PERFORMANCE ANALYSIS OF WLAN STANDARDS FOR VIDEO CONFERENCING APPLICATIONS

Lachhman Das Dhomeja[1], Shazia Abbasi[1], Asad Ali Shaikh[1], Yasir Arfat Malkani[2]

[1]Institute of Information and Communication Technology, University of Sindh, Jamshoro, Pakistan
[2]Institute of Mathematics and Computer Science, University of Sindh, Jamshoro, Pakistan
lachhman@usindh.edu.pk, shazia.abassi@usindh.edu.pk, asad.shaikh@usindh.edu.pk and, yasir.malkani@usindh.edu.pk

ABSTRACT

A number of traffic characterization studies have been carried out on wireless LANs, which indicate that the wireless settings pose major challenges, especially for high bandwidth and delay sensitive applications. This paper aims to evaluate a number of Quality of Service (QoS) parameters related to video conferencing over three major WLAN Standards 802.11a, 802.11b and 802.11g. To study the traffic characterization behaviour of these WLAN standards, we have simulated the environment for each of these standards and performed experiments. Results are verified through the delivery of successful H.261 video traffic import in OPNET-14 Network simulator. We found that a trade-off exists between the selected data rate, physical characteristics and the frequency spectrum (number of channels) for every standard. The traffic of video conferencing is characterized over each standard in terms of delay performance, traffic performance and load and throughput performance. The results show that quality of video traffic is a function of the frequency band, physical characteristic, maximum data rate and buffer sizes of WLAN standards.

KEYWORDS

WLAN standards, QoS support, video conferencing, OPNET-14.

1. INTRODUCTION

The field of wireless local area networks (WLANs) is being widely studied and used in various emerging research domains such as mobile and pervasive computing, where WLANs provide high-speed wireless connection and support accessing information from anywhere and anytime. WLANs[3-8] support a wide range of applications, which may include simple applications such as web browsing, file transferring, etc and the other ones, for instance, real-time multimedia applications (e.g., video streaming and video conferencing). The latter requires better quality of service than the former. A detailed survey of quality of service in WLANs can be found at [1]. While simple applications may well be supported by WLANs, the applications requiring better quality of services (real-time multimedia applications) may suffer due to reasons that the wireless channels are error prone, band-limited, etc [2].

IEEE 802.11[3-8] is a vital standard for wireless LAN, which adopts the standard 802 logical link control (LLC) protocol that is further divided into two sub layers: physical layer (PHY) and medium access control (MAC) layer. This configuration provides optimized functionality for

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wireless communication. Initially 802.11 had two physical layers: Direct Sequence Spread Spectrum (DSSS) and Frequency Hopping Spread Spectrum (FHSS) and later on the physical layer was categorized into three types with different physical characteristics and frequency spectrum [3].

The physical characteristic of 802.11a [5] and 802.11g [8] are identical – both are based on OFDM and support data rate of 54 Mb/s. However they differ in operating frequency spectrum – 802.11a operates on 5 GHz band, while 802.11g on 2.4 GHz. 802.11b [4] is based on DSSS and operates at 2.4 GHz band with transmission rate from 1 to 11 Mb/s. 802.11a has significant advantage due to the wide range spectrum of 5 GHz, having more number of independent channels. Both 802.11b and 802.11g are compatible with each other as both operates on 2.4 GHz spectrum, but this may cause degradation in system performance as 2.4 GHz is a small band spectrum with a lesser number of independent channels.

The main objective of the work presented in this paper is to study the performance of three WLAN standards, 802.11a, 802.11b and 802.11g, especially when supporting a video conferencing application, using these parameters: (i) used frequency spectrum and available number of orthogonal channels for each WLAN standards, (ii) used modulation technique of each standard, (iii) selected buffer size for application, (iv) Load of control and data channels in each standard. We have used OPNET-14 simulator [9-10] to simulate 802.11a/b/g-based WLANs for our study.

The remainder of this paper is organized as follows. Section 2 provides related work. Section 3 describes experimental setup in which we discuss how WLAN has been setup. Section 4 presents and discusses the results of various performance tests we have conducted. Finally, section 5 concludes the paper.

2. RELATED WORK

There exists a large body of research on Multimedia Traffic characterization either on wired or wireless LANs, such as [11,12,13,14,15,16,17,18,19,20]. In [11], video traffic has been analysed on Ethernet LANS over two different data rates: 10 Mbps and 100 Mbps focusing on characterization of quality of video in terms of glitches. The research efforts [12,13,14,15,16] focus on 802.11b network, where in [12], authors have characterized UDP traffic over 802.11b WLANs using parameters such as throughput, average delay, frame error rate, IP loss rate, etc. In contrast, in [13], the 802.11b has been investigated for its capabilities for voice traffic with the focus on minimizing Mean Opinion Score (MOS) requirements.

The authors [14] have developed a simple packet delay jitter analytical model for IEEE 802.11 DCF, which computes average packet delay and packet delay variability. The authors in [15] have extended their work carried out in [14] in which the proposed model is used to evaluate the performance of WLANs, especially for applications involving both voice and data. The parameters being used for performance evaluation include throughput, jitter, and loss rate probability.

In [16], an analytical model has been developed for IEEE 802.11b Distributed Coordination Function (DCF), which calculates various parameters such as an average voice packet, voice packet delay variation (jitter) and packet drop probability for voice packets. Additionally, authors have studied the impact of data transmission on voice capacity. Work carried out in [17] focuses on addressing the issues of real-time video streaming over WLANs, especially over

IEEE 802.11b. Their solution is based on combination of forward error control (FEC) coding with the ARQ protocol.

The authors [18] have investigated IEEE 802.11e standard for its capability for QoS support. This is done by evaluating both the Enhanced Distributed Channel Access (EDCA) and the Polling-based Channel Access modes of this standard for multiple traffics such as real-time audio and video traffic. Similarly, [19] also focuses on evaluation of WLAN standard's capability for QoS support and involves evaluation of two MAC layer protocols: DCF (Distributed Coordination Function) and EDCF (Enhanced Distributed Coordination Function). Their evaluation suggests that EDCF is better in providing QoS for multiple services environment as EDCF has a capability to distinguish and prioritize services. The authors [20] have evaluated the performance of 802.11 WLAN in terms of throughput, using four types of applications, http, remote login, video conferencing and voice over IP. Evaluation of throughput is done in presence of high priority traffic (video conferencing, voice over IP traffic) and low priority traffic (http, remote login traffic).

It can be noted that research efforts discussed above provide performance evaluation of a single WLAN standard. In contrast to these, our study provides performance analysis of three WLAN standards: 802.11a /g /b for video conferencing application.

3. Experimental Setup

In order to study the performance of three Wireless LAN standards for video conferencing application, we have simulated the network setup using OPNET-14 simulator and conducted various tests on it. A basic infrastructure mode network has been used for experimental setup, in which four Basic Service Sets (BSSs): BBS 0, BSS 1, BSS 2 and BSS 3 have been set, where every BSS is working as independent wireless LAN. Multiple number of wireless clients are running under BSS 0 and BSS 1, a wireless application server is running on BSS 2 and BSS 3 is configured as a backbone network for connecting other three LANs.

These three LANs, BSS 0, BSS 1 and BSS 2 are connected to each other with three routers. Each router has two WLAN interfaces; one of them serves as an access point for BSS 0, BSS 1 and BSS 2, while the other interface of three routers make up the WLAN-backbone (BSS 3). The first interface, IF0 of BSS 0, BSS 1 and BSS 2 is configured as an access point with BSS ID being set to 0, 1 and 2 respectively. Whereas the second interface, IF1 of three BSSs (i.e., BSS 0, BSS 1 and BSS 2) have been disabled for access point functionality and all of IF1s have been set with the same ID, which is 3. These three IF1s make up a Wireless backbone (BSS 3), as mentioned before.

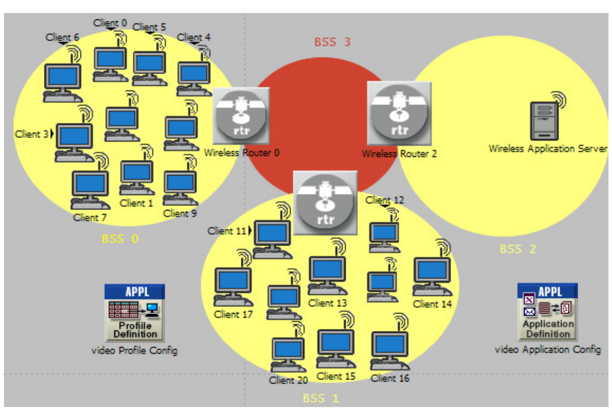

Figure 1: WLAN Setup

Attribute Setup: The attributes of each standard adopted according to the requirements. The most common parameters we used are tabulated below (table 1)

Table 1: Important parameters and their setting for the basic simulation

Attributes	Settings
WLAN Standards	802.11a / 802.11b/ 802.11g
Data Rate	54Mbps / 11 Mbps / 54 Mbps
Physical characteristic	OFDM / Direct Sequence/ OFDM
Frequency spectrum	5 GHz / 2.4 GHz / 2.4 GHz
Transmit Power	0.005 W
Packet Reception Power Threshold	-95
Buffer size	256000
Max. Receiver Life time	0.5 Sec
Roaming capability	Disabled
Beacon Interval	0.02 Sec
Short time limit	7
Long time limit	4

4. RESULTS AND DISCUSSION

In this section, we present the results of various tests we have conducted to analyze the performance of three wireless standards, 802.11 a, 802.11 b and 802.11g. Tests include Delay Performance, Traffic Performance and Load and Throughput Performance.

4.1 Delay Performance

Delay is an essential metric to characterize the QoS of any network, especially for real time Multimedia application. The delay is defined as the time taken by the system for data to reach the destination after it leaves the source. The delay for any network can be measured at three layers, end-to-end delay, wireless LAN delay and MAC (media access control) delay. Wireless LAN delay depends on used frequency band and media access delay on media access technique and physical characteristic of the standard, while end-to-end delay includes both wireless LAN delay and MAC delay. The following figures show the results of end-to-end delay test, wireless delay test and MAC delay test.

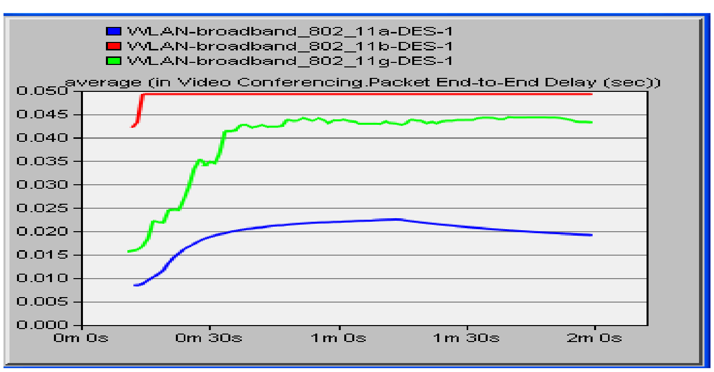

Figure 2: End-to-end delay of three standards

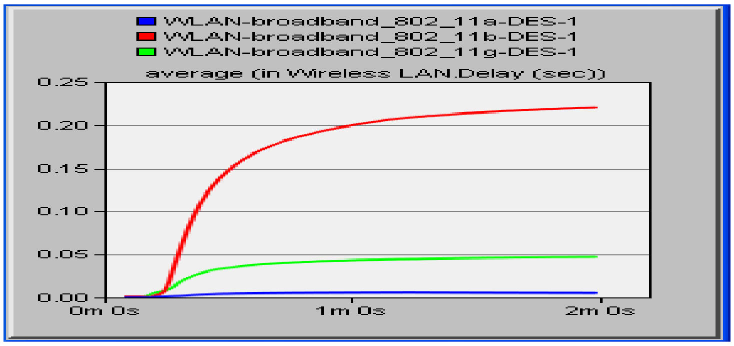

Figure 3: Wireless LAN delay of three standards

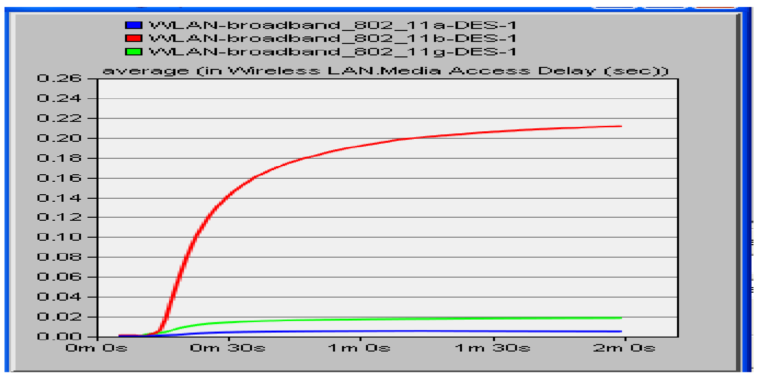

Figure 4: Media access delay of three standards

Results presented in figure 2, figure 3 and figure 4 indicate that the 802.11a has minimum delay, while the 802.11g has twice as much delay as in 802.11a, whereas 802.11b has maximum delay in all three cases. While in all three cases 802.11b has maximum delay, in end-to-end delay (figure 2) the performance of 802.11b is improved a little in comparison with other two cases (WLAN delay and MAC delay) because DSSS works efficiently with minimum orthogonal channels of 2.4 GHz. To summarize, all three results suggest that 80211a performs better than other two standards. We have also calculated sample mean, variance and standard deviation of all three tests (end-to-end delay, wireless LAN delay and MAC delay) for each standard, and the results are summarized in table 2.

Table 2. Sample mean, variance and standard deviation of performance delay test

Delay Performance	WLAN Standard	Sample mean	Variance	Standard deviation
Packet end to end Delay	802.11a	0.0196348008932	1.12652781103E-005	0.00335637871973
	802.11b	0.0491222211525	8.98037442955E-007	0.000947648375166
	802.11g	0.0397200175033	6.31130731542E-005	0.00794437367916
Wireless LAN delay	802.11a	0.00480128812775	2.87035722714E-006	0.00169421286359
	802.11b	0.169570800291	0.0046528157452	0.0682115514059
	802.11g	0.037609206252	0.000175778509105	0.0132581487812
Media Access Delay	802.11a	0.00439140768535	2.44990949064E-006	0.00156521867183
	802.11b	0.16274496359	0.0043023502159	0.0655923030233
	802.11g	0.0151322222921	2.70551934843E-005	0.00520146070679

4.2 Traffic Performance

One of the parameters that can influence on overall performance of the Wireless Local Area Networks (WLANs) is traffic analysis. Traffic analysis includes traffic sent, traffic dropped and traffic received. Traffic sent determines the capability of the system to transmit amount of data from the source point, while traffic received determines the amount of the data received at the destination. The traffic drop in applications such as video conferencing is often caused by the buffer overflow and the amount of data dropped can be determined from the amount of data transmitted and received. We have conducted various tests for traffic performance of three wireless standards and the following figures (Figures 5, 6 and 7) show the results of these tests.

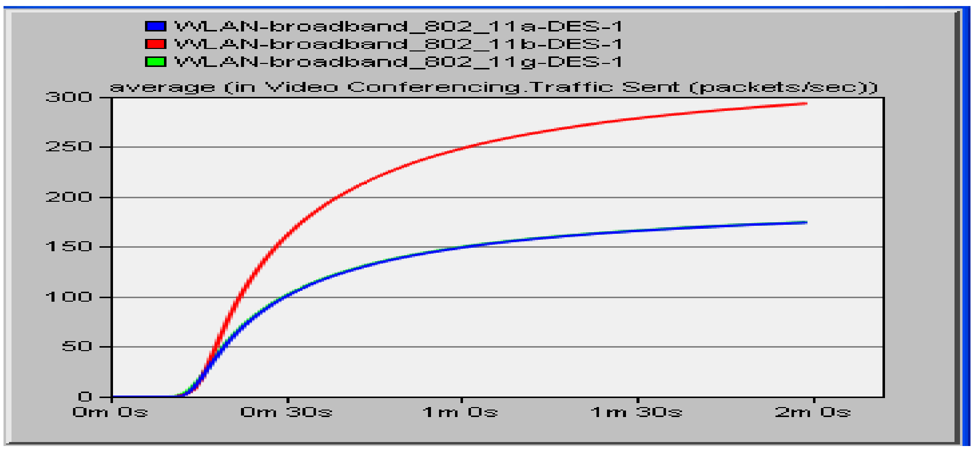

Figure 5: Video conferencing: traffic sent (packets/sec) of three standards

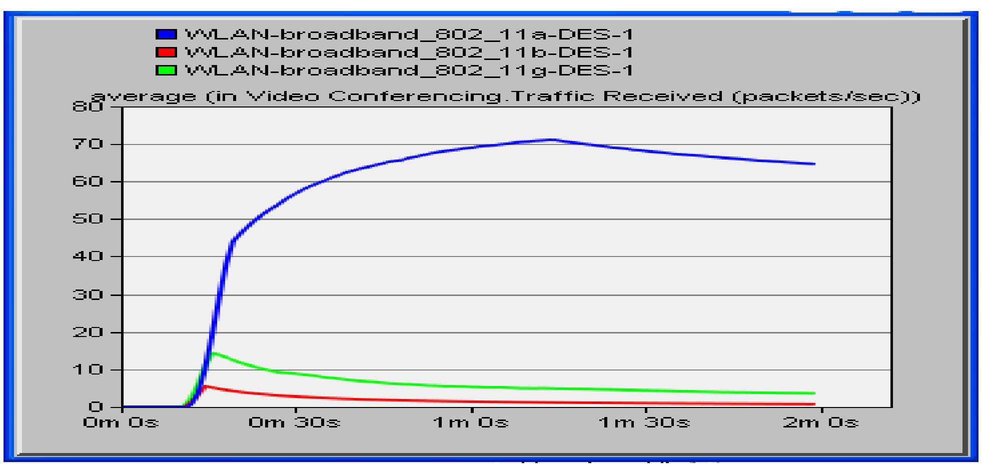

Figure 6: Video conferencing: traffic received (packets/sec) of three standards

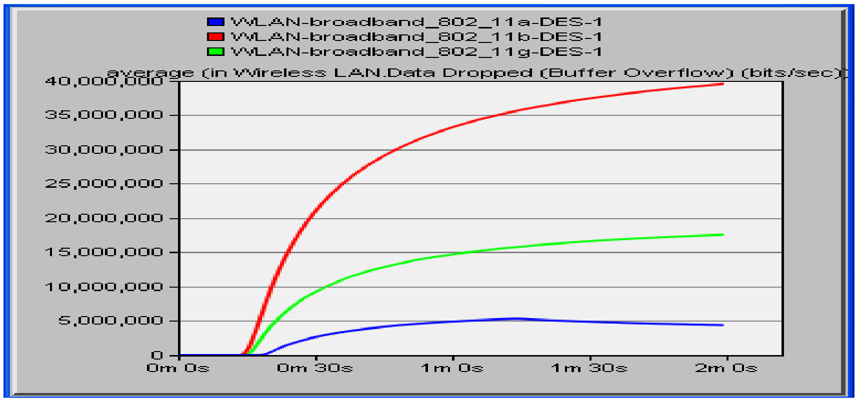

Figure 7: Video conferencing: data dropped (bits/sec) of three standards

To study the traffic performance of three wireless standards, the same amount of data was inputted to the system for each of three standards. As can be noted from the figures 5, 6 and 7, the 80211a has minimum data drop as compared to both 802.11g and 802.11b, hence maximum receipt. As compared to 802.11b, the 802.11g has lesser data drop. Figure 6 shows that 802.11a receives around 65% more data than the 802.11g and 70 % than 802.11b. With regard to capability of transmission of data, the results (figure 5) show that 802.11b performs better than 802.11a and 802.11g, while 802.11a and 802.11g perform almost equally. We have also calculated sample mean, variance and standard deviation of all three traffic performance tests (traffic sent, traffic received and traffic dropped) for each standard, and the results are summarized in the table 3.

Table 3. Sample mean, variance and standard deviation of traffic performance test

Traffic Performance	WLAN Standard	Sample mean	Variance	Standard deviation
Traffic Sent (packets /sec)	802.11a	0.0196348008932	1.12652781103E-005	0.00335637871973
	802.11b	0.0491222211525	8.98037442955E-007	0.000947648375166
	802.11g	0.0397200175033	6.31130731542E-005	0.00794437367916
Traffic Received (packets /sec)	802.11a	0.0048012881277	2.87035722714E-006	0.00169421286359
	802.11b	0.169570800291	0.0046528157452	0.0682115514059
	802.11g	0.037609206252	0.000175778509105	0.0132581487812
Traffic dropped (buffer over flow (bits/sec)	802.11a	0.0043914076853	2.44990949064E-006	0.00156521867183
	802.11b	0.16274496359	0.0043023502159	0.0655923030233
	802.11g	0.0151322222921	2.70551934843E-005	0.00520146070679

4.3 Load & Throughput Performance

Another parameter that influences the overall performance of the wireless standards is load & throughput. The load & throughput test is concerned with the receipt of the payload data without considering overhead of network against load. We have conducted three tests to analyse the load & throughput performance of each of three wireless standards: load carried by the system (figure 8), throughput of the system for offered load (figure 9) and retransmission attempts until either packet is successfully transmitted or it is discarded as a result of reaching short or long retry limit (figure 10).

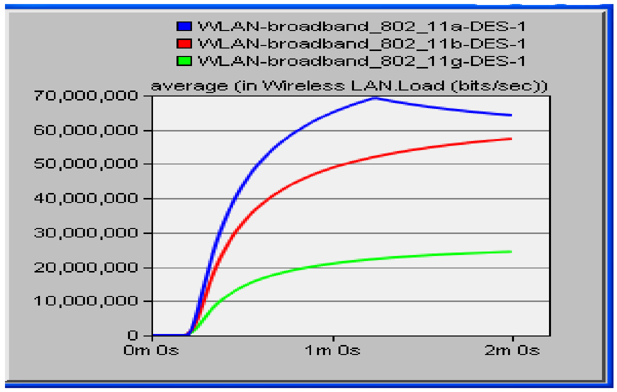

Figure 8: Wireless LAN load (bits/sec) of three standards

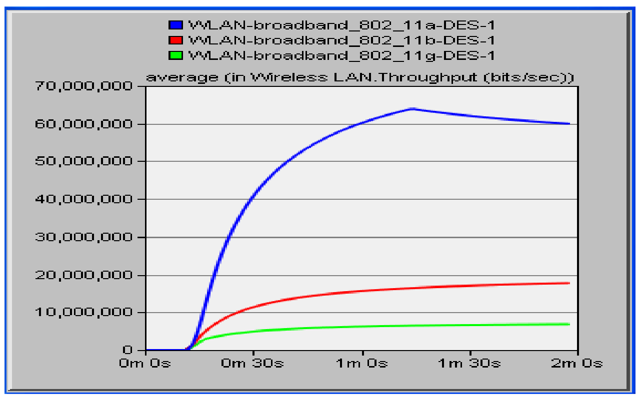

Figure 9: Wireless LAN Throughput (bits/Sec) of three standards

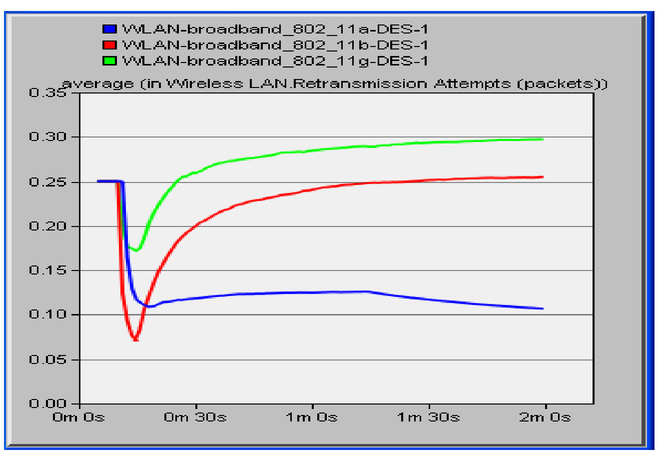

Figure 10: Wireless LAN Retransmission Attempts (Packets) of three standards

The purpose of this test is to identify which standard is an efficient under heavy load of system in terms of higher throughput with minim number of retransmission attempts. These plots show that the performance of 802.11a in a heavily loaded network is better than both 802.11b and

802.11g. The sample mean, variance and standard deviation of all three load & throughput performance tests for each standard are summarized in the table 4.

Table 3. Sample mean, variance and standard deviation of load & throughput performance

Load & Throughput Performance	WLAN Standard	sample mean	variance	standard deviation
Average Load (bits/sec)	802.11a	50,657,352.2283695	553,011,813,641,622	23,516,203.2148394
	802.11b	40,047,690.898171	367,763,492,205,956	19,177,160.6919783
	802.11g	17,185,538.0215591	65,634,393,372,658.8	8,101,505.62381208
Average Throughput (bits /sec)	802.11a	46,958,600.1995828	472,677,785,964,715	21,741,154.2003803
	802.11b	12,936,731.3084012	32,561,925,057,069.1	5,706,305.72762002
	802.11g	5,183,099.62016764	4,606,459,734,051.55	2,146,266.46389761
Average Retransmission attempts (Packs)	802.11a	0.127212416114	0.00106241441837	0.0325946992373
	802.11b	0.225022059352	0.00194173949542	0.0440651732712
	802.11g	0.273108083123	0.000952249981415	0.0308585479473

5. CONCLUSION

Main motivation behind the work presented in this paper was to investigate the performance of three main WLAN standards, 802.11a, 802.11b and 802.11g, especially for the applications which have high bandwidth requirements such as video conferencing application. Consequently, we performed various tests using OPNET-14 simulator. Performance tests conducted were Delay Performance, Traffic Performance and Load & Throughput Performance. In Delay Performance test, we observed the results for three cases: End-To-End Delay, Wireless LAN Delay and MAC Delay, which indicate that 802.11a has minimum delay. Traffic performance test included three cases: Traffic sent, Traffic Received and Data Dropped. The results of this test showed that the 80211a has minimum data drop, hence improved data receipt. Load & Throughput test includes three cases: WLAN load, Throughput and Retransmission Attempts. We observed that under heavy load of LAN traffic, 802.11a has maximum throughput with minimum retransmission attempts, while 802.11g performs poorly under traffic load and have minimum throughput. The results presented clearly indicate that the performance of WLAN varies depending on the selection of parameters such as used frequency band, physical characteristic and maximum data rate of WLAN standards. We observed that OFDM is an efficient while working on 5 GHz band whereas DSSS performs better on 2.4 GHz band. Considering the results of all three tests, the 802.11a falls out to be a better choice than two other standards, 802.11b and 802.11g, especially for the applications requiring high bandwidth for smooth operations.

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Authors

Dr. Lachhman Das Dhomeja is an Assistant Professor at the Institute of Information & Communication Technology (IICT), University of Sindh, Jamshoro, Pakistan. He got his Master's degree in Computer Technology from University of Sindh, Jamshoro (Pakistan) in 1991 and PhD from University of Sussex, UK in 2011. His main research area is Pervasive Computing in general and policy-based context-awareness in particular. His other research interests include secure device pairing in ubiquitous environments, software architectures, Distributed Computing and Wireless LANs.

Shazia Abassi is an Assistant Professor at the Institute of Information & Communication Technology (IICT), University of Sindh, Jamshoro, Pakistan. She got her Master's degree in Telecommunication from University of Sindh, Jamshoro (Pakistan) in 1997 and currently she is doing MPhil in the same University. Her main research interests are in the field of Telecommunication in general and Networking in particular.

Dr. Asad Ali Shaikh is an Associate Professor and director of the Institute of Information and Communication Technology (IICT), University of Sindh, Jamshoro, Pakistan. He did his Masters degree in Computers Engineering from Clarkson University, USA in 1991 and PhD degree in Information Technology from University of Sindh, Pakistan in 2006. His current research focus is on the protocol design, security issues in computer networks and software development.

Dr. Yasir Arfat Malkani is a Lecturer at the Institute of Mathematics and Computer Science (IMCS), University of Sindh, Jamshoro, Pakistan. He go his Master's degree in Computer Science from University of Sindh, Jamshoro (Pakistan) in 2003 and PhD from University of Sussex, Brighton, UK in 2011. His main area of research is Pervasive Computing. His research is focused on secure device/service discovery and access control mechanisms using policies and location/proximity data/information. He is also interested in sensor networks, wireless networks (including WiFi, Bluetooth, WiMAX, etc), and solutions to various issues in distributed and pervasive computing systems through the integration of tools and techniques from distinct disciplines/areas.