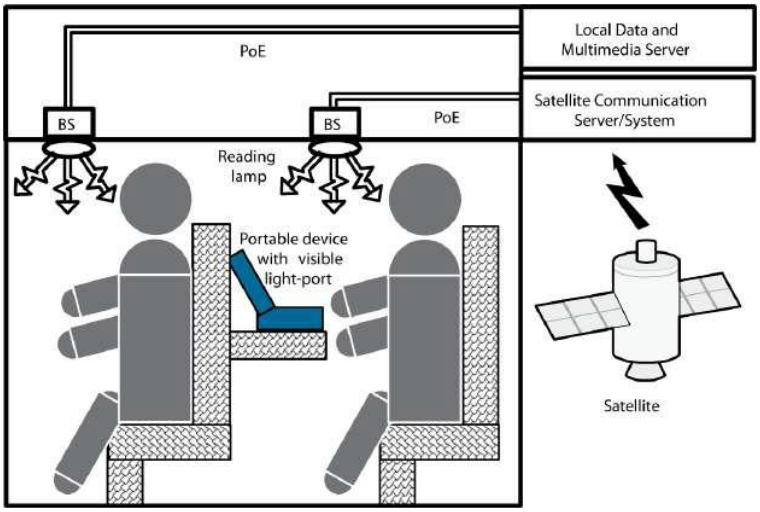

Fig 7 Data from internet to user through light

IV. CONCLUSION

The concept of Li-Fi is currently attracting a great deal of interest, not least because it may offer a genuine and very efficient alternative to radio-based wireless. As a growing number of people and their any devices access wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This may solve issues such as the shortage of radio-frequency bandwidth and also allow internet where traditional radio based wireless isn‘t allowed such as aircraft or hospitals. One of the shortcomings however is that it only work in direct line of sight.

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