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LIGHT FIDELITY: SOLUTION TO RF SPECTRUM CRISIS

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***Abstract*— This Paper demonstrates that optical wireless communication (OWC) has now reached a state where it can demonstrate that it is a viable and matured solution to the problem of looming radio frequency (RF) spectrum crisis. In particular, for indoor communication where most mobile data traffic is consumed, light Fidelity (Li-Fi) which is related to visible light communication (VLC) offers many key advantages, and effective solutions to the issues that have been posed in the last decade.**

Keywords: OWC- Optical wireless communication, RF- radio frequency, Li-Fi- Light Fidelity, VLC- Visible light communication

I. INTRODUCTION

Thirty years after the introduction of the first mobile communication systems, wireless connectivity has evolved into a fundamental commodity like gas and electricity. The exponential increase in mobile data traffic during the past two decades has led to the massive deployment of wireless systems. As a consequence, the limited available RF spectrum is subject to an aggressive spatial reuse and co-channel interference has become a major capacity limiting factor.

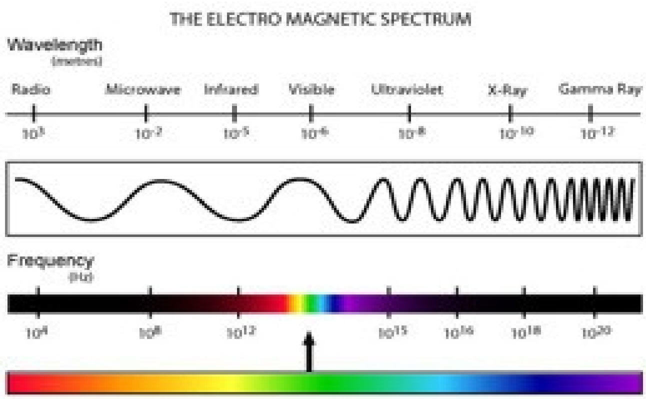

Figure 1: The Electromagnetic Spectrum

Therefore, there have been many independent warnings of a looming "RF spectrum crisis" as the mobile data demands continue to increase while the network spectral efficiency saturates despite newly introduced standards and great technological advancements in the field. It is estimated that by 2017, more than 11 Exabyte's of data traffic will have to be transferred through mobile networks every month. Most recently VLC has been identified as a potential solution for mitigating the looming RF spectrum crisis.

Over the past decade, significant research efforts have been directed towards exploring alternative parts of the electromagnetic spectrum that could potentially offload a large portion of the network traffic from the overcrowded RF domain. Very interesting results have been recently reported from the use of millimeter wave (mmWave) communication in the 28 GHz region as well as from the use of infrared and visible light. The latter is particularly enticting as lighting is a commodity that ahs been integrated in virtually every inhabited environment and sophisticated infrastructurs already exist. The use of visible light spectrum for high speed data communication is enabled by the emergence of the light emitting diode (LED) which at the same time is at the heart of the next wave of energy-efficient illumination.

The visible light spectrum includes 100s of THz of license free bandwidth, 10,000 times more than the entire RF spectrum up to 30 GHz, including the mmWave spectrum.Optical radiation, in general, does not interfere with other radio waves or with the operation of sensitive electronic spectrum. Therefore, it is ideal for providing wireless coverage in areas which are sensitive to electromagnetic radiation- some examples include: hospitals, airplanes, petrochemical and nuclear power plants etc. Firthermore, the inability of light to propagate through walls offers an inherent level of network security. The same feature can be exploited to eliminate interference between neighbouring cells.

Figure 2: light transmission: one way to solve the bandwidth crisis, switch to light transmission (Image: John Renstein/Getty)

In this paper section II contains a brief introduction about visible light communication and how it works while section III describes light fidelity with its genesis, workingand also compares it with Wi-Fi technology. Section IV would describe different technologies related to Light fidelity.

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II. VISIBLE LIGHT COMMUNICATION

Visible Light Communication (VLC) is the use of the visible light portion of the electromagnetic spectrum to transmit information.
This is in contrast to established forms of wireless communication such as Wi-Fi which use radio frequency (RF) signals to transmit data.With VLC, data is transmitted by modulating the intensity of the light, which is then received by a photo-sensitive detector, and the light signal is demodulated into electronic form. This modulation is performed in such a way that it is not perceptible to the human eye.VLC is a category of Optical Wireless Communications (OWC). OWC includes infra-red and ultra-violet communications as well as visible light. However, VLC is unique in that the same visible light energy used for illumination may also be used for communication.

A. How does VLC Works

When a constant current is applied to an LED light bulb a constant stream of photons are emitted from the bulb which is observed as visible light. If the current is varied slowly the output intensity of the light dims up and down. Because LED bulbs are semi-conductor devices, the current, and hence the optical output, can be modulated at extremely high speeds which can be detected by a photo-detector device and converted back to electrical current. The intensity modulation is imperceptible to the human eye, and thus communication is just as seamless ad RF. Using this technique, high speed information can be transmitted from an LED light bulb.

III. LIGHT FIDELITY

A. What is Li-Fi

Li-Fi is a wireless optical networking technology that uses light-emitting diodes (LEDs) for data transmission.

Li-Fi can be thought of as a light-based Wi-Fi. The term **Li-Fi** was coined by pureLiFi's CSO, Professor Harald Haas, and refers to VLC technology that delivers a networked, mobile, high-speed communication solution in a similar manner as 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.

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.
Figure 3 shows the first Li-Fi equipment.

Figure 3: First Li-Fi equipment.

B. Genesis of Li-Fi

Harald Haas, a professor at the University of Edinburgh is the pioneer behind a new type of light bulb that can communicate as well as illuminate – access the Internet using light instead of radio waves as shown in figure 4. He gave a debut demonstration of what he called a Li-Fi prototype at the TEDGlobal conference in Edinburgh on 12th July 2011. He used a table lamp with an LED bulb to transmit a video of blooming flowers that was then projected onto a screen behind him. During the event he periodically blocked the light from lamp to prove that the lamp was indeed the source of incoming data. At TEDGlobal, Haas demonstrated a data rate of transmission of around 10Mbps -- comparable to a fairly good UK broadband connection. Two months later he achieved 123Mbps.

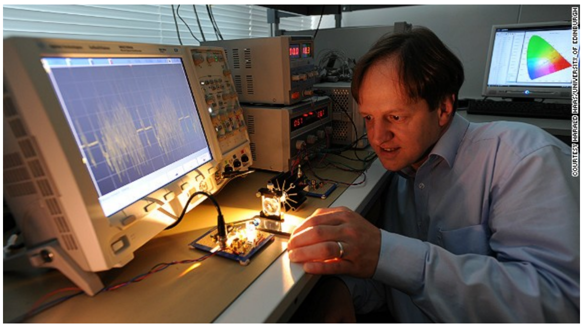

Figure 4: Professor Harald Hass experimenting for Li-Fi technology.

C. How does 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

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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.

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. The detailed description of how Li-Fi works is shown in figure 5.

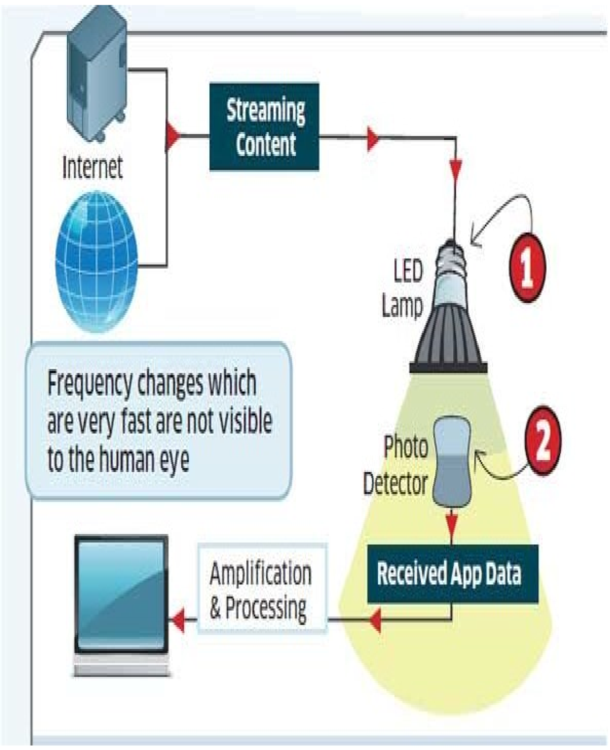

Figure 5: A Pictorial description of how Li-Fi works

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.

Radio frequency communication requires radio circuits, antennas and complex receivers, whereas Li-Fi is much simpler and uses direct modulation methods similar to those used in low-cost infra-red communications devices such as remote control units. Infra-red communication is limited in power due to eye safety requirements, whereas LED light bulbs have high intensities and can achieve very large data rates.

D. Comparison of Li-Fi with different technologies

Li-Fi technology is compared with Wi-Fi on the basis of some parameters as: Power, Speed, Data Density, Security, Reliability etc. and the comparison between two technologies is as shown in the table below.

Table 1: Comparison of Li-Fi with Wi-Fi

PARAMETER	Li-Fi	Wi-Fi
TRANSMIT/RECEIVE POWER	***	**
POWER AVAILABLE	***	*
SPEED	***	***
RELIABILITY	**	**
DATA DENSITY	***	*
RANGE	*	**
SECURITY	***	**
ECOLOGICAL IMPACT	*	**
DEVICE-TO –DEVICE CONNECTIVITY	***	***
MARKET MATURITY	*	***
OBSTACLE INTERFERENCE	***	*
BILL OF MATERIALS	***	**

*Low **Medium ***High

Li-Fi technology is compared with different technologies whether it is wired or wireless (current and future technologies) on the basis of two parameters – Speed and Data density and the comparison is shown in table 2 as shown below.

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Table 2: Comparison of Li-Fi with different technologies

TECHNOLOGY	SPEED	DATA DENSITY
	WIRED	
FIRE WIRE	800 Mbps	*****
USB3.0	5 Gbps	*****
THUNDERBOLT	2X 10 Gbps	*****
	WIRELESS (CURRENT)	
WI-FI-IEEE (802.11N)	150 Mbps	*
BLUETOOTH	3 Mbps	*
IrDA	4 Mbps	***
	WIRELESS (FUTURE)	
Wi-Gig	2 Gbps	**
Giga-IR	1 Gbps	***
Li-Fi	>10 Gbps	****

E. Advantages of Li-Fi

The benefits of using Li-Fi technology are listed below as:

- Higher speeds than Wi-Fi.
- 10000 times the frequency spectrum of radio.
- More secure because data cannot be intercepted without a clear line of sight.
- Prevents piggybacking.(Piggybacking, in a wireless communications context, is the unauthorized access of a wireless LAN. Piggybacking is sometimes referred to as "Wi-Fi squatting.")
- Eliminates neighboring network interference.
- Unimpeded by radio interference.
- Does not create interference in sensitive electronics, making it better for use in environments like hospitals and aircraft.

IV. VARIOUS TECHNOLOGIES RELATED TO LI-FI

1. GigaSpeed Technology

The Li-Fi Consortium offers the fastest wireless data transfer technology available. Our current solutions cover effective transmission rates of up to 10 Gbit/s, allowing a 2 hour HDTV film to be transfered within less than 30 seconds. Smaller files are transfered instandly.This high speed technology can be extended to several 100 Gbit/s in later versions.

2. Optical Mobility Technology

The mobility concept of the LiFi Consortium is based on state of the art optical receiver chip technology. Mobile devices do not depend on a line of sight connection between the mobile device and the optical router. New optical receiver chips will be able to read reflections, also of very weak signals. Its large dynamic range is the basic of our mobility technology.

Therefore, a room needs only one or few communication points in order to connect mobile devices to the optical network. This opens for an entirely new approach in optical mobile communication, enabling the implementation of additional features to an optical local network.

A. Optical Mobile

It is a modern mobile phone having 3 communication channel (RF, Mobile, Giga speed) as shown in figure given below

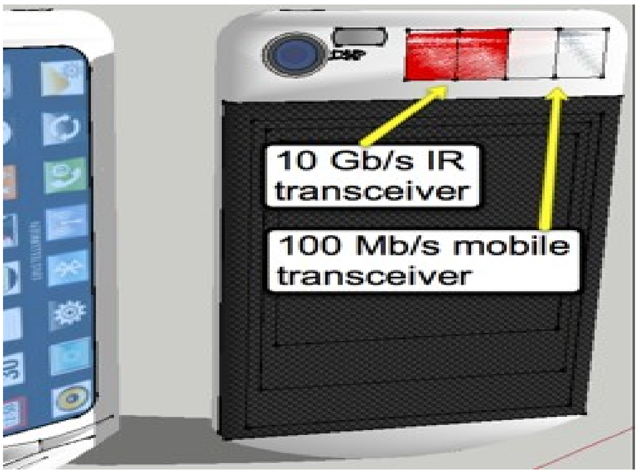

Figure 6: Diagrammatic representation of optical mobile.

What it does-

- Communicates through RF as a usual smart phone
- Communicates optical "on the move" at 100 Mbit/s
- GigaSpeed datatransfer and reception 10 Gbit/s
- Controls local Li-Fi cloud

What it is for –

- Control all features of the local Li-Fi cloud
- Provide optical mobile communication within a RF free environment
- Used as mobile phone as well as house phone
- Provides the fastest data transfer method of a mobile device

B. Optical Memory Stick

It is an inclusive giga speed and mobility transceiver as shoen in the figure below.

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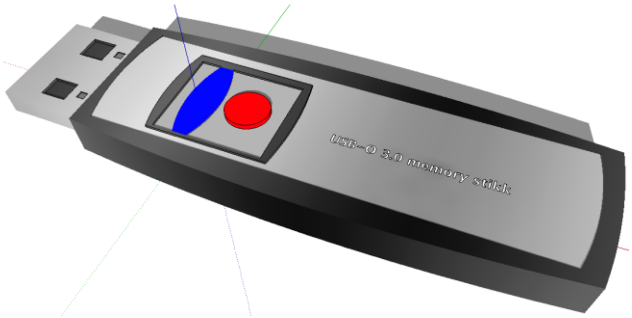

Figure 7: Optical memory stick.

What it does-

- Datastorage
- connects equipment to each other within a range of 1 m
- uploads and downloads files with GigaSpeed technology
- communicates with mobile device within a range of 2 m

What it is for-

- Connects office or entertainment equipment to the Li-Fi cloud
- Is the most basic version of a wireless optical data network

C. *Optical Router*

It is a routerfor Li-Fi cloudhaving hard drive for data storage and it is connected to external line (fiber optic cable, GigE etc.)

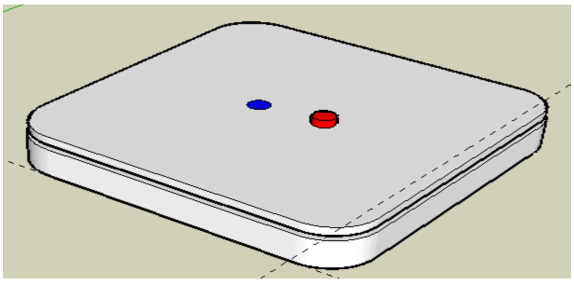

Figure 8: Optical router.

What it does-

- Stores data and functions as router/server for Li-Fi cloud
- Reads reflections of optical signals from mobile devices at 100 Mbit/s
- Transmits mobile communication data at 100 Mbit/s
- Can be equipped with GigaSpeed technology
- Connects office + entertainment equipment
- Covers radius of 5 to 10 m

What it is for –

- Private home wireless data network with cloud & server function
- Small office use as data network with cloud & server function

D. *Optical Room Connector*

It connects data within a Li-Fi cloud from one room to another (shown in figure 9 below) .

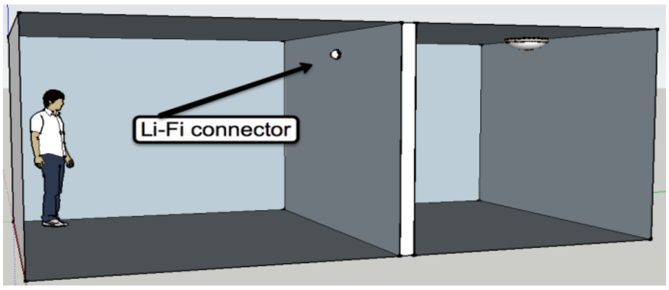

Figure 9: Optical room connector.

What it does-

- Transfers mobile data at 100 Mbit/s between rooms
- Covers a radius of 10 m
- Includes security functions
- Controls lighting & smart home functions

What it is for –

- Extends the Li-Fi cloud to other rooms

E. *Local Li-Fi cloud*

It is a Local optical communication network with local data cloud structure and in house server/router including-

- "on the move" data transfer at 100 Mbit/s
- GigaSpeed datatransfer and reception up to10 Gbit/s
- security features
- energy saving/environmental features
- controlled, for example, by optical smart phone

What it does-

- connects all office and entertainment equipment
- controls all data and entertainment equipment via smartphone
- displays all files on any screen (TV,PC, etc.)
- supports file access from any point + and via any device
- stores all data in one central server/computer
- supports data transfer and reception at 10 Gbit/s
- supports "on the move" data transfer at 100 Mbit/s
- monitors the entire optical network area
- detects motion in the entire optical network area if wanted
- controls all security features via smart phone
- controls lighting via smart phone
- supports control of heating
- supports control of any connected electrical equipment

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- supports energy saving/environmental features via smart phone
- bridges disparate data formats
- connects your local cloud to external line (fiberoptic, GigE, ADSL, etc.)

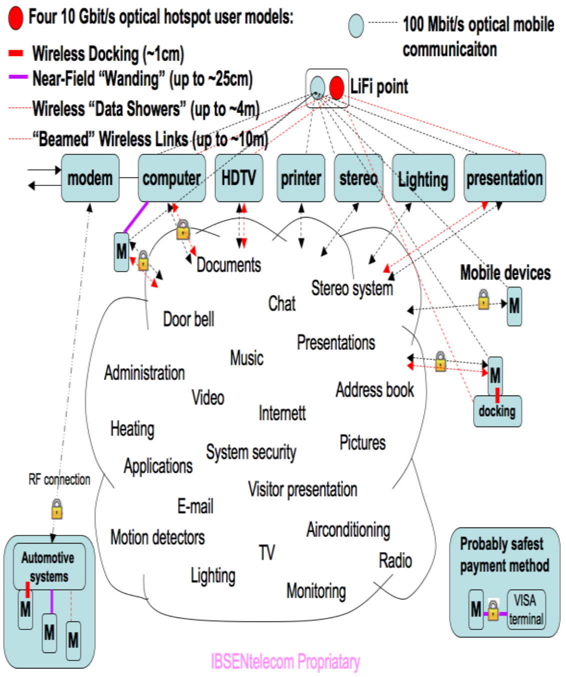

Figure 10: Li-Fi Cloud.

What it is for-

- Private home wireless data network with local cloud & server function
- Corporate wireless data network with local cloud & server function

3. *Li-Fi environment*

The concept of the Li-Fi cloud creates an environmental friendly, healthy and smart network environment. Here are the features that make it possible.

V. CONCLUSION

Li-Fi is the upcoming and on growing technology acting as competent for various other developing and already invented technologies. Since light is the major source for transmission in this technology it is very advantageous and implemented in various fields that can't be done with the Wi-fi and other technologies. Hence the future applications of the Li-Fi can be predicted and extended to different platforms like education fields, medical field, industrial areas and many other fields. The possibilities are numerous and can be explored further. If this technology can be put into practice use, every bulb can be used something like a Wi-Fi hotspot to transmit wireless data and we will proceed towards the cleaner, Greener, Safer and Brighter future.

REFERENCES

[1]. http://purelifi.co.uk/what_is_li-fi/applicationsof_lifi/
[2]. http://bangalorerockerz-123.blogspot.in/2014/03/li-fi-technology-internet connections.html
[3]. http://whatis.techtarget.com/definition/LiFi
[4]. http://purelifi.co.uk/what_is_li-fi/applicationsof_lifi/
[5]. http://compnetworking.about.com/b/2012/10/03/what-is-li-fi.htm
[6]. http://www.newscientist.com/article/mg21128225.400-will-lifi-be-the-new-wifi.html
[7]. http://www.digitaltrends.com/mobile/light-bulb-li-fi-wireless-internet

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