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Visible Light Communication Channel Optimization by Selecting The optimal Light Access Points

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ABSTRACT

Radio spectrum is encountered large scarcity on current times due to the increased demand of radio resources. New communication channels are required to test the new technology. Such demands put the technology provides in crossroad where they need to purchase new radio resources or perhaps reuse the available spectrum. Li-Fi is proposed to enable the unlicensed users to share the spectrum efficiently through using visible light network backbone. In this paper, we are intending to study users' behaviors and the method of integrating the user into the spectrum over Li-Fi technology. Using Additive white gaussian noise (AWGN) throughput is measured with different set of primary users. 782.18 bit/second is detected with single user existence while 544.85 is detected with 10 users existence.

Keywords: Spectrum sensing, frequency division multiplexing, primary user, licensed band, LI-FI, RSS

INTRODUCTION

Spectrum was segregated earlier among the available applications on that time and only small portion of the radio was left for future employment. Such policy of the spectrum allocation is set with limited application and technology is found inefficient for today's technology utilization. Spectrum reuse is proposed to overcome the deficiency of spectrum and the same is stated by Cognitive Radio (CR) approach [1].

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Data volumes are increased from users ends due to the development of computer systems and handset electrons. The stream of data is then demanded extra network capacities on spectrum level. The need of extra resources for data transmission is insisted need for accommodating further network expansion.

Spectrum is occupied by licensed users and applications that defined by international standard organizations. The traditional radio frequency networks such as wireless fidelity (Wi-Fi) are facing performance challenges related to the throughput and latency [2]. Due to the congestion on radio bands, new user's assignment has become more challenging. Other technologies are came into light such as visible light communication which is basically deploying visible light as a channel for accessing radio network resources [3-5].

In this paper, we are going to establish an access point for the radio network using the light fidelity (Li-Fi) network. Study aims to evaluate the throughput and average time delay while using the received signal strength (RSS) approaches.

SYSTEM MODELING

In order to perform data transmission, communication system needs to be modulated perfectly. Starting with source of information and transmitter internal process, signal is generated with ten frequencies that reflect ten licensed users. However, sinusoidal wave is generated so that frequency analysis is done smoothly. With 1000 KHz bandwidth, ten users may be labeled as one ideational array of "Freq".

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$$Freq = [100\ \ 200\ \ 300\ \ 400\ \ 500\ \ 600\ 700\ 800\ 900\ 1000]$$

Signal is passed through Additive White Gaussian Noise (AWGN) as demonstrated in Figure 1.

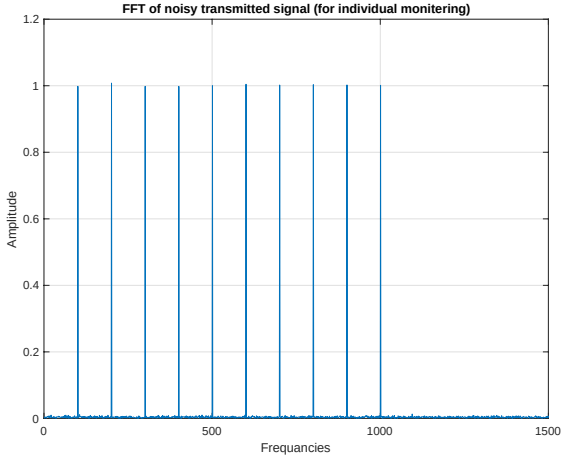

Figure 1: Transmitted signal of ten primary users (frequency domain).

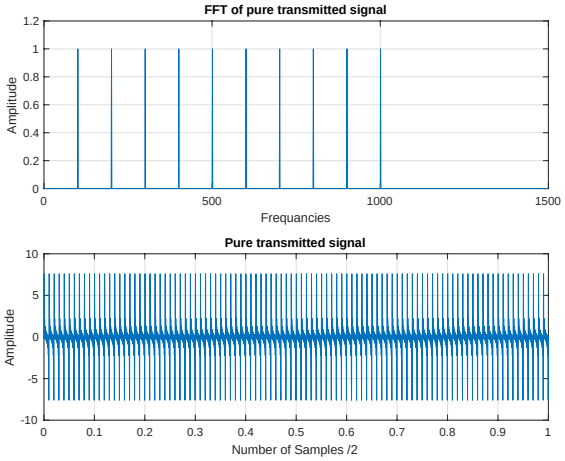

Figure 2: Transmitted signal of ten primary users (frequency domain and time domain).

In Figure 2, ten users are generated at the multiplexer in the source (transmitter), Fast Fourier Transform (FFT) is demonstrating the number of frequencies participation in the signal where the time domain signal is also shown in the Figure which is sent using Frequency Division Multiplexing (FDM). Thus, the signal is transmitted into the channel where AWGN exists, Figure 3 is demonstrating the signal at the channel where noise impact is clearly visible on FFT demonstration.

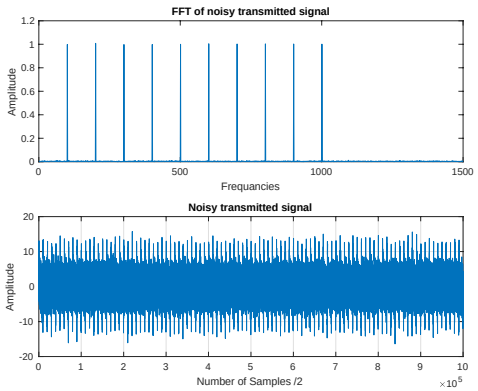

Figure 3: Transmitted signal under the impact of channel noise

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In traditional radio frequency channel, it is important to monitor the users behaviors in the channel that reflect the amount of time that users are using the slot (user existence in the particular spectrum slot).

Fast Fourier Transform (FFT) is provided the channel content information at early time of experiment Table 1 demonstrate the sample six frequencies along with channel effect where signal to noise ratio is set to (0.5).

Waiting time estimation approach is being used in this study, where secondary user can be allocated in the channel with accordance to the results of time estimator. Since primary user draw a random behaviors in the sense of channel occupancy, the time estimation for each user is generated randomly where user can take over the band for "T" seconds and depart the band at the end of "T" period.

In order to examine the system response for six primary users, experiment is repeated for n iterations (eight times) in each, occupancy time of every user is monitored. Time estimator data can be listed as below.

Table 1: Time (seconds) estimation data

				U1	U2	U3	U4	U5	U6
Iteration 1				16	3	13	4	9	7
Iteration 2				8	17	4	1	7	9
Iteration 3				2	9	15	4	1	8
Iteration 4				15	12	11	8	1	9
Iteration 5				9	14	13	18	2	11
Iteration 6				3	8	1	15	16	14
Iteration 7				6	4	16	18	20	15
Iteration 8				2	4	10	14	18	1

The above demonstration includes the user number versus the iteration. Each column involves time estimation of particular primary user in all iterations for example: primary user (U1) is taking over the band for 16 seconds and or 15 seconds at fourth iteration whereas for 2 seconds at third and eighth iteration respectively. Once the radio spectrum is allocated by primary users for different probabilities (eight iterations), monitoring the behaviors of primary users can be performed. This analysis is essential for studying the per band activity more likely to identify the busiest band by monitoring the light and heavy traffic phases.

LIGHT FIDELITY

Li-Fi is an optical wireless communications (OWC) system that, similar to Wi-Fi, employs light from light-emitting diodes (LEDs) as a medium for networked, mobile, high-speed communication. The Li-Fi market was predicted to increase at an annual pace of 82 percent between 2013 and 2018, reaching a value of more than $6 billion. On the other hand, the industry has not evolved as expected, and Li-Fi is still primarily used for technical testing [6].

By rapidly switching the current to the LEDs off and on at a rate too fast for the human eye to discern, visible light communications (VLC) eliminates flickering. To transmit data, Li-Fi LEDs must be turned on, although they can be dimmed to levels below human vision while still transferring data [7]. The visible spectrum is a critical technological problem since it is limited to lights and is not well adapted to mobile communication. With handover systems that allow roaming across several Li-Fi cells, switching between Li-Fi networks might be a breeze. Because light waves cannot flow through barriers, they have a far narrower range and are less vulnerable to hacking than Wi-Fi. To broadcast a signal, Li-Fi does not require a direct line of sight; light reflected off walls can reach 70 Mbit/s.

Li-Fi has the advantage of not causing electromagnetic interference in electromagnetically sensitive areas such as airline cabins, hospitals, and nuclear power plants [8]. Wi-Fi and Li-Fi both transport data using the electromagnetic spectrum, however Li-Fi uses visible, ultraviolet, and infrared light while Wi-Fi uses radio waves. While the US Federal Communications Commission has warned that Wi-Fi capacity could lead to a spectrum shortage, Li-Fi has few restrictions. The range of visible light is 10,000 times that of radio frequencies. Researchers were able to obtain data speeds of around 224 Gbit/s, which is much faster than the average

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high-speed internet connection in 2013. In terms of cost, Li-Fi is predicted to be ten times less expensive than Wi-Fi. A limited range, low dependability, and expensive installation costs are among the negatives [9].

PureLiFi announced the Li-1st, the first commercially available Li-Fi system, during the 2014 Mobile World Congress in Barcelona. In an IoT device, Bg-Fi is a Li-Fi system that integrates a mobile app with a basic consumer product such a colour sensor, microcontroller, and embedded software. Light from a mobile device's display is converted into digital data by the colour sensor in consumer devices. Light emitting diodes allow consumer goods to communicate with mobile devices in real time [10].

RSS BASED LIFI

As radio spectrum is established and allotted for all primary users, the challenge raised at the time of sharing the spectrum between primary users (those who are existing the spectrum) and secondary users (who are willing to join the spectrum and looking for the spectrum hole). Our model involves ten primary and secondary users, all to be transmit over 100-1000 KHz band at presence of AWGN. Spectrum sensing is vital for all functions in this paradigm. Most techniques used to perform spectrum sensing were majorly depending on energy detection method which conducts spectrum analysis with received signal strength (RSS). This technology is more sensitive to channel disturbances like noise and fading at such incident more likely when noise takes over an empty band, the decision of energy detector may be corrupted by noise inference and return wrong information about the spectrum availability. Known that spectrum congestion and scarcity problems are become serious threat of communication's future, a strong spectrum sensing is required for avoiding any non-précis decision. However, a proactive approach is proposed in this study for establishing noise independent spectrum sensing model underlying with time estimator information. The spectrum sensing model can be described by the following chart (Figure 4).

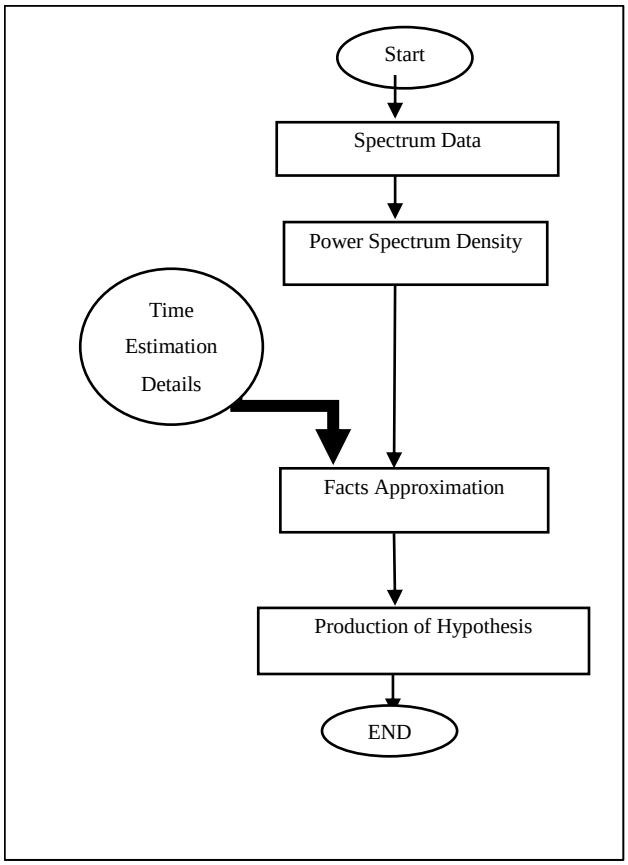

Figure 4: Spectrum sensing proactive paradigm.

The throughput measured using the RSS method and the same is demonstrated in Figure 5. Table 2 is detailing the throughput of the RSS in LiFi technique.

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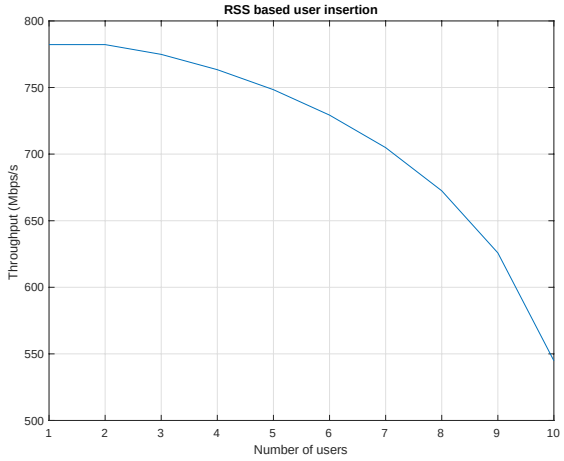

Figure 5: Throughout of the transmitted users (ten) users.

Table 2: Throughput of RSS method in Li-Fi technique

Number of transmitted users at the time.	Throughput (bit/second)
1	782.180721104445
2	782.200855796469
3	774.833368431131
4	763.394420975819
5	748.362260573384
6	729.284495856864
7	704.886223137547
8	672.482993647881
9	625.837734298677
10	544.850024333507

The impact of users mobility on the throughput is demonstrated in Figure 6.

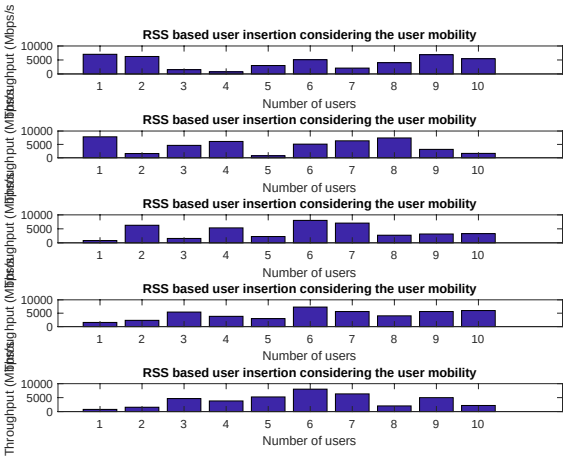

Figure 6: Impact of user's mobility on the throughput.

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CONCLUSION

LiFi is new technology that utilizes the visible light for supporting the radio frequency wireless network. in that, user assignment to the band is challenging since it is limited to the throughput expected by each user. Behaviors are derived by using time waiting estimation paradigm which provide precise time interval of each band occupancy. Efficient spectrum sensing is found essential to prevent the wrong holes detection in licensed band. Event such as high energy noise availability or primary user fluctuation (mobility) impact on the throughput is studied. The results shown that throughput using RSS technique is decreasing when number of users increases, that is sue to time waiting and congestion n the light band. From the other hand, users mobility is impacting the throughput as illustrated in Figure 6.

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