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A Study on LI-FI Transmission of data through Light

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ABSTRACT: Searching for an excellent data speed is a dream for any individual who has plenty of devices connected to a single source of the network.As the number of devices increase, the bandwidth obtained by any devise just gets reduced drastically. Obtaining a higher bandwidth has eventually become a need for today's individual. Herald Hass, a German Physicist, has come up with a solution to such a need by replacing the source of network from fibre optics to an LED light which can transmit data at a significant higher rate compared to conventional methods. Such a technology has already been used in transmitting data using infrared remote controls. Dr. Hass states that this technology can be very much useful as the intensity of the light emitted from the LED can determine the data transfer. There might be other problems that can be resolved by such a technology. One of those would be security of the network, in which only the devices very close to the source would only be able to make use of it.

KEYWORDS*:* Li-Fi, Wi-Fi, high-brightness LED, photodiode,wireless communication.

I. INTRODUCTION

A Finding an effective alternative for data transfer has become a need as the multiple connections made on a single source has led to slower speed of transfer. Light Fidelity (Li-Fi) is a 21st century solution behind this chaotically generated problem. The concept behind this technology is transmitting the data based on change in intensity of the LED source. Herald Hass, Chair of Mobile Communication, (School of Engineering, Universityof Edinburgh) is appraised as the Father of Li-Fi. Prof. Hass believes that the intensity of light emitting diodes are the soul of this technology.

The limitation of Wi-Fi technology which provides only a limited data transfer rate and more devices connecting to a single provider has led to the need for alternative methods and Li-Fi technology. This technology overcomes many of the disadvantages of the existing data transfer methods. Being cost effective is one of the prime advantages. Li-Fi also has diverse applications like transferring data effectively under water providing numerous military application and plenty others. Fig 2. Shows how data can be transferred with the help of light.

Fig 2. Data Transfer using light

Transmission of data with help of led light bulb is called as Li-Fi. Li-Fi can be termed as optical version of Wi-Fi. Herald

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Hass, introduced the basic idea of Li-Fi. LED's transmit digital 1 if light is on and 0 if light is off , it flickers so fast that a normal human being can't see it due to persistence of vision, due to this it is possible to encode data in light .Due to rapid modulation in the LED intensity ,human eye cannot notice and output appears constant. VLC data rate could be raised with more advanced techniques. Array of led is needed where each led transmits data at different rates. The frequency of light can be altered into different data channels using mixture of red,green and blue LED's.

Data can be transmitted parallel using LEDs. Syndicates believes it is possible to achieve more than 10 Gbps. Theoretically it can be said that a high definition movie can be downloaded in few seconds. In October 2011 number of pools introduced Li-Fi technology to promote high speed wireless systems which can overcome the limited amount of radio-based wireless spectrum. Li-Fi is more secured and protected than Wi-Fi, since Wi-Fi uses radio waves which can propagates through walls and is harmful to human body.

II. CONSTRUCTION

Li-Fi, the optical version of Wi-Fi provides a fast and cheap communication. It is based on Visible Light Communication (VLC).VLC uses visible light between 400 THz (780 nm) and 800 THz (375 nm) as optical carrier for data transmission. Fast pulses of light is used to transmit data and information.

Li-Fi communication is made available through:

i. A LED with which can act as transmitter.
ii. A silicon photodiode which acts as a receiver.

LEDs can be switched on and off to generate digital signals in form of 0's and 1's. To generate a new data stream, data can be encoded in the light by varying the flickering rate of the LED. The LEDs can be used as a sender or source, by modulating the LED light with the data signal.
Due to the fast flashing rate of LED the ON and OFF of LED cannot be detected by the human eye.
With the help of various multiplexing techniques, a communication rate of greater than 100 Mbps can be made available. VLC data rate can be increased by parallel data transmission using a set of LEDs where each LED transmits a different data signals. The Li-Fi emitter system consists of 4 subsystems namely:

i. Bulb
ii. RF power amplifier circuit (PA)
iii. Printed circuit board (PCB)
iv. Enclosure

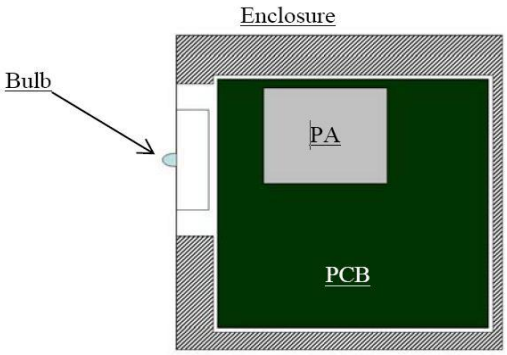

Fig 3. Block diagram of Li-Fi sub-assemblies

The input and output of different lamps is controlled via a PCB which is assisted with a microcontroller which manages the different lamp functions. RF power amplifier circuit (PA) generates a RF (radio-frequency) signal and guides it to the

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electric field of the bulb. .The bulb sub-assembly is the major component of the Li-Fi emitter. This assemblyconsists of a sealed bulb embedded in a dielectric material. The dielectric material serves two purposes:

i. It guides the RF energy transmitted by the PA.
ii. It focuses energy in the bulb at its center byacting as energy concentrator.

The content of the bulb is vaporised to a plasma state which is generated due to the high concentration of energy in the electric field. It serves an intense source of light and emits light of high intensity and full spectrum. This assembly is wrapped in an aluminium enclosure.

III.WORKING

Today's high brightness providing LED's prove to be a good opportunity for implementing Light fidelity technology using LED's. The logic incorporated to bring to Li-Fi technology into picture is quiet simple. A digital 1 is transmitted when the LED is ON or LED is at a higher voltage level. Similarly, to transmit a digital 0 the LED must be kept off or at a lower voltage level. Fig 4 shows the brief working of Li-Fi.

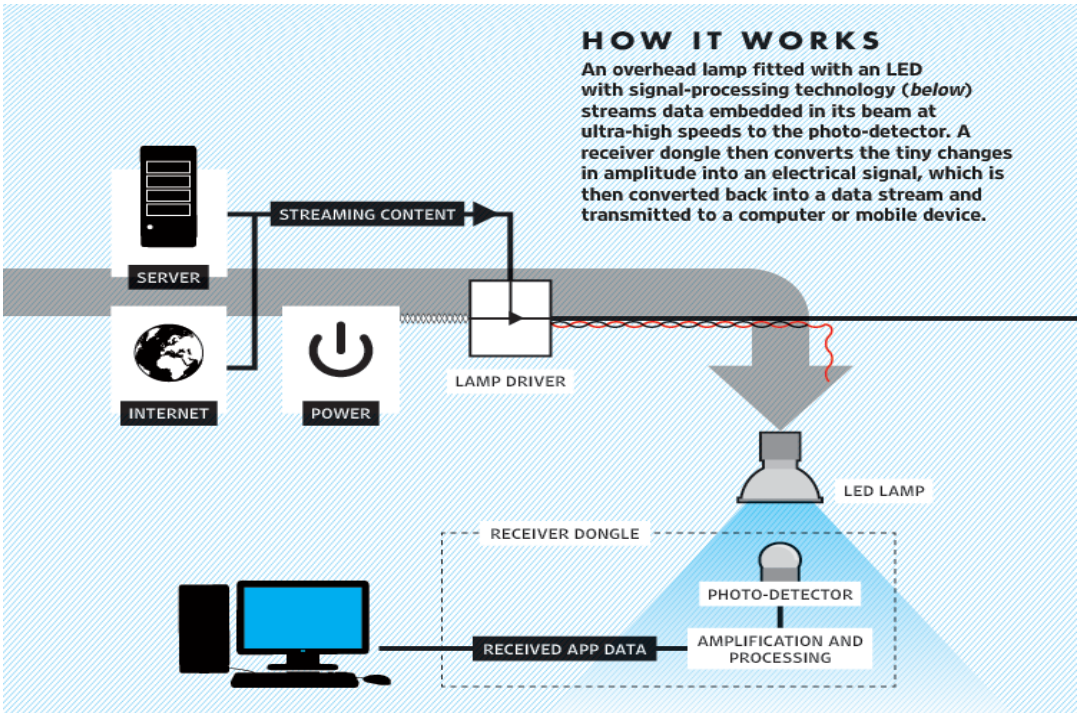

Fig 4. Working of Li-Fi

The working of Li-Fi using LED's take into account a light emitter on one side and a photodiode on the other. The light Emitter must be capable of emitting a high brightness light which can be easily detected by the photodiode also must encode the data in binary form. A silicon photodiode must provide good response to visible light and converted back to electrical current.The photo detector encounters abinary one when the LED is on and a binary zero if the LED is off. To create a message or data stream, the LED is flashed numerous times or an array of LEDs of a few different colours is used, to obtain data rates in the range of hundreds of Mbps (megabits).The rate at which LEDs flicker can be varied in order to encode the data in the light. This intensity of modulation is so high that it cannot be detected by the human eyes and the LEDs appear to be a constant light emitting source.

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Light-emitting diodesor LEDs andfound in traffic and newer street lights, car brake lights, remotecontrol units and countless other applications. They can be switchedon and off faster than the human eye can detect, causing an illusion to human eye such that thelight source appear to be continuous, even though it is 'flickering'. The intensity of modulation of the enables data transmission using binary codes: switching on an LED transmits a logical '1', switching it off transmits alogical '0'. By varying the rate at which the LEDs switch onand off, information can be encoded in the light to various combinations of 1s and 0s. This technique isreferred to as Visible Light Communication (VLC) where rapid pulsesof light to transmit information wirelessly.

III. RECENT ENHANCEMENTS IN LIFI

Using a pair of Casio smart phones, the technology was demonstrated at the 2012 Consumer Electronics Show in Las Vegas to exchange data using light of varying intensity given off from their screens, detectable at a distance of up to ten meters.Aconsortium called 'Li-Fi Consortium' was formed in October 2011 by a group of companies and industry groups to promotehigh-speed optical wireless systems and overcome the limitedamount of radio based wireless spectrum. For Giga-speed technologies, the Li-fi consortium discovered GigaMIMO, GigaSpot and GigaShower models. GigaShower provides unidirectional service where no uplink is required for example watching tv channels or listening to radio. Whereas GigaMIMO and GigaSpot are optical single and multichannel hot-spot solutions offering bi-directional gigabit-class communication in a room, hall or shopping centre. Different teams at the Universityof Oxford and the University of Edinburgh are focusing on parallel data transmission. For this they are using an array of LEDs, where eachLED transmits a different data stream. Other groups are usingmixtures of red, green and blue LEDs to alter the lightfrequency encoding a different data channel. Different Li-Fi products like Li-1st, Li-flame, Li-fire are soon going to been launched in the market. The Li-1st delivers a capacity of 5Mbps in the uplink and downlink channels, covering a range of "up to" three meters. Li-flame will allow letting you move between light sources without losing your connection. Fig 5. Shows the different channels in which data could be transferred. Fig 5 shows the use of Wi-fi using various colours as channels.Fig 6 and Fig 7 compares the amount of data transferred in Li-Fi and in Wi-Fi.

Fig 5. Different channels

IV. COMPARISION OF LI-FI AND WI-FI

PARAMETERS	LI-FI	WI-FI
Speed for data transfer	>1Gbps	150Mbps
Mode through which data transfer takes place	Uses Light as a carrier	Uses Radio Spectrum

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Spectrum Range	Visible light has spectrum 10,000 times wide than radio spectrum	It has a small spectrum range than visible light
Cost	Cheaper than Wi-Fi because free band doesn't need license and uses visible light	Expensive as compared to Li-fi
Network Topology	Point to Point	Point to Point
Operating Frequency	Few hundreds of THz	2.4 GHz

TABLE I. Comparison Of Speed Of Various WirelessTechnologies.

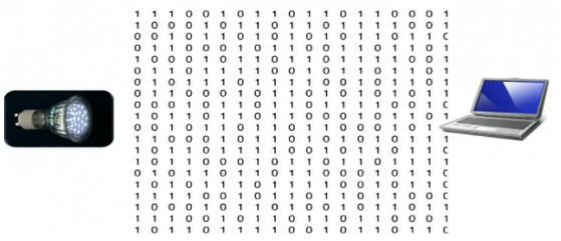

Fig 6. Data transfer in Li-Fi

Fig 7. Data transfer in Wi-Fi

V. ADVANTAGES AND DISADVANTAGES

Presently, about 1.4 million cellular mask radio stations have been deployed also we have more than 5 billion registered mobile phone users. Just like electricity and water, Wireless communication has become a utility. Wireless communications currently acquires radio waves for transmission. With the increasing demands, Radio spectrum has become congested and the capacity is drying up. Other alternatives to radio waves like Gamma Rays Ultraviolet Rays, X-Rays and Infrared Rays somehow or the other have health issues. To have an upper edge of the present scenario visible light must be adopted for communication. Fig 8 shows the light that is used to implement Light Fidelity.

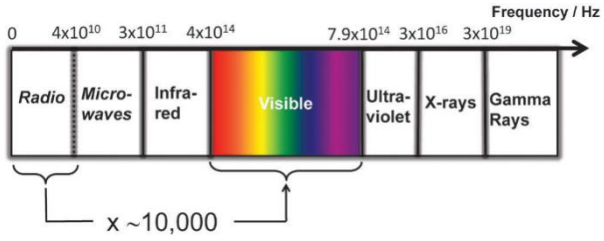

Fig 8. Spectrum of light used

Visible light makes use of Li-Fi technology. Li-Fi technology includes benefits pertaining to the capacity, energy efficiency, safety and security of a wireless communication with a number of key benefits over Wi-Fi but is naturally a complementary technology.

1. Capacity

i. Bandwidth: The visible light has a broad,unlicensed,free to use and plentiful spectrum which is 10,000 times more broader than RF spectrum.

ii. Data density: Data density of about 1000 times more than that of Wi-Fi can achieved using Li-Fi because visible light can be implemented in a confined illumination area whereas RF usually spreads out and causes interference.

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iii. High speed: Due to low interference, high device bandwidths and high intensity optical output, very high data rates can be achieved.

2. Efficiency

i. Low cost: The installation and maintenance cost of Li-fi is less as compared to Wi-fi, due to use of simple and cheap yet effective components.
ii. Energy: LEDs are efficient and effective devices which provide high brightness light. Incorporated data transmission will requires negligible additional power.
iii. Environment: RF transmission and propagation in water is extremely difficult but Li-Fi works well in almost all type of environment including under water communication.

3. Safety

i. Safe: Light has been around for millions of years.Life of humans evolve around light, so it is inherently safe and has no health issues.
ii. Non-hazardous: Visible light does not interfere with electronic circuitry as it does not make use of radio waves.

4. Security

i. Containment: Unlike Wi-Fi, Li-Fi signals are confined to a closely defined illumination area such as a room and hence cannot be secretly used by unwanted users.
ii. Control: While transferring data from one device to another there is no need for additional security such as pairing for RF interconnections because the user can see where the data is going.

VI. APPLICATIONS

In the coming years with the burst in use of LEDs (Light Emitting Diodes) for lighting, it has become possible to induce Wi-Fi technology in the LED environment.

Li-Fi can take up many internet applications such as video and audio downloads, live streaming, etc. These applications require a less of upload but in turn download a lot of data i.e. puts a heavy demand on downlink. As Li-fi has different channels for upload and download the major internet traffic is reduced from existing RF channels, and thus Li-Fi can extend to provide cellular and Wi-Fi services. Some of the basic applications of Li-Fi include:

i. RF Spectrum Relief: With the increasing demand of cellular networks, where mostly a bottleneck on the downlink occurs, RF communications can be easily replaced with light fidelity wherever possible.

ii. Smart Lighting: Some of the private and/or public lighting including street lights can be converted into free access point and the same sensor infrastructure can be made available for monitoring data and also it may prove to be useful for controlling traffic.

iii. Mobile Connectivity: All the smart devices like laptop including mobile devices can communicated directly using Li-Fi and a secure interconnection can be laid between them.

iv. Hazardous Environments: In several environments such as mines and petrochemical plants where electromagnetic interference from radio frequency occurs, Li-Fi provides a safe alternative and better experience.

v. Hospital & Healthcare: Li-Fi does not interfere with medical instruments and hence can be used for few medical surgery. Wearing an LED earring and linking it to sensors for tracking temperature, sugar levels and other vital health data, is a good self healthcare option.

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vi. Aviation: The seating layouts designed of aircraft passengers can be made light weight, cabling can be reduced and also flexibility can be added using Li-fi, where LED lights are already installed. In-flight entertainment systems can be integrated with passenger's mobile devices.

vii. Underwater Communications: As there is strong signal absorption in water, use of RF is practically impossible. Acoustic waves disturb marine life. Li-Fi is a good solution for such short-range communications.

viii. Vehicles & Transportation: Right from car headlights,tail-lights, street lamps, Traffic signals are also moving to LED. Hence the two vehicles can communicate with each other and prevent accidents. Road safety and traffic management can be other applications.

ix. RF Avoidance: Many people are highly sensitive to radio frequencies and are searching for an alternative. Li-Fi can prove to be a safe appropriate solution.

x. Location Based Services (LBS): Advertising and navigation which highly accurate location-specific information services which enable the recipient to receive appropriate, concerned information in time along with location.

xi. Toys: Many toys take into account LED lights and as a result many interactive toys can invented enabling low-cost communication between them.

VII. CONCLUSION

Li-fi is best ever design of internet which reduces the size of device which transfers data. Li-fi can reduce the growing hunger of communication by replacing the bulbs with array of LEDs which provides faster, easier and safer communication. Switching to Li-fi will target issues such as the shortage of radio-frequency bandwidth and also allow internet in places where traditional radio based wireless isn't allowed or can't be used such as aircraft or hospitals.One of the major drawbacks however is that it only work in direct line of sight.There are some disadvantages which could be overcome by further enhancement and research. Even a bulb can be used like a Network access point if this technology is implemented further which will lead to healthier, cheaper and brighter future.

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BIOGRAPHY

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