Light Fidelity (LiFi) Based Medical Networking for Secure and Anti-Theft Data Transfer with Protection for Radio Frequency Devices

Hoimanti Dutta[1*], Abhinandan Sarkar[2], and Rajdeep Chakraborty[3]

[1, 3]*Dept. of CSE, Netaji Subhash Engineering College, Kolkata, India.*

[2]*Dept. of ETCE, Shree Ramkrishna Institute of Science & Technology, Kolkata, India.*

[1]*hoimantidutta.nsec@gmail.com ORCiD: 0000-0002-2232-0852*

[2]*abhinandansarkar12@gmail.com ORCiD: 0000-0002-5527-7301*

[3]*rajdeep_chak@yahoo.co.in, ORCiD: 0000-0001-6641-0860*

Abstract.

Light-Fidelity (LiFi) is a new way of data communication through the visible light spectrum (4.3×10^{14} Hz to 7.5×10^{14} Hz) coined by Prof. Harald Haas in 2011. Since, in the span of ten years a lot of work being carried out, recently it is claimed that a 26Gbps speed of data transfer being achieved. In this paper, we propose a representation of medical networking using LiFi. LiFi is also considered one of the secure physical layer data transfers and thus it can be effectively used as an anti-theft data transfer. The other advantage of LiFi-based networking is that it doesn't interfere with many radiofrequency devices such as MRI Scanner whereas the conventional Wireless Fidelity (WiFi) based network does. The only disadvantage of LiFi is that it works on line-of-sight. In this paper, we first give a brief introduction of LiFi and then describe LiFi in detail with architecture and mathematical equations. Then we give a detailed literature survey stating why LiFi is important for medical networking. We give a scheme of a proposed model thereafter and then we discuss the probable implementation and its features.

Keywords. Light Fidelity (LiFi), Light Fidelity (LiFi) based medical network, Light Fidelity (LiFi) based anti-theft data transfer, Secure networking, Radiofrequency devices

1. INTRODUCTION

With the development of communication systems, the necessity and dependency on networking have also increased. If we look around two to three decades back, long-distance communication was a difficult task for people. But it has become so cheap and inevitable now. We can see the development of a generation of networks from 1G to 5G which is further stepping toward 6G. With this increase in the necessity, congestion of networks, theft of data, loss of speed, and interference of signal has all got included in the network and communication system. In 2011, Professor Harald Haas, University of Edinburgh, coined the term 'Li-fi', due to which the whole outlook of the networking and communication system changed. He showed the use of visible light as a data carrier and named it Li-Fi – Light Fidelity. As the radio wave spectrum is congested due to the increase in demand for

mobile communication, the visible light spectrum is vacant and still not commercially introduced. The wavelength of visible light communication ranges from 350 nm to 750 nm, with frequencies ranging from 4.3 x 10^{14} Hz to 7.5 x 10^{14} Hz. Making it an excellent mechanism for data transfer.[1] This band is readily available in all indoor environments and does not interfere with other waves in the specified space. A commonly used solid-state device, LED, transmits the data from the transmitter to the receiver. As LED is a current-driven device, the modulation technique is also simplified. An LED is a p-n junction semiconductor device, whose current intensity can be controlled or regulated. The lifetime of the light-emitting diode is comparatively longer when compared with the other sources. If we consider fluorescent light as a source, the durability and efficiency of the LED are much better [2]. To send and receive data, the transmitter has to modulate the signal and the receiver has to demodulate the signal received. When we use led as a source, with only intensity modulation the data becomes suitable for transmission, we do not have to include phase and frequency modulation techniques. For transferring 1 bit of data at a time the on-off keying technique is used. So, it can be said that led proves to be a good transmitter point.

Though radio waves have a long-range, can be communicated to distant places, it becomes a disadvantage for it when we consider it from a data loss or theft point of view. There is attenuation in radio waves and theft of data, while using visible light, it cannot pass through any opaque object, keeping the range very secure to nearby places and known persons. Considering VLC as communication illumination is a factor for proper data transfer, so from this point of view also if we study, the range of visible light from a led will be constricted to an indoor space only. So, data theft can be minimized or eliminated, if we use VLC for our local networking. Furthermore, it is surveyed that the maximum of the traffic generated is in an indoor environment, so visible light communication can serve as a good source of wireless connectivity [3]. VLC is a low power consumption system, with uncontrolled bandwidth allocation. The future is predictive of a hybrid model for RF and VLC, which will impart a much faster communication model [4].

Section 2 gives details about LiFi Technology with The OOK modulation in Section 2.1, Section 3 gives the literature review and motivation, Section 4 illustrates the scheme of the proposed LiFi-based networking model in medical hospitals, Section 5 gives a probable implementation and its features. Finally, Section 6 draws the conclusion. References are listed at last.

2. THE LIGHT FIDELITY (LIFI) TECHNOLOGY

Data transmission through light fidelity will be a life-changing prospect in near future. This is a subset under VLC, developed and tested in the indoor environment when invented, but conquering many of its misconceptions, like Li-Fi is Los technology, it does not work on sunlight, dimming is not advisable, lights flicker a lot, no uplinking is possible, [5] it has emerged to be a technology for versatile applications. It has gained its control in the field of smart cities, healthcare, delicate industrial sectors, airlines, defence, underwater data transfers, and many more [6]. Though there is some restriction to using Li-Fi or visible light for communication like attenuation, interference, or noise [1], using some advanced modulation techniques like OFDM and adaptive modulation with coding, the loss of data can be minimized.

Let us now understand the architecture of light fidelity. As Li-Fi comes under visible light communication, we can easily understand the architectural flow between the transmitter and receiver. The architecture consists of a physical layer, medium access control layer, and the application layer, for more security purposes in mobile communication we can use a security layer before the implementation of the application layer. The below diagram shows the layered architecture of Li-Fi (Fig 1.)

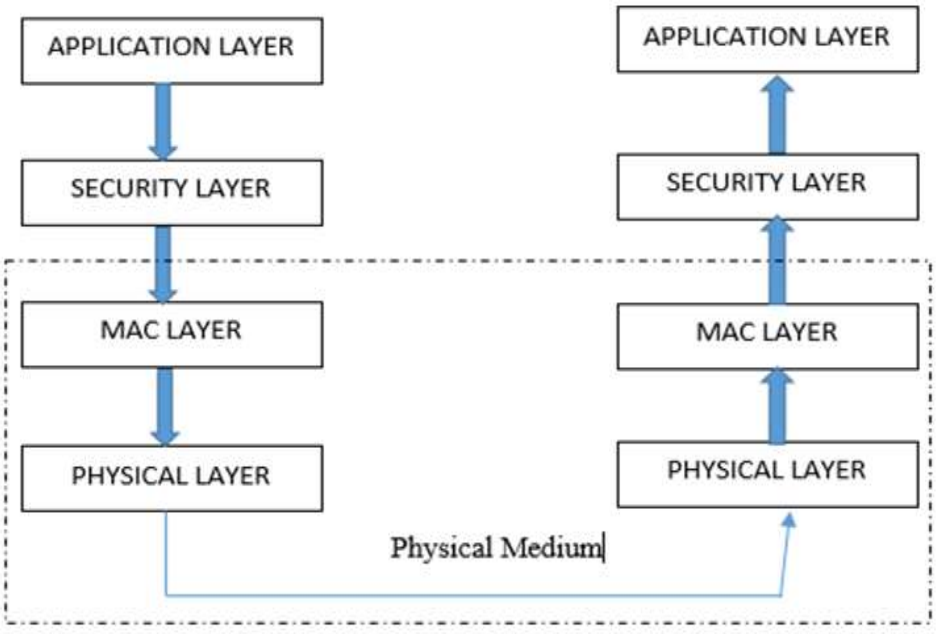

Figure 1. The layered architecture of LiFi

Discussing the physical system, we can design it for three sections: the transmitter module, channel, and receiver module. The transmitter module consists of the modulator and the light source, the channel is the distance between the transmitter and the receiver, the channel gain can be given by the equation 1 –

$$CC(f) = CL + CD(f), \qquad (1)$$

where CL is the path loss and CD is the channel gain [18], and the receiver section consists of the demodulator, signal conditioning and finally, we receive the data [7]. The data received in Li-Fi is non-coherent, positive, and real [1]. The received signal can be given by the relation $z = Lx + n$, where L is the multiple input LED channels.[12] Fig 2. Shows a physical system of visible light communication.

So, studying the complexity of systems, designs, and networking layers, it is understood that it can be established and used in many core application areas. Visible light communication or more specifically light fidelity will give a step forward towards the development of 6G communication. In Fig. 2, Blue arrows signify the outer channel of the communication and black arrows portray the inner channel of communication for both sender and receiver sections.

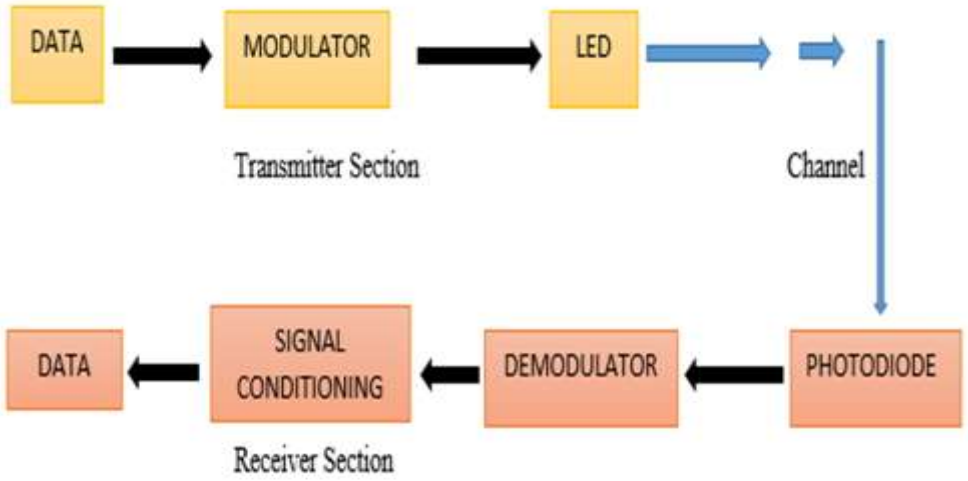

Figure 2. The physical system of visible light communication

While we develop some applications from new technology, understanding contemporary technology is very important, and in this article, as we propose to establish a complementary technology of RF spectrum, let us know some disadvantages of RF in the case of medical fields. Not only inside the medical premises, using radio wave spectrum for communication outside the medical buildings has a severe effect on the patients as well as the medical equipment of the Medical [8]. The equipment in the Medicals that are used for imaging or scanning of the human body, uses electromagnetic spectrum, frequency ranging in MHz, which interferes with the mobile networks near the building, and tends to give faulty results [9]. They imbibe noise within the signal and hamper the machine. Continuous propagation of radio waves inside the premises also has an adverse effect on the human body. The machines used in ICU get affected when the people inside the medical carry a mobile communication device with him/her. Not only on the machines, radiofrequency has a long-term effect on the human body, a study shows that when rodents are exposed to radio waves they mimic the lifetime human exposure, it also has an increased rate of schwannomas, malignant gliomas as well as chromosomal DNA damage. The brain development of children also decreases with exposure to mobile networks [10]. But knowing the effects on machines and human health, networking is also an integral part of life, without which a Medical cannot run. Proper communication between building floors, different wards, and laboratories is very important. Proper transmission of data is needed for prompt response and service deliveries in the healthcare sector. Li-Fi can be a stable alternative to these factors. The frequency used is very high in terms of 10^{14} Hz, and interference and signal fading are very minimal in Li-Fi. Due to the use of the current-driven solid-state device as transmitter output, modulation becomes easy, so the lagging of data is less, and the noise becomes very minimal when orthogonal modulation techniques are implied. Li-Fi can also be used for easy transmission of sensor data, making it suitable for use as patient monitoring device transmitters. The data can be easily received and plotted at respective storage areas [11]. As discussed previously, visible light cannot cross thick walls, and theft of data can also be neglected. With the use of optical filters and expressing automatic gain control

algorithms, Li-Fi can be used in outdoor communication systems, as the effect of sunlight and shot noise can be reduced [5].

Though the mobile network radio waves are fast and deployed in each corner of the world. Within a few years, a massive change will be noticed, when commercially Li-Fi will be implemented for indoor and outdoor networking, edge computing, and many modern tech applications. Making a radiation-free space for treatment at medical centres or Medicals.

2.1. The On-Off Keying (OOK) Modulation

The primary method used in this technology is On-Off Keying of OOK. In this technique, the LEDs are turned off to represent the logic value 0, and LEDs are turned on to represent the logic value 1. Let the Phl is the error probability of receiving 1 as 0 and also Let Plh is the error probability of receiving 0 as 1. This condition is also known as the coherent receiver. Then this probability is calculated as equation 2

$$Phl = Plh = \tfrac{1}{2}\, f(\sqrt{((E/N) * 1/4)}) \qquad (2)$$

Where, E/N is the Energy to Noise Ratio and function, f represents the complementary error function.

There are few important advantages of OOK modulation than other modulations in LiFi technology are:-

- OOK modulation is the closest digital modulation with analog modulation so, the conversion time from Analog to Digital and vice versa is very less, hence data transfer is fastest and bandwidth is also increased.
- The LIFi with OOK modulation also enhanced data security as encryption and decryption can be done right in transmission and receiving modules along with the signal itself.
- OOK modulation is very susceptible to distortion, noises, non-linearities and cross talk.
- OOK modulation provides the highest signal strengthen in a quite large distance.
- OOK modulation is cheapest to implement.

3. PREVIOUS WORK AND MOTIVATION

In this section of the article, we will be discussing some of the previous development with the thrust on the following and the primary motivating factor in writing this paper: -

Protection from Radiofrequency device interferences.

- Li-Fi can be used for real-time tracking of important prescribed and aseptic drugs e.g., cytotoxic drugs
- LiFi for remote monitoring
- LiFi for doctors, staff, and patients
- Li-Fi enabled tracking and relocation of the positions of key medical devices

As discussed earlier in this article's introduction section, the exposure to radio waves in a long term causes critical diseases, as well as it is studied to have interference with the medical instruments in the clinical areas. Li-Fi tends to be a better solution when establishing a network system in Medical and critical care units.

From the article [16], we can see that remote monitoring and a radiation-free environment can be created by using light fidelity, as the medium of data transmission. Through some embedded system designed on the concept of the internet of things, monitoring ECG, heart rate, blood oxygen level, non–invasive blood pressure, and overall health can be sensed. A device equipped with light fidelity can transmit this data fetched from the different sensors. This helps doctors and health workers to know about the health condition of the patient.

Interference of radio waves with the precision devices in the Medical is a crucial issue, in getting the proper result from the devices. Light fidelity plays an important role to eliminate this interference. Protection against radio waves is very much needed, as it may also cause heart stress, and insomnia and may reduce brain activity. When multiple Li-Fi transmitters are installed, they can transfer around 224 gigabits of data per second, which are much faster than Wi-Fi or a cellular network. So, networking in the Medical becomes very easy for doctors and other staff, as it can be noticed that medical illumination is very bright and at every corner, so fading or noise absorption also becomes very less [12].

Tracking the medication on a real-time basis for remote patients is very important. The sensitive patients treated at home needs, proper care, location update, and health parameter updates, from [11], it is studied that with the use of multiple sensors not only the parameters of the body but also the medication timing, injection timings can be monitored and checked. The use of respiration sensors and glucose sensors will help in getting the variable levels of glucose and inhale-exhale level while taking the medicines. When injected or orally taking any cytotoxic drugs, the glucose level varies in the body, so more this kind of critical medical also, Li-Fi serves a good purpose. The patients taking cytotoxic drugs are very weak, so exposure to radio waves mainly the cellular waves or wi-fi would harm their health condition in an adverse situation. So, communication through visible light prevents the worsening [10].

Multiple Li-Fi transmitters can be attached to a variety of places, to detect the movement of a patient, relocation of beds, and medical devices can be traced using network handover in inter LED communication module. While using multiple transmitters, inter–LED mitigation can be seen, which on using a technique known as channel inversion precoding can be minimized [12].

The Li-Fi technology is covering the whole world wherever there is a problem with the radio waves. Though much development and research are needed to establish a fully commercial system, it has been tested and introduced in many fields, other than healthcare sectors. Li-Fi plays a huge role in the development of smart cities, IoT devices, traffic lights, airlines, underwater data transmission, disaster management, defence as well as educational institutions also [17].

4. THE PROPOSED MEDICAL NETWORK SYSTEM

The proposed model is a scheme or representation of a Li-Fi-based patient monitoring system that uses white LEDs to transfer data through a VLC-based data transmission system in the medical network. In this proposed system, the illumination and the communication sources are provided by several LEDs that might be utilized and used as data transmission of sensors located in the static patients in bed. The usage of the illumination values in the LED lamps and a built-in transmitter that is connected with the medical database in turn will

allow downlink in a controlled manner. Since a typical patient kept in the ICU monitoring is static in time, so, a static proposed model is chosen here. The Installation of data transmission with LEDs is done for each of the sensors through a precision-based transmission module which makes the proposed system different from the existing system. In this model, the receiver is placed on the top of the patient i.e., the ceiling, and the transmission module points upward to the receiver at the ceiling [13]. The electronic medical database that just discussed transfers medical data to the Li-Fi transmitting module and this is a point-to-point connection. Photodetectors (PDs) are used as a receiver and placed on desktops, tablets, or user devices [12]. Moreover, transmission modules that are placed on the patient with LOS are also connected to the PDs that are placed on the ceiling. The other implementation perspectives are: -

- Multiple detectors minimize the diversity effects.
- Photodetectors spacing achieves robustness.
- This is an obstacles-free environment model in the ICU [14].

Fig. 3 illustrates the proposed scheme of LiFi-based medical network system.

The various biomedical signals collected in the proposed system are: -

- ECG
- Photoplethysmogram (PPG)
- Body Temperature
- Pulse rate
- SPO_2 Value

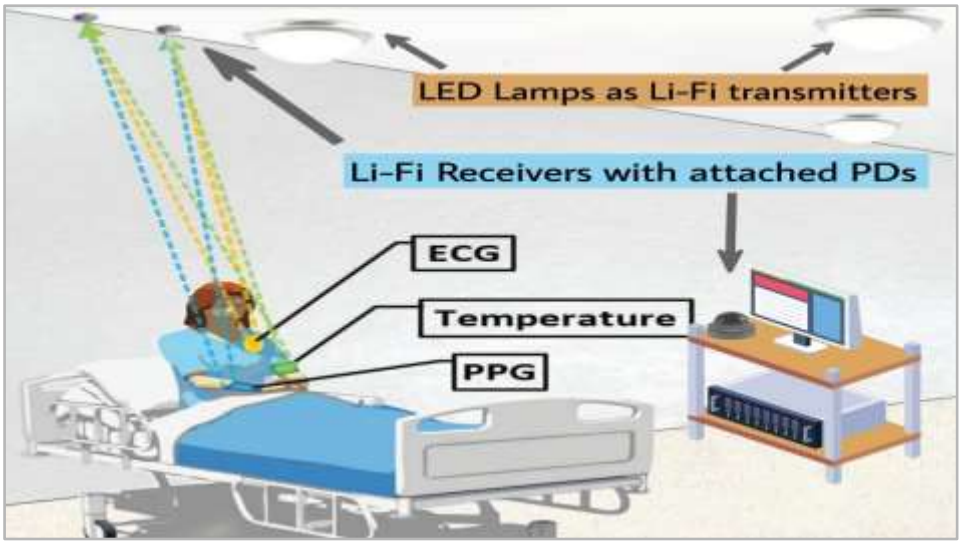

Figure 3. The Representation of Proposed Li-Fi based Medical Network System

We used here the OOK modulation because it provides both accuracy and reliability in this system [13]. We also achieved a very low bit error rate (BER), which is less than 10-5, at considerable SNR values in that service area [14]. Therefore, Li-Fi based system in medical communication is indeed a novel use as discussed in this section.

5. IMPLEMENTATION AND DISCUSSION

In Medicals, a patient's current medical condition is monitored by critical care equipment. Doctors, nurses, technicians, and caregivers use their smartphones, tablets, smartwatches, or desktop computers to monitor the same via data communication. van der R. Togt performed an electromagnetic interference test with several medical equipments. 20% of the incidents were classified as hazardous as a result of this test. To avoid such potentially hazardous equipment malfunctioning due to electromagnetic interference, only wired communication channels are used in Intensive Care Units (ICUs) instead of Wi-Fi. Hence, Li-Fi which permits high-speed data communication via Visible Light Communication (VLC) could be safely used to avoid such limitations of Wi-Fi in corridors, waiting rooms, patient rooms, and operating theatres. Nowadays, the security and reliability of data transmission are playing key roles in patient monitoring. However, all related technologies operate in the radiofrequency spectrum which not only jeopardizes patients' health but is also responsively congested and highly susceptible to hacking. Li-Fi is secure against hacking and data theft as light cannot penetrate through walls. Li-Fi is also used in the transference of curative text data and analog physiological signals can be used. Moreover, patients could connect to the internet to check emails, and news, listen to songs, play video games, access social media platforms, and watch movies and web series on OTT platforms to avoid feeling homesick during their medical stay. Hence, Li-Fi could monitor and report the movements and vital signs of patients on their beds in real-time without using wired communication channels. Li-Fi could assist the medical staff by tracking and relocating of crucial positions, as these devices are shared between various departments. Fig 4. Shows a summary of Li-Fi implementation between patients and caregivers.

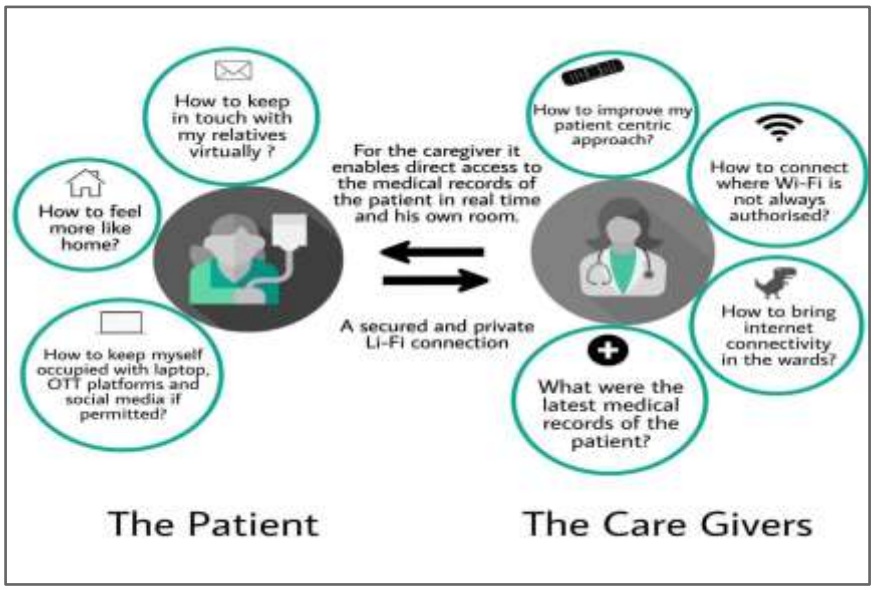

Figure 4. Summary of Li-Fi implementation between patients and caregivers

Li-Fi could be implemented using light-emitting diodes (LEDs) in medical environments to enhance comfortability for sufferers and carers which prevents the risk of disturbance that

can arise from electromagnetic waves interference disturbing the precision medical device. Indoor wireless communication could be achieved at a much faster rate by using LED bulbs as a data transmission medium instead of Wi-Fi. As the flickering rate is faster than the human eye can realize, people could still use the same light source in each room without interfering with medical equipment operation. The real-time tracking of advised aseptic drugs like cytotoxic drugs can also be performed from medical pharmacies. Li-Fi can aid pharmacists in receiving and screening electronically approved prescriptions directly in the unit. Healthcare professionals can access, monitor, and share the real-time status of patients' records in a suitable, rapid, and very safe manner on their smartphones without the necessity to make a call, go directly to the unit, or wait to collect their reports at the pharmacy terminals. Li-Fi could be implemented in data collection from any device enabled with Li-Fi technology using a secure network by data loggers to remotely observe a situation with data uploading periodically without the need of being collected from a desktop [15].

6. CONCLUSION

Thus, in this paper, we have successfully given the representation of LiFi-based medical networking and its probable implementation by discussing it. We also provided the architecture of this technology with the OOK method of transferring data with equations. The main advantage of this model is security and anti-theft transferring of data. It also protects radiofrequency devices such as MRI scanners. The other applications of this proposed model are Li-Fi for concurrent tracking of advised aseptic drugs like cytotoxic drugs, LiFi for remote monitoring, LiFi for doctors, staff, and patients, and Li-Fi for not only keeping in sight but also resettlement of the positions of crucial medical gadgets. In future work, we will insert machine learning into the model to implement some more applicability in smart computing. We will also incorporate Optical OFDM where a baseband signal is used to modulate the LED intensity.

REFERENCES

[1] J.G., Webster, A.R Ndjiongue, H.C. Ferreira, and T.M.N Ngatched, Visible Light Communications (VLC) Technology. In Wiley Encyclopedia of Electrical and Electronics Engineering, J.G. Webster (Ed.). 2015 doi: 10.1002/047134608X.W8267

[2] J. Gancarz, H. Elgala and T. D. C. Little, "Impact of lighting requirements on VLC systems," in IEEE Communications Magazine, vol. 51, no. 12, pp. 34-41, December 2013, DOI: 10.1109/MCOM.2013.6685755.

[3] H. Burchardt, N. Serafimovski, D. Tsonev, S. Videv, and H. Haas, "VLC: Beyond point-to-point communication," in IEEE Communications Magazine, vol. 52, no. 7, pp. 98-105, July 2014, doi: 10.1109/MCOM.2014.6852089.

[4] H. Abuella et al., "Hybrid RF/VLC Systems: A Comprehensive Survey on Network Topologies, Performance Analyses, Applications, and Future Directions," in IEEE Access, vol. 9, pp. 160402-160436, 2021, doi: 10.1109/ACCESS.2021.3129154.

[5] H. Haas, LiFi is a paradigm-shifting 5G technology,Reviews in Physics,Volume 3,2018,Pages 26-31,ISSN 2405-4283, doi:10.1016/j.revip.2017.10.001.

[6] D. Khandal, and S. Jain. "Li-fi (light fidelity): The future technology in wireless communication." International Journal of Information & Computation Technology 4.16 (2014): 1687-1694.

[7] L. Ullah Khan, Visible light communication: Applications, architecture, standardization and research challenges, Digital Communications and Networks, Volume 3, Issue 2,2017, Pages 78-88, ISSN 2352-8648, doi: 10.1016/j.dcan.2016.07.004

[8] E. Hanada. The electromagnetic environment of Medicals: how it is affected by the strength of electromagnetic fields generated both inside and outside the Medical. Ann Ist Super Sanita. 2007;43(3):208-17. PMID: 17938450.

[9] E. Hanada, K. Kodama, K. Takano, Y. Watanabe, Y. Nose. Possible electromagnetic interference with electronic medical equipment by radio waves coming from outside the Medical. J Med Syst. 2001 Aug;25(4):257-67. DOI: 10.1023/a:1010727220929. PMID: 11463202.

[10] B. Miller Anthony, E. Sears Margaret, L.L. Morgan, L.D. Devra, H. Lennart, O. Mark, S. Colin L., Risks to Health and Well-Being From Radio-Frequency Radiation Emitted by Cell Phones and Other Wireless Devices, Frontiers in Public Health, VOLUME=7,2019,10.3389/fpubh.2019.00223, ISSN=2296-2565

[11] S. Sudha, D. Indumathy, A. Lavanya, M. Nishanthi, D. M. Sheeba and V. Anand, "Patient monitoring in the Medical management using Li-Fi," 2016 IEEE Technological Innovations in ICT for Agriculture and Rural Development (TIAR), 2016, pp. 93-96, DOI: 10.1109/TIAR.2016.7801220.

[12] T. Ardi Nugraha, Y. Ardiyanto, "Li-Fi Technology for Transmitting Data in Medical Environments", 2020 IEEE 1st International Conference on Information Technology, Advanced Mechanical and Electrical Engineering (ICITAMEE) | DOI: 10.1109/ICITAMEE50454.2020.9398406

[13] W. Anugrah Cahyadi, T. Jeong, Y-H Kim, Y-H Chung, T. Adiono, "Patient Monitoring Using Visible Light Uplink Data Transmission", 2015 International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS) November 9-12, 2015, 978-1-4673-6499-7/15/$31.00 ©2015 IEEE

[14] S. Singh, S. Mishra, P. Asthana, S. Kumar, "Comprehensive Visible Light Communication System for Healthcare", IOSR Journal of Computer Engineering (IOSR-JCE) e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 19, Issue 3, Ver. II (May.-June. 2017), pp 08-11 www.iosrjournals.org

[15] Chukwuemeka Livinus, "Top 5 Applications of Li-Fi Technology", September 3, 2018 Available: https://www.lifitn.com/blog/2018/8/30/5-applications-of-li-fi-technology

[16] T. Ananth Kumar, et al. "LIFI-Based Radiation-Free Monitoring and Transmission Device for Medicals/Public Places." Multimedia and Sensory Input for Augmented, Mixed, and Virtual Reality, edited by Amit Kumar Tyagi, IGI Global, 2021, pp. 195-205. doi: 10.4018/978-1-7998-4703-8.ch010

[17] Kuppusamy, S. Muthuraj, and S. Gopinath, "Survey and challenges of Li-Fi with comparison of Wi-Fi," 2016 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET), 2016, pp. 896-899, DOI: 10.1109/WiSPNET.2016.7566262.

[18] Y. Wang, D. A. Basnayaka, X. Wu and H. Haas, "Optimization of Load Balancing in Hybrid LiFi/RF Networks," in IEEE Transactions on Communications, vol. 65, no. 4, pp. 1708-1720, April 2017, doi: 10.1109/TCOMM.2017.2654249.

Biographies

"A teacher by profession and a learner by passion."

Abinandan Sarkar has completed his Bachelor of Technology in Electronics & Instrumentation from Greater Kolkata College of Engineering and Management, M.Tech in VLSI from Techno India University. He is trained in multiple domains especially IoT, Circuit Designing and Curriculum Development, and Academic Leadership from the National Institute of Technical Teachers Training and Research Kolkata, Chandigarh. With a keen interest in administrative and managerial skills, he is undergoing MBA in Project Management from Jaipur National University and has undertaken professional certification from IIM, Bangalore. He is a registered Innovation Ambassador for MIC, AICTE, facilitating and cultivating an innovative and entrepreneurial mindset among the youth. He has mentored more than 5 projects at the National level for National Innovation Contest, MIC. He has been selected among the top 5 Innovation Ambassadors (2019 - 2020) in the Eastern Region. He has also performed as an Observer of the School Innovation Ambassador training Program conducted by MIC and has been honored as an invited reviewer for the World Journal of Engineering, Emerald Publications. He has successfully published a patent at IPO. He started his professional career in 2015 as an academician, presently he is working as an Assistant Professor at Shree Ramkrishna Institute of Science & Technology, Kolkata.

Hoimanti Dutta is currently pursuing a B. Tech degree in Computer Science from Netaji Subhash Engineering College, India. She is the Secretary of the IEEE Computer Society Student Branch Chapter at Netaji Subhash Engineering College. Her current research interests are Cloud Computing, Data Mining, Machine Learning, and Li-Fi technology. She has already published two conference papers and one book chapter in Springer's publication. Most Notably, she got Best Paper Award, for the article titled "An Approach Towards Near-Field Communication (NFC) with Light Fidelity (Li-Fi)" in the International Conference on "Current Research in Engineering and Technology (ICCRET-2021)", organized by Department of Computer Science & Engineering, Brainware University, in association with Institution's Innovation Cell (IIC) and technically sponsored by CSI, BWU student Chapter during November 26 – 27, 2021.

Rajdeep Chakraborty, Ph.D., working as an assistant professor last fifteen years. He has got several publications in international journals and conferences covering SCI - indexing, Scopus indexed, IEEE, Springer, Scrivener Wiley, CRC Press, and other major indexing/publications. He has got six Indian patents published and one research copyright grant/registration. He is a guest editor & reviewer in some international and national journals. He gave several guest lectures, keynote talks, and invited talks at various academic events. He has been associated with many international conferences in the capacity of organizer, session chair, and reviewer. He is a member of IEEE and many other professional societies. He has got many awards and appreciation letters and e-contents are available on YouTube. He is now guiding two Ph.D. research scholars at MAKAUT, West Bengal, India, and also guided several UG students and PG research scholars in his teaching career so far.