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An emerging technology of data transfer through light waves (Li-Fi)

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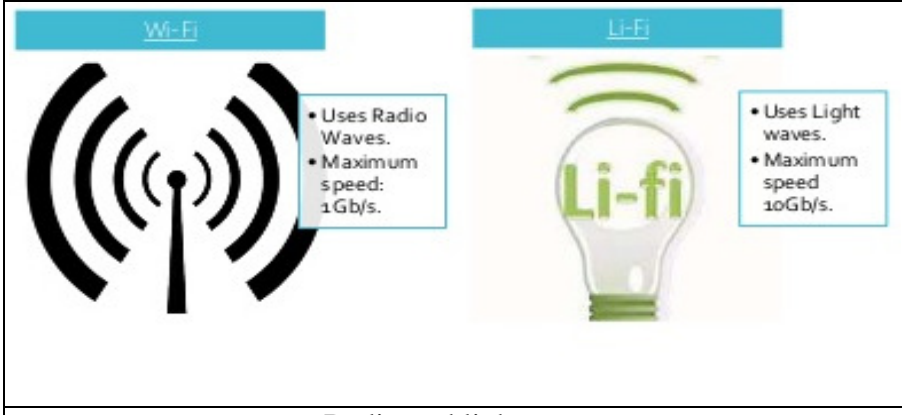
Abstract- Li-Fi (Light Fidelity) is a bidirectional, high speed and fully networked wireless communication technology similar to Wi-Fi. The term was coined by Harald Haas and is a form of visible light communication and a subset of optical wireless communications (OWC). It is so far measured to be about 100 times faster than some Wi-Fi implementations, reaching speeds of 224 gigabits per second. It is wireless and uses visible light communication or infra-red and near ultraviolet (instead of radio frequency waves) spectrum, parts of optical wireless communications technology, which carries much, more information. Li-Fi provides better bandwidth, efficiency, availability and security than Wi-Fi and has already achieved blisteringly high speed in the lab. By leveraging the low-cost nature of LEDs and lighting units there are many opportunities to exploit this medium, from public internet access through street lamps to auto-piloted cars that communicate through their headlights.

Keywords—Li-Fi, Wi-Fi, LED, wireless communication.

I. INTRODUCTION OF LI-FI TECHNOLOGY



Radio and light waves

Li-Fi Bulb

The data transfer rate (DTR) is the amount of digital data that is moved from one place to another in a given time. The data transfer rate can be viewed as the speed of travel of a given amount of data from one place to another. In general, the greater the bandwidth of a given path, the higher the data transfer rate. The speed used in data transfer using conventional equipments is very less as per the need of today's requirement in different industrial and research areas. In telecommunications, data transfer is usually measured in bits per second. For example, a typical low-speed connection to the Internet may be 33.6 kilobits per second (Kbps). On Ethernet local area networks, data transfer can be as fast as 10 megabits per second. Network switches are planned that will transfer data in the terabit range.

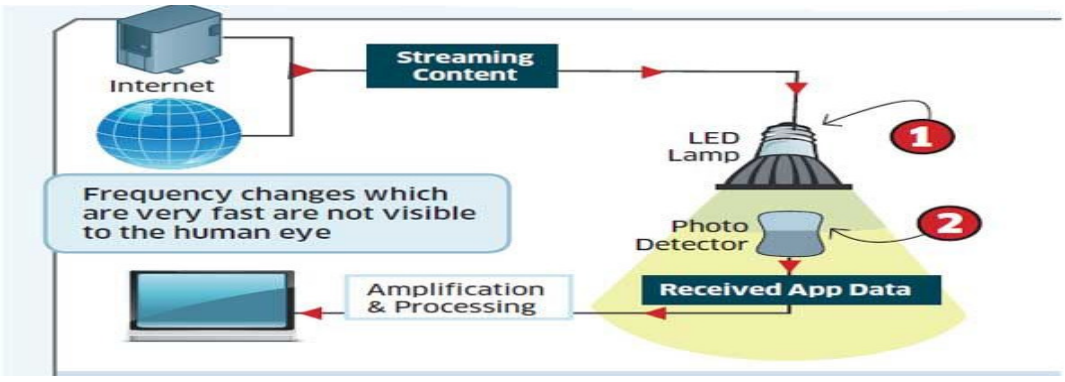
In simple terms, Li-Fi can be thought of as a light-based Wi-Fi. That is, it uses light instead of radio waves to transmit information. And instead of Wi-Fi modems, Li-Fi would use transceiver-fitted LED lamps that can light a room as well as transmit and receive information. Since simple light bulbs are used, there can technically be any number of access points.

This 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. 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 eyes cannot notice, so the output appears constant. More sophisticated techniques could dramatically increase VLC data rates. Teams at the University of Oxford and the University of Edinburgh are focusing on parallel data transmission using arrays of LEDs, where each LED transmits a different data stream. Other groups are using mixtures of red, green and blue LEDs to alter the light's frequency, with each frequency encoding a different data channel. Li-Fi, as it has been dubbed, has already achieved blisteringly high speeds 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. Haas has set up a spin-off firm to sell a consumer VLC transmitter that is due for launch next year. It is capable of transmitting data at 100 MB/s - faster than most UK broadband connections [6].

The idea of Li-Fi was introduced by a German physicist, Harald Hass, which he also referred to as ―data through illumination. The term Li-Fi was first used by Haas in his TED Global talk on Visible Light Communication. According to Hass, the light, which he referred to as D-Light, can be used to produce data rates higher than 10 megabits per second which is much faster than our average broadband connection [5].

II. HOW LI-FI WORKS?

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.



Block diagram of Li-Fi system

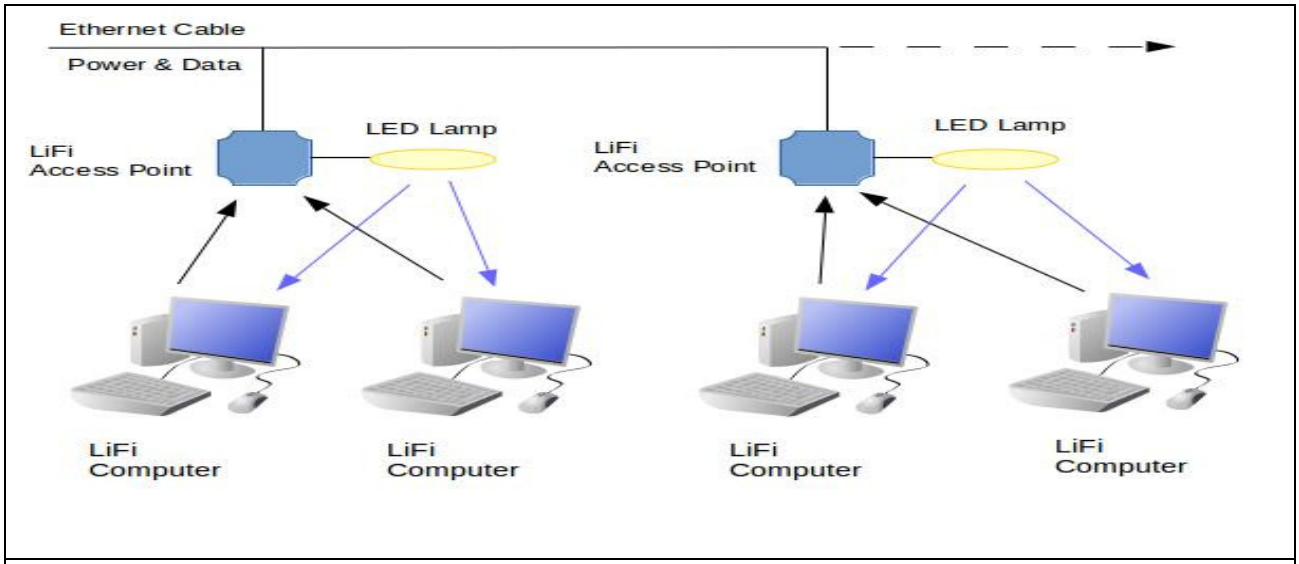
The operational procedure is very simple-, if the LED is on, you transmit a digital 1, if it's off you transmit a 0. The LEDs can be switched on and off very quickly, which gives nice opportunities for transmitting data. Hence all that is required is some LEDs and a controller that code data into those LEDs. All one has to do is to vary the rate at which the LED's flicker 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.

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.

LI-FI ACCESS POINT DIAGRAM

How a Li-Fi Wireless Access Point System Could Work Using Room Lighting. This Li-Fi Access Point System works using the existing lighting in a building and replacing the conventional lights, with Li-Fi AP (Access Point) LED lights. The lights can then be connected together with a Ethernet cable, which will connect them all to the main network and possibly power the lighting.

The LED bulb will send signals to devices on the network and provide lighting for the room. Another part of the AP will receive signals from the LiFi clients, creating a bidirectional full-duplex connection. In other words Li-Fi allows for two way communication between two Li-Fi devices at the same time. Li-Fi APs also allow for multiple devices to be connected to them as Wi-Fi APs also permit [7].



Li-Fi Access Point Diagram

ADVANTAGES OF LI-FI OVER WI-FI[2]

- There are billions of bulbs worldwide which just need to be replaced with LED's to transmit data.
- Integrated into medical devices and in hospitals as this technology doesn't deal with radio waves, so it can easily be used in all such places where Bluetooth, infrared, Wi-Fi and internet are broadly in use.
- Under water in sea Wi-Fi does not work at all but light can be used and hence undersea explorations are good to go now with much ease.
- Security is a side benefit of using light for data transfer as it does not penetrate through walls.
- The issues of the shortage of radio frequency bandwidth may be sorted out by Li-Fi.
- Using this Technology worldwide every street lamp would be a free data access point.

SOME LIMITATIONS OF LI-FI

The lights flicker.

We subtly modulate the current supply to the LED devices at relatively high speeds. We are not harshly switching the LEDs on and off, and we are not modulating at speeds anywhere near those perceptible to the human eye. Your TV and computer displays do flicker at just higher than perceptible rates; the same is true of some LED dimming technologies. VLC (Visible light communication) does not flicker the lights like this, it will not give you a headache!

You cannot dim the lights.

There are VLC patents pending on methods to dim the LED while maintaining high data rates until the current is dimmed to about 50%. After that the data rates will begin to diminish in a very graceful manner. So yes, you can dim the lights and maintain communications reliably.

VLC is uni-directional (downlink or broadcast only).

VLC can be used for transmission in either direction. The uplink and downlink can be isolated in a number of ways – wavelength, time, code and also by spatial or optical isolation. For practical and cost reasons VLC might be implemented for downlink only since this is where bottlenecks exist with existing technologies, e.g. Wi-Fi may already provide a reliable uplink where congestion is less likely and Li-Fi provides a high capacity uncongested downlink.

There will be interference from sunlight.

It is relatively simple to eliminate the vast majority of interference from natural and artificial sources using optical filters (which avoids receiver saturation). After the photo-detector further analogue and digital filtering ensure remaining interference is negligible.

Lights need to be on so this is inefficient.

To use VLC the lights do need to be on. However in the vast majority of industrial, commercial and retail environments the lights are on when the area is occupied. Given that the lights are usually on, VLC transmission power comes free as it is already used for illumination so this is highly efficient.

In domestic environments we do tend to switch off lights during daylight. Where the lights would have been off the power required for VLC is not free but the lights only need to be dimmed up to transmit data. The illumination need not be above ambient levels so will not be noticed. The power consumed is comparable with the watts/bit for radio transmission and so on aggregate even in domestic environments there is a significant net saving in power.

You must have line-of-sight.
Line of sight is a definite advantage because the signal will be stronger. However, if you look under the table you can still see despite there being no line of sight from the sun or from artificial sources. If a VLC receiver can collect photons, it can receive data, albeit at a lower data rate if light levels are low. Radio technology is similar in that indirect signals have a lower power and hence the data rate reduces. Visible light can be reflected but generally does not penetrate materials which can be a security advantage and perhaps a coverage disadvantage. Radio can suffer multipath interference from non-line of sight reflected signal cancelling each other by being in anti-phase – leads to signal fading. VLC signal always add and cannot cancel each other and cause fading which is a significant advantage.

This is a disruptive technology.
VLC is often regarded as a disruptive technology relative to radio technology. I do not believe this should be considered to be the case. I believe VLC is totally complementary to radio. In the same way as Wi-Fi is seen as complimentary to cellular data, VLC or Li-Fi is complementary to Wi-Fi. Cellular data is automatically off-loaded to Wi-Fi when in-doors, in the office or home. Cellular operators insist that smart phones used on their networks are Wi-Fi enabled for this reason, and for quality of service reasons we tend to turn this feature on automatically to the relief of the cellular operators. Unfortunately and consequently Wi-Fi is now becoming heavily congested. Li-Fi can provide a high speed, high density bearer onto which the congested Wi-Fi downlink traffic can be off-loaded. VLC is radio's friend we should not be considered enemies.

You need special LEDs
Specialist LEDs with ideal characteristics for VLC would be great. However, solid state LED lighting is currently being sold based on its performance for illumination purposes (color temperature, efficacy, CRI, lifetime, etc). Communications performance is not even a secondary consideration, so it is wholly unrealistic to expect the lighting industry to factor this into designs at this stage.

In a practical sense we can achieve excellent results with COTS LED devices, if better devices are available great, but to implement VLC we can use existing LED devices. When VLC becomes a significant part of the LED industry then we can start to influence the specification of these devices.

VLC is a complex technology
VLC is a very simple technology since it uses direct modulation and direct demodulation. Infra-red remote controls are very low-cost for exactly the same reason. On the other hand radio technology is complex since it requires radio frequency circuits to modulate the data onto the radio bearer and then it requires an antenna system to transmit the signal. The radio receiver is often even more complex requiring an antenna system, radio receiver and carrier synchronization circuits. Therefore VLC is much simpler than the equivalent radio system.

It will never work!
VLC technology has been proven to work by a number of companies and research establishments. The reliability of lighting systems has rarely been questioned but the reliability of wireless communications is increasingly in question. To my mind the question we need to be asking is; "Could we ever make wireless communications as reliable as lighting technology?"

III. RESULT

Li-Fi Technology is an emerging technology to work with high data transfer speed in different areas.

IV. CONCLUSIONS

The concept of Li-Fi is currently attracting a great deal of interest, not least because it may offer a genuine and efficient alternative to radio based wireless. As a growing number of people and their devices access wireless internet, the air waves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. So Li-Fi has a bright future.

V. ACKNOWLEDGEMENT

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