Proceedings of the International Conference on Communication and Electronics Systems (ICCES 2018)
IEEE Xplore Part Number:CFP18AWO-ART; ISBN:978-1-5386-4765-3

Li + Wi Fi: The Future of Internet of Things

Saily P. Bhanse
Department of Electronics and Telecommunication,
MIT Academy of Engineering,
Alandi (D), Pune 412105
Email: saili33b@gmail.com

Savita R. Pawar
Department of Electronics and Telecommunication,
MIT Academy of Engineering,
Alandi (D), Pune 412105
Email: srpawar@etx.maepune.ac.in

***Abstract* - Internet of Things abbreviated as IoT is been a global network where objects are linked together in such a way that they can share data among themselves so that they connect immediately. Similarly Ubiquitous computing is the rising trend of implanting computational ability into everyday objects to make them efficiently communicate to accomplish useful tasks. The evolution of these technologies leads to exponential growth of smart sensors and devices which require faster, secure, energy efficient data transmission. Light fidelity otherwise called as Li Fi is the high speed wireless communication technology that applies light as medium through light emitting diodes and is a greener, secure and safer technology for ubiquitous communication in IoT. In this paper firstly, we will understand the working of Li Fi. Secondly, we will see the role of Li-Fi in IoT and finally discuss how Li + Wi Fi is a true enabler of IoT.**

Keywords– Li Fi, Wi Fi, Hybridization (Li +Wi Fi), Internet of Things (IoT).

I. INTRODUCTION

According to the facts, consummation of wireless data increases by 60% each year. Nearly all the data consumed by Wi Fi that utilizes radio frequency is indoors and it is a limited incredible resource. Unfortunately, these networks have reached to their highest capacity and can cause a spectrum crunch. With a greater possibility of a spectrum crunch, sooner or later, it is difficult to keep up with increasing demand of data transfer and wireless speeds. It would be highly impossible for the internet service providers (ISP) to satisfy the requirements of different subscribers using big data servers and IoT devices. Light fidelity having 300 THz license free and still not used optical spectrum for wireless communications, has now come up with the solution to this problem. As light travels faster than the radio waves, we can use it to transfer data upto 250 times more than the fastest speed broadband. This technology uses only light bulbs in order to transmit data and is so very efficient and low cost. The main objective is to transfer the data at the highest speed possible which will provide illumination and communication both at low price [1]. Li Fi has that potential to complement Wi Fi due to the availability of broad bandwidth, non-existence of electromagnetic interference, high security, and etc. Although Li-Fi technology seems like a novel solution for wireless data improvisation, it comes with its own limitations. Since LED light bulbs are a foremost component of Li-Fi technology, the internet cannot work without a light source. This puts a limitation to the locations in which Li-Fi can be used. Moreover light sources may also interfere with signals transmitted or received. One of the major disadvantages is interception due to light signals coming from outdoors. For example: sunlight can interfere with the signals, which may lead to a disturbed Internet connection. Among both wireless systems, Wi Fi creates general wireless network whereas Li-Fi is used to cover dense and confined areas. As both the technologies have their own advantages and disadvantages we need to study them together and try to create a Li + Wi Fi networks which will have advantages of the two together. In this project, we will practically demonstrate the coexistence of both the technologies [2].

II. RELATED WORK

1) Li-Fi Technology

Li-Fi was invented in 1997 by Prof. Harald Haas, the co-founder and Chief Scientific Officer of pureLiFi Ltd. He firstly presented and stamped spatial modulation and Li-Fi. Prof. Harald Haas was an invited lecturer at TED Global 2011, and his talk: "Wireless Data from Every Light Bulb" has more than 2.2 million views. Li Fi has proved that it can work 100 times faster than Wi-Fi. In October 2011, companies and industry groups designed the Li-Fi association, to encourage high-speed optical wireless system and to find a solution to the limited amount of radio-based wireless spectrum accessible by bringing to use entirely different portion of the electromagnetic spectrum. By August 2013, data rates above 1.6 gbit/s was shown over a single colour LED. In 2013, a press announced that Li-Fi systems will not always need line-of-sight position. The fundament multiplexing to this achieve this technique is by using modified type of Orthogonal Frequency Division Multiplexing called SIM OFDM. Here, high throughput is achieved by splitting the serial data stream into thousands of parallel streams and by using multiple carrier frequencies to modulate the light source. [3]

2) Wi-Fi Technology

In 1985, 802.11 technology was made accessible for use by a U.S. Federal Communication Commission. Soon after that the IEEE was formed in 1990, of which Vic Hayes was the chairman, also popularly known as the "Father of Wi-Fi". Different types of wireless communication technologies come with different types of properties and markets like IEEE 802.11, 3G, and Long Term Evolution. In comparison with 3G, 4G, LTE and Wi Max, Wi-Fi has low cost and power consumption and high bandwidth. As Wi-Fi (802.11 a/b/g/n) has a good cost performance ratio, it is the best choice to provide internet services to public places wirelessly. It operates in Industrial, Scientific, and Medical band (ISM band) on various broadband speeds. The communication between nodes or computers is achieved by Access Points (APs). The access point can also be used as a wireless Ethernet adapter. The increase in number of laptops supporting Wi-Fi and the easy installation process has made Wi-Fi popular. Wireless has become the need of the hour due to dense population and closely spaced infrastructure and has a brought a rise in demand in business and everyday-life. Its importance in business and day to day life has grown because it is easy to arrange in markets, offices, airports, and other locations as it is of low cost and provides benefits like flexibility, mobility.

3) Internet of Things (IoT)

Internet of Things denotes to a broader vision where “things” means the everyday object which can be connected to each other with the Internet, expanding it from a network of interconnected computers to a network of interconnected devices. IoT aims to provide access for anyone and anything irrespective of any time and place. The advances in this technology will bring us close to the day where each one of us and each thing around us will be connected to one another via Internet. IoT also enables machine to machine learning. The fundamental concept is to achieve a connection between the real world and the virtual world through physical activities. IoT includes objects, sensor devices, communication infrastructure computational and processing unit that may be placed on cloud, decision making and action taking systems. Internet of Things brings us close to the everyday objects where they are connected to a system where we can fetch their information, share it and use it as and when we need it. Dynamic technical innovation in wireless sensors, nanotechnology and numerous fields can change the face of computing and communications to bring a technological revolution in IoT. [4]

4) Hybridization of Li-Fi and Wi-Fi (Li+Wi Fi)

a) Let’s consider a single Wi Fi access point and a single Li Fi access point to obtain hybridization. In this three systems will be compared in all. Firstly, the Wi-Fi will be used only obtaining the internet connection. While, in the second one, denoted as hybrid system, uplink will take place through Wi-Fi and the downlink of any one of the user will be connected through a Li-Fi link. Where as in the last one, denoted as aggregated, the user is connected in parallel to both, Wi-Fi and Li-Fi network.

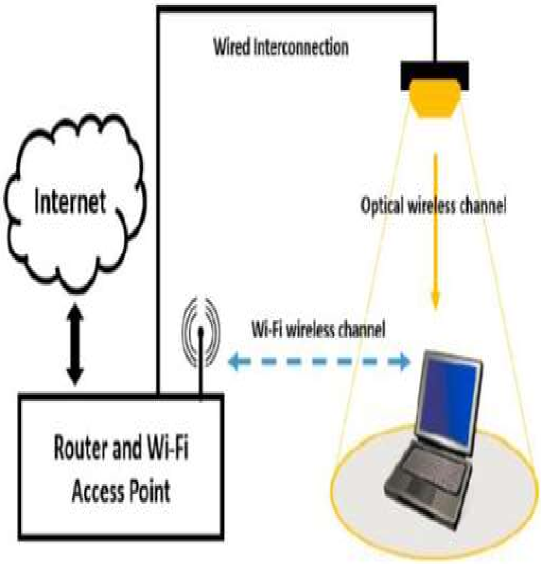

Fig 1: Hybridization [8]

Figure 1 illustrates the configurations of the hybrid system. Here, the unidirectional Li-Fi link is compliments the Wi-Fi downlink. [8]

b) A dynamic load balancing scheme in a Li-Fi plus Wi-Fi hybrid network is proposed, where they have considered the handover overhead situation. They have analysed the service areas of the Li Fi Aps and the throughput performance of the hybrid system is theoretically calculated. They have also simulated the user throughputs and studied the effects of the handover overhead on handover locations. Three conclusions were drawn on the basis of the analytical and simulation results:

i) The Li-Fi access points regions of service coverage are interconnected, which are usually smaller than the complete Li-Fi atto cells. According to the studies, it is found that these areas are circular in the non-CCI case, but are non-circular in the case of optical CCI.

ii) Even though the Wi-Fi and Li-Fi have independent spectrum transmissions, their throughputs in the hybrid network are interconnected. If we wish to enhance the Li-Fi throughput we have to increase the Wi-Fi throughput. Plus, the attainable data rates of the users served by Li Fi access points are more than or equivalent to the Wi Fi access point users.

iii) As suggested in the load balancing scheme a handover takes place only when the user moves through the bounders of the Li Fi service areas but there will be transmission loss due to the handover overhead which causes to a handover location offset. [5]

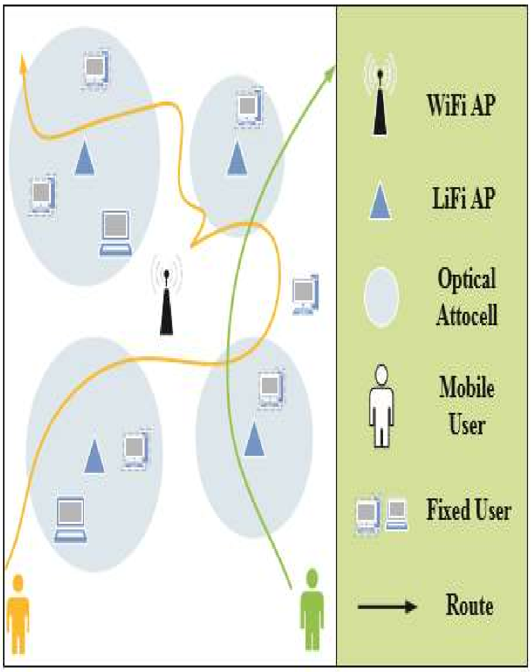

Fig 2: Load Balancing in Li Fi Wi Fi network [5]

III. Li + Wi Fi

The quest for faster internet connection is endless. Everyone needs information on time and any interruptions or delays causes annoyance and charges companies' money. Wi Fi is presently the finest internet service which everyone is consuming. As every coin has two sides, Wi Fi also has its own drawbacks that restrict the possibilities. The only reason that uses radio waves which is a narrow source seems to be its major drawback. Moreover, above 5 billion smart devices use Wi-Fi every day, and this causes a systems overload. This frequently happens with people at airports and in crowded areas. When a large number of people are within the same Wi-Fi access point (AP), the transmission resource allocated to each individual is very small and the user service would be seriously affected [6]. The number of devices we will be connecting to the internet using Wi Fi that much the bandwidth will get distributed between all the consumers and the outcome will result in slower connectivity. Thus, it is the necessity of time to have a fast and a trustworthy internet service if we wish to have IoT to be fully operational. To handle the ever increasing number of users accessing the internet and also to have a smooth functioning of IoT, its time we complement Wi Fi with Li Fi Technology. The estimated speed of Li-Fi will touch 3 to 5 GB per second, which is the ideal solution for IoT's and to discard the drawbacks and annoyances with Wi Fi technology. As we are aware of the fact that Wi Fi transmits data one at a time whereas Li Fi can transmit thousands of data strings with high speed and that too parallelly. Additionally, this high speed is achieved using a source of light instead of radio waves technology. There are clear problems with Li-Fi in its current iteration, even though it is still in the initial stages of development and it is expected that these will be ruled out with time [7]. Despite the numerous positives of Li-Fi, there are some negatives that mean Li-Fi will most likely need to work in tandem with a Wi-Fi connection. The most obvious issue is that Li-Fi signals can't pass through walls or ceilings. For whole-house connectivity, you will have to have Li-Fi capable bulbs in most, if not all, rooms. Outdoor applications are possible, but rain, fog, and intense sunlight could reduce the range and effectiveness of signal. Line of sight for this technology is not compulsory, but a direct path provides the highest data rate. Light propagates in a significantly more confined way, as radio waves. We may use reflected light, but after two reflections, the optical losses are too high for the required signal quality. The range limitation of Li-Fi comes with a silver line—the connection is much easier to secure than Wi Fi. Through well-designed implementations, Li-Fi can be limited to transmit only within a few meters of the light source. As a result, Visible Light Communications and Li-Fi are much more secure technologies than existing radio wave technologies. For now, It is not cost effective to replace Wi-Fi, with homes and offices which are already fitted with the infrastructure to provide it. Ripping all of this out and putting in Li-Fi technology is probable very costly. Nevertheless, in time it will be necessary [8]. Therefore, combining the two technologies will give us a faster, secure, reliable network for fully operating IoT. Li-Fi, which hires the visible light spectrum to transfer digital signals, is seen as a potential technique in next generation wireless communication. In general, LED lamps are the best options for Li-Fi AP, and the signals are transmitted by modulating the illumination power. Due to the innate property of light, a Li-Fi transmitter can only serve a confined area, which makes it possible for a dense deployment of Li-Fi access points and massive reuse of the bandwidth [9]. As a result, people previously in the Wi-Fi system can now be divided into several groups when using Li-Fi and each user would achieve a higher data rate by using more of the transmission resource. However, the light beams used by Li-Fi are susceptible to blockages, and the devices would be disconnected to the Internet when they cannot receive any light from the Li-Fi AP [10]. Recently research has been undergoing on hybrid Li+ Wi Fi network. This twin can be combined to offer a more efficient and robust wireless service. Li-Fi provides a high data rate and Wi-Fi guarantees a ubiquitous coverage. Thus, users can choose Li-Fi generally for high data rates, and automatically switch to Wi-Fi while the light is blocked or they move outside the Li-Fi coverage area. Since some of the network load is served by Li-Fi, people served by Wi-Fi can achieve better user experience by using more transmission resource. Li-Fi, which acts as a complement to Wi-Fi, can significantly improve the quality of the network. In the future, it can be imagined that the Li + Wi Fi network can cover the whole world and really gives us a life without hidden corners of Internet. [11].Visual light communications technology has a long way to go before it's installed in our houses and workplaces. To begin, Li-Fi will likely have to show its usefulness in industrial environments where Wi-Fi either doesn't work or is a poor solution. In most cases, we imagine that Li-Fi will have to work in combination with Wi-Fi. With a smartphone, for example, consumers will still want the network connection to remain active when the mobile device is in a pocket. Li-Fi alone wouldn't do, because it would only work when the smartphone was out and its photo receiver was visible to a Li-Fi LED. On the whole, Li-Fi does have a bright future as a complementary wireless technology [12].

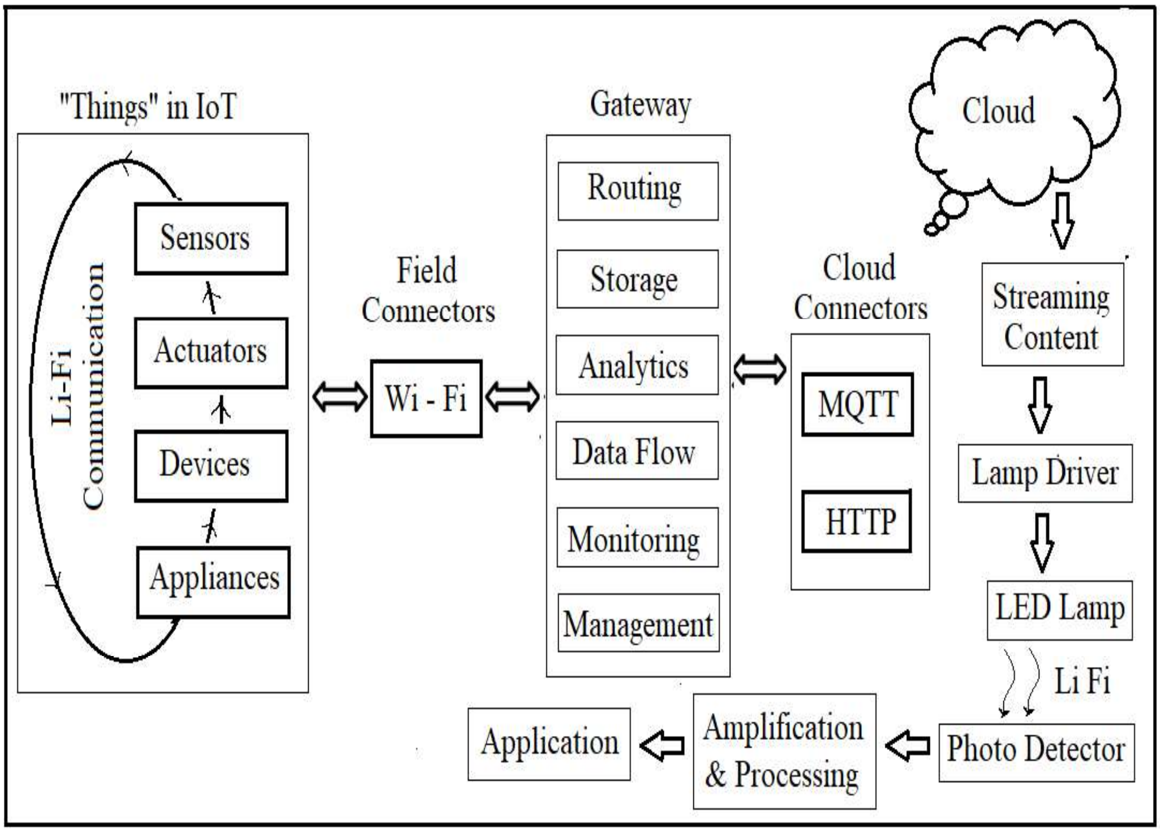

Fig 4: Li + Wi Fi enabled IoT

IV. Li + Wi Fi enabled IoT

Li-Fi could be a huge boost to reliably connect internet of things devices in various applications. Consider that every room in your house has one or more IoT nodes. This massive demand for data will eventually strain your Wi-Fi network and increase interferences. As discussed earlier, Wi-Fi alone will not be able to serve IoT devices which is why we have introduced the Li + Wi Fi technology in which Li-Fi will the complimentary technology [13]. Now-a-days devices use in IoT are low-power smart sensors that require less data then they traditionally used, but as the IoT market grows, Li- Wi Fi could provide the bandwidth required for heavy data transmissions. As shown in Fig 4 the Li + Wi Fi enabled IoT. In the first block, “things” in IoT could be array of sensors, actuators, and devices which will interact and communicate with one another real-time data using Li Fi communication. These “things” are also connected to Wi Fi through field connectors to access the gateway. The objective of the gateway is to achieve communication and inter relate the actions among the things and the cloud services. Sensors read and monitor environmental elements such as temperature, light, moisture and give back feedback status to the real-world. Sensor input is not only physical objects but also anything and everything that can be read such as files to specific data of the products is considered as input to the sensor. If a part of industrial equipment is taken as an example, which might have numerous data points distinctive to that product but still each point will be assumed as sensor [14].The other common “things” are called actuators. They generally tend to change the state of the product or environment either electromechanically or logically. With the help of actuators we can turn on or off the light or we can open or close a valve. The device block includes smart “things” like smartphones, laptops, tablet computers etc. Appliances or gadgets have a defined function which a human can control using various interfaces in smart environments. The major function of IoT Gateway is converting field protocols (here Wi Fi) to cloud protocols by allowing communication from the sensors to the Cloud. Routing data to cloud is another feature of IoT Gateway where it uses MQTT or HTTP protocols to communicate [15]. MQTT acronym for Message Queue Telemetry Transport achieves embedded connectivity between applications and middlewares on one hand and networks and communications on another using publish/subscribe architecture, where publishers, subscribers, and a broker are the three important components. Another standard protocol is HTTP used in IoT solutions in cases where latency and bandwidth are not the issues. We will be using Li Fi Technology at the downloading side. The data required to be downloaded is the streaming content which is given to the lamp driver. The content is converted into binary by using PWM or OFDM techniques. This streaming content is fed into the lamp driver which controls the LED lamp. The light fluctuations are captured by the photo detector and are then directed to the signal conditioning unit. Here the signal is amplified and through processing unit it is transmitted to the application. [16]

V. Conclusion

Primary characteristics of Li + Wi Fi technologies and the possibility for them to coincide are shown in this paper. Irrespective of their independent spectrum transmission, Wi Fi and Li Fi throughputs, show correlations when they come together as Li +Wi Fi. Off-loading situations for Wi Fi will become less as Li Fi will be made accessible for indoor stationary users. A close combination of Li Fi and Wi Fi can resourcefully triple the throughput for individual users and improve indoor coverage with high data rates required for today’s as well as tomorrow’s mobile network generation. Finally, we have given the direction to the upcoming researchers to incorporate both these technologies. Hence we conclude that the combination of Li + Wi Fi is a true enabler for Internet of things.

References

[1] Mayank Swarnkar, Robin Singh Bhadoria, Karm Veer Arya. "Chapter 7 Architectural Building Protocols for Li-Fi (Light Fidelity)", Springer Nature, 2018.

[2] Shivaji Kulkarni , Amogh Darekar , Suhas Shirol,“Proposed framework for V2V communication using Li-Fi technology”, 2017 International Conference on Circuits, Controls, and Communications (CCUBE), 2017.

[3] Hamada Alshaer, Harald Haas. "SDN-enabled Li-Fi/Wi-Fi wireless medium access technologies integration framework", 2016 IEEE Conference on Standards for Communications and Networking (CSCN), 2016.

[4]ung T "Analysis of security framework and protocol supporting for Internet of Things", Applied System Innovation, 2016.

[5] Yunlu Wang and Harald Haas, “Dynamic Load Balancing with Handover in Hybrid Li-Fi and Wi-Fi Networks” IEEE Transactions on Communications, vol. 62, 139–149, April 2015.

[6] Fang Wang ; Zhaocheng Wang ; Chen Qian ; Linglong Dai ; Zhixing Yang, “MDP-based vertical handover scheme for indoor VLC-WiFi systems” 2015 Opto-Electronics and Communications Conference (OECC),2015.

[7] S. Shao, A. Khreishah, M. Ayyash, M. Rahaim, H. Elgala, V. Jungnickel, D. Schulz, T. Little, J. Hilt and R. Freund, "Design and Analysis of a Visible-Light-Communication Enhanced WiFi System," OSA/IEEE Journal of Optical Communications and Networking (JOCN), vol. 7, no. 10, pp. 960-973, 2015

[8] Moussa Ayyash, Hany Elgala, Abdallah Khreishah, Volker Jungnickel, Thomas Little, Sihua Shao, Michael Rahaim, Dominic Schulz, Jonas Hilt, Ronald Freund, “Coexistence of WiFi and LiFi towards 5G: Concepts, Opportunities, and Challenges”,IEEE Network, vol. 28, no. 7, 2014.

[9] S. Wu, H. Wang and C.-H. Youn, "Visible light communications for 5G wireless networking systems: from fixed to mobile communications," IEEE Network, vol. 28, no. 6, pp. 41-45, 2014.

[10] X. Bao, X. Zhu, S. T. and Y. Ou, "Protocol Design and Capacity Analysis in Hybrid Network of Visible Light Communication and OFDMA Systems," IEEE Transactions on Vehicular Technology, vol. 63, no. 4, pp. 1770 - 1778, 2014.

[11] H. Chowdhury and M. Katz, "Cooperative Data Download on the move in Indoor Hybrid (Radio-Optical) WLANVLC Hotspot Coverage," Transactions on Emerging Telecommunications Technologies, vol. 25, no. 6, pp. 666-677, 2014.

[12] D. A. Basnayaka and H. Haas, "Hybrid RF and VLC systems: Improving user data rate performance of VLC system," IEEE Vehicular Technology Conference (VTC Spring), May 2014.

[13] M. Kavehrad, "Optical wireless applications: A solution to ease the wireless airwaves spectrum crunch," in SPIE OPTO. International Society for Optics and Photonics, 2013, pp. 86450G–86450G.

[14] C. Lee, C. Tan, H. Wong, and M. Yahya, "Performance evaluation of hybrid VLC using device cost and power over data throughput criteria," in SPIE Optical Engineering+ Applications. International Society for Optics and Photonics, 2013, pp. 88451A–88451A

[15] H. Chowdhury, I. Ashraf, and M. Katz, "Energy-efficient connectivity in hybrid radio-optical wireless systems," in Wireless Communication Systems (ISWCS 2013), Proceedings of the Tenth International Symposium on. VDE, 2013, pp. 1–5.

[16] M. B. Rahaim, A. M. Vegni, and T. D. Little, "A hybrid radio frequency and broadcast visible light communication system." in GLOBECOM Workshops, 2011, pp. 792–796.