LiFi: The Future for Indoor Wireless Data Communication

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Abstract This paper mainly focusing on discussion between existing wireless communication technologies and , their limitations and features and on the other hand it throws a light for a vibrant and one of the most popular future technology. It is the Era of mobile Technology where the connectivity is required all time. So, the demand to increase the bandwidth for these mobile computing devices become essential when live video streaming is required on any end user device. These tasks can vary from medical assistance to providing regular services. The aim of this research is to provide insight view of LiFi technology which is going to be the future technology for data communications due to its high bandwidth all time indoor availability with better connectivity and optimal QoS while having very low or no health effects due to radiation beams.

This research also intended to highlight some limitations of LiFi technology so the researchers currently working on this novel technology should also consider those issues and try to address them by coming up with some better technology to overcome limitations and offering better features for the end users.

Index Terms— LiFi, WiFi, OWC, Bluetooth, IrDA, Smart Architecture, QoS, LED, Radio Communication.

1 Introduction

Modern age is the age of technology and in this era data communication has become pervasive in every field of life. It has changed the way we live. Advancements in technology made the communication more efficient, by carrying more and faster signals. The transmission media plays an important role in efficient communication and the technologies used for transmission advanced from wired to wireless.

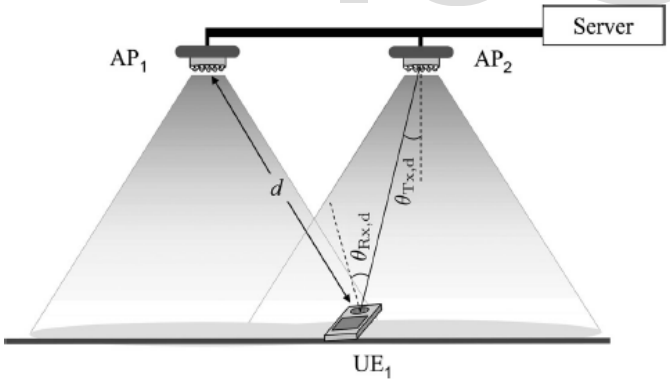

Figure 1: Illustration of interference in optical wireless network

Above Figure-1 illustrate the scenario of interference in optical wireless network. Where AP1 is the intended transmitter for the receiver UE1 and AP2 is an interfering transmitter which serves a different UE

Li-Fi is one such advanced wireless communication technology which uses LED's as a medium of data transmission. .Li-Fi technology was developed by a team of scientists lead by Prof. Harald Hass et al. at University of Edinburgh. The term Li-Fi was coined by Professor Harald Hass which stands for Light Fidelity. Haas introduced this technology in his TED GLOBAL Talk on Visible Light Communication in 2011.It will not be replacement. for Wi-Fi but we can say it is complimentary to Wi-Fi. The Li-Fi works on switching of LED's, which means transmission of digitals I.e. 1 and 0 takes place by switching LED ON and OFF consecutively. Since these transitions are very fast in case of light, so transmission of data becomes faster too.

Li-Fi uses the visible part of electromagnetic spectrum, which is beneficial for living beings not hazardous as radio waves, and provide huge bandwidth. As a result of which Li-Fi will provide safer use and will overcome the problems of heavy loads and speed

2 Construction of LIFI

To build a Li-Fi we require devices such as lamp driver, LED Lamp, and wireless devices like our mobile phones, PDA's, Laptops etc. These future wireless devices will be possessing photo detector which will process and amplify data. Lamp driver is directly connected to internet and LED Lamp with the help of optic fiber. Any LED Lamp can act as Li-Fi, only what is needed is a microchip to be installed. Li-Fi based LED Lamp consists of four components which are listed below:

- Enclosure
- Bulb
- PCB (Printed Circuit Board)
- PA (Power Amplifier)

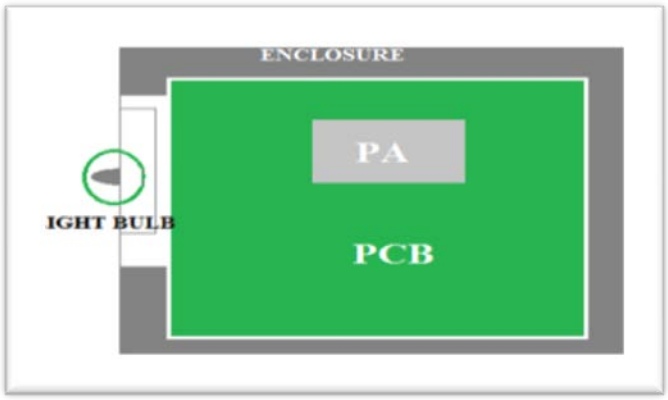

Figure 1: Li-Fi Simple Construction

Li-Fi LED Lamp consists of an aluminum jacket known as enclosure within which all the components reside. A bulb is fitted with enclosure which acts as a source of light (medium for communication). The PCB is responsible for managing lamp functions and controlling electrical signals. The RF Power amplifier (PA) helps in generating radio frequencies guided into electric field about to bulb.

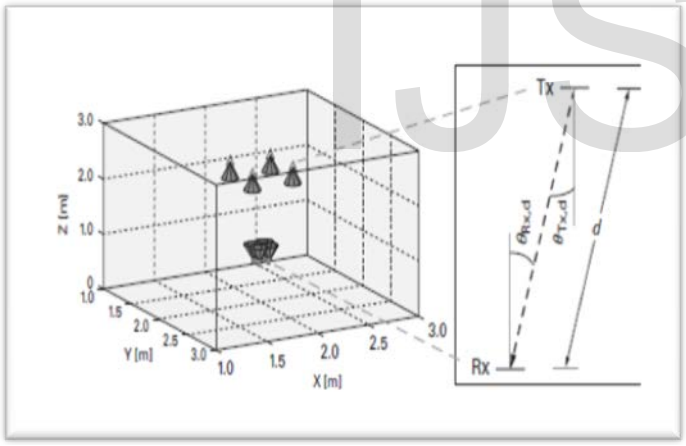

Figure 2: Geometric Scenario for Calculation of Channel Efficiencies

3 WORKING OF LI-FI:

As we know, the working of Li-Fi is based on VLC (Visible Light Communication) in which light acts as a medium of data transmission. The source of this medium (i.e. light) in Li-Fi technology is LED Lamp driven by lamp driver which in turn is directly connected to the internet. The flickering of LED's transmits digital data. This flickering can be modulated by the lamp driver either to speed up or slow down the transmission of data. This data contained light, emitted by the LED is received by a photosensitive device called photo detector which processes and amplifies it. Processing includes converting light signals into digital signals thus accomplishing the process of communication.

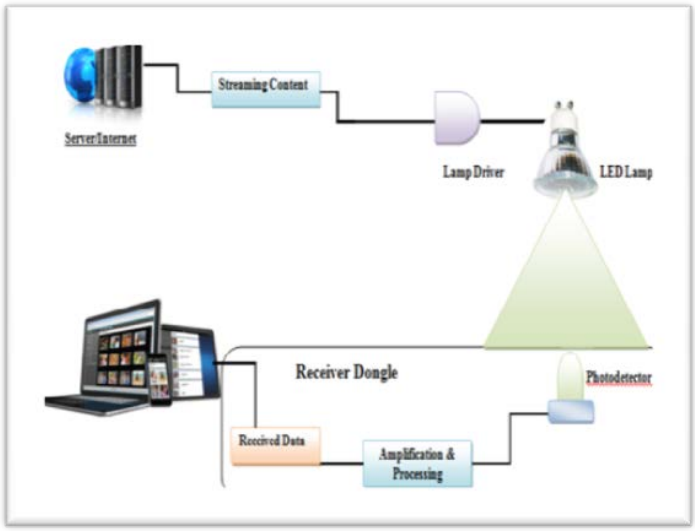

Figure 3: Flow Diagram for LiFi Working Schema

4 ADVANTAGES OF LI-FI

While deciding on any technology we take into consideration the advantages of that very technology over others. When taking the case of Li-Fi, we can keep many advanced, amazing and useful ideas in our mind. Like we can think of a technology that can allow us to download an HD movie within 30seconds as the data transfer speed for Li-Fi is more than 1Gbps[2].Some other interesting points that we can keep in mind while counting the advantages of Li-Fi are as under:

4.1 Availability: Li-Fi uses LED's as a medium to transfer data, allowing us to use simple light bulbs that can light our rooms as well as let us send and receive information. It just gives you liberty of transmission while just standing under any form of light. As the connection is made in the presence of light, you no longer need to be in any Wi-Fi enabled region. This easy availability of access points will reduce the internet usage charges and even you can imagine a world with free internet services.

4.2 Capacity: The spectrum available for the communication can increase the speed and users to the communication system. The 10ghtz radio frequency spectrum available for wireless communication can be replaced by a 10 000 times larger visible light spectrum which can be provided by each and every simple LED light source may it be a street light or an LED table lamp.

4.3 Greenhouse technology: Unlike the radio waves affecting our greenhouse Li-Fi is a Greenhouse technology having no ill effects on any form of life on earth.

4.4 Less Interference: You will experience less interference in transmission using light as light passes through easily may it be an ocean or any dense region

like forests where it is nearly impossible to establish Wi-Fi infrastructure.

4.5 Security: In transmission using Li-Fi technology you can implement security by just blocking the light, thus allowing easy implementation of security and hence a more secure data transmission.

4.5 Health risk: Even if not scientifically proved but it is believed that radio frequency signals are carcinogenic in nature and thus can be a threat to human health, whereas the visible light is safe to lighten your life and communication technique.

4.6 Existing Infra structure: For Li-Fi we can use the existing LED light sources as Access points thus reducing the cost of infrastructure development.

4.7 Energy Saving/Efficiency: In today's Wireless communication a large amount of energy is spent on the infrastructure and its maintenance than on the data transmission, e.g. lot of energy is used to cool down the base stations whereas you just need 60 watt simple LED bulb that can act as an access-point.

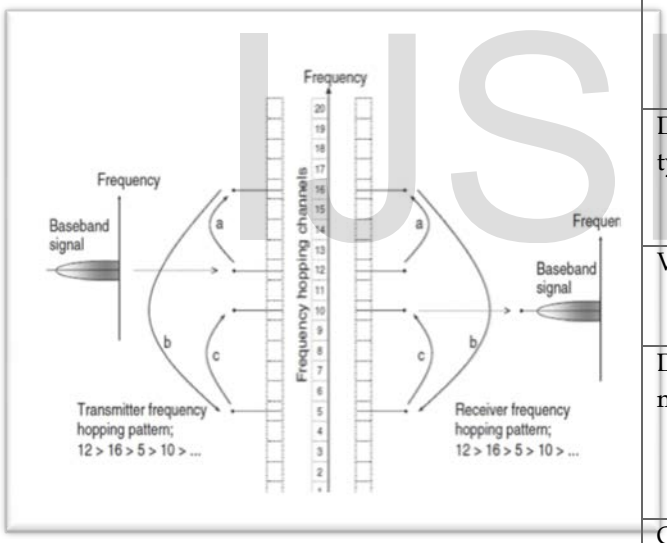

Figure 4: A Simple Explanation of FHSS

Technology	Speed	Data Density
Wi-Fi	150 Mbps	*
Bluetooth	3 Mbps	*
IrDA	4 Mbps	***
Li-Fi	>1Gbps	***

Table 1: Comparison between various technologies based on speed and data density

Following table 2 showing comparison between LiFi and WiFi Technology on different aspects to measure the performance for the end user devices in terms of wireless communication.

Features	Li-Fi	Wi-Fi
Security	More secure cannot be hacked	Less secure can be hacked easily
Medium	Visible light is used as a medium for transfer of data	Radio waves are used as a medium for transfer of data
Range	Range is limited up to 10 meters	Range is large can be extended up to 100 meters
Cost	It is cheaper as it uses the light	It is expensive as it uses radio spectrum
Topology	It uses point to point network topology	It uses point to multi point network topology
Data Density	Density of data is very high	Density of data is relatively very low
Value	Market value is low	Market value is high
Data transmission	Transmission of data takes place using bits directly	Transmission of data takes place using radio waves
Obstacle interference	Obstacle interference is very high	Obstacle interference is low or almost negligible
Availability	Almost available everywhere where there is light	Its availability is very low

Table 2: Comparison between LiFi and WiFi

Following Table 3: Comparison between Li-Fi and Bluetooth depicts major differences.

Features	Li-Fi	Bluetooth

Frequency	Light does not require frequency	2 4GHZ
Range	Based on LED Light	10 meters
Availability	Where ever light is available	WPAN
Data transfer	>1 Gbps	800Kbps
Power consumption	Medium	Low
Cost	Low	Low
Security	Highly secure	Less secure
Usage	Anywhere where there is availability of light e.g. Hospitals, roads, public places, under water etc	It can be used anywhere in the presence of other Bluetooth devices
Operating band	Operates at visible light band	Operates at 2.5MHz
Development	Development started in 2011	Development started in 1998

Table 3: Comparison between LiFi and Bluetooth

5 LIMITATIONS OF LI-FI

i. The main disadvantage of Li-Fi is that the light can't pass through objects, so if there is any object or any wall in between sender and receiver the signal will break at once.
ii. Interference from external sources of light like sunlight, bulbs, and opaque materials will cause disturbance in the transmission of light.
iii. Wi-Fi and radio frequency will be still needed in the remote areas where tree and wall will act as obstacle.
iv. VLC system has high initial installation cost ,but once it is implemented at large scale the cost can be reduced by its less operating costs like electricity bills, less maintenance charges and fewer operational staff.
v. Line of sight is must for VLC system, as light can't penetrate through solid surfaces, so transmitter and receiver need to be aligned in order to establish connection between them.
vi. Availability of light is must to startup a connection.
vii. It is very difficult to create completely new infrastructure for Li-Fi.

On the basis of current trends in technology and people's dependency on connectivity of devices and demand for high data rate we can conclude that LiFi would the most popular technology of near future which will be working as backbone for the infrastructure of Smart Cities and providing smart services to the end users with great speed and without effecting the health of end users. Manufacturer will start manufacturing all future devices with a LiFi Interfaces to connect with LiFi systems just as now a day almost every electronic devices have built-in Bluetooth and WiFi.

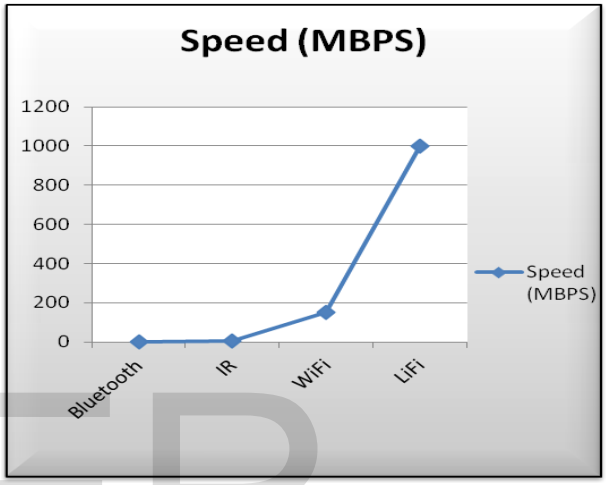

Figure 5: Graph between Speed and Technology

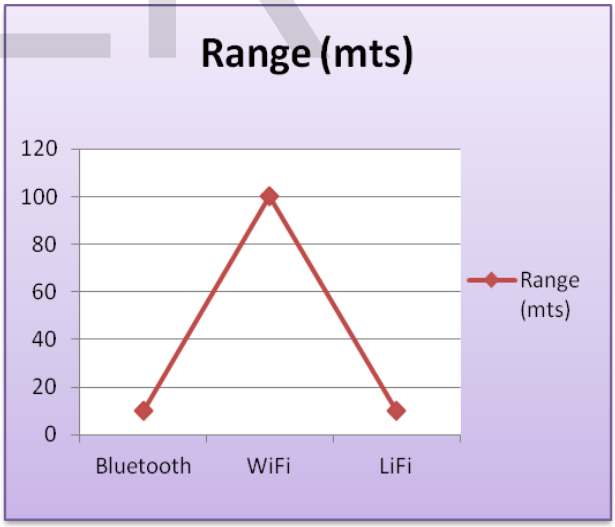

Figure 6: Graph between Range and Technology

6 APPLICATIONS OF LI-FI:

The efficiency, security, speed and other advantageous factors of Li-Fi technology makes us to implement this technology in various technological areas to make life more advanced, easy and more interactive. Some of the areas where we can use this technology are as under:

i. Li-Fi technology makes us think of a GPS

system for the cars that can receive traffic updates from the traffics lights e.g. information about accidents, traffic jams, road maps etc. Furthermore the Li-Fi enabled head and tail lights in our cars can enable car-to-car communication therefore possibility of a collision free traffic system.

ii. Li-Fi enabled setup of Plane-lights can be used to provide high speed connectivity to the passengers without any electromagnetic interference to hinder the communication system of the flight deck. Furthermore using Li-Fi will reduce excessive cabling that means a lighter plane

iii. Being highly secure the Defense System of any country can use Li-Fi for its highly confidential data transfers.

iv. The Conference Room lights can be used to increase the number of access points available for the participants in the meeting. Therefore the more access points the greater will be the speed of data transfers and downloads.

v. Since light can penetrate in water, we can use Li-Fi for under water wireless communications e.g. research and engineering, communication between ships, information about hurricane in the sea etc.

vi. In hospitals where security, interference and sensitivity of signals is an issue we can use Li-Fi which helps to install medical equipment that are highly secure or circulate investigation and diagnostic reports within a secure network. Furthermore using Li-Fi in the hospitals can provide online assistance to the doctors/surgeons without having any adverse effect on patient health as in the case of Wi-Fi.

vii. Li-Fi makes us think of the idea "Internet Of Everything" which means we can connect differ things in a network and add specific intelligence to them. By converting the lighting system at our homes to Li-Fi enabled lighting system we can connect all the ordinary appliances (refrigerators, washing machines, ovens etc.) used in our homes and can also enjoy the liberty of their remote control.

7 REVIEW OF RELATED STUDIES

Many wearable and portable devices, like personal communicators, cellular phones, laptops, are equipped with two or more battery packs. That leads to remarkable tradeoff between the device weight and/or size and the desired battery lifetime. To increase user flexibility in selecting the optimal form-factor/weight versus required lifetime trade off. For instance, the Compaq IPAQ PDA is equipped with an add-on module that contains PCMCIA expansion and an auxiliary battery pack. The user has the flexibility of selecting the optimal device with reasonable battery lifetime and weight/size. Recent work on battery-driven power management has demonstrated that: (1) sequential discharge is suboptimal in multi-battery systems and (2) lifetime can be maximized by distributing (steering) the current load on the available batteries, thereby discharging them in a partially concurrent fashion. Based on these observations, we formulate multi-battery lifetime maximization as a continuous, constrained optimization problem. That can be efficiently solved by nonlinear optimizers. While previously the lifetime has increased by 12% using scheduling algorithm. We show that a significant lifetime extensions (up to 160%) can be obtained with respect to standard sequential discharge. From the manufacturing standpoint, numerous issues must be faced when multiple batteries have to be accommodated into the case of a portable electronic appliance. They range from the selection of battery capacities and shapes to the design of the power supply circuitry (including the switching regulator that interfaces the various batteries to the current load). One degree of freedom that, so far, has not been fully exploited, is the policy to be used for discharging the available batteries. The main contribution of this paper is to develop new class battery lifetime maximization policies and state an approach for optimally tuning the policies for a given battery system [3]. Extending battery life for portable computing systems not only requires new power management techniques and high efficiency power delivery systems but also must addresses low power consumption modes. Mobile systems spend most of their operating time in very low power modes, in which the voltage regulators (VRs) that feed the different components typically exhibit low efficiencies. The advances in battery technology are not coping with the rapidly growing energy demands. Most laptops, handheld PCs, and cell phones use batteries that take anywhere from 1.5 to 4 hours to fully charge but can run on this charge for only a few hours. The battery has thus become a key control parameter in the energy management of portables. To meet the stringent power budget of these devices, researchers have explored various architectures, hardware, software and system-level optimizations to minimize the energy consumed per useful computation. Research in battery-aware optimization is now moving from stand-alone devices to networks of wireless devices, specifically, ad hoc and distributed sensor networks. Computationally feasible mathematical models are now available that capture battery discharge characteristics in sufficient detail to let designers develop an optimization strategy that extracts maximum charge [11]. Rao et.al presented a new battery management system for a lithium ion battery pack for more efficient operation and sturdy. The new system contains an embedded microcontroller to track the energy content of cell battery, optimize the output current, and provide extensive feedback of all the measurements taken. This system sends all data to a telemetry system so that the data can be relayed to a laptop via wireless signal. Two unique advanced features of the BMS are: the capability to optimize the battery pack energy and the ability to provide cell equalization. Since the BMS is used in an electric vehicle, very low power consumption is essential [7]. The experiments for this research work are done on different machines by running Win 7 OS. The installed operating system and other software are utilizing 32GB of the hard disk (10%). The display used in the studies laptop is the Super Extended Graphics Array Plus (SXGA+). It is a standard computer display with resolution of 1400×1050 pixels and ratio of 4:3. The screen resolution can be changes and varies down to 1024 x 768 pixels due to display preference or memo-

ry consumption. Also, the color quality can be set from low to high. The brightness can be reduced to the level of user comfort, which play big factor in saving battery power [7, 8].

Faheem Babar et all discussed the role of smartphone in changing routine life and the working habits of world , they figured out the domination of technology gadgets and new apps which totally changed the use of mobile phones, and now they are more towards needs rather than luxury which was considered in near past. Currently Mobile apps are facilitating in almost every field which is resulting in extensive use of mobile phones. One side these apps are considered as blessing while on the other side excessive use of mobile phone is creating some serious health issues. This paper is presenting a study about effect of mobile phone on human's life. [13]
Shahbaz Pervez et al discussed optimal power management and regeneration schema for longer battery backup which is ultimate requirement in data communication used by conventional wireless communication technologies and managing power for mobile communication devices is one of the biggest problem because of the power consumption by current scheme of wireless communication systems are providing connectivity with more power hungry wireless antennas [14].

8 FUTURE SCOPE:

Although not replacing the Wi-Fi technology completely, Li-Fi can be a cheaper, faster, secure, safer and efficient data transmission technology in future. Advancements to this technology can make every street lamp to be used somewhat like a Wi-Fi hotspot for transmitting data. It can be a technology that can help you avail the connectivity inside water, on Land or in an air-plane where interference in radio frequency was limiting the connectivity. Hence we can say in near future we can use light not only to enlighten our homes but Li-Fi can use it to light-up the world of transmission technology.

9 AUTHOR PROFILES & CONTRIBUTION

We have done this contributed paper to facilitate the researcher with new idea of much needed attention for LiFi Technology.

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