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li-fi: the future of wireless communication

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ABSTRACT: *Nowadays people and their electronic devices access wireless internet. But, clogged airwaves are going to make it increasingly difficult to latch onto a reliable signal. So, Radio waves are just one part of the spectrum that can carry our data.*
We can use "Data through Illumination". In this process, the data is sent through an LED source that varies in intensity faster than the human eye could follow. The future can be envisioned where the data for laptops, smart phones and all other smart applications is transmitted through the light in our living room. And security would be a snap—if you can't see the light, you can't access the data.

Keywords*: Wireless communication, Light-Fidelity (Li-Fi), Visible Light Communication (VLC), wireless networking, optical communication.*

I. INTRODUCTION

Li-Fi is a VLC technology. In simple terms, Li-Fi can be visualized as a light based Wi-Fi, in which light waves are used instead of the radio waves. The system will use a transceiver, fitted with LED lamps that can light a room as well as transmit and receive information. 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.

Theoretically, Li-Fi could transmit data at a rate of 3 GB/sec but in practical conditions, the data rate is 500 MB/sec. So this means that a 1080p HD video can be downloaded in just ten seconds.

The working

Li-fi is implemented using an array of LED bulbs at the transceiver. These devices are illuminated by applying a constant current. Now, when the intensity of the LED is varied at a very fast rate, such that it is unseen by the human eyes, the transmission of the data occurs. To get further grasp of Li-Fi consider an IR remote. It sends a data stream of bits at the rate of 10,000 – 20,000 bps.

Now replace the IR LED with a large normal LED. Now it is capable of sending thousands of such streams at a very fast rate.

A. Encoding the data

The data is encoded using a microcontroller and is then fed to the LED. Now when the LED is ON, a digital 1 is transmitted and when it is OFF a digital 0 is transmitted. The process is done at a very high speed such that it is invisible to the human eye and the data is transmitted from the source to destination.

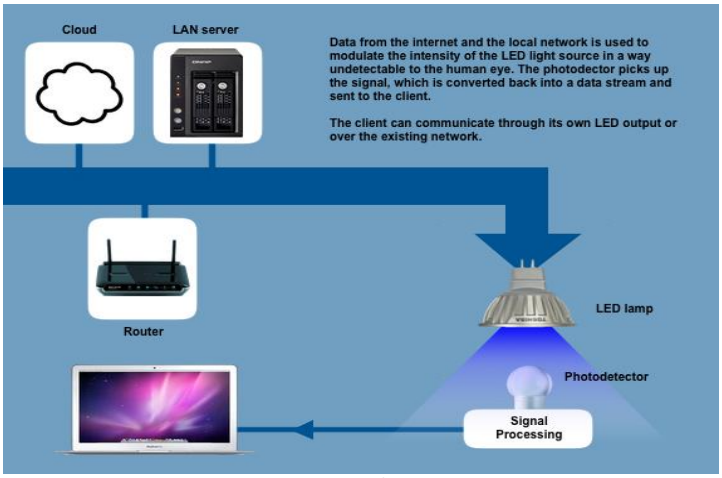

Fig.1 Transmission of data using Li-Fi

B. ***Enhancements to Li-Fi***

The Li-Fi can be further enhanced by using an array of LEDs, using red, green and blue LEDs, altering the frequency of the light with each frequency encoding a different data channel. This will help to download or stream 1080p HD video content at a rate of 10 GB/sec.

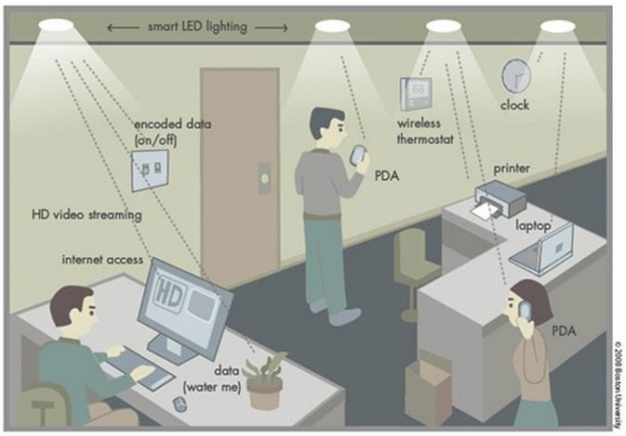

Fig.2 Multiple uses of Li-Fi

Need for Li-Fi

There are certain adverse effects caused by radio communication and hence the need for Li-Fi arises.

A. Present scenario of wireless communication

The present scenario of wireless communication is as follows,

- 1.4 million Cellular radio masts have been deployed.
- More than 5 million Wi-Fi devices are present.
- Nearly 700 TB of data transmission takes place per month.

Wireless communication has become an important utility in our everyday life. Life without wireless communication is now unthinkable. So, the need arises to improve the wireless technology and so the concept of Li-Fi has been introduced.

B. ***Issues with Wi-Fi***

There are mainly four issues with the current scenario as explained below,

1) Capacity

- Transmission of wireless data through radio waves is restricted to a certain range.
- These waves are scarce, expensive and so its availability is limited.

2) Efficiency

- Most of the energy consumed, is not used to transmit the radio waves, but is used to cool the base stations.
- The efficiency of such a base station is only at about five percent.

3) Health issues

- There are potential health issues associated with radio waves. In some cases extensive exposure to these waves may cause health problems like cancer.
- Consequently we have to switch off devices like cell-phones in places like hospitals

4) Security

- The radio waves can be intercepted, and somebody can make use of one's network.
- So, it remains as a major concern in wireless communication.

I.

II. THE BEST ALTERNATIVE

As, there are certain drawbacks in radio waves, a study was made in the electromagnetic spectrum and the results were concluded. The spectrum is shown in the below figure.

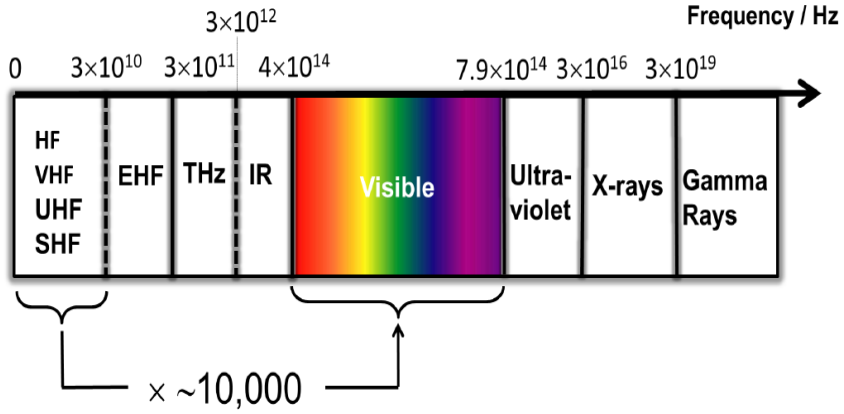

Fig.3 The electromagnetic spectrum

From the study of the spectrum, it was found that,

- Gamma rays can't be used as they could be dangerous for health.
- X-Rays also have similar health issues.
- UV rays is acceptable only in minute intensity, so it also can't be used.
- Infrared can be used only with low power due to eye safety regulations.

And so, the Visible Light spectrum is the most safest and efficient method of transmitting the data. It is nearly 10,000 times more efficient than the ordinary radio waves. So it has a very big advantage. 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.

III. THE ADVANTAGES OF LI-FI

A. Capacity

The spectrum region of visible light is nearly 10,000 times greater than that of the radio waves and hence it gives us the option to use more channel to transmit the data.

B. Efficiency

An LED consumes very less power and hence it is more efficient and power saving. Moreover, LEDs are available at a very cheaper rate and hence they are cost efficient.

C. Safety

Visible light poses no health issues, so it is completely safe to use it anywhere. It can also be used in aeroplanes, hospitals, and other areas where radio waves cannot be used.

D. Security

As the transmission is very fast and as it takes place in a fraction of second, it is very much secure than the radio waves and it is very difficult to interpret or eavesdrop the messages.

IV. APPLICATIONS OF LI-FI

The Li-Fi is still in development process but it has a very vast application. Some of them are as follows,

A. Traffic lights

Traffic lights can be made to communicate with the each other and can also communicate with each other. Vehicles also can be provided with LED lights so that they can communicate with each other and prevent accidents by exchanging information.

B. Intrinsically safe environments

Visible lights are much safer than RF and hence it can be used in where RF can't be used such as petrochemical plants, airplanes, hospitals, etc.

c. Internet hotspots

Using this technology, internet access can be provided to the public from the light sources available anywhere. For example, even the street lights can act as internet hotspots.

d. D. On ocean beds

Li-Fi can even work underwater where Wi-Fi fails completely and thereby throwing open endless opportunities for military or navigation operations.

VII. DISADVANTAGES

- The biggest disadvantage is that it needs direct line of sight to transmit data.
- There will be interference from sunlight.
- Requirement of special kind of LEDs.
- Flickering of the light.
- VLC is unidirectional.

- You cannot dim the lights.
- Lights need to be on, so this is inefficient.

VIII. OVERCOMING THE DISADVANTAGES

After studying carefully about the VLC system and Li-Fi, we have framed certain ideas and solutions to the disadvantages or restrictions mentioned above. The solutions for the problems are as follows.

A. Direct line of site

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.

B. Overcoming the interference problem

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.

C. Overcoming the need for 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 (colour 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.

D. Overcoming flickering problems

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 does not flicker the lights like this, it will not give you a headache!

E. Overcoming unidirectional issues

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.

F. Overcoming the dimming issues

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.

*G. **Overcoming** the issues with the LED lights always being ON*

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.

IX. CONCLUSION

Li-Fi is certainly not useless, but it has certain inherent limits for the technology. Li-Fi may not be able to replace conventional radios altogether, but it could turbocharge the development of wireless television and make it easier to throw a wireless signal across an entire house. At present, finding the ideal position for a wireless router is something of a divine art. If the signal could be passed via VLC from Point A to Point B inside a home, small local routers at both points could create local fields with less chance of overlapping and interfering with each other. Large scale areas that are saturated with radio signals or that don't permit them for security reasons could use Li-Fi as an alternate high-speed wireless network solution.

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