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WINGS TO YOUR THOUGHTS.....

Future of Wireless Communication-Light Fidelity (Li-Fi)

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***Abstract**: Nowadays many people are using internet to accomplish their tasks through wired or wireless networks. With the fast increase in technology the dependencies of humans on mobile, laptop and internet is also increasing. There are Wi-Fi hotspots at homes, hotels, airports and even cities due to which the Wi-Fi network is constantly increasing. Since the no of users are increasing wireless network speed is decreasing. Even though Wi-Fi gives us speed up to 150mbps as per IEEE 802.11n, it is insufficient to meet the growing demands of the user. Hence it was necessary to find an alternate way to transmit huge amount of data with greater speed. Li-Fi is a technology which uses visible light spectrum to transfer data using LED lights at a rapid rate which cannot be detected by human eye. Dr. Herald Haas, the professor of mobile communications at the University of Edinburgh School of engineering, first time publically presented the working prototype proof of Light Fidelity (Li-Fi), a method of Visible Light communication (VLC).This paper will focus on Li-Fi technology over traditional radio frequency in Wi-fi and challenges faced by VLC.*

***Keywords:** Light Fidelity (Li-Fi), Visible light communication (VLC), Free space optical (FSO), Light emitting diodes (LED), Line of sight (LOS).*

1. INTRODUCTION

We have 1.4 cellular base stations and 5 billion cellular phones. With these mobile phones we transfer 600 Terabytes of data every month. Wireless communication has become like utility like water and electricity. [3] We use it every day in our day to day personal lives and corporate lives. But there are places like aeroplanes and hospitals where we are kindly requested to turn off our cell phones. Hence it was necessary to look into issues this technology using electromagnetic waves and radio waves have. Radio waves are scares and limited and hence it cannot cope up with no of bytes of data we transfer every month and we are running out of spectrum.

The cellular base stations that we use currently are not that efficient, they consume lots of power. The efficiency of such a base station is only 5%. Security is also one of the major issues using radio waves. These waves can penetrate through walls, so someone can intercept the signals and use for bad purposes.

If we consider the electromagnetic spectrum shown in the fig 1 then we have Gamma and X rays on the higher end which can be very dangerous to humans. On the lower end we have radio waves which have the above discussed disadvantages. In the middle layer there is visible light. Light is around everywhere and hence would be an idle to see if visible light can carry data.[4]

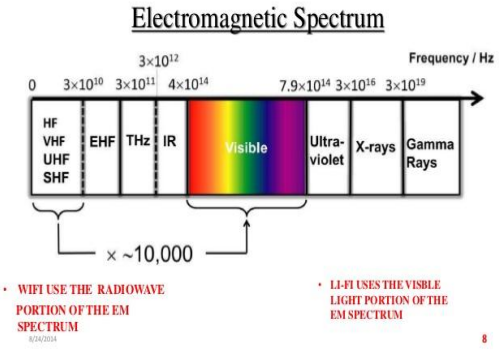

Figure 1: Electromagnetic spectrum

The term Li-Fi was first used in this context by a German physicist, DR. Harald Haas, who came 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. The idea is similar to the working behind infrared remote controls, but far more powerful. He found that visible light spectrum is 10,000 times RF spectrum. [3] The idea behind its working is very simple, if the LED is on, you transmit digital 1; if it's off you transmit a 0. The LEDs can be switched on and off very rapidly, which provides a technique for transmitting data.

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In order to exploit electromagnetic spectrum for wireless systems number of companies and industry groups formed a Li-Fi consortium. The consortium believes, it is possible to achieve speed more than 10 Gbps, theoretically allowing a high definition film to be downloaded in less than 30 secs[1]. Li-fi has the advantage of being able to use in places like hospitals, aeroplanes without causing any disturbances. It consumes less power and cannot penetrate through walls hence is more secure.

2. DESIGN

In order to commercialize Li-fi we need to replace inefficient incandescent light bulbs with LED bulbs.[6] The architecture for Li-fi is shown in the figure 3. Important factors we should consider using Li-fi are:

- Line of Sight (LOS)
- LED bulbs.
- Li-fi module.

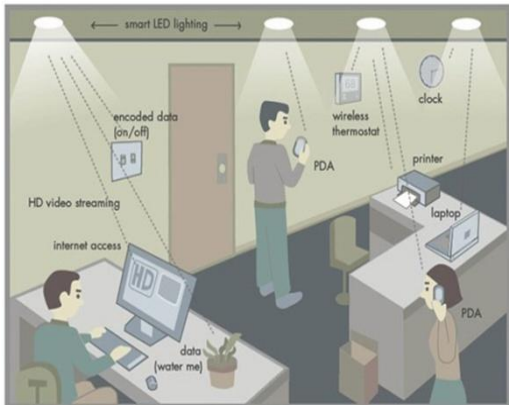

Figure 3: Basic working design

3. WORKING

LED's being a semi-conductor its intensity can be modulated at very high speed. It can be switched On-Off at very high speeds. This is the fundamental approach of this technology. Consider the closest spectrum to Visible light that is Infrared rays. Consider remote controls, which consist of a single LED bulb. We click the button for On-Off which thereby creates simple low bit data stream of 10,000 bits/sec which cannot be usable for YouTube video.[5]

Figure 4: Working of remote with single LED.

The working of Li-Fi is similar to that of a remote control. Instead of single low bit binary data stream of '1' and '0', we transmit thousands of data streams in parallel. This switching is faster because the operating speed of LED's is 1microsec hence the human eye cannot detect it causing it to appear continuously. All one has to do is to change the rate at which LED's flicker depending on the type of data to be encoded.

Figure 5: Working of Li-Fi with multiple LED's.

An LED-FSO network shown in figure 6 consists of a transmitter made up of LEDs and a receiver, located at some distance between a few centimeters to a few meters from the transmitter, made up of photodiodes to detect and convert the incoming light into electrical signal.[3] The transmitter amplifies the signal input which thereby adjusts the signal voltage level that is input into a driver stage. The driver modulates the current or voltage in order to encode the emitting light intensity with data and information according to the input signal. The LEDs are voltage driven. The modulation frequency is called the carrier frequency. The reverse process is performed at the receiver, which consist the photo-detector stage, and a data reproducing stage is next which is used for decoding.

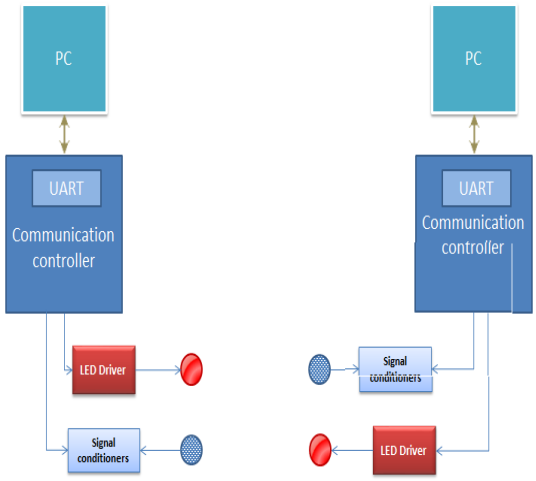

Figure 6: Hardware Design.

4. ANALOGY OF LI-FI AND WI-FI

Wi-Fi is a technology that is used for an electronic device to exchange data or remain wirelessly connected to the internet by using radio waves. Wi-Fi stands for Wireless Local Area network communication technology and is related to the IEEE 802.11 family of wireless networking standards. Li-Fi is a subset of optical wireless communications (OWC) and can be a complement to RF communication (Wi-Fi or Cellular network), or an alternate with respect to data broadcasting. [2] It is wireless and uses VLC (instead of radio frequency waves), subset of Optical wireless communications technology, which capable to carry much more information, and has been proposed to overcome the limitations regarding RF bandwidth.

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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.	Spectrum Range	Visible light spectrum has 10,000 time broad spectrum in comparison to radio frequency	Radio frequency spectrum range is less than visible light spectrum.
4.	Cost	Cheaper than Wi-Fi because free band doesn't need license and it uses light.	Expensive in comparison to Li-Fi because its uses radio spectrum.
5.	Network topology	Point to point	Point to point
6.	Operating frequency	Hundreds of Tera Hz	2.4 GHz

5. ADVANTAGES

- Availability: Visible light spectrum is available free of cost hence no need of licensing.
- High instalment cost but very less maintenance cost.
- This technology is cheaper than Wi-Fi.
- It can be even used in places like airplanes and hospitals since it does not interfere with the RF signals.
- Very less power consumption compared to cellular mobile towers..
- Secure since it does not penetrate through walls.
- Theoretically gives the speed more than 1Gbps which is much more than Wi-fi.

6. LIMITATIONS

Though there are many advantages of Li-fi over Wi-Fi it has to face some challenges. The biggest challenge for Li-Fi to work is Line of sight (LOS). It is necessary for LED light to illuminate directly. Secondly, the distance between the transmitter and receiver also matters. There should be no obstruction between transmitter and receiver because light can be easily blocked by any obstruction. Thirdly, light cannot penetrate walls hence it cannot be used for remote access and even the installation cost for VLC is high.

7. FUTURE APPLICATIONS

7.1 Street Lights: Our goal for Wi-Fi cities can be costly and not practical. The Li-Fi technology helps to achieve this goal. Firstly, street lights have to be replaced by LED lights. These lights can be used to transfer data. Since street lights are practically present everywhere it is possible to use it for wireless systems.

7.2 Airplanes: Airlines Wi-fi! You would be either an adventure freak or a fool to be using wi-fi in airplanes which interfere with airplane signals and causes security issues. Hence we are also requested to switch off our mobile phones. Li-fi would be the best alternate thereby which we can access net even in flights. Just the airplanes light have to be replaced by LED's and we can use these lights to access internet and data transfer.

7.3 Hospitals: Medical technology has lagged behind the rest of the wireless world. Operating rooms do not allow WiFi over radiation concerns. While Wi-Fi is present in many hospitals, radiations from cell phones and computers can block signals from monitoring equipment. Li-Fi solves both problems as lights are allowed in operating rooms and tend to be the most glaring fixtures in the room.

***7.4 Traffic Updates*:** Could you imagine having a car that uses a GPS system that receives information from traffic lights informing you of accidents and/or delays up ahead? Such a system is already in play for GPS navigational systems, but we can use traffic lights to update drivers using basic information or streaming video directly from news broadcasts.[7]

8. CONCLUSIONS

The possibilities are numerous and can be explored more. If this technology comes to practical use, then every bulb can be used as a Wi-Fi hotspot to transmit wireless data and we will proceed toward more cleaner, greener, safer future. The concept of Li-Fi is gaining interest because it may offer a genuine and very efficient alternative to radio-based wireless. Due to the growth in population and everyone accessing internet, the airwaves are becoming increasingly clogged, thereby making it more difficult to get a reliable, high-speed signal. Li-Fi also would 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. The main drawback is that it only works in direct line of sight.

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