The New Era of Transmission and Communication Technology : Li-Fi (Light Fidelity) LED & TED Based Approach

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ABSTRACT

Li-Fi is a label for wireless-communication systems using light as a carrier instead of traditional radio Frequencies [1], as in Wi-Fi. Li-Fi has the advantage of being able to be used in sensitive areas such as in Aircraft without causing interference. However, the light waves used cannot penetrate walls. It 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-, if the LED is on, you transmit a digital 1, if it's off you transmit a 0. The LEDs can be switched on and off very quickly, which gives nice opportunities for transmitting data. Hence all that is required is some LEDs and a controller that code data into those LEDs.All one has to do is to vary the rate at which the LED's flicker [2] 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 each frequency encoding a different data Channel. Such advancements promise a theoretical speed of 10 Gbps – meaning one can download a full high-definition film in just 30 seconds.

Keywords

Wi-Fi, Light-emitting diode (LED), Video LAN Client (VLC),

Technology, Entertainment and Design (TED), Visible Light,

Data utilization, server, lamp driver.

1. INTRODUCTION

Li Fi is a new wireless communication technology which enables a wireless data transmission through LED light. Li Fi is based on a unique ability of solid state lighting systems to create a binary code of 1s and 0s with a LED flickering that is invisible for human eyes. Data can be received by electronic devices with photodiode [3] within area of light visibility. This means that everywhere where LEDs are used, lighting bulbs can bring not only

The light but wireless Connection at the same time. With increasing demand for wireless data, lack of radio spectrum and issues with hazardous electromagnetic pollution, LiFi appears as a new greener, healthier and cheaper alternative to WiFi. The term was first used in this context by Harald Haas in his TED [4] Global talk on Visible Light Communication. 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 meters. 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 10 Gbps, theoretically allowing a high-definition film to be downloaded in 30 seconds. Li-Fi has the advantage of being able to be used in sensitive areas such as in aircraft without causing interference. However, the light waves used cannot penetrate walls [5].Later in 2012, Pure VLC, a firm set up to commercialize Li-Fi, will bring out Li-Fi products for firms installing LED-lighting systems. Moreover Li-Fi makes possible to have a wireless Internet in specific environments (hospitals, Airplanes etc.) where Wi-Fi is not allowed due to interferences or security considerations.

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 WiFi.

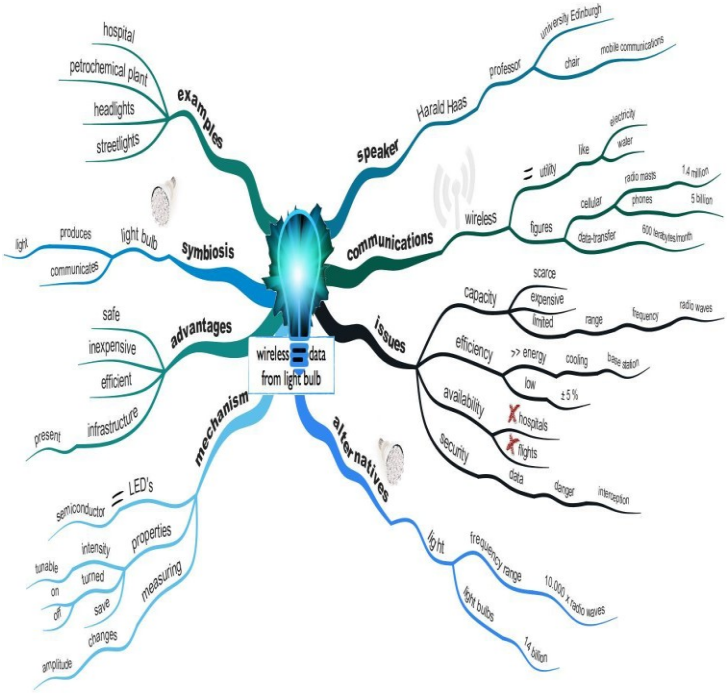

Figure1: Li Fi Technology

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 Edinburgh are focusing on parallel data transmission using array of LEDs, where each LED transmits a different data stream.

Fig2: Harald haas

Other groups are using mixtures of red, green and blue LEDs to alter the light frequency encoding a different data channel. The Li-Fi Consortium is an international platform focusing on optical wireless Technologies. It was founded by four

Technology based organizations in October 2011. The goal of Li-Fi Consortium is to foster the Development and distribution of optical wireless technologies such as communication, navigation, natural user interfaces and others

This is accomplished by inviting technology experts, OEMs, end users and standardization groups to discuss needs, Challenges and eco-system approaches [6]. Li-Fi could free up bandwidth, especially as much of the infrastructure is

Already in place. "There are around 14 billion light bulbs worldwide, they just need to be replaced with LED ones that transmit data," says Haas. "We reckon VLC is a factor of ten cheaper than Wi-Fi." Because it uses light rather than radio-frequency signals, VLC could be used safely in

Aircraft, integrated into medical devices and hospitals where Wi-Fi is banned, or even underwater, where Wi-Fi doesn't Work at all. His technology uses a part of the electromagnetic spectrum that is still not greatly utilized- The Visible Spectrum. Light is in fact very much part of our lives for millions and millions of years and does not have any major ill effect. Moreover there is 10,000 times more space available in this spectrum and just counting on the bulbs in use, it also multiplies to 10,000 times more availability as an infrastructure, globally.

2. WORKING PROCESS OF LI FI

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-, if the LED is on, you transmit a digital 1, if it's off you transmit a 0. The LEDs can be switched on and off very quickly, which gives nice opportunities for transmitting data. Hence all that is required is some LEDs and a controller that code data into those LEDs. All one has to do is to vary the rate which the LED's flicker depending upon the data we want to encode. Further at 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 each frequency encoding a different data channel. Such advancements promise a theoretical speed of 10 Gbps – meaning one can download a full high-definition film in just 30 seconds. To further get a grasp of Li-Fi consider an IR remote.(fig 3.3). It sends a single data stream of bits at the rate of 10,000-20,000 bps. Now replace the IR LED [7] with a Light Box containing a large LED array. This system, fig 3.4, is capable of sending thousands of such streams at very fast rate. Light is inherently safe and can be used in places where radio frequency communication is often deemed problematic, such as in aircraft cabins or hospitals. So visible light communication not only has the potential to solve the problem of lack of spectrum space, but can also enable novel application. The visible light spectrum is unused. It's not regulated, and can be used for communication at very high speeds. The University of Strathclyde in the UK has created a research center aimed at turning the constant flicker of LED lights into a way to transmit internet communications using visible light, as opposed to radio waves (Wi-Fi, cellular) or via cables. Dubbed, the Intelligent Lighting Centre (ILC)[8], the consortium is made up of researchers from several UK universities, and is backed with £4.6 million (US $7.28M) by the Engineering and Physical Sciences Research Council. Together the consortium aims to conduct research on a smaller LED than other groups around the world that are also investigating this technology. First, a bit on what they call Li-Fi from the university release (or you can go catch a TED talk on the topic):Underpinning Li-Fi is the use of light-emitting diodes (LEDs), a rapidly spreading lighting Technology which is expected to become dominant over the next 20 years. Imperceptibly, LEDs flicker on and off thousands of times a second: by altering the length of the flickers, it is possible to send digital information to specially-adapted PCs and other electronic devices – making Li-Fi the digital equivalent of Morse code. This would make the visible part of the electromagnetic spectrum available for internet communications, easing pressure on the increasingly crowded parts of the spectrum currently being used. Instead of researching Li-Fi LEDs around 1mm2 in size, the EPSRC-funded[9] team is developing tiny, micron-sized LEDs which are able to flicker on and off 1,000 times quicker than the larger LEDs. This would allow them to transfer more information, giving them greater capacity; think of comparable to the difference between DSL [10] and fiber connections.

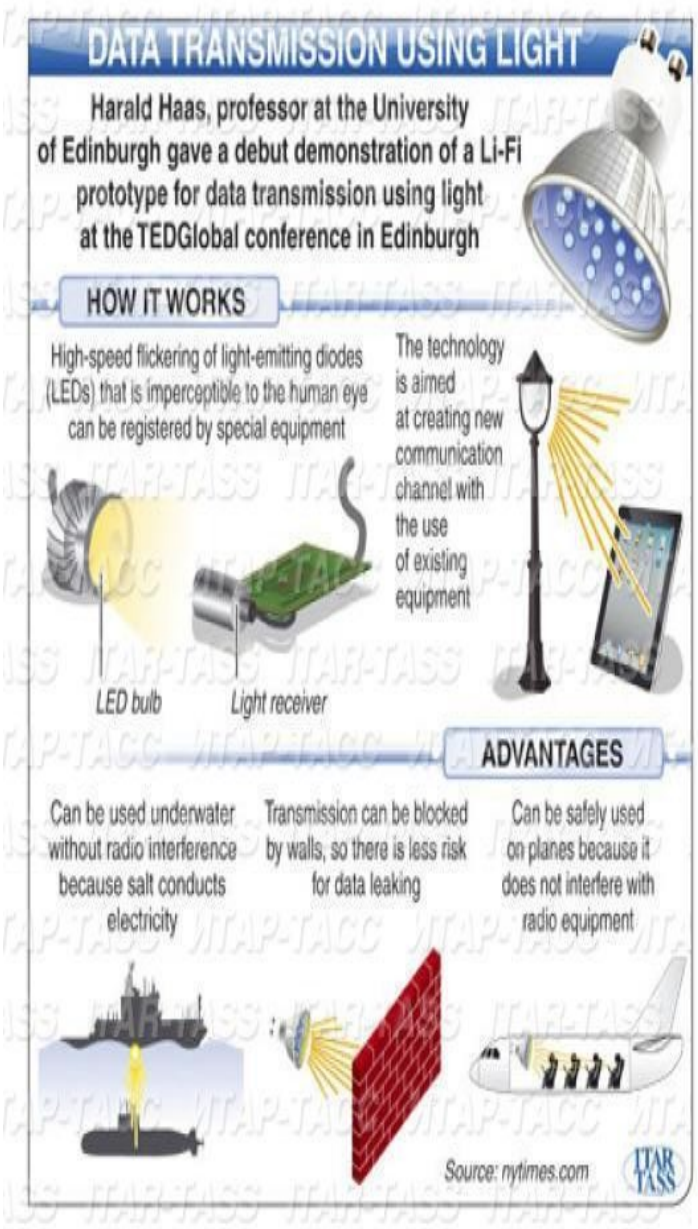

Fig 3: How Li-Fi works

In a video accompanying the release, it says the LED lights could transmit data at 1 gigabit per second. The crazy thing about these tiny LED is that while they are shooting information to one another, they could also be lighting your home or showing you a message or maybe even a picture. So far WO companies have spun out of this research group attempting to build out LED based wireless data transmission: m LED and pure VLC. The term Li-Fi is increasingly being used to refer to the use of Visible Light Communication
(VLC) technology in wireless computer networking. (Note: This is different from "LiFi" projection TV technology introduced by Panasonic in 2007.) Li-Fi made news last year as researchers demonstrated VLC running at rates up to

800 Mbps. Research and development work on VLC continues, with no real products expected to arrive on the market anytime soon, yet the technology Intrigues those looking for alternatives to Wi-Fi.

A unique aspect of VLC is that connections only work when the device has a direct line of sight to the light transmitter. In some cases, especially when using mobile devices, this could become a major annoyance. Others, though, see it as a helpful security feature: Neighbors (or even people in the next room) will have a hard time sniffing your VLC connection.

3.1 Visible Light Communication

VLC is 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:

1. A high brightness white LED which acts as a communication source
2. Silicon photo diode which shows good response to visible wavelength region.

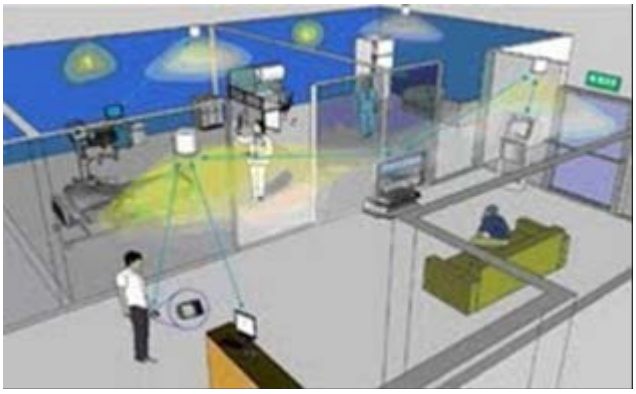

Fig3.1: overview of visual light communication

LED illumination can be used as a communication source by modulating the LED light with the data signal. The LED light appears constant to the human eye due to the fast flickering rate. The high data rate can be achieved by using high speed LED's and appropriate multiplexing tech-niques. Each LED transmits at a different data rate which can be in-creased by parallel data transmission using LED arrays. Many different reasons exist for the usage of LED light in spite of fluorescent lamp, incandescent bulb etc which are available.

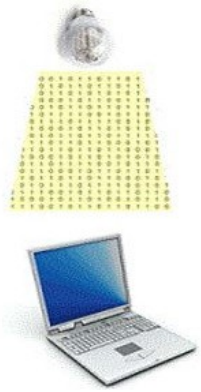

Fig 3.2: Transfer of data in the form of 0's and 1's

4. COMPARISON BETWEEN LI FI AND WI FI

LI-FI is a term of one used to describe visible light Communication technology applied to high Speed wireless communication. It acquired this name due to the similarity to WI-FI, only using light instead of radio. WI-FI is great for general wireless coverage within buildings, and Li-Fi is ideal for high density wireless data coverage in confined area and for relieving radio interference issues, so the two technologies can be considered complimentary.

TECHNOLOGY	SPEED	DATA DENSITY
WIRED		
FIRE WIRE	800 Mbps	*****
USB3.0	5 Gbps	*****
THUNDERBOLT	2X 10 Gbps	*****
WIRELESS (CURRENT)		
WI-FI-IEEE (802.11N)	150 Mbps	*
BLUETOOTH	3 Mbps	*
IrDA	4 Mbps	***
WIRELESS (FUTURE)		
Wi-Gig	2 Gbps	**
Giga-IR	1 Gbps	***
Li-Fi	>10 Gbps	****

The table also contains the current wireless technologies that can be used for transferring data Between devices today, i.e. Wi-Fi, Bluetooth and IrDA[11]. Only Wi-Fi currently offers very high data rates. The IEEE 802.11.n in most implementations provides up to 150Mbit/s (in theory the standard can go to 600Mbit/s).

Although in practice you receive considerably less than this. Note that one out of three of these are an optical technology.

TABLE I
COMPARISON BETWEEN LI-FI VS. WI-FI

S.No.	*Parameters*	*Wireless Technologies*	
		Light Fidelity	**Wireless Fidelity**
1.	**Speed for data transfer**	**Faster transfer speed (>1 Gbps)**	**Data Transfer speed (150 Mbps)**
2.	**Medium through which data transfers occurs**	**Used Light as a carrier**	**Used Radio spectrum**
3.	**Network topology**	**Point to point**	**Point to point**
4.	**Operating frequency**	**Hundreds of Tera Hz**	**2.4 GHz**

5. HOW IT IS DIFFERENT?

Li-Fi technology is based on LEDs 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 [12] or the visible part of the spectrum. Also, the speed of the internet is incredibly high and you can download movies, games, music etc. in just a few minutes with the help of this technology. Also, the technology removes limitations that have been put on the User by the Wi-Fi. You no more need to be in a region that is Wi-Fi enabled to have access to the internet. You can simply stand under any form of light and surf the internet as the connection is made in case of any light presence. There cannot be anything better than this technology.

6. FUTURE SCOPE

The area of Li-Fi is very broad in the manner of Hospitals, Academics, Airlines and more. Can be used in the places where it is difficult to lay the optical fiber like hospitals. In operation theatre LiFi can be used for modern medical instruments. In traffic signals LiFi can be used which will communicate with the LED lights of the cars and accident numbers can be decreased. Thousand and millions of street lamps can be transferred to LiFi lamps to transfer data. In aircraft LiFi can be used for data transmission. It can be used in petroleum or chemical plants [13] where other transmission or frequencies could be Hazardous.

7. CONCLUSION

The possibilities are numerous and can be explored further. If his 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 toward the cleaner, greener, safer and brighter future. 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 many 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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