Li-Fi –The Future of Communication System

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Abstract

The concept of visible light communications (VLC), or Li-Fi has received a lot of attention in recent years, mostly due to the growing prevalence of LED lighting. Unlike incandescent and fluorescent bulbs, LEDs are solid-state electronics, meaning they can be controlled in much the same way as any other electronic component, and switched at a high speed. VLC is essentially Wi-Fi but using terahertz radiation (light) instead of microwaves (Wi-Fi). Instead of oscillating a Wi-Fi transmitter, VLC oscillates an LED bulb and of course, on the receiving end there's a photo detector instead of an antenna. LiFi is a wireless optical networking technology that uses light-emitting diodes (LEDs) for data transmission.

Keyword- LED, Li-Fi, Wi-Fi, Visible Light Communications (VLC)

I. LI -FI TECHNOLOGY

A. Introduction

With the use of light radiating diodes LiFi technology transfers data through wireless. There has been a complete shift in wireless technology due to increase demand for faster and more secure and protected data transmission. Li-Fi is a new exemplar for photosensitive wireless technology to provide unprecedented connectivity within a localized data centric environment. Li-Fi is such a free band which is license free that is why it is less at cost than Wi-Fi.

With the use of special intonation using a distinctive signal processing technology thousands of streams of data can be transferred simultaneously at higher speed. Li- Fi is useful in aircraft because the lights present above head can be used for data transmission. It is useful in controlling traffic at traffic signals as it communicates with LED lights of cars. Where there is difficult to amateur optical fibers LI-Fi is used. The new Li-Fi technology can be well managed very easily and it is pretty simple .The LED light starts glowing and will give an output of either binary 1 or binary 0.

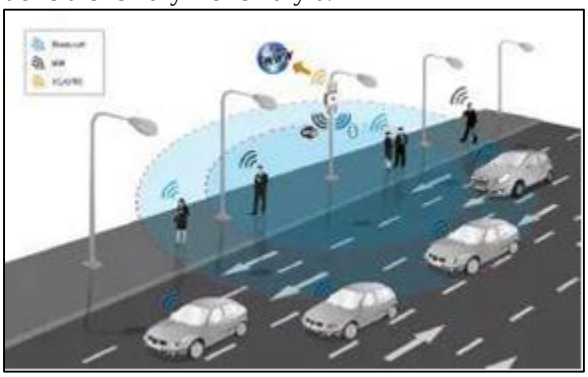

Fig. 1: Li-Fi Technology

II. MICRO LED LIFI

At the moment, commercial LEDs don't get much smaller than 1mm. The Scottish researchers, however, are developing LEDs that are just 1μm - one micron; one thousand times smaller. Not only can you cram more of these micron-sized LEDs into the same space as a larger LED, but apparently they can also flicker on and off 1,000 times faster. A grid of 1,000 micro-LEDs, flashing 1,000 times faster, would be able to transmit data a million times faster than a normal LED.

These LEDs would be a lot smaller than those in smart phone's Retina display. A huge array of these LEDs that double up as a room's light source and a display and provides networking capability on the side. Perhaps a next-gen console would communicate with your gamepad, smartphone, and other peripherals via a Li-Fi equipped TV.

On a more general level, LiFi might be used to extend wireless networks throughout the home, workplace, and in commercial areas. LiFi is restricted by line of sight, so it won't ever replace WiFi, but it could augment it nicely.

The previous VLC system was capable of transmitting up to 500Mbps over four meters (13 feet), or 120 Mbps over 20 meters (67 feet). Rather than actually using a standard LED bulb, Fraunhofer's VLC system is a black box, with an LED and photo detector on the front and an Ethernet jack on the back to connect it to the rest of the network. In this system, the hardware only allowed for 30 MHz of bandwidth to be used, limiting the total throughput. [1]

To reach 3Gbps, the HHI researchers have found a way of squeezing 180 MHz of bandwidth out of the LEDs and instead of using just one LED, they now use three different colors. It is not clear whether this new technique has a higher or lower range than the previous, but it is likely the same. In real-world testing at a trade fair, with less-than-optimal atmospheric conditions, 3Gbps becomes 500Mbps -still pretty darn fast.

Visible light communication has a slew of advantages. In essence, LiFi can turn any LED lamp into a network connection. LiFi, by virtue of operating at such high frequencies (hundreds of terahertz), is well beyond the sticky tentacles of the wireless spectrum crunch and regulatory licensing.

For the same reason, LiFi can be used in areas where there's extensive RF noise (conventions, trade fairs),or where RF noise is generally prohibited (hospitals, airplanes). The Fraunhofer researchers even claim that VLC improves privacy, because your signal can be easily obscured from prying eyes with opaque materials but as you can imagine, that's also a tick in the "con" column as well.

Moving forward, we're still waiting for the first commercial LiFi LED bulbs and Li Fi-equipped laptops/smartphones to come to market. There are a few startups that are making headway, and numerous research groups, but no one seems to have a definitive roadmap for commercial products. With so many possible uses, from street lamp-to-car communications through to ultra-fast short-range communications, and the growing maturity of LED lighting, it's really just a matter of time until LiFi becomes a reality.

Now read: Micro-LED LiFi: Where every light source in the world is also TV, and provides gigabit internet access.

A. Lifi Works

Operational procedure is very simple, if the led is on, a digital 1 is transmitted, if it's off adigital 0 is transmitted.

B. Why Only VLC

- Gama rays cannot be used as they could be dangerous.
- X-rays have similar health issues.
- Ultraviolet light is good for place without people, but otherwise dangerous for the human body.
- Infrared, due to eye safety regulation, can only be used with low power.

III. WORKING TECHNOLOGY

The LEDs can be switched on and off very quickly, which gives nice opportunities for transmitting data.
One should have an LED on one end and a photo detector on the other. If the LED is on the photo detector register a binary one otherwise it's a binary zero. Flash the LED enough times and one can build up a message. [2]

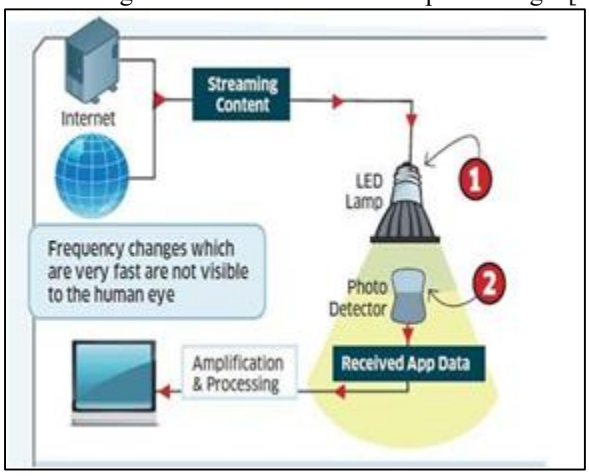

Fig. 2: LED Working Technology

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 10Gbps meaning a full high-definition movie can be downloaded 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.

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. 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 (commonly referred to as LEDs and found in traffic and street lights, car brake lights, remote control units and countless other applications) 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'. This invisible on-off activity enables a kind of data transmission using binary codes: switching on an LED is a logical '1', switching it off is a logical '0'. Information can therefore be encoded in the light by varying the rate at which the LEDs flicker on and off to give different strings of 1s and 0s.

This method of using rapid pulses of light to transmit information wirelessly is technically referred to as Visible Light Communication (VLC), though it's potential to compete with conventional Wi-Fi has inspired the popular characterization Li-Fi.

A. Visible Light Communication (VLC)

"A potential solution to the global wireless spectrum shortage"

Li-Fi (Light Fidelity) is a fast and cheap optical version of Wi-Fi, the technology of which is based on Visible Light Communication (VLC).VLC is a data communication medium, which uses visible light between 400 THz(780nm)and 800 THz (375 nm) as optical carrier for data transmission and illumination. It uses fast pulses of light to transmit information wirelessly. It works basically like an incredibly advanced form of Morse code - just like switching a torch on and off according to a certain pattern can relay a secret message, flicking an LED on and off at extreme speeds can be used to write and transmit things in binary code.

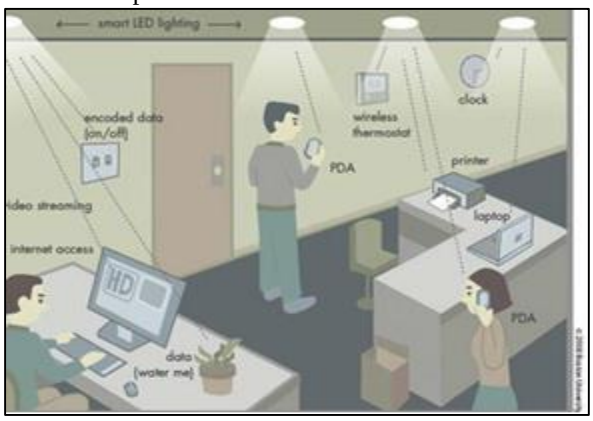

Fig. 3: Visible Light Communication

The main components of this communication system are 1) a high brightness white LED, Which acts as a communication source and 2) a silicon photodiode which shows good response to visible wavelength region serving as the receiving element. LED can be switched on and off to generate digital strings of 1s and 0s. Data can be encoded in the light to generate a new data stream by varying the flickering rate of the LED. To be clearer, by modulating the LED light with the data signal, the LED illumination can be used as a communication source. As the flickering rate is so fast, the LED output appears constant to the human eye. A data rate of greater than 100 Mbps is possible by using high speed LEDs with appropriate multiplexing techniques. VLC data rate can be increased by parallel data transmission using LED arrays where each LED transmits a different data stream.

These are reasons to prefer LED as the light source in VLC while a lot of other illumination devices like fluorescent lamp, incandescent bulb etc. are available.

Technology	*Speed*	*Data Density*
wireless(current)		
WI-FI - IEEE 802.11n	*150 Mbps*	*
Bluetooth	*3Mbps*	*
IrDA	*4Mbps*	***
Wireless(future)		
WiGig	*2Gbps*	**
Giga-IR	*1Gbps*	***
Li-Fi	*>1Gbps*	****

Table 1: current wireless technologies

IV. COMPARISON BETWEEN LI-FI & 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 complementarily-Fi is more secure than Wi-Fi and it's reported that embedded light beams reflected off a surface could still achieve 70 megabits per second. Li-fi can also be used in all places where Wi-Fi can be used. Li-fi is present wherever there is availability of light, in turn eradicating the necessity of having hot-spots only at selected places. There are four criterions to judge on the working of Li-Fi and Wi-Fi that is, capacity, efficiency, availability and security. Both Li-fi and Wi-Fi uses electromagnetic spectrum for data transmission, but whereas Wi-Fi utilizes radio waves, Li-Fi uses visible light communication in the range of 100Mbps.

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. Only Wi-Fi currently offers very high data rates. The IEEE 802.11.n in most implementations provides up to 150 Mbit/s (in theory the standard cano to 600 Mbit/s) although in practice one receive considerably less than this[3]. Note that one out of three of these is an optical technology.

Fig. 4: optical technology

A. 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 or the visible part of the spectrum. Also, the speed of the internet is incredibly high and users 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. No more need for one to be in a region that is Wi-Fi enabled to have access to the internet. The person 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.

V. APPLICATION OF LI-FI

A. Security [4]

In a meeting room environment, the access area of each channel is the width of the light pool, and can be accessed by multiple users. Each user can receive higher data rates than would be the case for an equivalent Wi-Fi channel. In the Wi-Fi case, each user or group of users directly competes for access to bandwidth. The net result is that the more connections there are, the slower the download speeds are for all. By contrast, in the case of Li-Fi, with its greater number of available access points, each pool of light provides full channel data rates with fewer simultaneous users. The overall net benefit to each user is up to 1000 times greater speeds. In addition, and in contrast to radio waves, the light does not pass through the walls. Therefore, with minimal precautions to avoid leakage from windows, etc., security is fundamentally enhanced as compared with Wi-Fi.

B. Dense Urban Environments

Dense urban environments by their nature tend to have complete artificial lighting coverage. This lighting infrastructure can provide always available high data rate access for users as they move through that environment. For example, along a hotel corridor or reception hall a number of users can receive high data rate downloads at any point. Moreover, high speed wireless communication would be available in every room since the light waves do not propagate through walls. This results in interference-free wireless communication, and spectrum does not have to be shared among a large number of users in the rooms.

C. Cellular Communication

In external urban environments, the use of Li-Fi enabled street lamps would provide a network of internet access points. In cellular communication, the distance between radio base stations has come down to about 200-500 metres. So, instead of deploying new radio base stations in our cities, street lamps could provide both, illumination during night, and high speed data communication 24/7. Surprisingly, even when the lights are off as perceived by the eye, full data communication rates are still possible. There is also an additional cost benefit as installing new radio base stations usually comes with large cost – for installation and site lease.

D. EMI Sensitive Environments

On aircraft, Li-Fi enabled lighting will allow high data rate connectivity for each passenger. It will allow connectivity at all times, without creating electromagnetic interference (EMI) with sensitive radio equipment on the flight deck. The reduction in cabling requirement also means a lighter aircraft.

E. Augmented Reality

Exhibits in museums and galleries are illuminated with specific lighting. Li-Fi enabled lighting can provide localised information within that light. This means that a visitor's camera or mobile phone can be used to download further information regarding the object being viewed from the light that illuminates the exhibit.

F. Localised Advertising

By using shop display lighting as a Li-Fi broadcast channel, it is possible to transmit advertising information on the goods being viewed, as well as say special offers and coupons. This will allow the merging of the high street and online shopping experience, and provide novel retail business models to emerge. Catalogue information, discount coupons, and advertising videos could all be provided to shoppers.

G. Underwater Communication

Radio waves are quickly absorbed in water, preventing underwater radio communications, but light can penetrate for large distances. Therefore, Li-Fi can enable communication from diver to diver, diver to mini-sub, diver to drilling rig, etc.

H. Safety Environments

In explosion hazard environments, the use of electrical equipment, including mobile phones, is generally greatly restricted. The use of Li-Fi to pass data will simplify the configuration of data networks in such environments, and can enable new systems to enhance security in these environments.

I. Intelligent Transportation Systems

Car headlights and tail lights are steadily being replaced with LED versions. This offers the prospect of car-to-car communication over Li-Fi, allowing development of anti-collision systems and exchange of information on driving conditions between vehicles. Traffic lights already use LED lighting, so that there is also the prospect offered of city wide traffic management systems. This would enable car systems to download information from the network and have real time information on optimal routes to take, and update the network regarding conditions recently experienced by individual vehicles.

J. Connectivity

Our homes already have lighting widely installed. The use of Li-Fi enabled lighting will transform the applications that can be envisaged, not only the interconnection of devices, such as televisions, computers and Hi-Fi, but also connecting ordinary domestic appliances, such as fridges, washing machines, microwaves and vacuums. The "internet of everything".

K. Sensitive Data

Hospitals are a specific case of an environment where both EMI sensitivity and security of data are issues. Li-Fi can enable the better deployment of secure networked medical instruments, patient records, etc.

L. Indoor Navigation

Y identifying each light (for example, through the use of the widely used MAC codes used by data routers and computers) it is possible to provide a smartmeans of navigating through urban environments. The identification of each code would be linked to a specific location. For example, light received from the closest fixture can indicate to a mobile user their exact position as they travel along a corridor.

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