2016 UKSim-AMSS 18th International Conference on Computer Modelling and Simulation

Performance Evaluation of Wi-Fi and White-Fi : Simulation Approach

Rafiza Ruslan, Ahmad Hafizuddin Mohd. Nor, Rizauddin Saian
Faculty of Computer & Mathematical Sciences
Universiti Teknologi MARA Perlis, Malaysia
{rafiza.ruslan, rizauddin}@perlis.uitm.edu.my,
hafizmohdnor93@gmail.com

Mohd. Hasbullah Omar
School of Computing
Universiti Utara Malaysia, Kedah, Malaysia
mhomar@uum.edu.my

Mazani Manaf
Faculty of Computer & Mathematical Sciences
Universiti Teknologi MARA, Malaysia
mazani@tmsk.uitm.edu.my

Abstract — **Wi-Fi is widely used to connect electronic devices wirelessly using ISM radio bands. Previous studies have reported traffic congestion in Wi-Fi due to several reasons. As an alternative, unused spectrum in TV band known as TV white space (TVWS) can be utilized for the same purpose. The use of Wi-Fi technology in TV band is also known as White-Fi. TVWS ranges in VHF and UHF that is not utilized by licensed user in a particular time and location. This paper presents a network performance comparison between Wi-Fi and White-Fi by evaluating the average throughput, end-to-end delay and packet delivery ratio (PDR). The simulation result shows White-Fi (IEEE 802.11af) has a significant percentage of average throughput and PDR with 25.94% and 24.06% compared to Wi-Fi (IEEE 802.11g) respectively. In addition, the percentage of average end-to-end delay in White-Fi is 60.79% lower than Wi-Fi.**

Keywords - Wi-Fi; White-Fi; DSO; TVWS

I. INTRODUCTION

The rapid development of wireless devices is due to the increasing of wireless applications. In order to run the applications; clients, servers and databases should be effectively associated with a reliable internet connection. Some critical time applications such as media streaming, interactive gaming and real-time voice/video calls required uninterruptable Internet connection [1].

Today, many places increasingly offer wireless access to the Internet; such as coffee shops, shopping malls and hotels. These services may be free to all, free to customers only, or fee-based. It is convenient for mobile users who have their wireless-enabled devices along with them. In no specific venue, one can observe most people either on the smartphones, laptops or tablet PC talking, texting or surfing the Internet. Due to the easy access service, Wi-Fi is the most well-known technology being implemented besides mobile broadband that allows access to the Internet [2].

Efficient wireless communication environment is required to accommodate the overwhelming development of wireless applications and devices. However, the demand of utilizing Wi-Fi has led to traffic congestion. Furthermore, Wi-Fi has limited access and prone to interference of transmission signals [2].

On another view, the existing fixed spectrum allocation has contributed to spectrum scarcity as well [3]. In addition, the occupancy level of the spectrum is relatively unbalanced. For example in Malaysia, some parts of the country experience network traffic congestion and some are even underutilized. A routine scan by Malaysian Communication and Multimedia Commission (MCMC) confirmed this situation (see Fig.1).

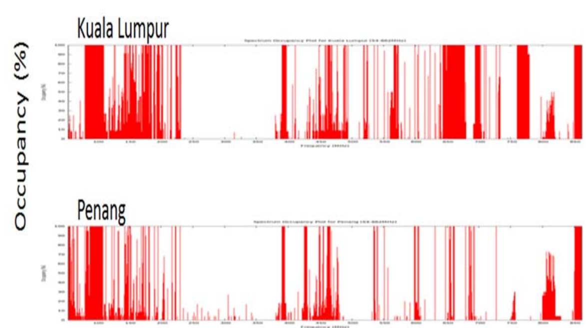

Figure 1. Spectrum Usage in two cities in Malaysia [4].

Fig.1 shows spectrum occupancy scans for two cities in Malaysia (Kuala Lumpur and Penang). In order to mitigate problem such as underutilized spectrum and spectrum scarcity, the concept of cognitive radio (CR) was introduced. CR allows unlicensed users to utilize available spectrum, provided no harmful interference to the primary user [2, 5].

Incidentally, Federal Communication Commission (FCC) has agreed to offer the use of TVWS that includes extended wireless local area network (White-Fi) [6, 7]. TV band may adopt and implement innovative and more efficient dynamic spectrum access (DSA) supported by CR technology. The regulation and standards of TVWS are explained in [8].

978-1-5090-0888-9/16 $31.00 © 2016 IEEE
DOI 10.1109/UKSim.2016.38

This paper analyses the network performance of Wi-Fi (IEEE 802.11g) and White-Fi (IEEE 802.11af); and compares the network performance between Wi-Fi and White-Fi in six scenarios with increasing number of nodes. The network performance is evaluated by capturing the throughput, end-to-end delay and PDR.

The remaining of the paper is organized as follows: Section II demonstrates some previous related work on White-Fi. In Section III, simulation setup is described. Result and analysis is presented and discussed in Section IV. Finally, the paper is concluded in Section V.

II. Related Works

Current throughput is not sufficiently achieved due to the traffic congestion and radio interference [2]. One of the services that users are able to use is accessing the internet through Wi-Fi connection using IEEE 802.11a/b/g/n standards. However, Wi-Fi has some limitation. Based on the previous researches, White-Fi has some advantages compared to traditional Wi-Fi. Harada has confirmed that white space communication can configure a dependable and robust network and become one of the techniques to do load balance of traffic in a network [2].

Zhou presented the first world prototype system of Wi-Fi in TVWS based on TGaf draft specification and discovered the advantages of White-Fi operating in TV band (470-710MHz) that offers longer distance and broader bandwidth [7]. Researcher in [5] also did a quantitative analysis of downlink throughput of three 802.11 standards which are 802.11af in TVWS, 802.11g in 2.4GHz and 802.11p in transportation system in TVWS and discovered that White-Fi is cost effective, high data rate and provide significant coverage compared to existing 802.11 Wi-Fi systems. Moreover, WLANs in the TV band provides better speeds, longer range and more reliable connection as cited in [6].

In days to come, there will be more available spectrum after digital switchover (DSO) TV transmission replaces the current analogue system. Recently, many countries started to replace the current analogue television technology with digital television (DTV) [2, 6,7]. Several regulators such as FCC in US, OfCom in UK and MCMC in Malaysia are considering secondary utilization in TV band as the white space. Currently, Malaysia is expected to switch to DTV latest by year 2020.

III. Simulation Setup

The simulation implemented OMNeT++ with INET 3.1.1 framework [9] that consists of an enhancement of a modular and extensible new 802.11 mac model. Hence, the main model for this simulation is lan80211 with relevant modules; WirelessHost, AccessPoint, RadioMedium and configuration. Fig. 2 shows an overview of the WirelessHost submodules. It assigns per-interface IP addresses, strives to take subnets into account, and can also optimize the generated routing tables by merging routing entries.

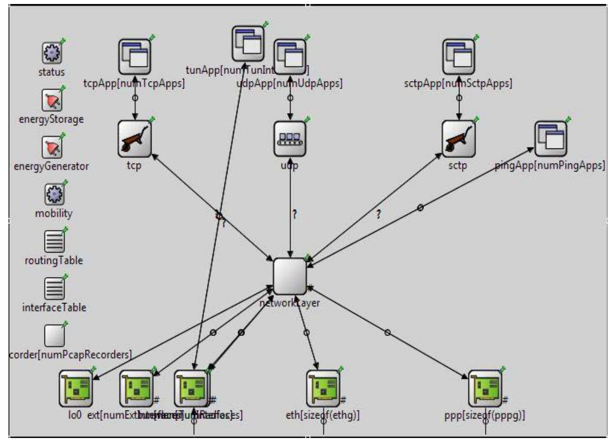

Figure 2. An overview of in the wirelessHost submodule.

Two different parameter setting is needed to simulate Wi-Fi and White-Fi as shown in Table I. The parameter setting is according to the standard specification [10].

TABLE I. Simulation Setup for Wi-Fi and White-Fi

PHY layer parameters	802.11g (Wi-Fi)	802.11af (White-Fi)
Carrier Frequency	2.4 GHz	0.79 GHz
Bandwidth	2MHz	6MHz
Transmission power	2mW	100mW
Bit Rate	2Mbps	26.7Mbps

There are various performance metrics to evaluate the IEEE 802.11g and IEEE 802.11af such as bandwidth, throughput, delay, PDR and routing overhead. However, the network performance for this simulation is measured based on throughput, end-to-end delay and PDR, that involves the sent packets, receive packets and sent bytes.

Throughput is defined as the number of received bits in one second. Throughput is measured in bit per second (bit/s) [11]. Throughput can also be measured in number of packets/bytes received by the source per unit time. It is an important metric for analyzing network protocols. Equation (1) shows the calculation of throughput.

$$Throughput = \frac{\sum Bytes\ Received\ \times 8\ bits}{\sum Simulation\ Time\ (200s)} \quad (1)$$

Delay is an important performance metric that refer to the time taken for a packet to be transmitted across a network from source to destination. Delay could be measured by referring the difference of packet arrival time and packet initial time [12] as shown in (2).

$$Delay = packet\ arrival\ time - packet\ initial\ time \quad (2)$$

The third performance metric is PDR is the total number of packets successfully delivered to total packets sent [13]. Equation (3) shows the equation to calculate PDR.

$$PDR = \frac{\sum Packet\ Received}{\sum Packet\ Sent} \quad (3)$$

Total of six scenarios with increasing number of nodes with 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 nodes were simulated to capture each performance metric. The simulation time is 200 seconds. Fig. 3 shows one of the simulation layout.

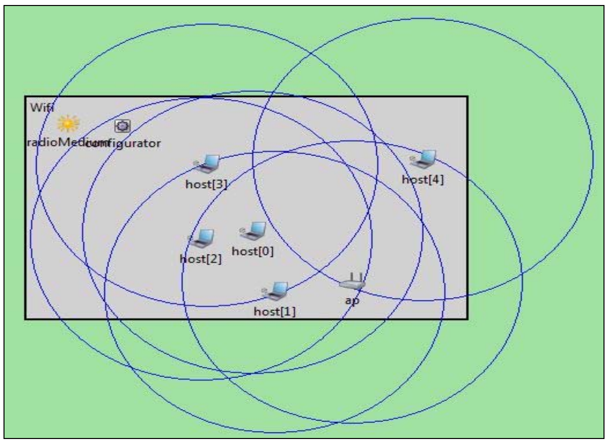

Figure 3. The simulation layout.

IV. Result and Analysis

The performance of both scenarios for IEEE 802.11g and IEEE 802.11af is evaluated by comprehensive simulation study considering the effect of the number of nodes. Throughput for IEEE 802.11g is not consistence. However, throughput for IEEE 802.11af increases with the increase in the number of nodes. IEEE 802.11af outperforms IEEE 802.11g as the number of nodes increases. Fig. 4 shows the overall throughput for 100 nodes.

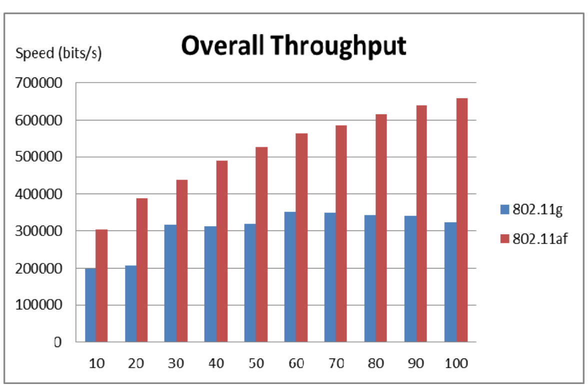

Figure 4. The overall throughput for IEEE 802.11g and IEEE 802.11af.

The average throughput for 802.11g is about the same even though the number of nodes increasing. However, throughput in IEEE 802.11af is obviously increasing with the increasing number of nodes. Throughput in IEEE 802.11g is due to the interference occurring among other nodes.

End-to-end delay is important in measuring network performance especially transmitting real-time data. Fig. 5 shows the comparison of average end-to-end delay between IEEE 802.11g and IEEE 802.11af.

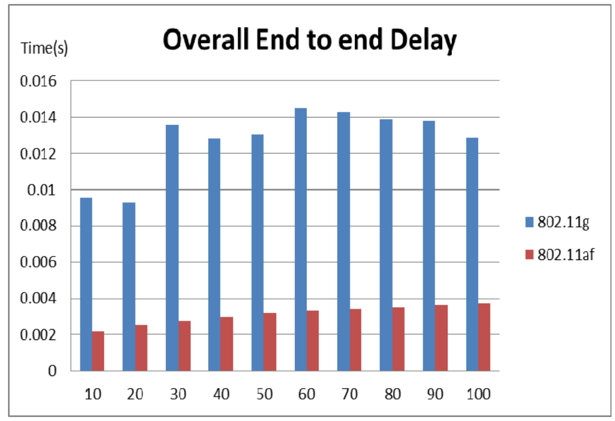

Figure 5. The overall delay for IEEE 802.11g and IEEE 802.11af.

Higher end-to-end delay reduces the network performance. The plotted result shows IEEE 802.11af has a lower end-to-end delay compared to IEEE 802.11g. IEEE 802.11af obtains a slight increase of delay with the increasing number of nodes. Whereas end-to-end delay in IEEE 802.11g has an average delay even though the number of node increases. Packet delivery ratio is also affected by the increasing number of nodes in IEEE 802.11g and IEEE 802.11af. PDR decreases with the increase number of PDR for both networks, as shown in Fig. 6.

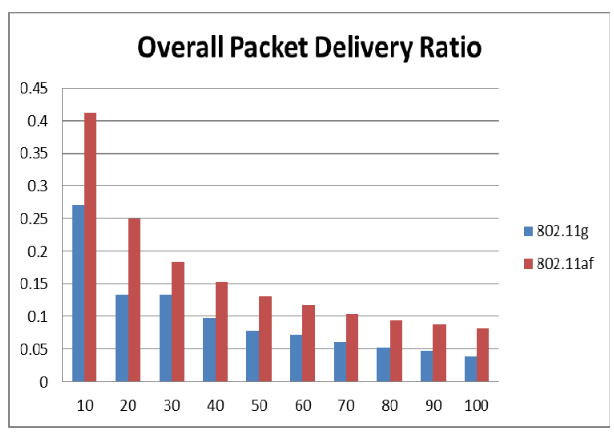

Figure 6. The overall PDR for IEEE 802.11g and IEEE 802.11af.

The result shows that IEEE 802.11af has a higher packet delivery ratio compared to IEEE 802.11g. Higher PDR means that the network performance is better. Fig. 7 depicts the summary of results from all scenarios.

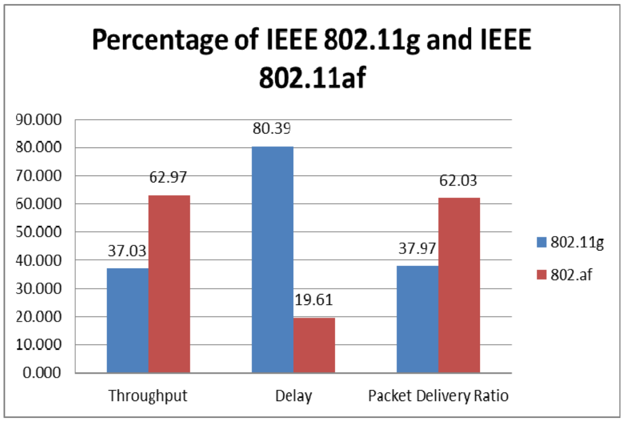

Figure 7. Summary of IEEE 802.11g and IEEE 802.11af.

The average throughput for IEEE 802.11g and IEEE 802.11af are 37.03% and 62.97% respectively. The difference between the two standards is 25.94%. IEEE 802.11af has lower frequency with higher transmission powers that affect the throughput. For end-to-end delay, the difference is 60.79% where IEEE 802.11g has higher end-to-end delay compared to IEEE 802.11af. IEEE 802.11g needs more time to send or receive packets. For packet delivery ratio, IEEE 802.11g is 40.89% while IEEE 802.11af is 16.69%. The difference between the two standards is 24.06%.

V. Conclusions and Future Work

This paper has presented a network performance comparison between Wi-Fi (IEEE 802.11g) and White-Fi (IEEE 802.11af). This research is implemented by increasing the number of host to obtain the results of the throughput, end-to-end delay and packet delivery ratio. Based on the data collected and observation from the scenarios created in WLAN environment, White-Fi shows a significant network performance compared to Wi-Fi. However, a real implementation on both standards will be carried out to obtain accurate results after the digital switchover TV transmission replaces the current analogue system. There are more to consider such as the available channel at a given area, population in rural or urban and the density of access points.

Acknowledgment

The authors wish to thank Universiti Teknologi MARA, Malaysia and Ministry of Higher Education of Malaysia (MOHE) for funding this study under funding this study under the FRGS Grant Scheme code **600-RMI/FRGS 5/3 (157/2013)**.

References

[1] Abdel Abdel-Rahman, M. J., Shankar, H. K., and Krunz, M., “Adaptive cross-layer protocol design for opportunistic WLANs over TVWS,” 2014 IEEE International Symposium on Dynamic Spectrum Access Networks, DYSPAN 2014, 519–530.

[2] H. Harada, K. Ishizu, and H. Murakami, “A wireless network system in TV white space,” 2013 16th International Symposium on Wireless Personal Multimedia Communications, WPMC 2013, 1–5.

[3] H.Elshafie, N.Fisal, M.Abbas,W.A.Hassan, H.Mohamad, N.Ramli, ”Asurvey of cognitive radio and TV white space in Malaysia”. Transactions on Emerging Telecommunications Technologies, Wiley Online Library.2014. DOI: 0.1002/ett.2778

[4] Omar MH, Hassan S, Shabli AHM, “Feasible study of using IEEE 802.22 wireless regional area network (WRAN) in Malaysia,” Second International Conference on Network Applications Protocols and Services (NETAPPS 2010); 198-202.

[5] Mitola III J,”Cognitive radio: making software radios more personal,” IEEE Personal Communication (1999); 13-18.

[6] Reham A, Nor Fadzillah Abdullah, Angela Doufexi and Andrew R.Nix, “Performance evaluation of 802.11 standards operating in TVWS and higher frequencies under realistic conditions,” (2014).

[7] Zhou L, Keiichi Mizutzni, Gabriel V and Hiroshi H, ”Design and implementation of a Wi-Fi prototype system in TVWS based on IEEE 802.11af,” IEEE Wireless Communications and Networking Conference (WCNC) (2013):MAC; 750-755.

[8] IEEE 802.11-2012, “(Revision of IEEE standard 802.11-1999),”2007.

[9] OMNeT++. (2012). *INET Framework for OMNeT++*. University of Kassel: OpenSim Ltd.

[10] L. Demian and M. Roman, “Comparison of 802.11af and 802.22 standards-physical layer and cognitive functionality,” Elektrorevue; Vol.3,No.2, June 2012.

[11] Dhobale, J. V, Kalyankar, N. V, and Khamitkar, S. D.’ “Computer Network Performance Evaluation Based on Different Data Packet Size Using OMNeT++ Simulation Environment,” (2014) 2(2). http://www.ijarcst.com/doc/vol2-issue2/dhobale.pdf

[12] V. Mehta and N. Gupta, “Performance Analysis of QoS Parameters for Wimax Networks,” International Journal of Engineering and Innovative Technology (IJEIT), 1(5), (2012) 105–110.

[13] Katheeth, Z. D., and Raman, P. K. K., “Performance Evaluation with Throughput and Packet Delivery Ratio for Mobile Ad-hoc Networks,” International Journal of Advanced Research in Computer and Communication Engineering, IJARCCE 2014, 3(5), 6416–6419.