Li-Fi

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ABSTRACT
We all experience the need for fast uninterrupted browsing wherever we go. Be it malls, cafes, our offices, etc. However as the number users on the line increases, we are not able to achieve the required data rates as we are sharing the same bandwidth with others. A German physicist named Harald Haas has come up with an interesting solution to this problem by using the previously ignored visible spectrum of light for data transmission instead of using radiowaves. This solution or rather this technique is called as Li-Fi. Li-Fi is a new paradigm for enhancing wireless communication speeds. The principle of operation of Li-Fi, its advantages over the currently existing Wi-Fi technology, its basic functioning its applications and further scope for its development has been discussed in the following paper.

General Terms
Wireless Communication, Herald Hass, Light, Eco-Friendly

Keywords
Light Fidelity, Herald Hass, Wireless Communication, High Security

1. INTRODUCTION
Li-Fi or light fidelity basically refers to communication using the previously ignored spectrum of communication i.e visible spectrum. It basically uses a system of high speed light emitting diodes as a source of light used for transmission. The need of Li-Fi arose due to the fact that the radio spectrum in today's time has been exploited to such a limit that to accommodate the ever increasing data sent through wireless networks the RF spectrum was expected to fall short within the next few years. In spite of tremendous technological advancements, the spectral efficiency of wireless networks has become saturated. In such a scenario it became necessary for researchers all over the world to look for alternatives to meet the current need thus paving the way to exploit the visible spectrum by using Li-Fi as a medium.

Fig 1. Source of light

2. PRINCIPLE OF OPERATION
The heart of the Li-Fi technology is the high brightness LED. As LED is a manufactured using Semiconductor technology it is different from a normal lamp in many aspects. One difference lies in the fact that the speed of operation of LED is very fast as compared to a conventional lamp i.e. it can turn on and off at pretty high rates. Switching from one state to the other can happen in as fast about 1 microsecond making it difficult for the human eye to detect it and still be functional. The switching ON of LED's can correspond to logic 1 whereas the switching OFF can correspond to a logic 0. It is also possible to encode the data by varying the rate at which light flickers to generate different strings of 0's and 1's. A light sensitive device like a photo detector could then be used to convert the data back to its equivalent form.

3. PROBLEM WITH THE ELECTROMAGNETIC SPECTRUM

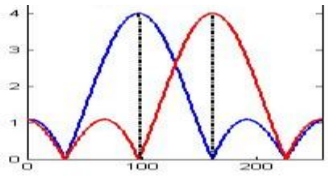

Figure 2: Inter Channel Interference

The above figure shows the inter-channel interference that takes place when we opt for digital communication (due to the various drawbacks of analog communication). Due to inter-channel interference, there is a limit to the number of channels that can be accommodated in a given bandwidth. Due to this and the ever increasing no of applications there happens to be a tremendous pressure on the available bandwidth to give place for new applications without compromising on the already existing ones. Hence there was a need to search for a new spectrum for using wireless technology. This gave way to using the visible spectrum by use of Li-Fi

4. ADVANTAGES OF LI-FI TECHNOLOGY
- ACCESSIBILITY: Light emitting devices like car lights, ceiling lights, street lamps can be used as hotspots for internet connectivity. This as a result helps to lower architecture cost for hotspot.
- AVAILABILITY: Visible light is about 10000 times more plentiful than the radio spectrum and can

achieve far greater density. Bandwidth is unlimited so no need to pay for license and communication.

- EFFICIENCY: The fact that makes LEDs different from the other kinds of lamps is that are semiconductors. Because of this, it has switching time of the order of a few nanoseconds or a billionth of a second. Thus it would be possible to obtain data rates of the order of 1 GB/s which would make it about 10 times better than that of a Wi-Fi
- HIGH SECURITY: Light does not penetrate through solid walls. Thus the data receiver should be in the line of sight of the transmitter bulb to use Li-Fi. This makes it nearly impossible to hack private networks. The data leakage is minimum and the data remains safe.
- LOW COST: Li-Fi transmitters and receivers are cheap compared to the costly RF units.
- REMOTE REACHING ABILITY: Li-Fi can be used underwater without radio interference. This has applications in military and fishing services. Also Li-Fi can be used in air planes because it does not interfere with radio equipment which renders Wi-Fi futile.
- ECO FRIENDLY: Li-Fi uses light for data transmission unlike Wi-Fi which uses radiowaves. It is safer than radiowaves which harm humans, animals as well as the environment. Hence it is eco friendly.

5. WORKING OF LI-FI SYSTEM

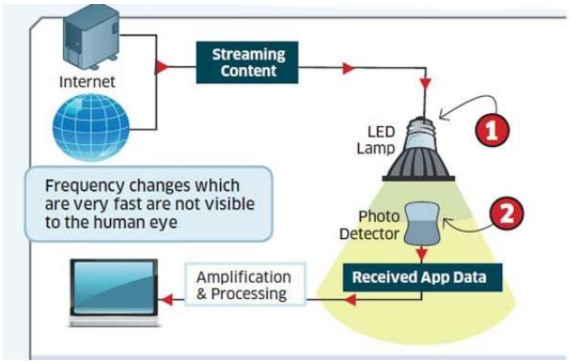

Figure 3: Block Diagram of Li-Fi System

The entire Li-Fi system has the following primary sub assemblies.

1) The microcontroller setup

2) The radio frequency power amplifier

3) The bulb or lamp which is used to generate the source of information.

4) PCB

The microcontroller setup is used for manipulating the inputs and outputs of the lamp and controlling the different lamp functions. The RF power amplifier generates an RF signal which is guided through the field in the bulb. The high energy content in the field vaporizes the contents in the bulb and takes it to a plasma state. This generates a highly intense source of light.

The design of the bulb assembly also is crucial when it comes to the working of the Li-Fi. Unlike traditional bulbs or lamps which use degradable metal electrodes, the bulb assembly in Li-Fi is embedded in a dielectric material. The dielectric further serves two important purposes. First it acts as a waveguide for the energy generated by the radio frequency power amplifier and second for focusing energy in the bulb. The energy then heats up the substance in the bulb to a plasma state which generates a highly intense source of light.

For decoding the contents of the light, we make use of photo sensitive material which generates electric signals as per the variation of the light received from the light sources. These electric signals which are equivalent to the data sent are further amplified and made use of.

Research is also currently done to reduce the potential size of LEDs that are currently being used in a Li-Fi system. At the current time commercial LEDs are not available in sizes below a $1mm^2$. However Scottish researchers are currently working on to reduce the size of LED's to a range of about 1 micron. This would help greatly in increasing the package density along with providing a faster speed as compared to a conventional LED. However this technology would be useful only in the line of sight range.

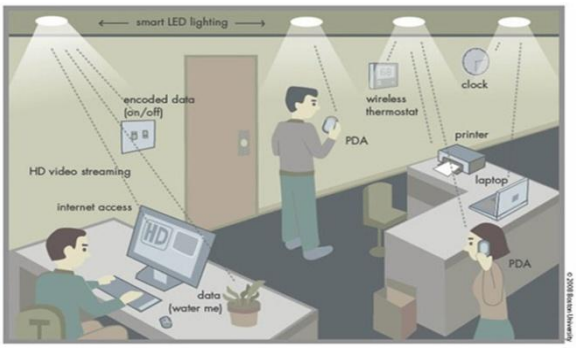

Figure 4: Future Li-Fi Environment[2]

6. EXPERIMENTS THAT LED TO THE DEVELOPMENT OF LI-FI

Li-Fi technology[1] truly began in the 1990's in countries like Germany, Korea; Japan discovered that LED's could be retrofitted to send information. But the major breakthrough was done by Prof. Harald Hass, senior professor at University of Edinburgh, UK. Around 2004, he began his research in visible light communications. He named his solution "Data Through Illumination", sending data through an LED light bulb that varies in intensity faster than the human eye can follow. It's the same idea behind infrared remote controls, but far more powerful. Haas says his invention, which he calls D-Light, can produce data rates faster than 10Mbps, which is speedier than an average broadband connection.

He gave a debut demonstration on a Li-Fi prototype at the TED global conference in Edinburgh in 2011. In this demonstration, he successfully transmitted a video of blooming flowers from his device to a projector screen using a table lamp with an LED bulb. During this even he periodically blocked the light from the lamp to prove that the lamp was indeed the source of incoming data. The data transmission rate was found to be 10Mbps. Li-Fi is now part of the Visible Light Communications (VLC) PAN IEEE 802.15.7 standard.

"Li-Fi is typically implemented using white LED light bulbs. These devices are normally used for illumination by applying a constant current through LED. However, by fast and subtle

variations of the current, the optical output can be made to vary at extremely high speeds. Unseen by the human eye, this variation is used is used to carry high speed data", says Dr. Povey, Product Manager of the University of Edinburgh's Li-Fi program "D-Light Project".

7. ADVANTAGES OF LI-FI OVER WI-FI

Li-Fi is a mode of wireless communication which uses light as the propagating medium. On the other hand Wi-Fi uses radio frequencies for transmission of data.

Recently the researchers at Germany have found that Li-Fi offers a speed of 1Gbps under normal lab conditions. The speed of data transfer for Wi-Fi is 150Mbps. This tells us about the efficiency with which pictures, videos, and movies will be downloaded through Li-Fi.

Li-Fi is based on the light of LEDs for the transfer of data. This light can belong to any spectrum of frequency i.e. invisible, ultraviolet or the visible part while Wi-Fi works only on the radio frequencies. This makes Li-Fi much more accessible as the light spectrum is about 10000 broader than the radio spectrum. Radio frequencies have a limited bandwidth in which a particular set are allocated to various regions of the world. If that range is exceeded infringement takes place and huge penalty is to be paid. This hurdle is not faced by Li-Fi as the light spectrum is free is accessible to everyone. This makes the Li-Fi mode of communication cheaper.

Wi-Fi is used in majority of places where common wireless coverage is required while Li-Fi is ideal for confined spaces.

8. APPLICATIONS

In medical technology, Wi-Fi can't be used as the radio waves hamper with the medical equipments hampering the patient's life. Cell phones and computers block signals from monitoring equipment. This makes Wi-Fi at a great disadvantage. Li-Fi which uses light as the carrier medium can be easily used as a substitute over Wi-Fi as light is found in abundance in the operating rooms.

On-the-road applications include data transfer using traffic lights. Also the sensors implanted at the front and rear bumpers could receive data transmitted from the rear lights of the nearby cars avoiding collision and accidents.

The experience of retail shopping can be enhanced with the help of Li-Fi by providing on the spot information of the product and make the process less intrusive.

Aircraft communications will get a huge leap through the means of Li-Fi. It will transform air travel by providing data communication to passengers through the means of overhead cabin light.

In places with low range Wi-Fi signals like tunnels, subway stations, Li-Fi could be a cheaper alternative by just illuminating the area with lamps and tube lights.

Chemical and petroleum Power plants require high speed internet connectivity for co-ordination between its various core reactors and to control temperature. But Wi-Fi can't be used as the radio waves may interfere with the operations taking place in the reactor. Hence Li-Fi could provide safe connectivity at a small cost of installing lights throughout the plants.

Underwater data communication could be hugely benefited from Li-Fi. Huge lights could be installed underwater for communication between scuba divers. Also the huge variety of life found can be captured through photography and documented for further studies.

9. CONCLUSION

The problem with the currently existing radio wave spectrum has been discussed. Li-Fi as a potential replacement for Wi-Fi has been introduced in the paper. Along with that the paper also deals with some other aspects of the Li-Fi like its inception, the rough outline for a Li-Fi system, the advantages of Li-Fi over Wi-Fi, etc. Along with that the paper also discusses the applications of Li-Fi with short mentions on its future scope.

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