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Li-Fi(Light Fidelity): The Next Generation of Wireless Network

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Abstract: Using wireless networks in the malls or cracking others passwords to connect to the Internet; probably you would be frustrated at the slow speed as many devices access the same host. Everyone wants to use wireless data but capacity is drying up. Wireless radio frequencies are getting higher, complexities are increasing and RF interferences continue to grow. In order to overcome this problem in future, one German physicist, Dr. Harald Haas has amazed people by streaming high definition video from a standard LED global in July 2011. "If you think of a shower head separating water out into parallel streams, that's how we can make light behave," said Prof. Harald Haas, an expert in Optical Wireless Communications at the University of Edinburgh and one of the project leaders. Li-Fi is now part of Visible Light Communications (VLC) PAN IEEE 802.15.7 standard. VLC signals work by switching bulbs on and off within nanoseconds which is too quick to be noticed by a human eye. More sophisticated techniques could dramatically increase VLC data rate. Li-Fi is an emerging technology that could see specialized LED light bulbs providing low-cost wireless internet connectivity almost everywhere. These devices are normally used for illumination by applying a constant current through the LED.

Key words: LED (Light Emitting Diode), VLC (Visible Light Communication), Li-Fi, Wi-Fi.

Introduction: It was first demonstrated at a TED talk in 2011 by German physicist Harald Haas**,** is a new standard developed to transport data through light beams at speeds ranging theoretically from 800 to 1300 mbps. Li-Fi or light fidelity, refers to 5G visible light communication systems using light from light emitting diodes(LED) as a medium to deliver networked, mobile, high-speed communication in a similar manner as Wi-Fi. Li-Fi is a major breakthrough technology for the mobile internet community and for the connected objects domain. Li-Fi can be thought of as a light-based Wi-Fi. Li-Fi uses light 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.

The technology truly began during the 1990's in countries like Germany, Korea, and Japan where they discovered LED's could be retrofitted to send information. Harald Haas continues to wow the world with the potential to use light for communication.

Two third of the total population in the world does not have access to internet, gaining access to internet by just turning on the light bulb will be more than just an achievement. 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. Direct line of sight isn't necessary for

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Li-Fi to transmit signal and light reflected off of the walls can achieve 70mbps. The light waves cannot penetrate walls which makes a much shorter range, though more secure from hacking, relative to Wi-Fi. Li-Fi is the transmission of data through illumination by taking the fiber out of fiber optics by sending data through a LED light bulb. This varies in intensity faster than human eye can follow.

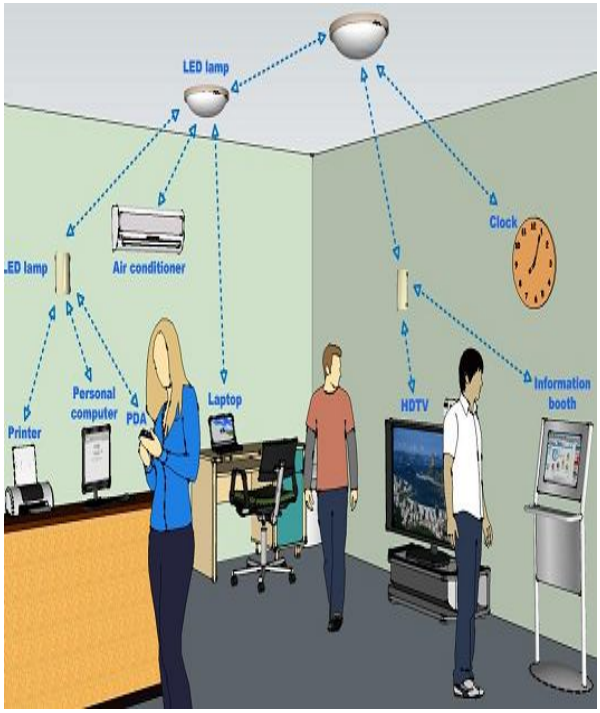

Fig 1: Li-Fi Environment

The US federal communication commission has warned of a potential spectrum crisis because Wi-Fi is close to full capacity, Li-Fi has almost no limitation on full capacity. Visible light is part of the electromagnetic spectrum and its bandwidth is 10,000 times bigger than the radio frequency spectrum used by existing communication systems, affording vastly greater capacity. Researchers have reached data rates of over 10gbps, which is more than 250 times faster than super fast broadband. Li-Fi is expected to be 10 times cheaper and more environmentally friendly than Wi-Fi. Short range, low reliability and installation cost are the potential downsides.

Li-Fi has the advantage of being able to be used in electromagnetic sensitive areas such as in aircraft cabins, hospitals and nuclear power, plants without causing electromagnetic interference. Li-Fi can even wok underwater were Wi-Fi fails completely, thereby throwing open endless opportunities for military/navigation operations. Evenly spaced LED transmitters could provide much more localized and consistent internet connectivity throughout buildings.

How Li-Fi works?

Li-Fi or Light Fidelity is a technology that uses light emitting diodes to transmit data wirelessly. The functioning of new Li-Fi technology is just simple. That is a light source at one end like a LED and a photo detector (Light Sensor) on the other end. The LED is connected to the internet through the modem and the receiver decodes the information, which is then displayed on the device. 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 as RF. Even incandescent lamps turn off and on 60 times in 1 second(60 Hertz), and we already have the perception that it is continuously on. Using this technique, high speed information can be transmitted from an LED light bulb. As soon as, LED starts glowing, photo detector or light sensor on other end will detect light and get a binary 1(on) otherwise binary 0(off). Flashing a LED certain times will build up a message to transmit.

Flashing of light is detected by the photo detector or light sensor and it will receive a message. Li-Fi bulbs are outfitted with a chip that modulates the light imperceptibly for optical data transmission. Li-Fi data is transmitted by the LED bulbs and received by photoreceptors. Communicates with a very high speed with a theoretical limit of 1Gbps.

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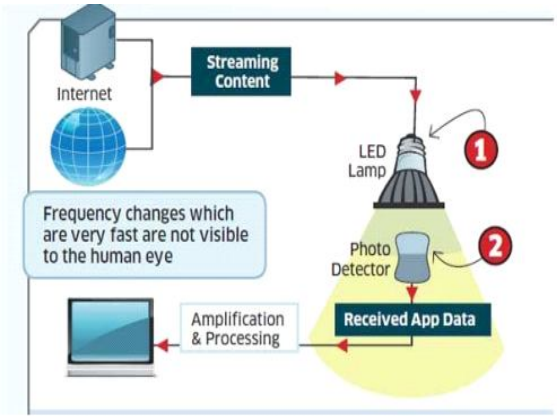

Fig 2: Transmission of Data Using Light LED.

A free band that does not need license. Hence it is cheaper than Wi-Fi. 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.

Why only VLC?

Visible Light Communication(VLC) is a data communications medium using visible light between 400 THz (780 nm) and 800 THz (375 nm). Using visible light is less dangerous for high-power applications because humans can perceive it and to protect their eyes from damage.

- Gamma rays can't be used as they could be dangerous.
- X-rays have similar health issues.
- Ultraviolet light is good for place without people, but otherwise dangerous for the human body.
- Infrared, due to high safety regulation, can only be used with low power.

Features:

Li-Fi offers a number of key benefits over Wi-Fi but is inherently a complementary technology.

Technology	Speed	Data Density
Wired		
Fire Wire	800 Mbps	*****
USB 3.0	5 Gbps	*****
Thunderbolt	2x10 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	****

Table 1: Comparison Between Wired And Wireless Technology.

Capacity:

Bandwidth: The visible light spectrum is plentiful (10,000 more than RF spectrum), unlicensed and free to use.

Data density: Li-Fi can achieve about 1000 times the data density of Wi-Fi because visible light can be well contained in a tight illumination area whereas RF tends to spread out and cause interference.

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

Planning: Capacity planning is simple since there tends to be illumination infrastructure where people wish to communicate, and good signal strength can literally be seen.

Efficiency:

Cost: Instead of running close to a mile worth of cable, the LED powered Li-Fi connection could be used to beam the information directly to the destination using a point-to-point array, office buildings can stay connected to each other without the use of additional cables being laid from one access point to another. The only problem the two buildings could be faced with is obstruction by solid objects or dense whether patterns such heavy fog or snow.

Energy: LED illumination is already efficient and the data transmission requires negligible additional power.

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Environment: RF transmission and propagation in water is extremely difficult but Li-Fi works well in this environment.

Safety:

Safe: Life on earth has evolved through exposure to visible light. There are no known safety or health concerns for this technology.

Non-hazardous: The transmission of light avoids the use of radio frequencies which can dangerously interfere with electronic circuitry in certain environments.

Security: Containment: It is difficult to eavesdrop on Li-Fi signals since the signal is confined to a closely defined illumination area and will not travel through walls.

Control: Data may be directed from one device to another and the user can see where the data is going; there is no need for additional security such as pairing for RF interconnections such as Bluetooth.

Applications:

The dramatic growth in the use of LEDs (Light Emitting Diodes) for lighting provides the opportunity to incorporate Li-Fi technology into a plethora of LED environments.

Li-Fi is particularly suitable for many popular internet "content consumption" applications such as video and audio downloads, live streaming, etc. These applications place heavy demands on the downlink bandwidth, but require minimal uplink capacity. In this way, the majority of the internet traffic is off-loaded from existing RF channels, thus also extending cellular and Wi-Fi capacities. There are many applications for Li-Fi. These include:

RF Spectrum Relief: Excess capacity demands of cellular networks can be off-loaded to Li-Fi networks where available. This is especially effective on the downlink where bottlenecks tend to occur.

Smart Lighting: Any private or public lighting including street lamps can be used to provide Li-Fi hotspots and the same communications and sensor infrastructure can be used to monitor and control lighting and data.

Mobile Connectivity: Laptops, smart phones, tablets and other mobile devices can interconnect directly using Li-Fi. Short range links give very high data rates and also provides security.

Hazardous Environments: Li-Fi provides a safe alternative to electromagnetic interference from radio frequency communications in environments such as mines and petrochemical plants.

Hospital & Healthcare: Li-Fi emits no electromagnetic interference and so does not interfere with medical instruments, nor is it interfered with by MRI scanners.

Aviation: Li-Fi can be used to reduce weight and cabling and add flexibility to seating layouts in aircraft passenger cabins where LED lights are already deployed. In-flight entertainment (IFE) systems can also be supported and integrated with passengers' own mobile devices.

Underwater Communications: Due to strong signal absorption in water, RF use is impractical. Acoustic waves have extremely low bandwidth and disturb marine life. Li-Fi provides a solution for short-range communications.

Vehicles and Transportation: LED headlights and tail-lights are being introduced. Street lamps, signage and traffic signals are also moving to LED. This can be used for vehicle-to-vehicle and vehicle-to-roadside communications. This can be applied for road safety and traffic management.

RF Avoidance: Some people claim they are hyper-sensitive to radio frequencies and are looking for an alternative. Li-Fi is a good solution to this problem.

Location Based Services (LBS): Highly accurate location-specific information services such as advertising and navigation that enables the recipient to receive appropriate, pertinent information in a timely manner and location.

Game Consoles: An innovative idea would be to put sensors on a television in order to receive information from game consoles. This would allow the unit to be

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placed literally anywhere within the room as long as there is a direct line of site to the sensor.

Li-Fi V/S Wi-Fi:

In Wi-Fi, modulated signal is radio waves where as in Li-Fi modulated signal is light. It is visible electromagnetic spectrum and has higher bandwidth than Wi-Fi but has line of sight limitation.

Li-Fi / Wi-Fi comparison

Parameter	Li-Fi	Wi-Fi
Speed	***	***
Range	*	**
Data density	***	*
Security	***	**
Reliability	**	**
Power available	***	*
Transmit/receive power	***	**
Ecological impact	*	**
Device-to-device connectivity	***	***
Obstacle interference	***	*
Bill of materials	***	**
Market maturity	*	***

* low ** medium *** high

Table 2: Difference Between Li-Fi And Wi-Fi.

Advantages:

- High speed 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.
- 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.

Drawbacks:

- It is a one-way connection, permitting download but no upload from the connected device.
- The light cannot get through walls and has a limited field of action.
- The power cord immediately becomes your data stream, so if you have power, you have internet.
- Difficulties with mobility.

Conclusion: If this technology can be put into practical 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. In future, data for laptops, smart phones and tablets can be transmitted through light in room by using Li-Fi. In Li-Fi we don't need a license to set up a light bulb, as we set up a Wi-Fi network over radio waves. It is likely to supplement networks in congested urban areas, or in areas where it can't reach, like deep in the ocean. The increasing demand for higher bandwidths, faster and more secure data transmission as well as environmental and undoubtedly human friendly technology heralds the start of a major shift in wireless technology, a shift from RF to optical technologies. As a growing number of people and their many devices access wireless internet, the airways becoming increasingly clogged, making it more and more difficult to get a reliable, high speed signal. Li-Fi consortium believes it is possible to achieve more than 10gbps, theoretically allowing a high definition film to be downloaded in 30 seconds. Both Wi-Fi and Li-Fi transmit data over the electromagnetic spectrum, but whereas Wi-Fi utilizes radio waves, Li-Fi uses visible light. The visible light spectrum is larger than the radio spectrum. Since optical waves do not pass through walls this could be used as a means of secured communication.

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