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Li-Fi over Wi-Fi in Internet Data communication

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Abstract: Internet data communication is a crucial activity for modern society. Since internet communication needs secure, efficient and high data rate communication, researchers propose different form of internet data communication. The current wireless data communication, Wireless-Fidelity, is based on radio frequency and uses router for signal transmitter and Wi-Fi card or chip as receiver which are built in modern computers and smart phones. This radio frequency based technology is limited in bandwidth, interfered with signals of different electronic equipment and easily accessed or hacked by unwanted hidden peoples. Light Fidelity (Li-Fi) is a new technology that, proposed in late 2011 by prof. Harald Haas, uses illumination for internet data communication and will be implemented in a near future. Li-Fi uses semiconductor diodes for both data source and data receiver. It uses different color light emitting diodes (LEDs) as a transmitter and photodiodes as a receiver which are connected with computers or smartphones. Li-Fi technology uses the very simple technique of transmitting data using LED bulbs i.e. if the LED is ON, then the digital signal 1 is transmitted else if the LED is OFF, the digital signal 0 is transmitted which are detected by the photodiode at the receiver side. Li-Fi has many advantages over wireless fidelity (Wi-Fi). The advantage of Li-Fi over Wi-Fi is due to data communication spectrum differences. The electromagnetic spectrum bandwidth used for visible light communication (VLC) of Li-Fi is 10,000 times greater than for electromagnetic spectrum bandwidth of radio frequencies for Wi-Fi. Li-Fi technology has many advantages over Wi-Fi as a result of its unlimited bandwidth, its poor object penetration capacity, its low electromagnetic interference property and its possibility to integrate with the existing light infrastructure. But Li-Fi technology has some draw backs than Wi-Fi due to its radiation range, radiation direction and penetration capacity through objects and opaque materials. Since Li-Fi is clean, cheaper, and efficient and secure, most computer related companies will join and the draw backs will be reduced.

Keywords*:* Wi-Fi, Li-Fi, VLC, LEDs, Electromagnetic spectrum.

I. INTRODUCTION

Wi-Fi, wireless fidelity, is using radio waves for data transmission with some distance range. It is a system of wirelessly connecting internet access points (routers) with devices like Laptops, palmtops, smart phones and PC notes etc. that uses radio waves, allowing for connection between devices without the expense of cumbersome cables or without needing them to be facing one another within the distance up to 100 meter distances possibly extends to 150 meter distance with its weak signal strength. It operates in 2.4 GHz and 5 GHz radio spectrum and supports variable data rates up to 150 Mbps even the modem speed is up to 600Mbps. It uses radio cellular base stations as data transceivers which consume a lot of energy and mostly (95%) to cool them rather to transmit data and therefore only operational up to 5% efficiency. Getting the access of Wi-Fi is difficult in electromagnetic sensitive areas like hospitals, airplanes and also in thermal power plants due to radio waves interference. Since radio waves penetrate walls of buildings, security is the big issue in Wi-Fi data communication. As parallel to the increment of wireless devices users for Wi-Fi data communication, in the last 5 years there has been a massive increase in radiofrequency (RF) exposure from wireless devices as well as reports of hypersensitivity and diseases related to electromagnetic field and RF exposure like. Multiple studies correlate RF exposure with diseases such as cancer, neurological disease, reproductive disorders, immune dysfunction, and electromagnetic hypersensitivity.

Light fidelity, coined by Prof. Harald Haas in Global TED Talk in July 2011, is an emerging technology that uses illumination for data transmission and operates in the visible layer of electromagnetic spectrum. It is fast, cheap and secure optical version of Wi-Fi technology and also it can be regarded as light-based Wi-Fi, i.e. instead of radio waves it uses light to transmit data. In place of Wi-Fi modems, Li-Fi would use transceivers fitted with LED lamps that could light a room as well as transmit and receive information by using underutilized visible portion of the electromagnetic spectrum. Visible light for communication instead of radio waves using Light Emitting Diodes as a medium to high-speed data transmission can help to conserve a large amount of electricity by transmitting data through light bulbs and other such lighting equipment. The 5G communication through visible light, Light Fidelity, surpasses the present day RF communication in terms of speed, capacity, security, accuracy, cost, electromagnetic interference and efficiency. The Li-Fi technology is still under research and further exploitation could lead to wide applications.

Harald Haas began his research in the field in 2004 and gave a debut demonstration of what he called a Li-Fi prototype at the TED Global conference in Edinburgh on 12th July 2011 and a data rate of transmission of around 10Mbps and two months later he achieved 123Mbps. Researchers at the Heinrich Hertz Institute in Berlin, Germany, have reached data rates of over 500 megabytes per second using a standard white-light LED in 2012 and similarly the rate is achieved at a distance of 10 meters using a pair of Casio smart phones to exchange data using light of varying intensity given off from their screens. By August 2013, data rates of over 1.6 Gbps were

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demonstrated over a single color LED. In September 2013, a press release said that Li-Fi do not require line-of-sight conditions. The data rate can be achieved by using a single color 5mW LED is 4 Gbps with short distance and 1.1 Gbps is at 10 meter distance was presented at BOLD talks by Prof. Haas in 2014. The Li-F inventor, prof. Harald Haas believe, that even though the distance was nominal, it is sure that there would be a rapid increase in the distance of transmission and a speed of more than 10 Gbps with different color LEDs can be achieved.

II. WHY LIGHT FIDELITY OVER WIRELESS FIDELITY

Even though both Wi-Fi and Li-Fi transmit data over the electromagnetic spectrum, Wi-Fi utilizes radio waves but Li-Fi uses visible light. Wi-Fi uses complex receivers, antennas and radio circuits for its operation whereas Li-Fi uses low cost LED's and other simple devices to establish communication. In the electromagnetic spectrum, portion of visible is the vast potential of unused, unregulated, safe green spectrum and is 10,000 times larger than the entire radiofrequency spectrum.

Li-Fi uses visible light as a communication medium with frequency between 400THz to 800THz to wavelength of between 780nm to 375nm.

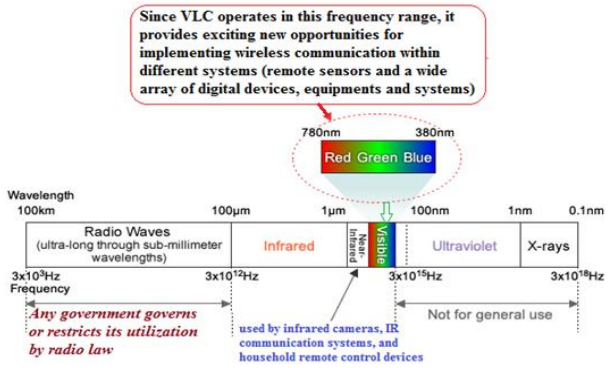

Figure 1: Electromagnetic Spectrum

Using VLC can solve problems that couldn't be by radio waves' Bluetooth, infrared, Wi-Fi and internet due to electromagnetic interference and health problem like in medical devices of hospitals. Underwater communication is possible by using VLC even though Wi-Fi couldn't. Since there are around 19 billion bulbs worldwide, they just need to be replaced with LED ones that transmit data. VLC is at a factor of ten cheaper than Wi-Fi and its security is another benefit since light does not penetrate through walls. Li-Fi provides cheap, secured and high bit rate wireless indoor communication which is not achieved by Wi-Fi technology.

In present scenario the bandwidth capacity of radio frequency which is available is finite & is not capable enough to sustain with the constantly increasing demand of wireless data transfer size. Light is inherently safe and can be used in places where radio frequency communication is often deemed problematic, such as in aircraft cabins, nuclear power plants or hospitals, without causing electromagnetic interference. The visible light spectrum is unused; it is not regulated, and can be used for communication at very high speed.

As per the Cisco Survey of the usability of the existing spectrum, 80% of the existing capabilities of the data utilization are using. Due to this survey, currently there are more than 7.3 billion smartphones, 1.58*1019 bytes (almost 16 Exabyte) per month data transfer interest in 2018 and also 1000 wireless devices per person will be required in 2020 which are impossible to achieve by using only radio transmitter base stations. United States Federal Communication Commission also has warned of a potential spectrum crisis because Wi-Fi is close to full capacity. But Li-Fi has almost no limitations on capacity. The spectrum is unregulated (free- no government has a license for this), huge, safe and can be exploited with existing infrastructure with extremely cheap LED. The amount of data sent through wireless networks is expected to increase 10-fold during the next four years even though there isn't enough new RF spectrum available to allocate and the spectral efficiency (the number of bits successfully transmitted per Hertz bandwidth) of wireless networks has become saturated, despite tremendous technological advancements in the last 10 years.

Wi-Fi allows users to gain convenient wireless internet access, though without the sufficient security precautions it can also let outsiders or intruders to do the same without anyone noticing. As "hot-spots" are becoming increasingly popular and cities working towards becoming entirely wireless, users is becoming more vulnerable to cyber-crime. Techno-criminal can attack a user's wireless network in order to gain free internet usage or obtain personal and valuable information.

III. OPERATION PRINCIPLES AND DIFFERENCES

A. Wi-Fi operation

Wi-Fi is a wireless networking technology that allows computers and other devices to communicate over a wireless signal, radio waves, to transmit data with the maximum rate. Radio waves are transmitted from Wi-Fi antennas are picked up by Wi-Fi receivers, such as computers and cell phones that are equipped with Wi-Fi cards. Whenever, a computer receives any of the signals within the range of a Wi-Fi network, which is usually not more than 100 meter from antennas, the Wi-Fi card reads the signals and thus creates an internet connection between the user and the network without the use of a cord. Wi-Fi cards as being invisible cords that connect your computer to the antenna for a direct connection to the internet and it can be external or internal. This card communicates with access points or hotspots for accessing internet. If a Wi-Fi card is not installed in computer, it is possible to purchase a USB antenna attachment (for laptops, PCMCIA card) and connect to USB port or install/insert directly to the computer at antenna-equipped expansion slot (for laptops, PCMCIA slot).

Access points, consisting of antennas and routers, are the main source that transmit and receive radio waves through their Antenna that can work stronger and have a longer radio transmission with a radius of less than 150 meter, which are used in public areas while the weaker yet effective router is more suitable for homes with a radio transmission of less than 50 meters. Hotspot is an area

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where Wi-Fi access is available and created by installing an access point to an internet connection. It can either be through a closed wireless network at home or in public places like restaurants or airports. When a Wi-Fi enabled device such as a Pocket PC encounters a hotspot, the device can then connect to that network wirelessly. Most hotspots are located in places that are readily accessible to the public such as airports, coffee shops, hotels, book stores, and campus environments. The largest public Wi-Fi networks are provided by private internet service providers (ISPs); they charge a fee to the users who want to access the internet.

Figure 2: Wi-Fi chip with its generation

In Wi-Fi data communication, network components are based on one of the 802.11 standards developed by the IEEE and adopted by Wi-Fi Alliance. These standards are

Standards	Year	Frequency	Range	Speed
802.11a	1999	5GHz	10m	54Mbits/s
802.11b	2001	2.4GHz	50m	11Mbits/s
802.11g	2003	2.4GHz	75m	54Mbits/s
802.11n	2007	2.4GHz & 5GHz	100-150m	300Mbits/s
802.11ac	2013	5GHz	150m	1Gbits/s

Table 1: IEEE standards of Wi-Fi

Nearly all modern computers (most mobile devices, video game systems, and other standalone devices) have a built-in Wi-Fi chip that allows users to find and connect to the wireless routers. When a device establishes a Wi-Fi connection with a router, it can communicate with the router and other devices on the network in the principle of radio wave communication. However, the router must be connected to the internet (via a DSL or cable modem) in order to provide internet access to connected devices. Therefore it is possible to have a Wi-Fi connection without internet connection which is known as ad-hoc connection for local data sharing.

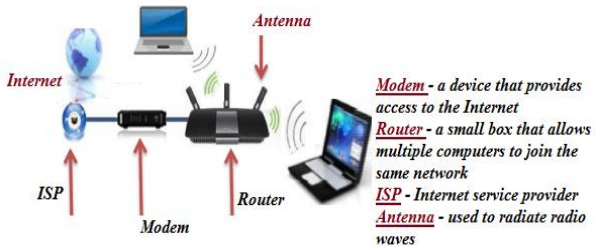

Figure 3: Wi-Fi network

B. Li-Fi operation

Li-Fi uses the visible light communication (VLC) as the means of data transmission rather than the overly used radio waves by using white LED light bulbs to transmit the information as well as fulfilling the purpose of illumination. Through fast and slight variations of the current (which is applied to the LED), the optical output can be made to vary at very high speeds. The variation caused in the current which is passed to the LED will carry data at high speed and cannot be seen by the human eye. Harold Haas has proposed the very simple technique of transmitting data using LED bulbs i.e. if the LED is ON, then the digital signal 1 is transmitted else if the LED is OFF, the digital signal 0 is transmitted. Thus encoding of data by changing the rate of flickering of LED is the basic principle of Li-Fi.

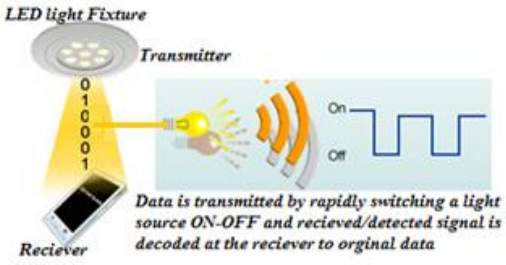

Figure 4: Li-Fi operation principle

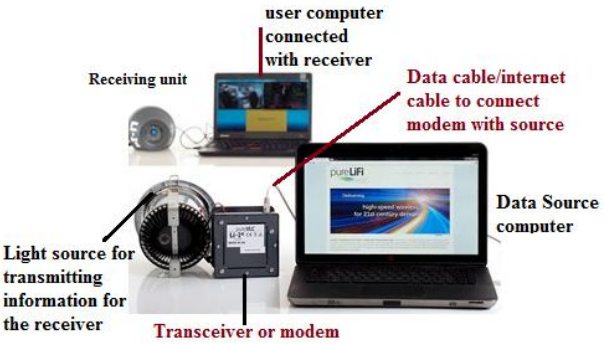

Figure 5: Li-Fi operation implemented by Prof. Haas

Li-Fi technology was practical demonstrated by prof. Haas to transmitted data in bi-directional way. This demonstration was implemented by using LEDs bulb as data source from data source computer after converting to stream of ones and zeros data at modem or transceiver. This light data was detected by the light sensor screen at in front of light source bulb and converted to original data and displayed move at user computer.

Li-fi uses two main section, transmitter and receiver, for reliable data transfer. Both transmitter and receiver use semiconductor diode, light emitting diode and light sensor/detector diode respectively. A transmitter at one end of the communication link sends a modulated signal and then a receiver at the other end detects the modulated light, converts it back to Zeros and Ones, and decodes the digital messages and data.

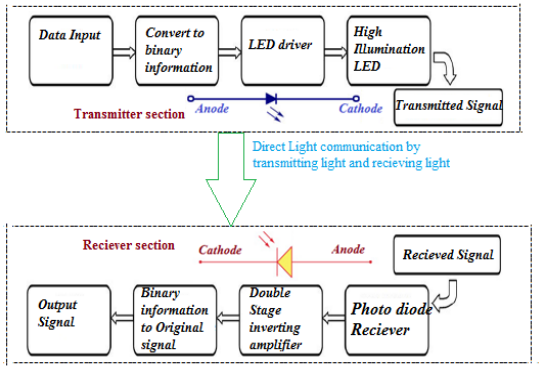

Figure 6: Li-Fi Transmitter and Receiver block diagram

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The input data from the source computer is converted to bits, zeros and ones, to represent as digital signal. Depending on this stream of digital ones and zeros data, the high illuminated LED bulb ON-OFF condition is controlled with the help of driver circuit. This highly flickered LED light is transmitted to the nearby receiver, photodiode. This weak received signal is the amplified and the converted to binary signal of ones and zeros. Finally this converted zeros and ones stream data is read by the receiver computer or device.

Transmitter section

This section of visible light internet communication is designed for transmitting encoded signal to the receiver part by accepting data from the internet service providers as the form of light. Data from the sender is converted into an intermediate data representation i.e. byte format and then converted into light signals which are emitted by the transmitter. This given Li-Fi transmitter can be generalized as follows.

Source Computer → Data Reading Module → Data Conversion Module → Transmitter Module

- **Data Conversion Module** – converts data into bytes so that it can be represented as a digital signal. It can also encrypt the data before conversion. It uses data converters and microcontroller unit as encoder or modulator.
- **Transmitter Module** – generates the corresponding on-off pattern for the LEDs by the help of driver circuit.

Currently, there are different companies working on transmitter of this technology. Techriders Li-Fi technology, Renesas R&D Engineers, SunPartner Technologies, Fraunhofer Henrich Hertz Institute, Austria Micro Systems and other companies are trying different Li-Fi technology.

Techriders Li-Fi technology produces the down link transmitter.

Figure 8: Techriders Downlink Transmitter

Each Lamp of the transmitter contains many in number and different in color, to increase the data rate, LEDs which are becoming smaller in size and faster in flashing. The Scottish researchers are developing micro-LEDs that are just $1\mu m^2$ (1000 times smaller) and 1,000 times faster in flickering, would be able to transmit data a million times faster than a normal LED. The efficiency of normal LED is almost 50 times greater than a simple tungsten lamp and the response time is in the range of 0.1 microseconds when compared with 100 milliseconds for a tungsten lamp. The visible lights that an LED emits are usually orange, red, yellow, or green and blue color which is recently invented.

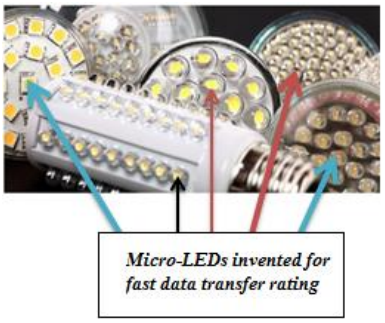

Figure 7: invented LEDs

The light signal is received by the photodiode at the receiver side. The main components of a VLC receiver can be generalized as follows.

Destination Computer→Receiver Module → Data Interpretation Module → Data Display (GUI)

- **Receiver Module** – has a photo diode to detect the on and off states of the LEDs. It captures this sequence and generates the binary sequence of the received signal and boosts this received signal by using amplifier.
- **Data Interpretation Module** – detects and decodes or converts data into the original digital signal format with the help of microcontroller unit. If encryption was done at transmitter, it also performs decryption.

The VLC Evaluation Kit is designed to be very easy to use. This developed kit is for low speed applications and high speed applications.

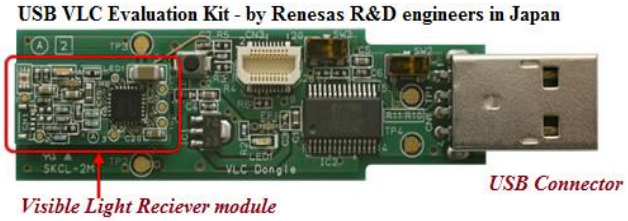

Figure 9: USB evaluation Kit

After the included communication evaluation software is installed on a PC and the USB device is plugged in, customers can measure and analyse reception rates, error rates, and other evaluation parameters.

VLC receivers can be incorporated readily into smartphones or tablet computers. If duplex communication links are needed, the transmitter and receiver can be paired together in a transceiver module. This transceiver module, USB Flash with receiver photodiodes and transmitter arrays of LEDs, enables computers to access fast internet data through Li-Fi.

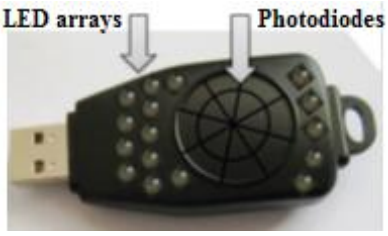

Figure 10: Li-Fi transceiver

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SunPartner Technologies produced Wysips Crystal Mobile Phone screen. The Wysips Crystal technology is transparent photovoltaic component which is integrated during the manufacturing process and connected to an electronic screen that transforms any screen into a solar panel that can generate its own electric energy and send and/or receive data through light. This energy is then used to recharge the batteries of the mobile device and enabling screens and mobile devices to receive and transmit data over light waves (VLC-Visible Light Communication). Sunpartner Technologies produced joining forces with Alcatel OneTouch smart phones to use Li-Fi for charging purpose and also for as data receiver from sourced internet by LED bulbs.

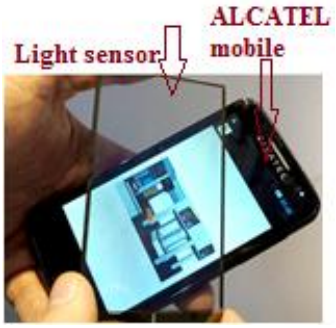

Figure 1: Light sensor screen for mobile internet data

Researchers at the Fraunhofer Henrich Hertz Institute (HHI) in Germany have successfully transmitted data at 3Gbps using conventional LED bulbs in a laboratory setting. Fraunhofer's VLC system is a black box, with an LED and photo-detector on the front, and an Ethernet jack on the back to connect it to the rest of the network.

Figure 2: Fraunhofer Li-Fi transceiver

C. Operation Difference of Li-Fi and Wi-Fi

Although electromagnetic spectrum is used for data communication between devices for both technologies, the energy, frequency and bandwidth level is different. Li-Fi and Wi-Fi technologies are differentiated each other with different parameters listed below.

Table 2: LI-Fi versus Wi-Fi

Parameters used for comparison	Wi-Fi (Current Technology)	Li-Fi (Future Technology)
Main part of Transmitter	Antenna	LED
Part of Receiver	Antenna	Photodiode
Inbuilt device on modern electronics for internet	Wi-Fi card/Wi-Fi chip	Under research and development
Average operation speed	150 - 600Mbps	Under research (Greater than 10Gbps)
Operation speed controllability	Fixed for one device (Can be changed by changing the router with different speed)	Can be controlled the LED driver and increasing number of LED colors
Signal radiation distance	Up to 150 meters	Under research (currently up-to 10m)
Signal radiation strength	Can penetrate walls and possible for indoor and outdoor access	Can't penetrate walls and impossible for outdoor access without direct light
Spectrum range for operation	Radio spectrum range	1000 times greater than Wi-Fi
Data transfer medium	Use radio spectrum	Use light as a carrier
Frequency band	2.4 GHz	100 times of THz
Latency	In the order of ms	In the order of µs
IEEE standard used	IEEE 802.11xx	IEEE 802.15.xx
No of users	Depend upon access point	All over word under lamp.

IV. ADVANTAGE OF LI-FI OVER WI-FI

Wi-Fi is great for general wireless coverage while Li-fi is ideal for high density coverage in a confined region. It is believed that the technology can yield a speed more than 10 Gbps, allowing a HD film to be downloaded within few seconds. With the introduction of Li-Fi, household lighting could soon double as a form of data transmission that's up to 100 times faster than Wi-Fi.

Li Fi seeks to resolve the global struggle for diminishing wireless capacity by developing and delivering technology for secure, reliable, high speed communication networks that seamlessly integrate data and lighting utility infrastructures and significantly reduce energy consumption. Aside from its superior speed, Li-Fi also provides a number of other benefits over Wi-Fi.

→ Li-Fi can solve problems related to the insufficiency of radio frequency bandwidth because this technology uses Visible light spectrum that has still not been greatly utilized.

→ Since light cannot penetrate walls, it provides privacy and security by reducing interception of signals and also used for hidden communication military and defence based communications as well as communications in hospitals.

→ The enabling of the Internet-of-Things (100 times more devices).

→ Enhanced energy-efficiency by combining data communication and illumination (100 times energy reduction)

→ Dedicated cable/connector replacement such as USB3.0, Gigabit Ethernet, industrial protocols

→ Radio waves cannot be used in water due to strong signal absorption disrupt marine life, Li-Fi offers a solution for conducting short-range underwater communications.

→ Li-Fi technology increases traffic management and safety by providing communications between the LED lights of cars to reduce and prevent traffic accidents by replacing car headlights and tail lights by LED for effective vehicle-to-vehicle as well as vehicle-to-signal communications.

→ Like retail stores, casinos also have rich lighting environments which could be easily harnessed for Li-Fi, which can find application in the large amount of video monitoring equipment that most casinos employ.

→ Li-Fi can find application in the new smart class technology which is quickly becoming imperative for progressive schools and colleges in the world.

→ Li-Fi can be used for Smart Lighting by replacing street lamps as Li-Fi hotspots and can also be used to control and monitor lighting and data.

→ Li-Fi can act as an alternative in regions with high density wireless communication where 500 or more users may be contending for Wi-Fi. This would lead to low access speeds for the users. Li-Fi can be used to share some of the load of Wi-Fi.

→ Li-Fi can be used as a solution to any situation in which hypersensitivity to radio frequencies is a problem and radio waves cannot be used for communication or data transfer.

→ Visible light is safer than RF; hence it can be used in RF restricted and hypersensitivity areas/environments like:

- Hospitals and Medical Laboratories: Since radiated radio frequency for Wi-Fi around and in operating rooms of hospitals causes electromagnetic interference with different medical equipment. Li-Fi can solve this type of interference because visible light doesn't interfere with medical equipment.
- Airlines and Aviation: Since aircrafts already contain multiple lights, Li-Fi can be used for data transmission and Wi-Fi is often prohibited in aircrafts
- Power Plants and Hazardous Environments: Power plants require fast and interconnected data systems for monitoring grid intensity, demand, temperature even though Wi-Fi is impossible due to its interference. Li-Fi can provide safe connectivity throughout the power plant. Li-Fi offers a safe alternative to electromagnetic interference due to radio waves in environments such as petrochemical plants and mines.

→ There are more than 1.4 million cellular radio masts worldwide with the efficiency of 5% those consume massive amounts of energy, most of which is used for cooling the station rather than transmission of radio waves.

→ The radio waves used by Wi-Fi to transmit data are limited as well as expensive. With the development of 3G and 4G technologies, the amount of available spectrum is running out.

→ Integrated into medical devices and in hospitals as this technology does not deal with radio so it can easily be used in such places where Bluetooth, infrared, Wi-Fi and internet are banned. In this way, it will be most helpful transferring medium for us.

→ There are around 19 billion bulbs worldwide, they just need to be replaced with LED ones that transmit data since VLC is at a factor of ten, cheaper than WI-FI.

→ Visible light spectrum has 10,000 time broad spectrum in comparison to radio frequency used in WI-FI.

→ LED lights consume less energy and are highly efficient.

V. DRAWBACK OF LI-FI THAN WI-FI

Since Li-Fi it is light-based, its major drawbacks are coming from its radiation range, radiation direction and penetration capacity through objects and opaque materials.

❖ The main problem is that light can't pass through solid objects and buildings, so if the receiver computer, laptop and also mobiles should be insight of the LED bulb or its reflected light.

❖ High installation cost of the VLC systems.

❖ Network coverage is the major issues to be considered by the companies while providing VLC services.

❖ High installation cost of the systems can be complemented by large-scale implementation of VLC though adopting this technology will reduce further operating costs like electricity charges, maintenance charges etc.

❖ It is impossible to provide data to a high-speed moving object or to provide data in a remote area where there are trees, walls and obstacles.

VI. FUTURE SCOPE OF LI-FI

Li-Fi technology is now under research and even it is not implemented except laboratory experiments. Future improvements will be focused on

1. Data transfer rate and coverage area will be increased. Currently, researchers at the University of Oxford employed Li-Fi to attain bi-directional speeds of 224 Gbps. These speeds would allow 18 movies (1.5 GB each) to be downloaded in a single second with specialized broadcast LEDs and receivers which operated with different fields of view as well as bands that impact the data rates. The link operates over a range of about 3 meters at 224 Gbps and 112 Gbps with a wide field of view of 60° and 36° respectively, thereby offering practical room-scale coverage.
2. Low power and high speed diodes will be manufactured
3. Integrated transmitters and receivers will be manufactured. Presently, A custom-designed transmitter driver and receiver (each with the size of 0.18 µm CMOS) chip is going to develop by Austria Micro Systems. The transmitter chip with 4 independent digital-to-analogue converters (DACs), each capable of directly driving an individual light emitting diode (LED) and the receiver chip featuring nine individually-addressable avalanche photo diode (APD) receivers.
4. Modulation will be achieved with low cost and with less complexity with the help different algorithms

5. The next wave of energy efficient lighting will be based on laser diodes. One of the leading Li-Fi proponents is already looking much beyond LEDs to laser-based lighting to bring a tenfold increase in data rates i.e. using lasers diodes the speed is easily beyond 100 Gbps that is checked at the University of Edinburgh by prof. Haas.
6. Modern computers and smart phones will come with inbuilt receiver and even with transceiver.
7. Cars headlight and backlight and Traffic lights will be changed with Li-Fi technology
8. Aircraft cabins, hospitals and hazardous environments will access internet with Li-Fi.
9. Li-Fi technology is being developed into a ubiquitous systems technology, consisting of application specific combinations of light transmitters, light receivers including solar cells
10. Efficient computational algorithms and networking capabilities that can be deployed in a wide range of communication scenarios and in a variety of device platforms is being developed
11. Different companies will concentrate their interest on Li-Technology. Currently there are many international developers of VLC technologies including Intel, Siemens, CASIO, VLCC, Philips, Fraunhofer, Samsung, ByteLight and the LiFi Consortium.

VII. CONCLUSION

In the near future internet data communication will be changed from radio wave spectrum to visible light spectrum. Using this spectrum is becoming the solution for problems in security, efficiency and limited bandwidth of Wi-Fi. Li-Fi technology will replace the traffic lights, street lights, car lights and indoor lights by LED light source for both lighting and internet services. It also reduces high maintenance costs in petroleum and other RF sensitive power plants by providing better communication for detection, prevention and forecasting. Since researchers are developing different Li-Fi technology components and systems, Li-Fi coverage area and data transfer rate will be increased. Through Li-Fi, internet will be everywhere including hospitals, aircrafts and underwater.

Since Li-Fi is clean, cheaper, and efficient and secure, most computer and electronic communication related companies will join to implement the technology and also enhance its data rate, coverage area and easily accessibility with a short period of time. The future Li-Fi implementation cost will be randomly decreased because of the production of micro-chip transceiver, integration of transceivers with computers and mobiles, replacement of semiconductor diodes by laser diodes and the reduction of modulation complexity with different algorithm. All mobile screens will come with LiFi Connected Screens for charging purpose and Li-Fi internet i.e. transmitter and receiver of internet data which is practiced by Sunpartner Technologies. In the near future, I hope Li-Fi technology will replace Wi-Fi technology markets as a result of data rate, data security and free spectrum of un-limited band width and the power consumption by huge radio base stations will be reduced dramatically.

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