Li-Fi: Implementation and Applications in Current Scenario

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Abstract: Light Fidelity as the name suggests uses light as communication medium. The working of the Li-Fi is based on the simple sender and receiver model, where sender is responsible for processing and encoding the data into light signals which are received by the receiver and is represented in the form of data. Li-Fi has wide applications in modern world. It can be used for transmission of multimedia, i.e. sound and image. It can also be used for vehicle to vehicle communication system, thereby helps to reduce vehicles’ accidents. Apart from these, it can be used to improve communication by increasing transmission capacity in the indoor scenario for 5G wireless mobile networking technology. It can also be combined with other techniques such as Radio Frequency and Wi-Fi.

Introduction

Li-Fi is a new development in the field of wireless communication. It stands for Light Fidelity and due to the increase in wireless network users and the limited range of radio frequency; there is a need for the development of new communication system that uses other communication medium \cite{1, 2}. This lead to the emergence of Li-Fi that uses visible light that have range of 400 to 800 thz and is capable of carrying more information as compared to radio waves \cite{3}. The binary data is represented by the light states; binary 1 is represented when the light is on and binary 0 by off state. The data is mapped onto light states and the corresponding sequence of light states is generated in order to transmit data. Li-Fi uses LED light to produce the sequence of on off states as these can change the state quickly in a time period which is not noticeable by the human eye and thus giving constant light \cite{4}. The basic diagram of Li-Fi communication is given in fig. 1.

Implementation

The Li-Fi system works on simple concept of transmitter and receiver \cite{5}. Fig. 2 shows the different steps in implementation.

2.1. Sender side

The sender is responsible for processing and modulating the input signal received from the internet access point with the required time period. It then transmits the data in the form of 0 and 1. The sender module consists of the following components:

2.1.2 Controller chip

The controller chip is responsible for processing the analog signals received from the internet access point and it then uses modulation technique to modulate the intensity of light to generate corresponding LED on off pattern to encode the data that will be sent to the receiver. The various forms of modulation techniques are as follows:

- On off keying (OOK)
  The on off keying modulation scheme is the simplest form of modulation and is based on of amplitude shift key modulation. The amplitude shift key modulation represents the binary data with respect to the amplitude of the signal. The presence of carrier wave represents binary 1 and its absence represents binary 0. The on off key uses the same mechanism and the digital 1 is represented by light ‘on’ state and 0 by light ‘off’ state.

- Variable Pulse Position Modulation (VPPM)
  The Variable Pulse Position Modulation method is used for optical communication where efficiency is required and no external interference occurs. This Modulation method is used to transmit digital signals by encoding the data using the position of the pulse within the set time period. The time period of the pulse should be large enough to have various positions that could be identified. In this scheme 0 is represented by a negative pulse at the beginning of the time period and followed by a positive pulse. Similarly 1 is represented by a positive pulse at the beginning followed by a negative pulse.
Colour shift keying

The colour shift keying modulation mechanism is used in visible light communication where different colour Led is used. In this modulation technique the primary colour Led i.e. red, green and blue are mixed together to get different colors which are coded as information bits. This modulation scheme is the most suitable modulation technique for Li-Fi as it not only provides a way to encode data to be transmitted but also provides a constant light and thus serving both the purpose of illumination as well as data transmission.

2.1.2 Timer

The timer is used to provide the required time interval between each bit that needs to be transmitted.

2.1.2 Light Source

The receiver module consists of light source that can provide high rate of light output and is capable of switching between on and off state quickly in the very short time interval. These requirements are fulfilled by LED that are faster in switching the states as compared to the conventional lighting system and also the illumination exists everywhere therefore these can be used as lighting device and for data transmission simultaneously.

2.2 Receiver side

The receiver is responsible for receiving the data sent by the sender in the form of LED light flashes by capturing and generating the sequence of 0’s and 1’s. The digital data is then represented in the form of data which was sent by the sender. The receiver consists of the following components:

2.2.1 Photodiode

The photodiode is a semiconductor device that captures the light states on and off and converts the light into current. These are responsible to detect the presence and absence of LED lights.

2.2.2 Data converter

The data converter module converts the current generated by the photodiode into the digital signal. The digital data is then interpreted and represented in the original format as sent by the sender.

Applications of Li-Fi

Li-Fi has wide applications in modern world. The various applications are as follows:

3.1 Transmission of multimedia

Li-Fi can be used for transmission of multimedia. Assabir et al [6] have proposed to use Li-Fi technology in the transmission of the sound at the base of Pulse Width Modulation due to scarcity of Radio Frequency spectrum. An audio signal generated by a mobile phone is transmitted. A sawtooth signal is used in order to create a PWM signal. After this, the modulated signal is transmitted by LED. The photodiode detects the signal and converts it into an electrical signal. Further, the
signal is demodulated and desired results are obtained. Mahendran [7] has proposed a technique to transmit an image using Li-Fi. When LED light is ON digital data bit stream of 1 is transmitted. On the other hand, when LED light turns off, digital bit stream of 0 is transmitted. On this basis, image transmission was done through Li-Fi.

### 3.2 Vehicle to vehicle communication

Li-Fi can be used in case of vehicle to vehicle communication. Scopigno et al [8] have discussed the possible roles of Li-Fi on Vehicle to Vehicle communications and positioning. The evaluation by simulations is also discussed. Abdulsalam et al [9] have presented basic designs and results of prototype of a vehicle to vehicle communication system using Li-Fi technology. The proposed use of Li-Fi technology helps to reduce vehicles’ accidents. LED bulbs are used as means of connectivity by sending data. Two scenarios have been considered: when vehicle in front is braking and when vehicle is in T-junction. Bhateley et al [10] have developed a smart vehicular communication system using Li-Fi technology. LEDs placed in the head and tail lights can be used for short range communication with the photodetectors. The design is cost effective due to low cost of LEDs and low complexity algorithms are used for signal generation and transmission. Simulation results are provided by the authors.

### 3.3 To improve communication

Li-Fi can also be used to improve communication. Abdallah and Boudriga [11] have proposed to use Li-Fi technology to improve transmission capacity in the indoor scenario for 5G wireless mobile networking technology. Orthogonal Frequency Division Multiplexing (OFDM) is investigated to reach targets using 5G optical wireless access in terms of data rates and transmission delays.

### 3.4 To obtain benefits by combining with other techniques

Li-Fi can also be combined with other techniques such as Radio Frequency and Wi-Fi. Wang et al [12] have proposed Li-Fi and radio frequency (RF) hybrid network for providing better services to users in case of IoT. Li-Fi offers high data rate by using the large spectrum of visible light and the RF system guarantees a seamless coverage. The authors have proposed a load balancing algorithm which is based on evolutionary game theory. The users are allowed to choose the APs and adapt their strategies. It helps in reducing computation load of the central unit. Experimental results indicate that the proposed algorithm gives better results as compared to the conventional centralized algorithms in terms of the user satisfaction. Wang and Haas [13] have considered hybrid network combining Wi-Fi and Li-Fi. In indoor scenarios, Li-Fi AP can provide very high throughput while Wi-Fi offers basic coverage. Due to presence of mobile users, it suffers from the problem of variable user locations, and results into large variations in traffic demand. It is proposed to dynamically allocate resources to users, where the utility function depends on throughput and fairness. Experimental results indicate that the proposed scheme always outperforms in terms of fairness and can attain better aggregate throughput in the case of low user density.

### Conclusion

Li-Fi has been widely used in modern world in various applications such as transmission of multimedia, i.e. sound and image, vehicle to vehicle communication systems, improving communication by increasing transmission capacity in the indoor scenario for 5G wireless mobile networking technology, combining with other techniques such as Radio Frequency and Wi-Fi, etc. As a part of future work, we will investigate applications of Li-Fi in day today life, i.e. communication between electronic devices.

### References

7. Mahendran, R. Integrated LiFi (Light Fidelity) for smart communication through illumination, in Advanced Communication Control and Computing Technologies (ICACCCCT), 2016 International Conference on. 2016. IEEE.
8. Scopigno, R., et al. The potential benefits of on-board Li-Fi for the cooperation among vehicles. in Transparent Optical Networks (ICTON), 2015 17th International Conference on. 2015. IEEE.
9. Al Abdulsalam, N., et al. Design and implementation of a vehicle to vehicle communication system using Li-Fi...

11. Abdallah, W. and N. Boudriga. Enabling 5G wireless access using Li-Fi technology: An OFDM based approach. in Transparent Optical Networks (ICTON), 2016 18th International Conference on, 2016. IEEE.
