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Design and Simulation of Wireless Local Area Network for Administrative Office using OPNET Network Simulator: A Practical Approach

Elechi Onyekachi O
Computer Science Department, Faculty of Physical Sciences,Ebonyi State University Abakaliki, Nigeria
kachyelechi@yahoo.com

Abstract
Wireless local Area Network (WLAN) is a networking standard that links two or more devices with the use of wireless signal (radio frequency). It is based on the IEEE 802.11 standards (IEEE Standard 2007). Its advantages over the traditional wired technology, includes: reduction in wires, mobility and flexibility. It can be deployed in ad-hoc (infrastructure less) and infrastructure based, which uses access point as its central coordinating facility. In this paper, infrastructure-based WLAN is used. In this case, there is an access point (AP) and stations/clients (that could be mobile). This BSS connects to other neighbouring BSSs through a high speed back-bone, the back-bone then connects to the ISP through a modem for internet services. As a result, we designed and simulated WLAN and identified the key network performance parameters (such as delay, throughput, packet drop, etc) that must be addressed to guarantee optimal service delivery
Keywords: WLAN, QoS, Broadband, Bandwidth, Throughput.

1. Introduction

As opposed to traditional wired LAN, a wireless LAN is a grouping of computers and peripheral devices that share a common communications backbone. As is implied by the name, a WLAN allows users to connect to the LAN wirelessly via radio transmission. Wireless technology has helped to simplify networking by enabling multiple computer users to simultaneously share resources in a home or business without additional or intrusive wiring. These resources might include a broadband Internet connection, network printers, data files, and even streaming audio and video. This kind of resource sharing has become more prevalent as computer users have changed their habits from using single, stand-alone computers to working on networks with multiple computers, each with potentially different operating systems and varying peripheral hardware.

Wireless networking enables the same capabilities and comparable speeds of a wired 10BASE-T network without the difficulties associated with laying wire, drilling into walls, or stringing Ethernet cables throughout an office building or home. Laptop users have the freedom to roam anywhere in the office building or home without having to hunt down a connector cable or available jack. Every room in a wireless home or office can be “connected” to the network, so adding more users and growing a network can be as simple as installing a new wireless network adapter. A WLAN typically extends an existing wired local area network. WLANs are built by attaching a device called the access point (AP) to the edge of the wired network. Clients communicate with the AP using a wireless network adapter similar in function to a traditional Ethernet adapter (Peppas *et al,* 2007; Elechi & Eze, 2013).

2. Literature Review

In their research, Peppas *et al* (2007) presumed that in the forthcoming years Wireless Local Area Networks are expected to be widely utilised in hotspots such as city centres, airports, café, restaurants, etc where high capacity is necessary to serve a large number of demanding data users. Consequently, the presumption of Peppas *et al* came to pass as Wireless Local Area Networks (IEEE 802.11 standard wireless LAN) has become a household name. Currently, every home, business as well as government administrative offices, restaurants, city centres, cafeteria, airports, secondary and tertiary institutions, all feels the dire need of Wireless Local Area Networks. WLANs (IEEE 802.11a/b/g/n standards wireless LAN) are growing rapidly (Ghazala *et al,* 2009).

According to Elechi & Eze (2013), IEEE 802.11a/b/g/n standards wireless LAN can provide the benefits of network connectivity without the restrictions of being tied to a location or restricted by wires. In spite of the convenience of mobility, the performance of the Wireless Local Area Networks must be considered carefully prior to its adoption as intrinsic part of an enterprise network. In this research, the effect of various basic network performance parameters bothering on the actual overall network performance of IEEE 802.11 based Wireless LAN is verified through various controlled experiments/simulations using OPNET modeller 16.0 network simulation tool.

3. Simulation Setup

For the simulation of this WLAN, OPNET modeller is the tool used for the designing, testing and comparative analysis of the performance of the above network. The figure 1 below shows the network design of the above WLAN scenario in OPNET environment. As you can see, the three subnets of the network are connected to the router and the router connected to the Ethernet server of the ISP for internet services. Each of the subnet has one AP, thus in all, there are 3 Aps, each predefined in the subnets for managing the requirements of its network.

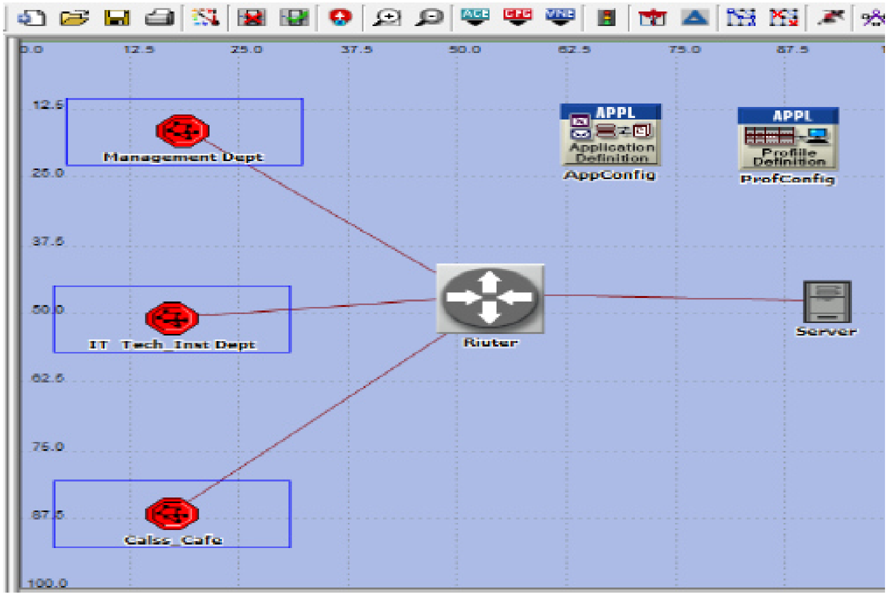


Figure 1: Simulation Design

The Applications defined in the Application Configuration section are video, voice, http, ftp and email. Their description is as shown below in figure 2.

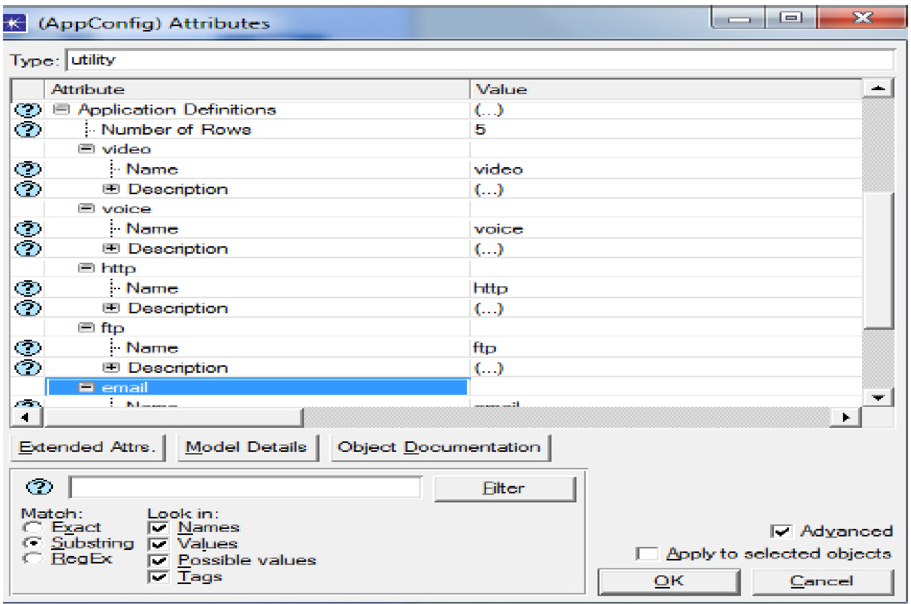


Figure 2: Application Configuration

The applications have the following descriptions:

Video conferencing – we use high resolution video
Voice – PCM Quality speech is speech
Http – light/heavy browsing is used
Ftp and email both used medium load.

The above points are responsible for the behaviour of our results obtained from the simulation. In the Profile

Configuration, 3 profiles representing the 3 subnets are defined. This is shown below in the screenshot from the OPNET Group_1 simulation environment. Note that in the Mgt_prog (management programs), all five applications (video, voice, http, ftp and email) are defined, in the ITStaff_prog (IT/Staff programs) voice, http, ftp and email are defined. While for the ClassCafe_prog (Class/Café programs) http, ftp and email are defined.

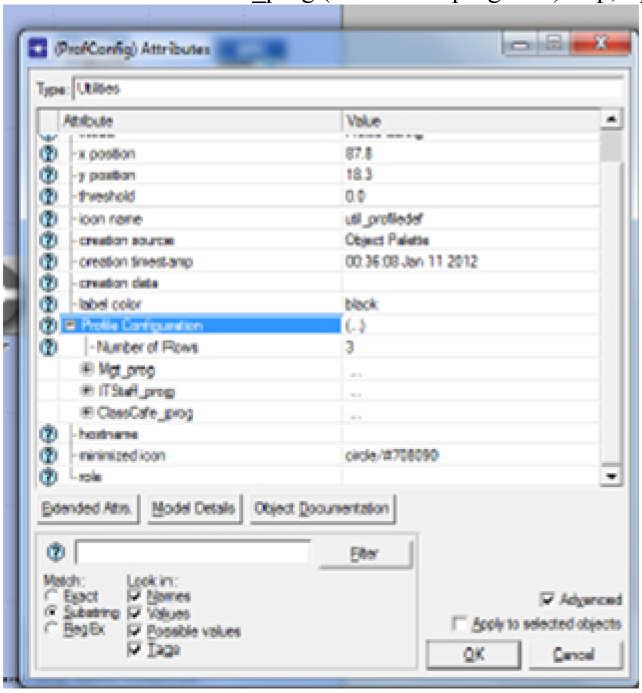


Figure 3: Profile Configurations

Here the screen shot of the management department subnet is shown. All the workstations in this subnet and the access point (AP1) are manually assigned the SSID (Service Set Identifier) of 1. This is to make the subnet more secure and interference free from the external (unwanted) access to the network. All other two subnets are similarly configured. SSID of 2 and 3 are used for the IT and the class room Access point respectively. Below is the screen shot of Management Subnet.

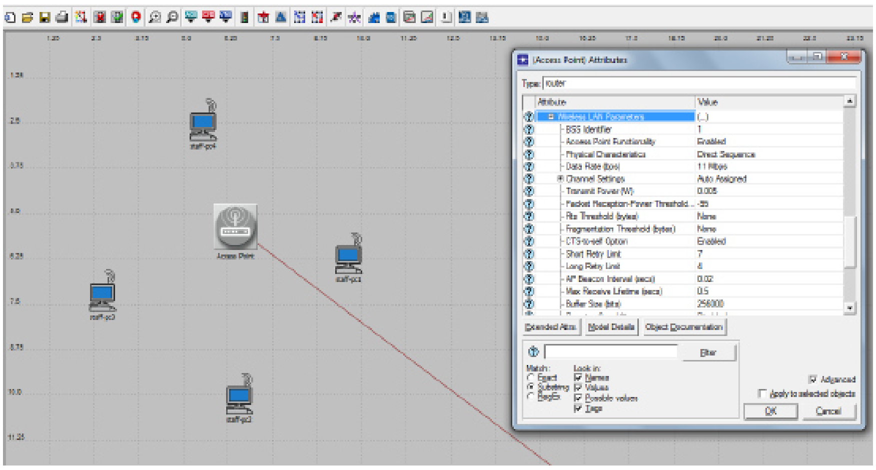


Figure 4 : Management Subnet

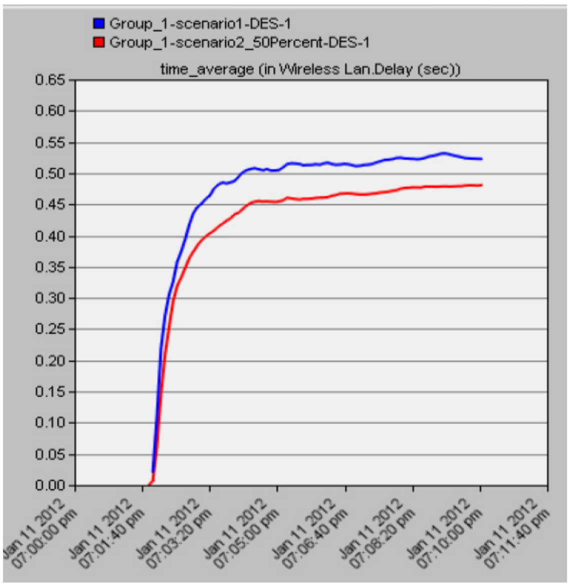
Testing and Analysis of Result

50% Traffic Increase (Results and Analysis)

The comparison of the network performance between the scenario1 and scenario2 after 50% increment in traffic is analysed below.

Access Point 1 (Management) Scenario 1 And 2

Delay: From the graph (Figure 5) below, it can be inferred that there is more delay in the first scenario than in the second scenario. This is due to increment in the traffic on the network.



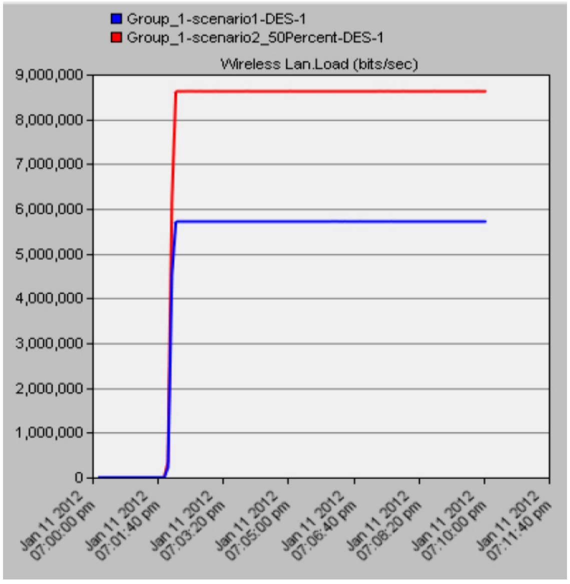
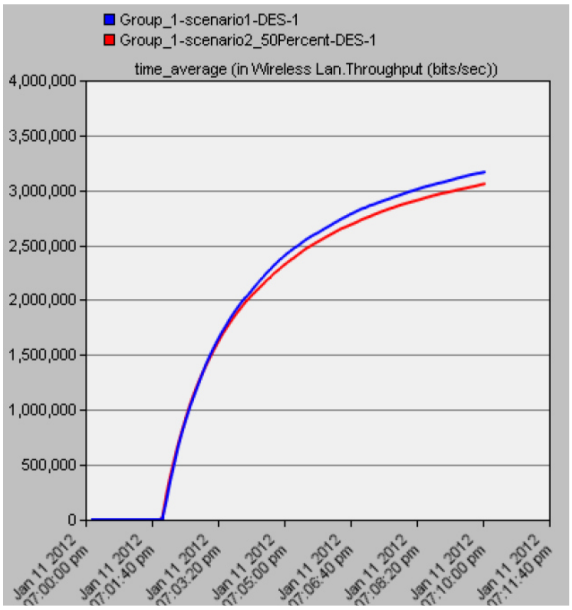


Figure 5: Delay comparison for AP 1 **Figure 6: Load Comparison for AP 1**

LOAD: If the traffic is increased by 50%, then by implication, the load is also increased. It can be seen from the graph in Figure 6 that the load increases from 5.9Mbps to 8.9Mbps. Therefore traffic increase affects the load. Also considering services such as voice and video that has huge impact on the traffic.

THROUGHPUT: From the graph in Figure 7 below, we can see that packet delivered per seconds in the second scenario has reduced to about 3 Mbps from about 3.2 Mbps in scenario 1. Though the difference is not very significant, but this is due to increase in data drop rate, bandwidth limitation and congestion.



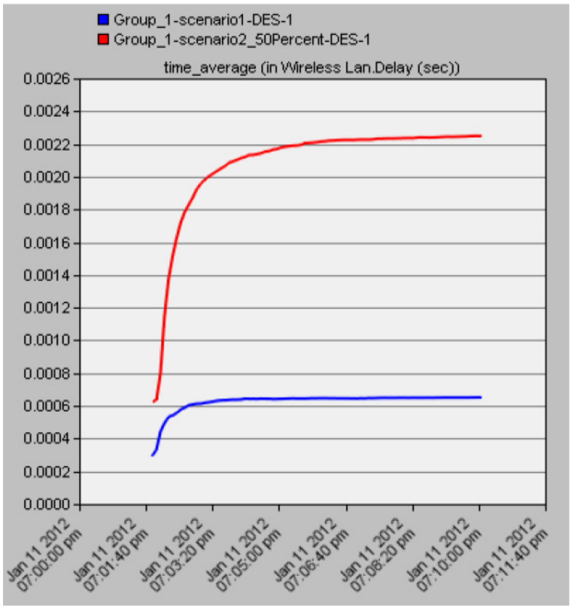


Figure 7: Throughput Comparison for AP 1 **Figure 8: Delay Comparison for AP 2**

ACCESS POINT IT/STAFF SCENARIO 1 AND 2

DELAY: The graph contained in Figure 8 shows the average delay against simulation run time comparison of two different scenarios running HTTP, Mail and Voice services on the WLAN of but the second scenario has 50% increment of traffic. From the graph we can infer that the red line which represent delay in scenario 2 experience more packet delay as a result of 50% increment of Traffic on the WLAN. This significant difference is recorded because of the bandwidth consuming Applications such as voice running in IT/Staff subnet.

LOAD: Also, when the traffic is increased by 50%, the load in the IT AP increases, hence it increases from 3.7Mbps-5.7Mbps, which obviously shows the increase in load due to increase in data packets transmitted

(Figure 9).

THROUGHPUT: The graph as contained in Figure 10 below shows that the number of packets delivered by the access point increases in the second scenario (i.e. scenario 2). This is due to fact that since there is more traffic on the network, the number of packets increased, and also increases the throughput of the network from about 3.7Mbps in scenario 1 to about 5.8 Mbps in scenario 2.

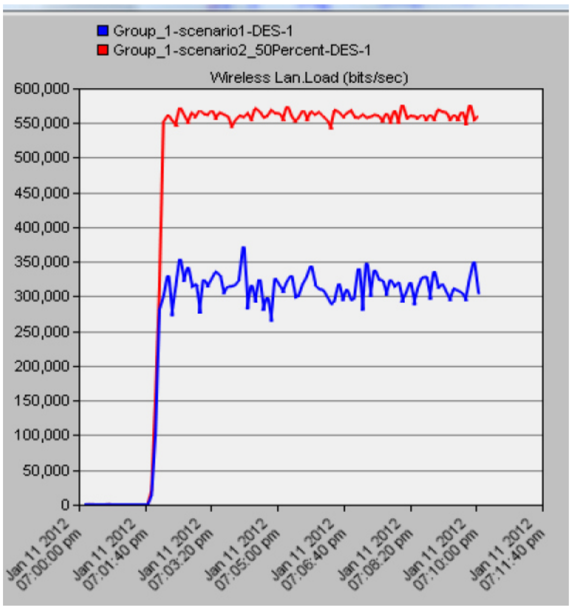


Figure 9: Load Comparison for AP 2

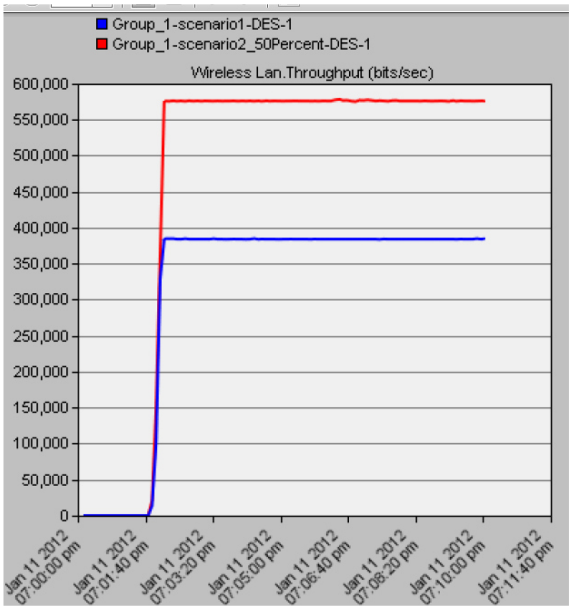


Figure 10: Throughput Comparison for AP

ACESS POINT 3 CAFÉ SCENARIO 1 AND 2

DELAY: The graph in Figure 11 shows the average delay against simulation run time comparison of two different scenarios running HTTP, Mail and ftp services on the WLAN, but the second scenario has 50% increment of traffic. From the graph we infered that the red line which represent delay in scenario 2 experience less packet delay as a result of 50% increment of Traffic on the WLAN.

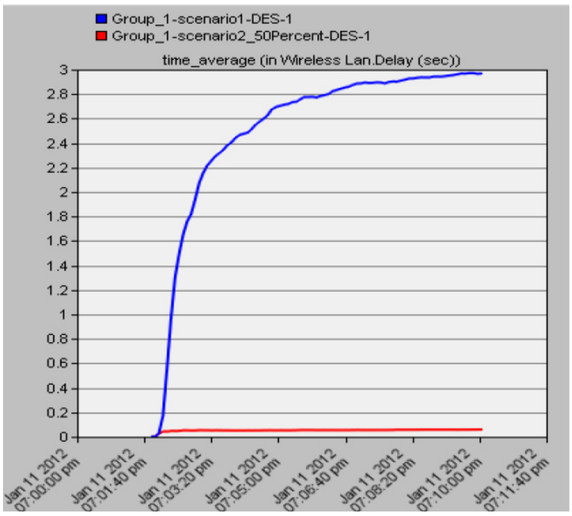


Figure 11: Delay Comparison for AP 3

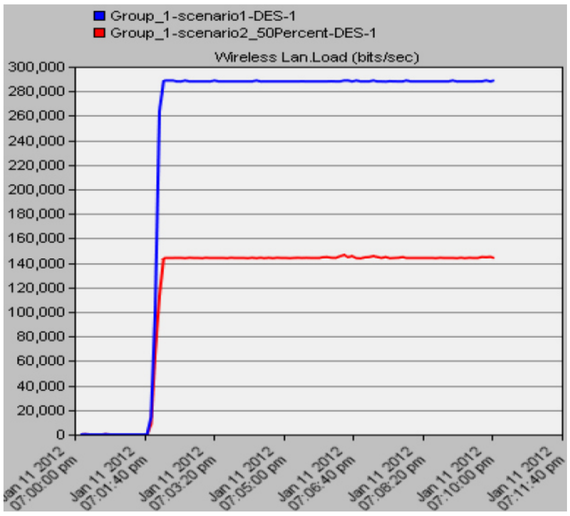


Figure 12: Load Comparison for AP 3

LOAD: There is a slightly different scenario here, because of the load information on the AP's CPU; it performs better in load balancing in contrast to its utilization. This is because, given that a host under that AP is heavily loaded, then certainly it has almost 100% utilization (CPU), (Figure 12).

THROUGHPUT: The graph in Figure 13 below shows that the number of packets delivered by the access point reduced in the second scenario (i.e. scenario 2). This is due to fact that since there is more traffic on the network, bandwidth utilization dropped as result of congestion and other factors, thus, data drop rate increases and then reduces the throughput of the network. Overall average reduction in the throughput is about 1.8Mbps in scenario

1 to 1.2 Mbps in scenario 2.

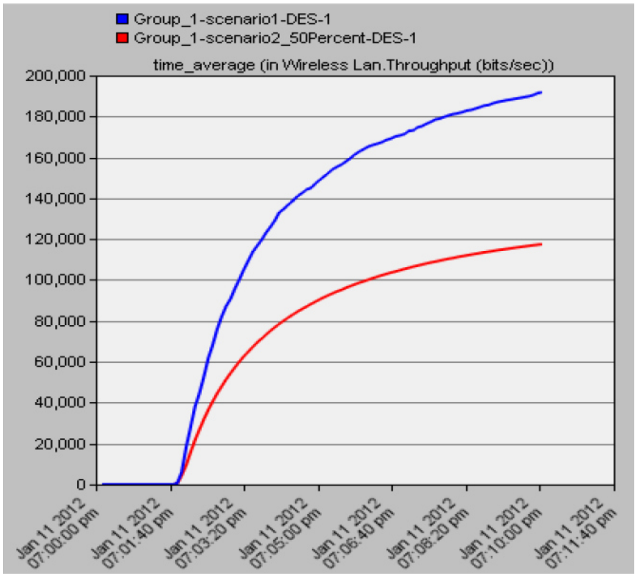


Figure 13: Throughput Comparison for AP 3

CONCLUSIONS: From the above test and analysis of graphs of the various access points, the metrics of evaluation of the network performance in each of the scenarios can be summarised as follows:

Scenario 1

Table 1: Performance metrics result for Scenario 1

Access points	**Performance Evaluation Metrics**		
	DELAY (SEC)	**LOAD (Mbps)**	**THROUPUT (Mbps**
AP 1	0.5	5.8	4.25
AP 2	0.00065	3.7	3.9
AP 3	2.9	2.75	2.9

Scenario 2

Table 2: Performance metrics result for Scenario 2

Access points	**Performance Evaluation Metrics**		
	DELAY (SEC)	**LOAD (Mbps)**	**THROUPUT (Mbps**
AP 1	0.48	8.9	3.2
AP 2	0.0023	5.7	5.8
AP 3	0.1	1.4	1.8

From the above table we can then conclude that the performance of a WLAN network is a function of the metrics (delay, load, throughput, etc.). And we can also see that changing the traffic value on the network has significant effects on those metrics in each of the three Access Point in the network. The effect of traffic increase is seen more in the Access Points 1 and 2; this is because they handle more bandwidth demanding applications like video and voice.

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