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Analyzing the Performance Issues in Lifi Technology and Proposed a Solution to Improve its Performance

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ABSTRACT

Light Fidelity (LiFi) is a wireless technology that transmits high-speed data using visible light communication (VLC) in the network systems. Light Fidelity technologies are becoming well-liked everyday due to their important role in different applications such as Hospitals, Smart Lighting, Underwater Communication and Harmful Environments etc. The Light Fidelity **(**LiFi) technologies are in front of different kinds of performance issues in the terms of Signal – to – Noise Ratio (SNR) and Bit – Error Rate (BER). We have done a near examination on different performance issues in Li Fi technology and finally proposed a solution to improve its performance. It was done in experimental approach to the proposed VLC model acknowledges physical layer models portraying the noticeable range mapped to a variety of optical modulation schemes.
. We also considered device mobility and direction which exclusively impact an optical receiver. We are also described the adopted physical models, the structure of the NS3 model implementation, and express performance assessment for an Radio Frequency (WiFi) and LiFi (VLC) situation. In this case, when we understand and known to analyze of the VLC (LiFi) downlink and the Radio Frequency (WiFi) uplink are paired using the combination of our NS3 VLC component and accessible NS3 in Radio Frequency modules. When we use the network simulator showed that how this situation can be concentrated regarding the Light Fidelity network in the VLC of Signal – to Noise – Ratio[SNR] and Bit – Error – Rate[BER] boundaries, and in the subsequent of the Network Performance measured.
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Key words: LiFi, VLC, SNR, BER, RF, NS3

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1. INTRODUCTION

1.1 Background of the Study

A remote optical systems administration innovation that utilizations light-transmitting diode (LEDs) for information transmission is Light devotion (LiFi). Light Fidelity is intentional to utilize LED lights like those by and by being used in numerous vitality mindful homes and workplaces. Notwithstanding, Li-Fi bulbs are set up with a chip that tweaks the light imperceptibly for optical information transmission Light Fidelity information is transmitted by the light emitting diodes bulbs and received by the photoreceptors. Light Fidelity (LiFi) near the beginning developmental models was accomplished of 150 Megabits-per-second. Some of the business units empowering that speed have been discharged. In the lab, with more grounded Light producing diodes and distinctive innovation, specialists have empowered 10 gigabits-per-second (Gbps), which is quicker than 802.11ad[1].

Light fidelity (LiFi) is newer wireless-communication systems which uses light as a carrier as an alternative of traditional radio frequencies, as in Wi-Fi. LiFi is a cutting edge thought in data innovation, one that focuses on eventually supplanting radio recurrence remote signs with those that originate from light sources. This type of technology is still being developed, and may have the possible to introduce greatly improved wireless services [2]. Light fidelity (LiFi) is a VLC Technology created by a group of researchers including Dr. Gordon Povey, Prof.Harald Haas and Dr. Mostafa Afgani at the University of Edinburgh.. The term LiFi was instituted by Professor Haas when he amazed individuals by gushing top quality video from a standard Light producing diodes light, at TED Global in July 2011. Light fidelity is now parts of the VLC criticize IEEE 802.15.7 standard.

LiFi is in general implemented using white Light emitting diodes light bulbs. These gadgets are generally speaking utilized for brightening by applying a steady current through the Light radiating diodes. Be that as it may, by quick and slight variations of the current, the optical output can be made to be different at extremely high speeds. Light Fidelity involves a broad scope of frequencies and frequencies, from the infrared through obvious and down to the bright range. The remote innovation of LiFi dependent on incorporates sub Gigabit and Gigabit class correspondence speeds for unidirectional and bidirectional information move utilizing view or diffuse connections, reflections and considerably more [2]. LiFi isn't restricted to Light emitting diodes or laser technologies or to a exacting receiving technique.

LiFi is a structure for these giving new capacities to current and future administrations, applications and end clients. This splendid thought was first show cased by Harald Haas from University of Edinburgh, UK, in his TED Global chat on noticeable VLC [3]. He clarified, basic, if the Light transmitting diodes is on, you transmit computerized 1; if it's off you transmit a 0. The LEDs can be turned here and there rapidly, which gives great open doors for transmitting information [3][4]. Dr. Harald Haas calls it as Data through light and he is able to flow HD video from a regular Light emitting diodes lamp.

Prof. Harald Haas started his exploration in this field in 2004, gave a presentation exhibition of what he called a LiFi model at the TED Global Conference in Edinburgh on 12th July , 2011. He showed an information pace of transmission of around 10Mbps. After two months he accomplished 123Mbps. [8]. In October 2011, various organizations and industry bunches shaped the Li-Fi Consortium, to advance rapid optical remote frameworks and beat the restricted measure of radio-based remote range accessible by misusing a very surprising piece of the electromagnetic range.

The innovation was exhibited at the 2012 Consumer Electronics Show in Las Vegas utilizing a couple of Casio advanced mobile phones to trade information utilizing light of alterable power emitted from the screens, noticeable a good ways off of up to ten meters [5]. Li-Fi has the upside of having the option to be utilized in touchy territories, for example, in airplane without causing obstruction. Later in 2012, Pure Visible light correspondence, a firm was set up to market Li-Fi and to achieve Li-Fi items for firms introducing Light emanating diodes lighting frameworks.

Examiners are using Visible Light Spectrum go between 400 THz (780 nm) to 800 THz (375 nm) concerning transmission of data since that is unblemished yet. We can achieve data pace of more than 1 GB/s using Li-Fi instead of 54-600 megabits for each second (Mbps) of Wi-Fi which is must for the current High Definition Digital world [6]. The sending and accepting is basic as we use transceiver built-in Light emitting diodes lamps for both purposes with normal lightening room property but in Wi-Fi we use modems for only data transmission. Obvious light correspondence is an information correspondence Medium, which utilizes noticeable light between 400 THz (780 nm) and 800 THz (375 nm) as optical bearer for information transmission and light. Quick heartbeats are utilized for remote transmission. The correspondence framework parts are: A high splendor white Light radiating diodes which goes about as a correspondence source and Silicon photograph diode which shows great reaction to noticeable frequency area [39] .

LiFi innovation will in future empower quicker, progressively dependable web associations, in any event, when the interest for information utilization has grown out of the accessible gracefully from existing advancements, for example, 4G, (Light Emitting Transistor) LET and Wi-Fi. It won't supplant these advances, yet will work faultlessly close by them [38].

Utilizing light to convey remote web will likewise permit network in conditions that don't as of now promptly bolster Wi-Fi, for example, airplane lodges, clinics and perilous situations. Light is as of now utilized for information transmission in fiber-optic links and for point to point joins, yet Li-Fi is an uncommon and novel blend of advancements that permit it to be all around received for versatile ultra-fast web correspondences [7] .

Move information starting with one spot then onto the next is one of the most significant everyday exercises. The current remote systems that interface us to the web are extremely moderate when different gadgets are associated. As the quantity of gadgets that get to the web expands, the fixed transfer speed accessible makes it increasingly more hard to appreciate high information rates and interface with a safe system. These days, Everyone is keen on utilizing his cell phone, PC to speak with others through Wireless-Fidelity (Wi-Fi) frameworks, and this innovation, Wi-Fi, is generally utilized in every open zone like home, bistros, lodgings and air terminals by individuals, likewise the time use of remote frameworks is expanding exponentially consistently; yet the limit is going down, because of the impediment of Radio Frequency (RF) assets, so we will experience the ill effects of serious problem [8] .

Security issues in light fidelity (LiFi) technology are vulnerable to a variety of attacks. Its security is a vital and difficult issue to consider when designing network system [16]. A study of security issues in Li Fi technology have many properties such as: Integrity, brilliance, availability and confidentiality. These properties are important to secure it. As a result, security standard services such as confidentiality, integrity, availability, authentication and access control. We will study the threat, attack, and a study of security issues in Li Fi technology of network system. However, the main goal of this study was to describe different types of analysis security issues in Li Fi technology of network system using network simulator version three (NS3) Simulators which was chosen because of its high reliability under a new powerful graphical user interface, optical communication systems to obtain accurate results and propose a solution to improve its security [29].

Most by far of noticeable light correspondence "VLC" examination to date has concentrated on the improvement of the physical medium. Although some initial work on the performance of hybrid RF/VLC (LiFi) systems has been explored [40], we have lacked strong tools to perform system performance studies that incorporate large cross networks involving VLC components Current system test systems, for example, OPNET, NS2, NS3, OMNeT++ and NetSim have the structure to help assessment of huge scope systems;

however they don't have the capacity to assess noticeable light correspondence (VLC).
.This has spurred our work in the advancement of a VLC segment inside NS3 so as to offer open sources organize level obvious light correspondence (VLC) test system [44]. System test system form three (Ns3) is an open-source discrete-occasion organize test system that gives an open situation to arrange designers and analysts. The accompanying have driven us to choose NS3 as the test system where we actualize our obvious light correspondence (VLC) part:

The quantity of NS3 clients, engineers, and specialists has been multiplying since 2013 [29].

- NS3 is open source and unreservedly accessible for analysts keen on assessing framework level arrangements.
- NS3 comprises of a lot of libraries and other outer programming libraries that can be consolidated together to assess huge systems with an assorted variety of access advancements.
- NS3 convention substances are intended to be near genuine gadgets regarding execution which takes into account examination of enormous systems without the need to send the physical framework.
- NS3 portability models can be finished to fuse direction, making it conceivable to dissect the impact of gadget versatility on obvious light correspondence (VLC) organize arrangements where VLC point reliance separates it from radio recurrence (RF).
- NS3 recreations bolster constant schedulers that permit them to cooperate with genuine frameworks [44].

According to [21], A new component, visible light communication "VLC" as an extension of the NS3 core libraries. The part comprises of classes and models for researching VLC based systems. The component contains a VLC channel representation, VLC mobility representation, VLC aides and model scripts. Aides are to comprehend actualized to control enormous scope noticeable light correspondence systems while the VLC channel and versatility models consolidate separate attributes of VLC. In assessment, we present aftereffects of test contents utilizing an assortment of balance plans, for example, Variable Pulse Position Modulation (VPPM), OOK. and Pulse Amplitude Modulation (PAM). We assess the nature of information transmission through SNR, BER and over an asymmetric Radio frequency or/ Visible light communication connection.

There are many problems on the existing research of a study of security issues in LiFi network technology. Several kinds of attacks carried out in network boundary like impedance from outside light sources like daylight, ordinary bulbs, hazy materials in the way of transmission will cause interruptions in the communication, doesn't work in the dark or light can't pass through objects and needs line of sight (LOS) and getting gadget would not be move in indoors [9]. This study analyses security issues and performance aspects of Li Fi network technology, more specifically, the current study addresses security risk, vulnerabilities, and performance factors and solutions Li Fi technology in relation to performance.

The remainder of this paper is structured into 5 sections as follows: Section 2: Literature Review, Section 3: Methodology, Section 4: Network Design, Simulation Study And Performance Evaluation, Section 5: Results And Discussions, Section 6: Conclusion and Future Works.

2. LITERATURE REVIEW

The related resources i.e. books, articles and research that we reviewed for this study are discussed in this section.

2.1 Overview Li – Fi Network

Li-Fi represents Light Fidelity'. Li-Fi is transmission of information through enlightenment by removing the fiber from fiber optics by sending information through light discharging diodes (LED) light that changes in force quicker than the natural eye can follow. Li-Fi is the term some have used to name the quick and modest remote correspondence framework, which is the optical variant of Wi-Fi. Light reaches about all over the place so correspondence can likewise oblige light without any problem. Light Fidelity is a part of optical remote correspondence which is a rising innovation. By the teacher of portable interchanges at the University of Edinburgh, UK, first time publically showed the confirmation of Light Fidelity (Li-Fi), a technique for Visible Light correspondence (VLC). Li-Fi is the exchange of information through light by removing fiber from fiber optics and sending information through LED light [9].

Li-Fi innovation gives transmission of information through brightening by sending information through a light radiating diode (LED) light that shifts in force quicker than the natural eye can follow. Wi-Fi is incredible for general remote inclusion inside structures, while Li-Fi is perfect for high thickness remote information inclusion in kept region and for mitigating radio obstruction issues. Li-Fi gives better transmission capacity, effectiveness, accessibility and security than Wi-Fi and has just accomplished blisteringly fast in the lab. By utilizing the minimal effort nature of LEDs and lighting units there are numerous chances to abuse this

medium, from open web access through road lights to auto-guided vehicles that convey via their headlights.

Haas imagines a future where information for Laptops, Tablets and Smart Phones will be transmitted through the light in a room. By utilizing LiFi in all the lights in and around a structure, this innovation could empower more noteworthy zone of inclusion than a solitary Wi-Fi switch. Lifi utilizes obvious light rather than Gigahertz radio waves for information move which makes it quick and modest method of remote correspondence [22].

Li-Fi assuming a significant job to defeat the deficiency of radio signs data transmission by utilizing light source. Its execution is getting the beginning and making an incredible unrest in remote system documented. Various analysts and researchers are accomplishing their incredible work done to illuminate the basic issue of Li-Fi. Some improvement advances and issues are talked about in different exploration papers which are clarified as beneath with the great contribution of researchers: Mushammad Usama, Kamran Saeed et. [11], has proposed a new method for Li-Fi using new technology i.e. Mobility in IP-based Communication Approach. They formulated a problem in Li-Fi technology i.e. loss of connection due to obstacle occur between source and destination as light signals can't penetrate through the building walls due to which loss of connectivity in mobile users takes place [21].

2.2 Component of Li Fi Networks

The principle segments of Li-Fi framework are as per the following:

- A high splendor white LED, Which goes about as a correspondence source.
- A silicon photodiode which shows great reaction to noticeable frequency locale filling in as the as the getting component. Driven can be turned here and there to create computerized series of 1s and 0s. Information can be encoded in the light to produce another information stream by fluctuating the glimmering pace of the LED. To be more clear, by between 400 THz (780 nm) and 800 THz (375 nm) as optical transporter for information transmission and enlightenment [8].

2.3 LiFi Access Point System

Li-Fi Access Point System as shown in Figure 1 works by using the accessible lighting in a building and replacing the conventional lights, with Li-Fi AP (Access Point) LED lights. The lights can then be connected together with an Ethernet cable, which will connect them all to the main network and possibly power the lighting. The LED bulb will send signals to devices on the network and provide lighting for the room. Another part of the AP will receive signals from the Li-Fi clients, creating a bidirectional full-duplex connection. In other words Li-Fi allows for two way communication between two Li-Fi devices at the same time. Li-Fi APs also allow for multiple devices to be connected to them as Wi-Fi APs also permit [12].

2.4 The Architecture of LiFi

According to [12], the paper categorized the architecture based on layered. Figure:1 is the layered architecture of LiFi. In layered engineering, LiFi comprise of 3 phases for example application layer, MAC layer, and Physical Layer. IEEE 802.15.7 characterizes just two standard for example PHY and MAC layer.

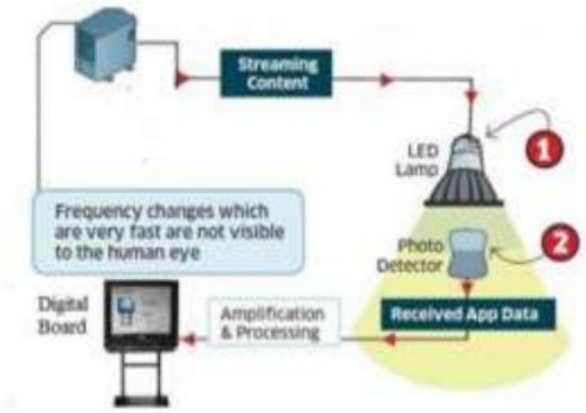

Figure 1: Access Point System of Li – Fi

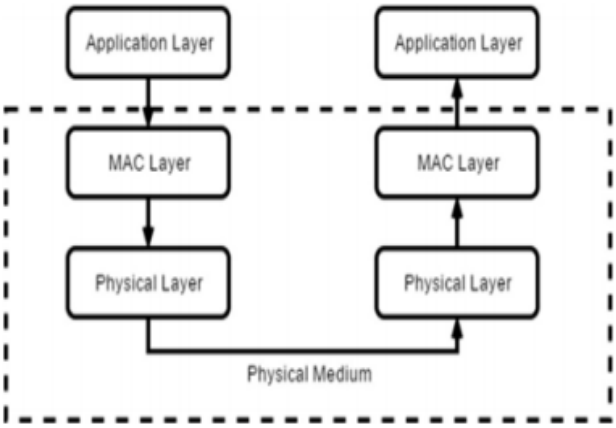

Figure 2: Architecture of LiFi [13]

2.4.1 IEEE 802.15.7 Layered Architecture

2.4.1.1 PHY Layer

PHY layer mindful in transmission and gathering, opening and deactivation of optical handset, and recognition of condition of transmission channel, is it inactive or occupied state. There are 3 activity modes in PHY layer (Table 1). The distinctions of every activity modes are appear in table

Table: 1: Operation Modes PHY Layer [13]

Operations modes	Usage	Categories	Rate
PHY I	Outdoor	Low	11.6 Kpbs – 266.6 Kbps
PHY II	Indoor	Moderate	1.25 Mbps – 96 Mbps
PHY III	Multiple optical transceiver	CSK Modulation	12 Mbps – 96 Mbps

2.4.1.2 MAC Layer

Three system topologies are characterized in MAC layer: Peer to peer, broadcast and star[12].

2.4.1.2.1 Peer to peer: - There are two devices that communicate. One of them is act as a coordinator.

2.4.2.2 Star: - Communication occurs in a few gadgets. One of them is go about as an organizer and it's utilized as a light foundation.

2.4.2.3 Broadcast: - One gadget for example A facilitator sends information to a few gadgets. The correspondence is unidirectional way.

2.5 Common LiFi IEEE 802.15.7 Standard for Visible Light Communications

The IEEE802.15.7 draft standard for VLC was produced few years ago This standard spreads both the physical layer (PHY) air interface and the medium-access control (MAC) [14]. The 802.15.7 draft standard is significant for our VLC community because we may now begin to develop products that will be compliant with a future international standard. It also provides a minimum benchmark for future developments. If enhancements are to be proposed to the standard, these enhancements must be based on a significant benefit over what is already written into the proposal. In the following paragraphs I will try to summarize some of the key parameters within the 802.15.7 standard. [13]

The standard is being proposed for an assortment of noticeable light correspondence "VLC" applications identifying with Wireless Personal Area Networks (WPAN). The MAC presently underpins three numerous entrance topologies; shared, star setup and communicate mode.

The MAC likewise handles physical layer the executives issues, for example, tending to, crash shirking and information affirmation conventions. The physical layer is separated into three sorts: PHY I, II & III.

PHY I: which can be designed for outdoor, low data rate applications. It provides data rates in the range 12 – 267 kbit/s. Convolutional and Reed Solomen codes can be used for forward error correction, and OOK or VPPM are used for modulation.

PHY II: indicates that to design for indoor operation with moderate data rates in the range 1.25 – 96 Mb/s. Reed Solomen codes can be used for forward error correction, and OOK or VPPM are used for modulation. Note that to accomplish 96 Mb/s an optical clock pace of 120 MHz is required which most off the rack optical gadgets won't support. At the more reasonable clock pace of 15 MHz an information pace of 9.6 Mb/s can be accomplished. [13].

PHY III: it is also designed for applications where RGB sources and detectors are available. It provides data rates in the range 12 – 96 Mb/s. Again Reed Solomen codes can be used for forward error correction and this time CSK with 4, 8 or 16 colour constellations are used.

2.6 Key Potentials of Li-Fi Based Network

some of the key potentials of Li-Fi based network are given below

2.6.1 Multiple Accesses in Li-Fi

Li-Fi can suit numerous clients with concurrent system get to [16]. Optical space division different gets to (SDMA) can be helpful which utilize a point decent variety transmitter. When compared with the optical time division multiple accesses (TDMA) technique, it has been shown that optical SDMA can achieve more throughputs with in a Li-Fi network. Be that as it may, such execution improvement requires cautious plan of the point assorted variety transmitter and tedious client gathering calculations dependent on comprehensive inquiry.

OFDMA gives a straight forward strategy to multiuser get to [17] where clients are served and isolated by various symmetrical subcarriers but subcarriers with lower frequencies generally provide users with high SNR statistics. Therefore it is important in OFDMA to use appropriate user scheduling techniques to ensure that fairness in the allocation of resources (subcarriers) is maintained. In order to enhance the throughput, non-orthogonal multiple accesses (NOMA) was proposed which utilize the broadcasting nature of LEDs, the performance of a Li-Fi network can be efficiently enhanced with the application of NOMA. NOMA is unique as compare to orthodox multiple access technologies because it can serve an increased number of users by using its unique resource allocation method which is non-orthogonal in nature [17].

2.6.2 Li-Fi based Internet AP

In an indoor Li-Fi based system [18], each lighting place in a room can go about as an optical passageway (AP). On the off chance that the separation between APs is little, at that point the impedance between them is unavoidable. This issue can considerably affect the performance of a network. To solve this issue, angle diversity based optical photo detector is proposed to mitigate the LOS interference. This optical photo detector is consists of narrow FOV along with multiple number of directional photodiode. The indoor based Li-Fi network is comprises of two parts, Li-Fi Access Point (AP) and the Li-Fi terminal.

The Local Area Network (LAN) of Li-Fi is consists of two layers, MAC layer and PHY layer. The PHY layer guarantees the efficiency of data stream whereas the MAC layer is used to manage the flow between transmitter and optical receiver. It also guarantees that the information is properly transmitted and received in to the form of frames. The MAC layer uses an RJ45 port to connect with the switch. The digital module of PHY layer is used to process the transmitted data stream and LED received an encoded digital signal which is transmitted using an LED light. An optical photo detector is used to receive the beam of a light at receiver end. This optical photo detector transform optical signal back to original data signal [18].

2.6.3 Hybrid indoor System based on Li-Fi and Wi-Fi

Li-Fi networks can achieve high throughput by deploying large number of APs [19]. Be that as it may, the spatial conveyance of the information rates vacillates because of the CCI. So as to expand the framework execution and to ensure similarly high Caliber of Service (QoS) among clients, Wireless-Fidelity (WiFi) overlay can be deployed. As Li-Fi is using a different band of frequency spectrum as compare to Wi-Fi so there is no impedance among these frameworks. Therefore, a hybrid system consists of Wi-Fi and Li-Fi network is capable of achieving the desirable throughput. Wireless Gigabit Alliance (WiGig) is one of the latest member of Wi-Fi family can be considered for hybrid network. This latest protocol can operate on three bands of frequency and also consists of some modern advance features. By considering a half breed arrange between Wi-Fi and Li-Fi, client's at all potential areas inside an expanded inclusion territory can profit by altogether improved client throughput and QoS. This hybrid system can provide benefits of reduction of contention as a result losses of spectrum efficiency will reduce. Li-Fi system can provide offload to the present Wi-Fi system and additional benefit of coverage at dead spots can be achieve [23].

2.6.4 Li-Fi as Intelligent Lighting

Li-Fi system can act a smart system by giving an advance feature of power saving. The brightness level of lighting system can be controlled according to the number of users and their requirement to save power by using sensors. These sensors can be deployed to monitor multiple parameters such as intensity of light, blinking level of LED and its color.

The coverage area of a light emitting (LED) transmitter can also be controlled by using dimming level of a LED transmitter. This intelligent lighting system can provide a smart solution to control the power consumption of LEDs. These networks can be used in smart home systems [20] where LED based lighting can provide illumination and data communication at the same time. In these smart homes devices which are used for data communication such as laptop, cell phone, and other smart devices can also perform short distance communication at high speed using visible light spectrum.

2.7 Analyzing Security Issues for Li-Fi Based Communication System

The Li-Fi based communication system faced different kinds of security issues. These issues limit its performance and can decrease the overall efficiency of the network. A portion of the principle issues are given underneath:

2.7.1 **LED Related Issues**

Some of the light emitting diode (LED) related issues are listed as follows:

2.7.1.1 LED Light ON-OFF Mode

Indoor Li-Fi based communication system aims to provide illumination with communication, so ON-OFF speed of a LED plays a vital role. For a Li-Fi based system it is always compulsory to have a Light source in ON condition but it initiates main problem of how data transmission will occur when the LEDs are turned OFF.

A data transmission can still be possible if brightness level of a LED transmitter is very low. The dimming level of LED bulb can be organized in such a way that a desired data rate can be achieved using light intensity. In hybrid setup, radio frequency (RF) or infrared can be useful to provide communication in LED OFF mode but in Li-Fi based communication it is still a challenge to find a suitable solution of how communication will be possible in any undesirable situation when light emitting diode (LEDs) are in its OFF mode [23].

2.7.1.2 LED Junction Temperature

The management of thermal temperature is a critical design issue of high power LEDs. High junction temperature can affects spectral efficiency. Junction temperature of LED can be increase due to variation in drive current, self-heating and ambient temperature. This high junction temperature could cause degradation in power of a single with respect to time which reduces the signal to noise ratio (SNR) and degrades the lifespan of LEDs [21]. The effect could cause serious problems if array of hundreds of LEDs are connected closer to each other in a lighting system at large scale.

2.8 Indoor Modeling Issues

Some of the indoor modeling issues are as follows:

2.8.1 FOV Alignment

In Li-Fi network an assumption is consider before communication that transmitter and receiver have a LOS connection. The LOS connection can provide high data rates because the transmitter and receiver are aligned their FOV to maximize the channel response. Nevertheless, in real life practical scenarios, a receiver FOV can be changed and it can also move from one place to another [20]. The change in orientation of a receiver and its mobility suggest that receiver's FOV cannot always be aligned with the transmitter. Therefore it is essential to design such techniques which can handle the scenario of FOV misalignment and provides desirable data rates. This needs modification in schemes and development of new approaches to handle this problem but designing such schemes and methods is extremely challenging and it is an important direction of future research [21].

2.8.2 Shadowing

The data rate in Li-Fi network will decline if an obstacle blocks the LOS channel as a result overall performance of the network will degrades. Not enough research is done until now to understand the indoor model and effect of shadowing on Li-Fi [22]. Shadowing could be one of the reasons of LOS channel blockage and it can produce variations in received signals therefore it is necessary to have a mechanism to provide an alternative wireless connection in a typical blockage event. It is also possible that the blockage event is of very short duration caused by the passing of obstacles or humans so it necessary to propose such a schemes and mechanisms that can provide a solution of problems such as FOV misalignment and shadowing [21, 22].

2.8.3 Interference

In Li-Fi system light from any other energy source except of LED such as sun light or free ordinary electric light source can cause interference because it can interrupt the LOS channel between transmitter and receiver. The interruption in path of transmission will affect the data communication therefore for indoor communication new techniques are required to find solutions regarding this condition.

2.9 Receiver Design Issues in the Case of Mobility

Li-Fi receivers can consist of an optical photo detector or an imaging sensor for receiving the beam of light. The photodiode is more beneficial for stationary users because in this case receiver FOV can be aligned easily to the LED.The imaging sensor has comparatively larger FOV so they can be useful for devices which support mobility but imaging sensors are less energy efficient and also produce delays in data reception as a result can decrease the overall achievable data rate. Therefore it is challenging to design such an optical receiver that can control FOV misalignment and increase robustness. Hence for both static and mobility cases, an enhancement in optical receiver design is needed to ensure high data rates along with power efficiency.

2.10 Li-Fi Internet Connectivity Issues

For Li-Fi based broadband access network, it is essential that LEDs driving circuit is connected with internet [23]. The expense of web arrangement for Li-Fi and the impedance of remote associations is a restricting variable which can decrease the feasible information rate utilizing web. Productive planning procedures are required to give desirable internet connectivity speed using LEDs at affordable deployment cost. Therefore it becomes a challenging task to propose a model which can provide internet using Li-Fi for large scale communication.

2.11 Up link Transmission Issues

A Wireless communication network is incomplete without the facility of uplink communication. In Li-Fi uplink requires that transmitter and receiver maintains a directional link during transmission. It can significantly reduce the overall throughput of the network if both devices are constantly moving. So, in Li-Fi also there is a challenge that how the uplink traffic in a network will be operate [13]. The radio frequency and infrared can be considered for transmitting uplink data in Li-Fi network but still more innovative ideas are require for solving the uplink issues in Li-Fi networks.

2.12 Connectivity and Coverage Area Issues

It is necessary for a Li-Fi system to maintain continuous and high speed connectivity within a coverage area of a Li-Fi cell and between the Li-Fi cells. So advance schemes for link layer are require which can maintain rate adaptation and frame aggregation to cope up with connectivity issues. In a Li-Fi based network it is essential that smooth handover of devices as well as handover of technology will occur for efficient communication in advanced Li-Fi based system.

2.13 Security Threats

In ongoing exploration [24] it is proposed by the specialists that Li-Fi system can likewise experience the ill effects of security dangers. An assailant might be available inside or outside a room can perform listening in utilizing the light signals. These signals can be obtained from gap between floor and door, cracks inside flooring or from partially shielded windows. This threat indicates that more research is required to understand and resolve the security issues and privacy concerns of Li-Fi network.

2.14 Security Concern of Li-Fi

Li-Fi network is highly secured than other wireless networks like Wi-Fi, Bluetooth, and Wi-Max etc. Its security features are described as follow:

Li-Fi is not public Li-Fi. It just works in indoor rather than outside so it can execute in areas or manufacture an atomic plant. Military and so on where high security is required as it drops the chances of framework hacking [25]. It's

information transmission happen at fast for example in nanoseconds which can't be perceivable by the human visual framework so human eye can't observe how data stream transmission is happening. They can only observe light and it will secure the system from cyber criminal's attacks and resist data manipulation over the network. It has no need of extra encryption standards like Wi-Fi because it has itself inbuilt security feature i.e. resistance against outdoor unauthorized usability.

In 2012, the paper distributed by Jyoti Rani and colleagues was Li-Fi-The future innovation in remote correspondence [26]. Through this paper it is comprehended that transmission is finished by removing fiber from fiber optics and information is sent through LED light. In 2014, Navyatha's gathering distributed the paper Li-Fi-Led based choices [27]. Equal information transmission is finished by utilizing any range of light like red, green, blue. In 2015, Gagandeep Kaur Virk distributed the paper Li-fi: A New Communication Mechanism [28]. Li-Fi is progressively secure as light waves can't infiltrate through dividers and can't be captured by anybody outside the brightening of light radiating diode (LED).

Recreation based testing can encourage to connote whether the time and money related speculations are significant. Reproduction is the most widely recognized methodology for the expanding and testing new convention for investigation of security issues in Li Fi innovation. A Number of points of interest are considered in this methodology, including lower cost, simplicity of execution, and authenticity of testing enormous scope systems. Simulation is not as perfect as real environment and that there are a number of popular analyses of security issues in Li Fi technology simulators available. Thus the designs of various simulators created are accurate and most useful for different situations/applications.
Numerous network details of analysis of security issues in Li Fi technology are not finalized and consistent. Constructing a analysis of security issues in Li Fi technology tested is very costly. Executing real experiments on a test bed is costly and has complexity. In addition, repeatability is basically compromised and it will affect the experimental results. It is inflexible to isolate a particular aspect. Furthermore, running real experiments is constantly time consuming. Therefore, analysis of security issues in Li Fi technology simulation is significant for analysis of security issues in Li Fi technology developers. These simulators permit users to separate different factors of tuning configurable parameters [29].

VPPM is a common modulation scheme for VLC to provide control over both communication and illumination. In [38], authors proposed Multi-Pulse Position Modulation (MPPM) by changing the number of pulses within one period of a symbol. The communication side of the proposed scheme is compared in terms of the normalized power requirement and spectral efficiency, to VPPM and variable OOK (VOOK). Another study in [39], combined pulse width modulation (PWM) and VPPM coding scheme to control dimming. The study provided the results in term of BER. Unlike our study neither authors in [38] nor [39], evaluate the performance of VPPM at higher layers. VLC can be joined with other system advances, for example, WiFi to build information rate and reduce the heap on RF range. Introductory work on the conjunction of crossover framework coordinating VLC and RF dependent on recreation and examination were presented in [13, 40–42].The work in [40] developed practical system implementations consisting of hybrid WiFi/VLC in which the uplink challenge is resolved using an RF-VLC HetNet.

In addition the authors observed system throughput and user experience for the Web browsing. The proposed module is integrated into ns3 core library and can be used with the exiting ns3 WiFi module to study the performance of heterogeneous networks (HetNets). There is other recent work on network performance using VLC. As per [44] thinks about framework throughput, inertness, and different boundaries in a framework involved free space optical systems administration joined with RF to provide multiple access.

According to [29], vehicular ad hoc networks (VANETs) based on simulation of urban mobility (SUMO) and ns3. The previously mentioned related-works center around reenactment of VLC inside a solitary layer and without down to earth approval in a genuine framework. Our work centers around coordinating VLC physical models, crossing various layers, fusing half and half models, and an approval in a test bed. Execution of the equipment parts of noticeable light correspondence (VLC) framework was proposed in numerous papers, especially the case of point-to-point configuration. The common point is that the demonstration consists of two parts: digital signal processing and analogue part where diverse modulation schemes can be used. In reference [43], for example, the signal processing part implemented on top of V irtex − 5 FPGA and the analogue front-end consists of a driving circuit, a commercial Osram (OSTAR E3B) high-power LEDs and trans-conductance amplifier. The receiver side utilizes photodiode, imaging optics, two stage trans-impedance amplifier, color filter and band pass filtering. According to [45], a throughput of 125 Mbps over the distance of 5 meters based on OOK is proposed.

The experiment setup consists of a single lamp with six chips where a luminous flux of 400 lumen is provided. In this testbed blue filtering is applied to overwhelm the slow component of the phosphorescent. Also the receiver utilizes a large area of 100mm2 of silicon diode to receive the optical signal in addition to the polymer lens with 70o FOV. The BER performance under luminance level of 800 lux is investigated.
The authors in [50], propose a Gbps VLC based on red, green and blue (RGB) is demonstrate. In this work, QAM is used on a discrete-multitone (DMT) where the link is utilizing wavelength division multiplexing. In this study, silicon avalanche photodiode, with large area, is used with glass lens

of 20mm diameter and 20mm focal length for detecting optical power. In addition, the testbed provides baseband bandwidth of 100 MHz. The receiver side also, implements a low-impedance amplifier to set the signal within the operation range of the photo detector. Reception and the software side were done using GNURadio.

The reason of using a single USRP is for the validation purpose and to reduce processing delay. In addition, multiple USRPs can be utilized in our testbed to provide multiple-input and multiple output VLC system (MIMO). GNURadio is very rich with various types of modulation schemes that can be used to process and demodulate the signal. Also, different types of LEDs can be applied to the front-end of the testbed. The receiver side can be any type of silicon photodiode receiver. In comparison with other VLC testbed, the feature of our testbed can be summarized in the following points:

1. In term of scalability:
   - A wide range of LED types and quantity can be used as transmitter in our test bed.
   - The test bed can utilize various software for signal processing (i.e large selection of modulation schemes).
2. In term of usability:-
   - The testbed is simple and provide point-to-point communication but can be extended to a complex form (i.e. multiple input multiple output (MIMO)).
   - The testbed is straightforward to implement and start the communication.
3. The testbed is efficient in cost.
4. The testbed is capable of evaluating real communication of VLC or hybrid VLC/RF network.[16]

Recently, authors began to investigate higher layer protocols based on a visible light channel. In reference [44] for example, efficient multiple access schemes based on different modulations is provided. The paper evaluated system throughput, latency, BER, etc. Furthermore, some studies of VLC vehicular networks are introduced in [45]. These studies gauge the performance of higher layers not limited to network layer.

Furthermore, network simulator version three (NS3) has been used with different tools to simulate the performance of vehicular networks. For example, NS3 and SHINE simulation tools are used to simulate packet transmission on vehicular networks and Vehicular Ad Hoc networks (VANETs) simulation based on SUMO and NS3 is studied in [45]. The purpose of this work is to provide a validated open source ns3 simulator to study VLC under different error mechanisms. As far as we could possibly know, none of the current work executed VLC into NS3 to concentrate huge VLC arrangements at or over the system layer. This work introduces an extended module to study and simulate VLC at higher layers based on NS3. The advantage of this work is to provide an openly available VLC simulator to study the impact of large-scale VLC deployments at and above the network layer [44][45]. From the above works we concentrated to improve the performance of LiFi.

3. METHODOLOGIES

3.1 Methodology of the Study

In the case of this research the following three stages of analyzing and designing was held. In the primary stage the proposed obvious correspondence innovation (VLC) module acknowledges physical layer models portraying the noticeable range planned to an assorted variety of optical balance plans. We additionally consider device mobility and direction which individually impact an optical receiver. The second stage we describe the adopted physical models, the structure of the NS3 model implementation, and demonstrate performance assessment for an asymmetric Radio frequency/VLC situation. For this situation, the VLC downlink and the RF (WiFi) uplink are matched utilizing the mix of our new NS3 VLC segment and existing NS3 RF modules. The third stage Simulations exhibit how this situation can be concentrated as far as VLC SNR and BER boundaries, and in the subsequent system execution estimated has been finished.

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3.2 Analytical Modeling of VLC Channel

VLC is implemented with Intensity Modulation (IM) and Direct Detection (DD) such that the signal is represented by variations in the immediate optical power and the received optical signal is directly converted to an electrical current. We assume that the optical transmitter has Maximum optical power limitation, C, and the source of optical emitter produces a direct optical power, X (t), in watts controlled by $0 \leq X(t) \leq C$. Since optical intensity is non-negative, a direct current bias is integrated into the signal. In a double use lighting and communication VLC system we have a light restriction that specifies average optical power. In order to achieve a specified average transmitted optical power, the signal may not necessarily utilize the entire range of the source. Accordingly, we define min(X (t)) and max(X (t)) as the minimum and maximum optical power and define the immediate optical signal power as $x(t) = X(t) - \min(X(t))$. Average optical power and average optical signal power are therefore defined as E[X (t)] and E[x (t)], respectively [45].

3.3. VLC Channel Model

When we taking into consideration a most important LOS path in a visible light communication system, the received optical power is represented by the item for consumption of the transmitted optical power and the direct current channel increase [13]. A primary difference between VLC and Radio Frequency is that VLC channel gain is extremely dependent on the angle of radiance, φ, and angle of incidence, ψ.

Assuming a Lambertian emission sample, the VLC channel increase is defined as [45]:

$H = \frac{(m1+1)A}{2\pi d^2} \cos^{ml}(\varphi)\ Ts\ (\psi)\ g\ (\psi) \cos(\psi)$ ……equation (1)

Where ml is Lambertian order, A is photo detector area (m2), d is distance connecting transmitter and receiver (m), Ts is optical filter increase, and g (ψ) is the increase of the receiver optics.

3.3.1 VLC Performance Model

The Channel quality can be evaluated by computing the SNR. The performance of a link is evaluated in terms of "Bit error rate" which is a function of the "Signal – to – Noise ratio" for a specified modulation scheme.

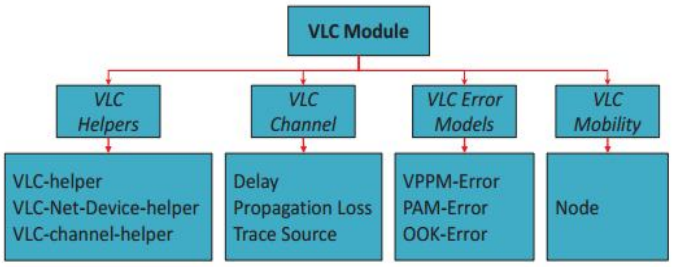

Figure 3: Implemented VLC Component

3.4 Design Requirements and Principles

In this section, we describe the VLC module is accessible in Figure: 3 and contains the following objects: VLC helpers, VLC channel, VLC error models, and VLC mobility models.

3.4.1 VLC Helper Classes

In order to easily create larger complex systems, we implemented three helper classes. Our helper directory is comprised of **VLC helper**, VLC **Channel helper** and VLC **Net-Device helper**.

The VLC helper handles the whole VLC system. This helper manages methods that relate the channel to the Net-Device and performs tasks such as creating Net-Devices. It also enables system protocols such as IP addresses, queues, etc. The VLC channel collaborator manages the connection between the VLC channel and the Net-Device, Node and Queue classes. We control this connection using the VLC channel helper. It also enables the addition of facial appearance such as propagation loss and delay attributes when creating a VLC channel. The VLC Net-Device helper handles the connection between the Node and the Channel. VLC is used to address the link between the Net-Device. In addition, also we used the "VLC" Net-Device helper to connect our error model.

3.4.2 VLC Channel Class

The VLC channel class represents an instance of a VLC channel and captures the unique optical characteristics required for accurate simulation. The Figure: 3 shows the attributes of the visible light communication "VLC" channel are: Delay, Propagation loss, and Trace source.

Delay: - represents the transmission delay from side to side the channel. **Propagation loss** is a pointer to the most wanted propagation loss model. **Trace source: -** can be indicates broadcast of packets from end to end the VLC channel. Each and every one are computed when we using the transmitter and receiver network device properties and the VLC Channel representation. The transmitted powers, Lambertian order, filter increase, photo detector area, receiver field of observation, and refractive indexes are properties used to evaluate the channel increase. With additional parameters for noise, the received SNR is evaluated. The Noise parameters include photo detector area, temperature, and electrical filter bandwidth. For more flexibility, these attributes are accessible by the user and can be modified to easily investigate their effects on the SNR, and network performance.

3.4.3 VLC Error Model Classes

The VLC link performance is studied using VPPM, PAM and OOK modulation. We introduced error models into the receiver's Net-Device to compute the BER for each scheme. The blunder model class comprises of models for every adjustment conspire. Every error model consists of the signal parameters such as α and M for VPPM and PAM respectively. The BER is evaluated according to the value of the SNR and the specified modulation scheme.

3.4.3.1 Error Model in VPPM Modulation

To determine packet drops, we use the Document Corrupt command, if a generated random number is less than the packet error rate (PER), the simulator rejects the packet delivery.

3.4.3.2 Error Model in PAM Modulation:

Just about the same method for variable pulse amplitude modulation[VPPM] is followed for pulse amplitude modulation[PAM], however the PER must description for the number of Bits (0 or 1 per Symbol. Remember that on – off – keying "OOK" is a separation of the PAM scheme with M = 2 such that "SER" and "BER" are the same.

3.5 VLC Mobility Class

The VLC Mobility portrayal is the direction of the transmitter and the collector gadgets. Therefore, users can evaluate the result of orientation on the link and network performance. The VLC mobility reproduction includes attributes for Azimuth, Elevation and Position.

Azimuth: - show that when we represents the left and right rotation of the device. **Elevation: -** indicate b**y** represents the up and down rotation of the device and **position**: - can be represents the device location. These attributes are used within the transmitter, receiver Net-Devices and the channel representation to determine the angle of incidence and the angle of radiance.

3.6 Tools

The following tools were used to check this work result

3.6.1 NS3 – Simulation

Network simulation version three (NS3) NS3 has been created to give an open, extensible system reproduction show place, for systems administration examination and instruction. In a nutshell, NS3 gives models of how bundle information systems works and performs, and gives a reenactment motor to clients to direct recreation tests. A portion of the motivations to utilize NS3 incorporate investigations that are progressively troublesome or impractical to perform with genuine frameworks, to examine framework conduct in a very controlled, bit of text condition, and to find out about how systems work. Clients will take note of that the available model set in NS3 centers around displaying how web conventions and systems work, yet NS3 isn't restricted to web frameworks; a few clients are utilizing NS3 to demonstrate non web – based frameworks.

There are numerous reenactment devices exist for arrange reproduction examines. The following are a couple recognizing highlights of NS3 as opposed to different tools.

- Network simulator Version 3 is planned as a lot of libraries that can be consolidated together and furthermore with other outer programming libraries. While some reenactment stages give clients a solitary, incorporated graphical UI condition in which all undertakings are completed, NS3 is increasingly secluded in such manner. A few outside artists and information investigation and representation instruments can be utilized with NS3. Notwithstanding, clients ought to hope to work at the order line and C++ and/or python software development tools.

- NS3 is principally utilized on Linux framework, despite the fact that help exists for FreeBSD, cygwin for windows, and nearby windows visual studio support is being created.
  .

3.6.2 Ubuntu 16.04.4 LTS

Ubuntu LTS, which represents Ubuntu "long term support", is a steady form of the Ubuntu Linux based operating system that is to a great extent focused toward movement grade server environments.. Ubuntu 16.04.4 "xenial xerus" is one of the most recent Ubuntu LTS release.

3.7 Data Sources

In order to find out solution for selected model area LiFi network design, the following two ways of data collection method was used.

1. Primary source: - by using the above simulation software, testing has been done on proposed design.

2. Secondary sources: - previous works that are already passed through the related with this research were used as secondary source.

3.8 Performance Design

Before simulation process, installation and configuration of NS3 in Ubuntu 12.04.5 LTS operating system was done. As describe in we consider the scenario illustrated in Figure: 3 to run our simulator.
The Li – Fi network design was done based on the following implementation plan steps:

- ❖ The connection between Node1 (Wi-Fi AP) and Node2 (Relay A) is a point-to-point connection with 2ms delay and data rate of 200 Mbps.

- ❖ The uplink between Node3 and Node2 is represented by using the accessible NS3 WiFi representation.

- ❖ The last connection between Node3 and Node4 (Mobile Terminal) is point to point with data rate of 200 Mbps and 2ms delay.

4. NETWORK DESIGN, SIMULATION STUDY AND PERFORMANCE EVALUATION

4.1 Network Design

The VLC design was done by rearranging and can be concentrated regarding VLC, BER and SNR boundaries, and in the subsequent system execution estimated**.**

4.2 Simulation Study

The simulation work of this work has been implemented in NS3. This simulation tool uses two types of programming language C++ and python.

4.3 Performance Valuations

Before simulation process, installation and configuration of NS3 operating system was done. NS3 is open-source under GNU GPLv2 permit. NS3 is extremely rich; here we give an outline of the segments of NS3 and start to exhibit how our VLC part is accomplished with these deliberations. The central part abstractions within Network simulator version (NS3) are as follows:

4.3.1 Node: we can represent of a network device (mobile terminal or access point) where different functionality can be added such as protocol stacks, peripheral cards, or Mobility functions.

4.3.2 Net Device: shows us installed inside a node and acts as a peripheral card or Network Interface Card (NIC). Net-devices allow a node to use a specific channel.

4.3.3 Channel: it also represents the communication channel in which data flows between nodes. Channels connect to nodes via Net-Devices and may be used by multiple nodes.

4.3.4 Helpers: indicates that we can used to manage large networks that consist of a lot of nodes, channels and Net-Devices.

4.3.5 Application: it tells that how the application represents basic abstraction that generates some activities to be simulated. These abstractions are collected (interconnected) to realize a network instantiation in NS3. In terms of basic function, NS3 provides models of how network packets flow and a simulation engine for users to go on with experiments What's more, NS3 demonstrates how to utilize utilities to dissect packet traces, one of which produces bundle catch (Pcap) follow documents. New modules can be speak to how to included and utilized with the available NS3 Libraries. NS3 underpins the improvement of new parts utilizing C++ or Python. In our work we have picked to utilize C++.

In order to create a new module in Network simulator version three, we can use the NS3 python create-module tool (*create-module.py*), which is writing provided, by NS3 to initiate a module framework and create directories.

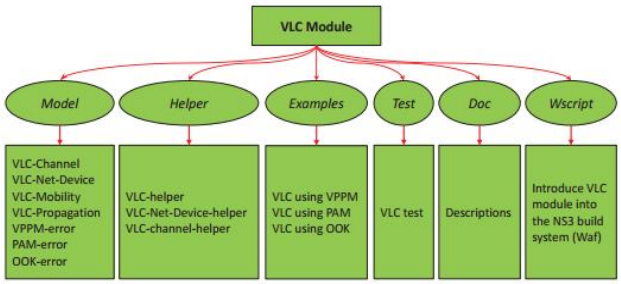

Figure 4: Extended VLC module structure

The all-encompassing VLC module structure appeared in Figure: 4. The module structure includes 6 indexes: Model, Helper, Examples, Test, Doc and Wscript. The **model** directory which contains the source and headers files of the VLC component classes. These include VLC channel, VLC propagation loss, VLC mobility, and Modulation scheme classes for error rate evaluation as a function of signal to noise rate (SNR) which is dependent on the modulation and coding scheme used.

The **helper** directory can be used to hold the visible light communication component helpers. The objective of the helper in Network simulator version three is to simplify the creation of complicated networks. The network Topology helper allows the transfer of internet protocol addresses to a set of nodes or to perform similar tasks on a container consisting of node, Net-Device, and channel objects. Theoretically, helpers are to organize code into a structure easily understood by anyone familiar with NS3.

An example directory is indicates that holds samples on how to use the module. The Test catalog which can be contains records used to check the accuracy of the segment of the system execution and the DOC index speaks to that contains documentation documents to clarify how the module functions and the extension and impediment of the module. WScript catalog it is likewise used to consolidate the new module with NS3 by acquainting it with the NS3 fabricate framework.

4.4 Simulator Experiment

To show the efficacy of our NS models we demonstrate the use of the system via an example scenario. We built a small network consisting of four nodes. The model with next jump addresses is shown in Figure 5. We used static routing to enforce packets flow in one direction across the network. The network Packets can be flow out from Node1 WiFi(AP) through a point-to-point connection to Node2 with Relay A, from Node2 to Node3 with Relay B using Visible light communication connection, then from Node3 to Node4 (Mobile Terminal) through a point-to-point connection.

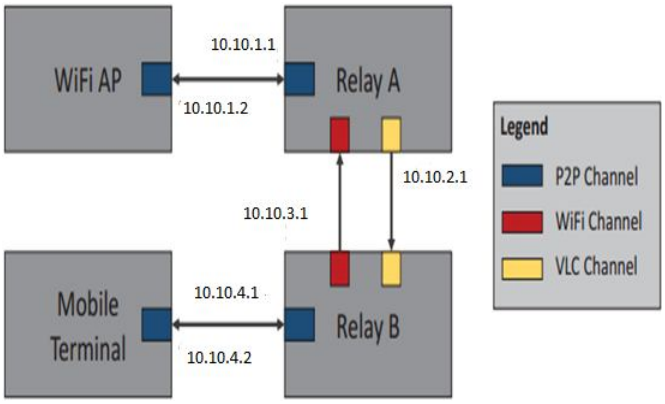

Figure: 5: Example Simulations

The equivalent process is frequent in the radio frequency on uplink but using Wi-Fi for the connection between Relay B and Relay A. when we can used the network tools to run the simulation using NS3 and collect the data across the VLC connection. We then plotted the collected data using gnu plot.

4.5 Simulation Settings

We consider the scenario illustrated in Figure 5 to run our simulator. The connection between Node1-Wi-Fi AP and

Node2 -Relay A is a point-to-point connection with 2ms delay and data rate of 200 Mbps. The uplink between Node3 and Node2 is represented using the accessible NS3 WiFi model. The last connection between Node3 and Node4 (Mobile Terminal) is point to point with data rate of 200 Mbps and 2ms delay.

Table 2: Parameters for Simulation

Parameter	Value
Transmitted Power, Pt	48.575(dbm)
Lambertian Order Semi angle, Φ1/2	70°
Filter Gain, Ts	1
Boltzmann's constant, k	1.3806e−23 J/K
Noise bandwidth factor, I_2	0.562
Background current IB	5100−6 A
Open-loop voltage gain, Gol	10
fixed capacitance of photo, Cpd	112pF/cm2
Field-effect transistor (FET) transconductance (gm)	30m/s
electronic charge, q	1.60217e−19 C
I_3	0.0868
Photo Detector Area, A	1.0e−4 m2
Refractive Index, n	1.5
field of view, ψcon	70°
Transmitter coordinate	(0.0,0.0,50.0)
Transmitter Azimuth	(0.0)
Transmitter Elevation	(180.0)
Receiver coordinate	(0.0,0.0,dist)
Receiver Azimuth	(0.0)
Receiver Elevation	(0.0)
α	0.85
Bandwidth factor, B	10
lower wavelength, λmin	380nm
upper wavelength, λmax	380nm
Distance, d	50m
Absolute temperature, Tk	290
Temperature	5000
FET channel noise factor	1.5
PAM, M	4
Electric filter bandwidth	5e6 b/s

The VLC can be it is also (LiFi) downlink between Node2-Relay A and Node3-Relay B is the designed VLC connection using the parameters provided in Table 2. To study the VLC connection at Network parameter when we created two moving Nodes equivalent to a transmitter and receiver using the VLC mobility representation inside Node2-Relay A and Node3-Relay B respectively. The VLC channel in Figure: 5 was implemented using VLC channel helper. It is also when we increased the separation between the source and destination from 0 to 50 meters. The quantity of transmitted data is 1MB, where each packet carries 1040 bytes using a TCP connection.

5. RESULTS AND DISCUSSION

In this research, we used NS3 simulation tool the good put results for VPPM, PAM and OOK modulation schemes are illustrated in Figures 6, 7 and 8 respectively. In Figure: 6 the good put is shown versus increasing distance between the transmitter and receiver. The results show that the good put is very high, reaching 9 ∗ 106 bytes.

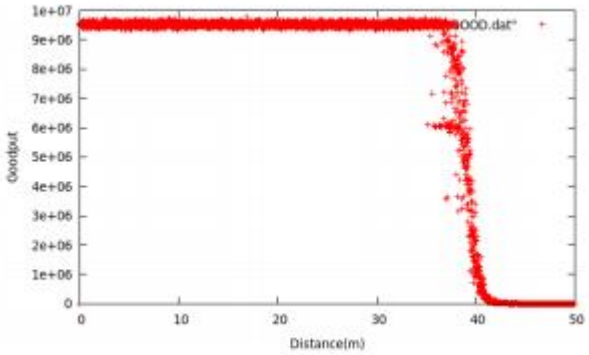

Figure: 6: VPPM – Good Put

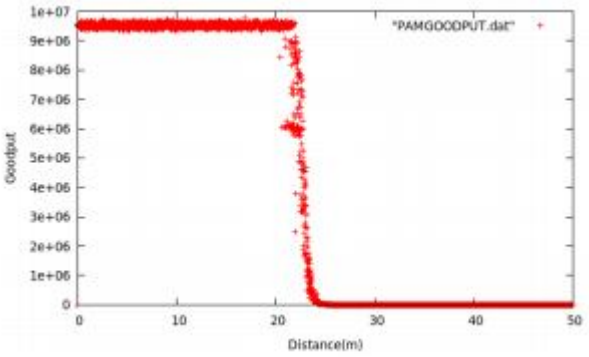

Figure 7: PAM – GOOD PUT

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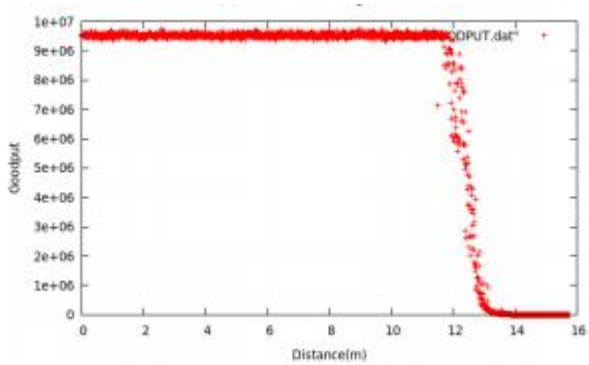

Figure 8: OOK – GOOD PUT

From the Figure 4 the expanded VLC Module Structure Simulation Results are as follows:
The simulation result show that when the distance between the Receiver and Transmitter is less than 38 meters. None of the packets were retransmitted. The good put decreases sharply beyond 38 meters. This is noted by high retransmission activity, resulting in collapse of VLC link to the point where good put reaches zero.

In above the Figure 6 the VLC link starts to breakdown at ≈ 25 m while this does not happen for VPPM until the receiver is ≈ 38m away from the transmitter. From the result VPPM outperform PAM in term of long distance communication as shown in Figure 7.
The OOK case, shown in Figure 8 it is also shows that when we the result to performs poorly in terms of good put as compared to the other two schemes. The VLC result show that the connection starts to deteriorate at ≈ 12m between the source and the destination.

The Bit Error Ratio (BER) for Variable pulse position modulation, Pulse amplitude modulation and on – off – keying schemes are shown in below figures.

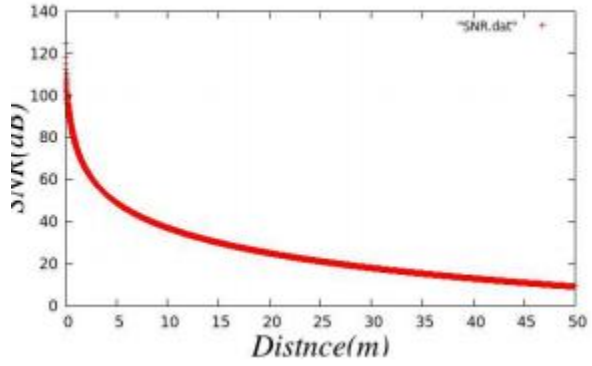

Figure 9: Simulation Results: SNR VS Distance

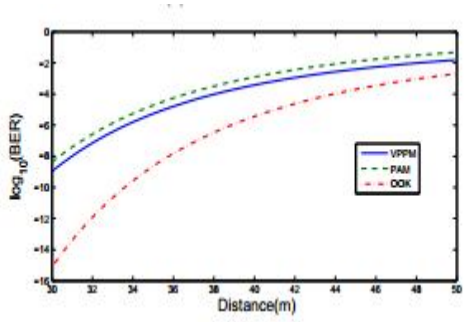

Figure 10: Simulation Results: BER VS Distance

In the above Figure 10. The simulation results showed that on – off – keying has lower Bit – Error – Ratio than VPPM and PAM but the simulation result show that increases sharply as distance increases. This causes the connection to fail faster than the other schemes. it is also the simulation result show as VPPM has higher Bit Error Ratio than On – Off – Keying because in our simulation parameter we set α (task cycle) = 0.85 while if α = 0.5 then VPPM will perform similar to On – off – keying in term of Bit error ratio. PAM has the highest BER among the rest. The reason is that it transmits more bits than VPPM and OOK which results in more error when the separation increases. The system SNR is accessible in above the Figure 8.When the distance increases, the optical power decreases according to equation (1) which leads to reduction of the SNR value to ≈ 16 dB at a distance of 50 meters as shown in Figure 9. From the experiment results, when the distance increased then the LiFi performance was affected due to SNR and BER. By implementing light-Emitters/Reflectors in the LiFi network especially around the coverage limit area, it may solve the SNR and BER problems and improve the performance of the LiFi network. The following Figure11 illustrates our proposed model.

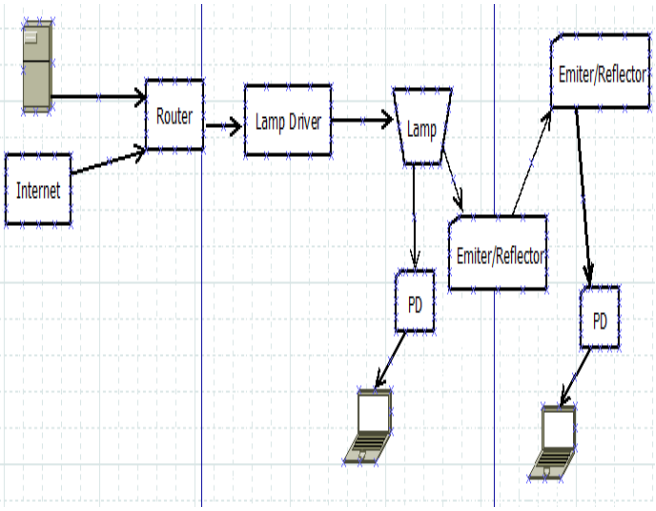

Figure 11: Proposed Model

6.CONCLUSION AND FUTURE WORK

6.1 Conclusion

In this Research we proposed and established to analyzed LiFi network technology how a variety of VLC physical layer modulation techniques and a baseline channel model can be simulated in the context of a larger model of a cross (hybrid) network system. Our approach is to approve accessible VLC channel and modulation techniques into a narrative illustration of network simulator (NS) to enable studies of cross upper connection in Radio frequency and down connection in visible light communication systems under most operating conditions. By the proposed network simulator VLC components can be explain when we explored the Bit – Error - Rate (BER) and high-quality put of VPPM, pulse amplitude modulation (PAM) and on – off – keying (OOK) analyzed in the LiFi network simulations

designed to show the effectiveness of the tool. In this study about the LiFi network simulation (NS3) results show that on – off – keying has lower than Bit – Error Rate (BER) but the LiFi network simulator tools shows that the result is radically increasing as distance increase comparing to VPPM and PAM. The simulation result showed that when the distance between the Receiver and Transmitter is less than 38 meters. None of the packets were retransmitted. The good put decreases sharply beyond 38 meters. This is noted by high retransmission activity, resulting in collapse of VLC link to the point where good put reaches zero. The reason is that it transmits more bits than VPPM and On – Off – Keying (OOK) which results in more error when the distance increases. The system Signal – Noise - Ration (SNR) is accessible in above the Figure 6. When the distance increases, the optical power decreases according to equation (1) which leads to reduction of the Signal – Noise - Ration (SNR). The proposed method may control the SNR and BER and it may improve the performance of the LiFi network.

6.2 Recommendations and Future Work

The future work will include Enhancements including:-

- The finding shows that it needs further work to use of Orthogonal Frequency Division Multiplexing (OFDM) and consideration for multipath effects due to reflections.

- We also anticipate dissemination of the work as open source. it would be good to critically investigate the security is our hope that this work will lead to new system simulations that will further enhance VLC as a possible new wireless networking technology.

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