The Performance of an 802.11g/Wi-Fi Network Whilst Streaming Voice Content

P. O. Umenne, and Odhiambo Marcel O.

Abstract**—**A simple network model is developed in OPNET to study the performance of the Wi-Fi protocol. The model is simulated in OPNET and performance factors such as load, throughput and delay are analysed from the model. Four applications such as oracle, http, ftp and voice are applied over the Wireless LAN network to determine the throughput. The voice application utilises a considerable amount of bandwidth of up to 5Mbps, as a result the 802.11g standard of the Wi-Fi protocol was chosen which can support a data rate of up to 54Mbps. Results indicate that when the load in the Wi-Fi network is increased the queuing delay on the point-to-point links in the Wi-Fi network significantly reduces until it is comparable to that of WiMAX. In conclusion, the queuing delay of the Wi-Fi protocol for the network model simulated was about 0.00001secs comparable to WiMAX network values.

Keywords**—**WLAN-Wireless Local Area Network, MIMO-Multiple Input Multiple Output, Queuing delay, Throughput, AP-Access Point, IP-Internet protocol, TOS-Type of Service.

I. Introduction

THE IEEE 802.11 standard is a communications standard for Wireless local Area networks (WLAN) environments [1]. It is commonly called Wi-Fi due to the compatibility certification among devices by the Wi-Fi alliance.

The IEEE 802.11 family of standards consists of the 802.11a, 802.11g and the 802.11n standard which is the latest standard. Generally these differ by the Data rates achievable with them.

802.11a	802.11b	802.11g	802.11n*
5 GHz	2.4 GHz	2.4 GHz	2.4 or 5 GHz
11+	3	3	14
54 Mbps	11 Mbps	54 Mbps	600 Mbps
30 m	100 m	100 m	70 m
802.11n	802.11g, n	802.11b, n	802.11a, b, g***

Fig. 1 Data rate of the 802.11 standard

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As can be observed from Fig. 1 above the data rate of the 802.11g standard goes up to 54Mbps and the highest achievable data rate of the Wi-Fi standard is 600Mbps with the 802.11n standard [2]. The operational range of the Wi-Fi networks is within a few hundred feet or 100metres of the AP. Wireless coverage is measured by the range in which a mobile device can maintain a useable wireless LAN connection. Range is impacted by the available signal to noise ratio available at different carrier frequencies and data rates. The RF propagation characteristics at 5GHz operation experience a higher loss than that of 2.4GHz. Thus an 802.11a Wireless LAN infrastructure requires more access points than an 802.11 b/g network to cover the same area. The 802.11n standard specifies the use of multiple input multiple output technology that is not included in the a/b/g standards, MIMO is the main reason why 802.11n has a higher range and throughput.

II. Simulation Methodology

A. Model

OPNET Modeler 17.1 is a powerful discrete-event simulation tool with an easy and convenient development environment and GUI.

OPNET modeler 17.1 with Wireless LAN module was used to develop a simulation for this paper. The Wi-Fi 802.11g standard protocol was simulated in this paper and the key parameters such as delay, network load and throughput where captured.

A snapshot of the system simulation model used is captured in Fig. 2.

The proposed model consists of a Wireless network implemented using the Wi-Fi 802.11g standard. It was modeled within an area of 10km*10km. It consists of eight subnets, with each subnet consisting of 10 fixed Wireless LAN subscriber stations that connect via a Wireless LAN based router to the main ASN router.

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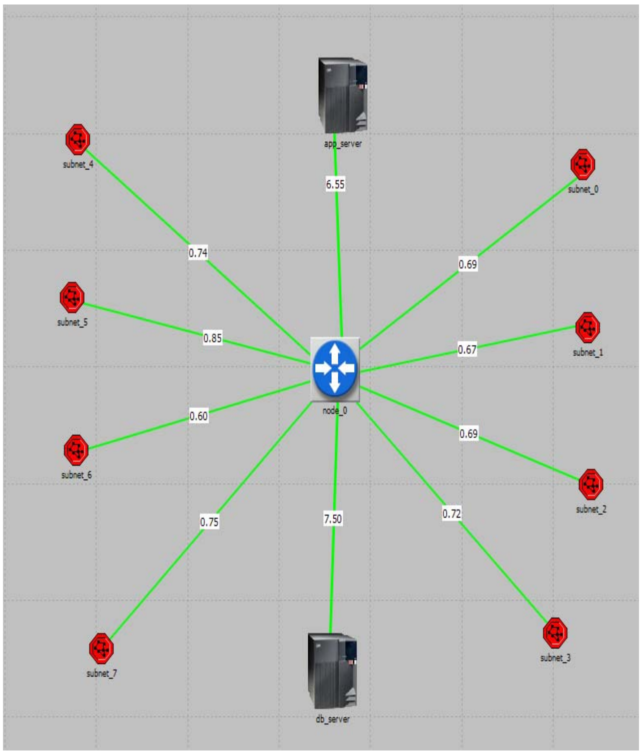

Fig. 2 Wi-Fi Model Design

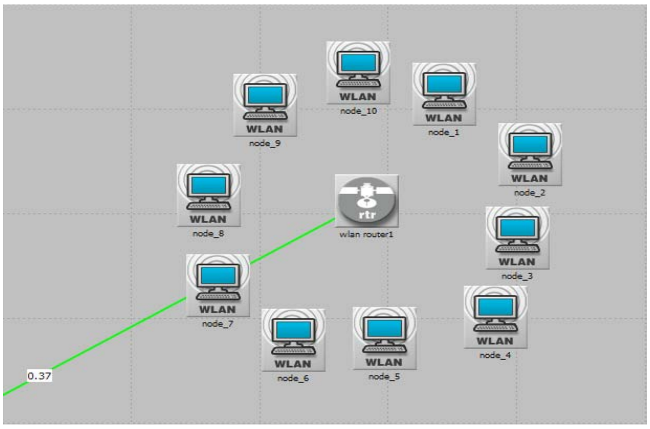

Fig. 3 Wi-Fi subnet configurations

Fig. 3 shows the Wi-Fi subnet configuration with the Wireless LAN subscriber stations connecting to a Wireless LAN router.

The router of course has slip IP connections that enable it to be connected to the ASN router and WLAN connections than enable it connect to the WLAN subscribers.

The ASN router which acts as the main switch is also connected to two servers, an application server and a database server. The ASN router has about 12 IP connections used to link the servers and the WLAN routers from the subnets.

The Open Shortest Path First (OSPF) protocol was used to create automatically and dynamically the ASN routers routing tables, thus enabling it select routes in an adaptive manner.

The purpose of the scenario is to demonstrate the implementation of the Wi-Fi 802.11g standard as a Wireless network and monitor its performance.

B. Application

Using the Application configuration node; 4 applications where set up on the model as seen in Fig. 4 below namely; Oracle three tier transaction, which is essentially a database retrieval application, ftp, http, and a voice application. For the Oracle application, subscriber stations try to communicate with the application server at the remote site via the WLAN routers then the application server retrieves data from the database server and forwards the data to the WLAN based subscribers. The ftp, http and voice applications are of course two level applications. The IP addresses of all the nodes in the network were automatically addressed and the global attribute “IP Interface Addressing Mode” was set to automatically “addressed.

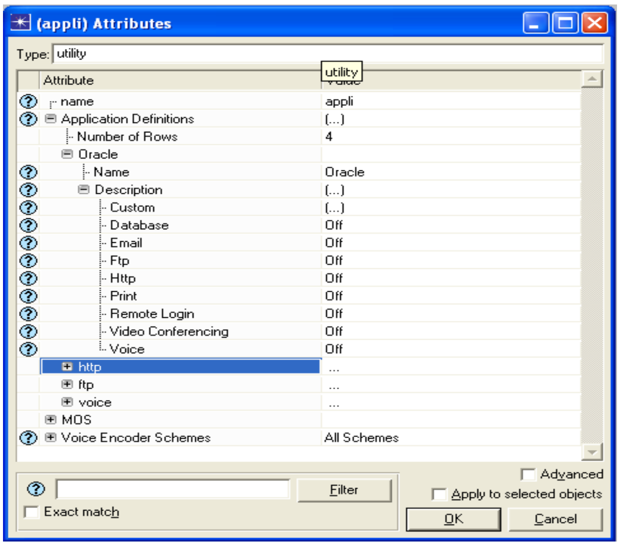

Fig. 4 Setting Application Attributes

The custom application table and the task description table for the applications chosen were configured but mostly for the Oracle application which is a custom application as shown below in Figs. 5 and 6.

The TOS chosen to run on all applications and the subscribers was the Best effort scheduling method.

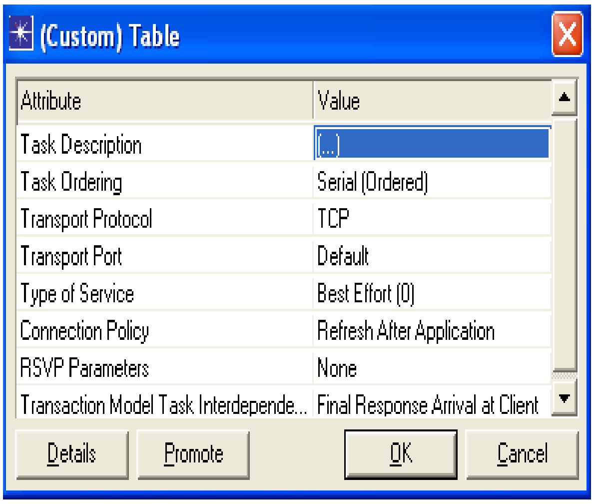

Fig. 5 Custom application table

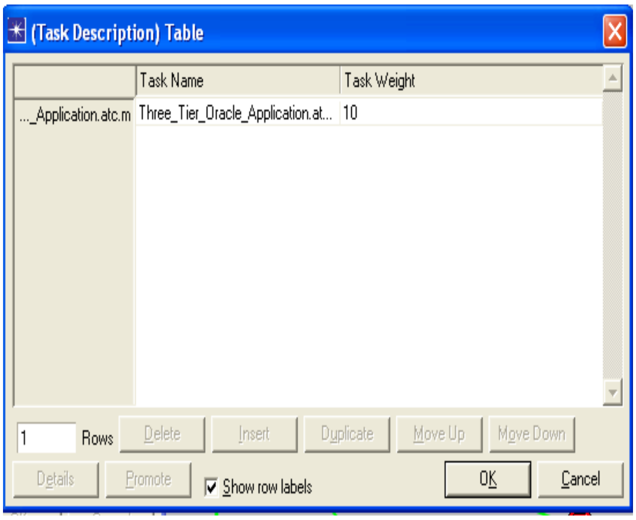

Fig. 6 Task description table

The Task configuration node in Fig. 7 is essentially used for the custom application "oracle" to select and upload the ACE file necessary for the "oracle" application to run. All details about the nodes involved and the traffic they generate is specified in the file.

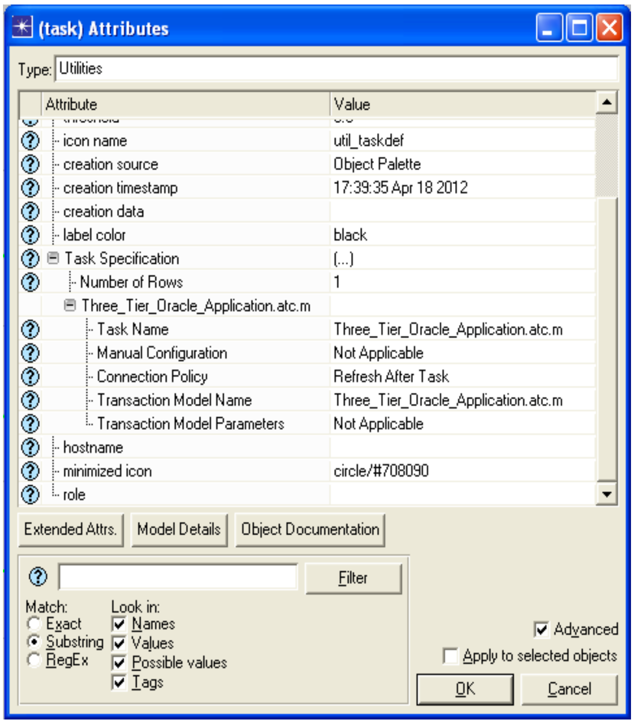

Fig. 7 Task Configuration attribute

C. Tunneling

Tunnels were defined in the IP setup for the point to point links between the WLAN routers and the ASN router as well as for other point to point links. Each tunnel is bi-directional and has an IP interface, with a source and destination IP address.

III. Simulation Results

Upon completion and simulation of the above scenario in OPNET for a simulation time of 1 hour the following performance factors were recorded delay, WLAN load and throughput.

A. Overall Throughput

Fig. 8 shows that the load and throughput are stable throughout the simulation time of 1hour, indicating that the links of the network are able to support the required bandwidth and there are no network failures. The fact that load and throughput are of similar magnitude means that the packet drop rate is low. The throughput of about 5Mbps is generated mainly by the voice application being applied over the 802.11g Wi-Fi standard. The slight spike in delay is caused by the oracle application when the application server attempts to retrieve data from the database server and forwards this to the WLAN subscribers.

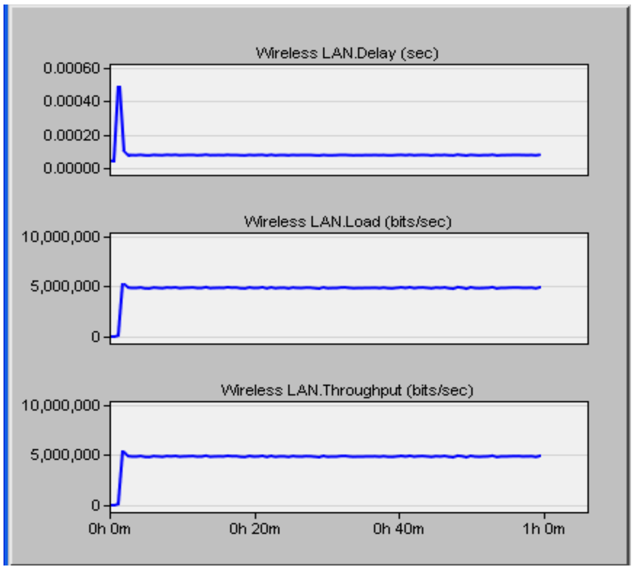

Fig. 8 Delay, Load and Throughput for Wireless LAN

B. Server Throughput

As can be seen from Fig. 9 the application sever sends slightly more data to the WLAN subscribers via the ASN router and the WLAN routers than it receives due to the fact that it supplies the application running in the network whilst the database server receives more from the network than it sends as it acting as a storage system.

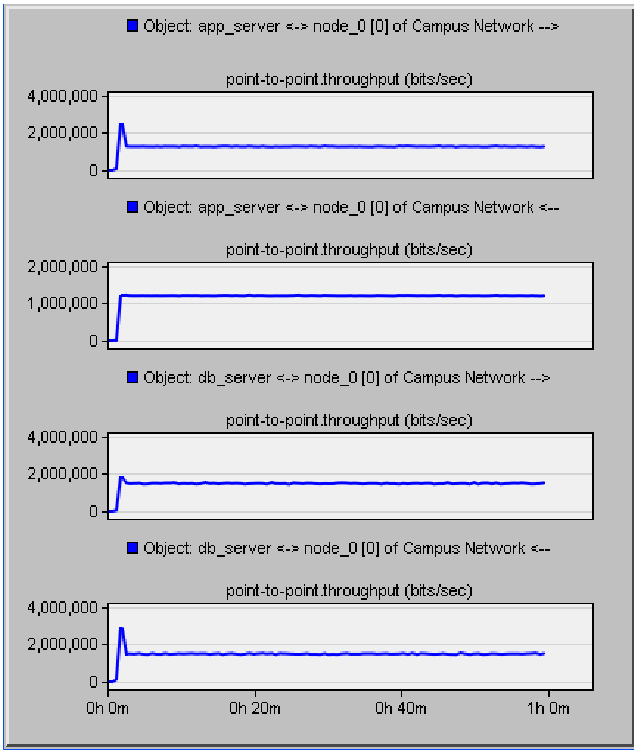

Fig. 9 Point to Point throughput for the servers

C.A Subnet Throughput

Fig. 10 shows the throughput values for a subnet in this case subnet [0]. The throughput is a little bit higher from the ASN router to the subnet than that from the subnet to the ASN router, reason being that the data query sent from the subnet to the application server is a bit less than the actual data received from the database upon retrieval to the WLAN workstations.

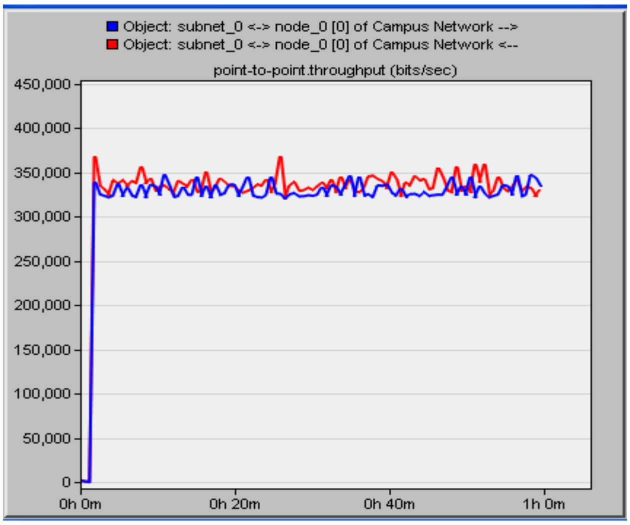

Fig. 10 Point to Point Throughput for a subnet [0]

D. Top 10 Values of Point to Point Throughput

From Figs. 11 and 12 one can see that the highest throughput occurs on the ASN router to the database server link. The applications are divided fairly evenly between the servers, the oracle application makes use of both the application server and the database server, the ftp uses the database server, http uses the application server whilst the voice application uses the two fairly evenly, the only difference coming in since the ftp application has a higher load than the http application.

	Object Name	Minimum	Average	Maximum	Std Dev
1	db_server <-> node_0 [0] <--	669.56	1,456,046	2,905,994	286,20
2	db_server <-> node_0 [0] -->	488.67	1,446,720	1,885,756	255,23
3	app_server <-> node_0 [0] -->	209.33	1,242,636	2,535,922	247,40
4	app_server <-> node_0 [0] <--	311.11	1,176,874	1,229,952	206,11
5	subnet_6 <-> node_0 [0] <--	654.44	327,712	417,924	58,73
6	subnet_4 <-> node_0 [0] <--	632.44	327,634	386,386	57,46
7	subnet_2 <-> node_0 [0] <--	654.44	326,924	379,951	58,00
8	subnet_0 <-> node_0 [0] <--	132.67	326,889	368,855	58,05
9	subnet_7 <-> node_0 [0] <--	494.44	326,288	395,137	58,17
10	subnet_5 <-> node_0 [0] <--	671.11	326,210	394,952	58,14

Fig. 11 Top ten values of throughput point to point links average (bps)

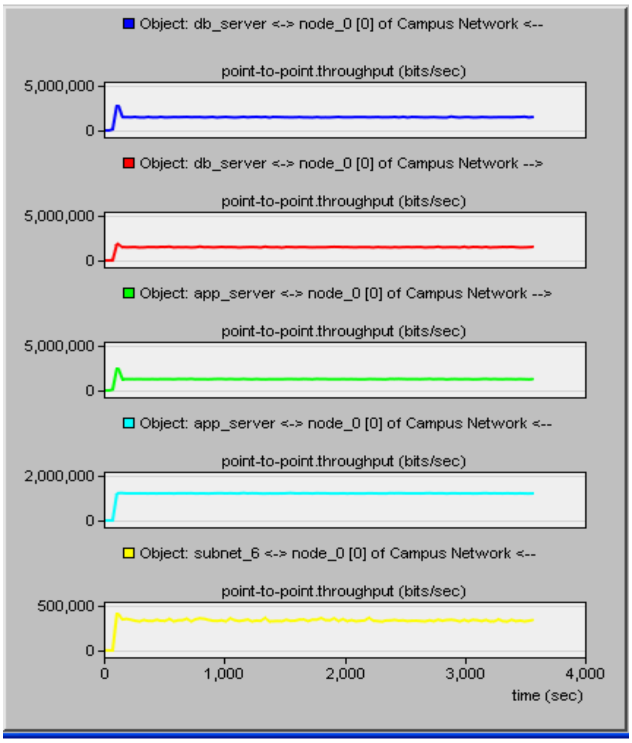

Fig. 12 Top 5 values of throughput point to point links (bps)

E. Top 10 Values of Object Throughput

From Figs. 13 and 14 below the highest average value of throughput is about 300kps and is mainly for the WLAN routers, the WLAN workstations generate an average of about 30kps, when compared to [3], the WIMAX throughput via the base stations was on average 20kbps with the workstations being less about 2kbps. However one can attribute that mainly to the fact that i have simulated about 4 applications on this model, oracle included whilst in [3] it's only the oracle application running hence the WLAN routers experience a higher throughput, due to the fact that when the oracle application is not running then other application like voice sustain the high throughput.

	Object Name	Minimum	Average	Maximum	Std Dev
1	subnet_4.wlan router8	0.000	293,095	333,753	51,385
2	subnet_2.wlan router3	0.000	292,906	339,460	51,490
3	subnet_7.wlan router5	0.000	292,690	340,486	51,522
4	subnet_0.wlan router1	0.000	292,510	319,582	52,011
5	subnet_5.wlan router7	0.000	291,919	353,912	52,046
6	subnet_6.wlan router6	0.000	291,853	341,124	51,852
7	subnet_1.wlan router2	0.000	291,283	321,742	51,655
8	subnet_3.wlan router4	0.000	291,130	346,536	51,182
9	subnet_1.node_3	42.667	30,724	55,791	6,940
10	subnet_6.node_4	42.667	30,682	52,160	6,939

Fig. 13 Object throughput Average values in (bps)

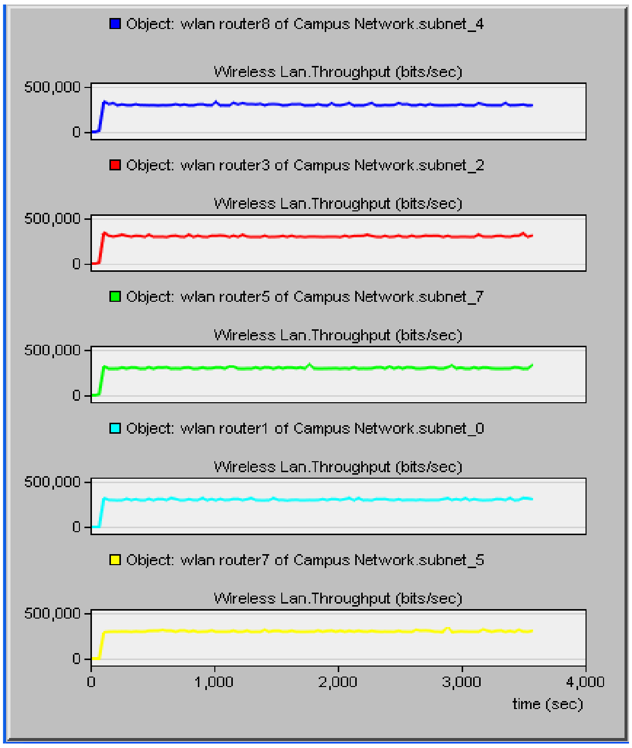

Fig. 14 Top five values of throughput for the objects

F. Point to Point Queuing Delay

For the point to point queuing delay the highest value of delay occurs on the application server to ASN router link due to the fact that there is one more application requesting the use of this server than the database server, that is oracle, http and voice as compared to ftp and voice for the database server so the applications server has the highest queuing delay. This can be observed on Figs. 15 and 16.

	Object Name	Minimum	Average	Maximum	
1	app_server <-> node_0 [0] -->	0.0000011480	0.0000013840	0.000019106	0.(
2	subnet_1 <-> node_0 [0] <--	0.0000010812	0.0000012743	0.000014639	0.(
3	subnet_7 <-> node_0 [0] -->	0.0000010792	0.0000012553	0.000014548	0.(
4	db_server <-> node_0 [0] -->	0.0000010773	0.0000012445	0.000009510	0.(
5	db_server <-> node_0 [0] <--	0.0000010845	0.0000012406	0.000011413	0.(
6	subnet_3 <-> node_0 [0] <--	0.0000010767	0.0000012148	0.000008375	0.(
7	subnet_5 <-> node_0 [0] <--	0.0000010817	0.0000012054	0.000007092	0.(
8	subnet_4 <-> node_0 [0] <--	0.0000010864	0.0000011893	0.000005406	0.(
9	subnet_2 <-> node_0 [0] -->	0.0000010792	0.0000011858	0.000007571	0.(
10	subnet_6 <-> node_0 [0] <--	0.0000010862	0.0000011856	0.000004521	0.(

Fig. 15 Point to Point Queuing delay

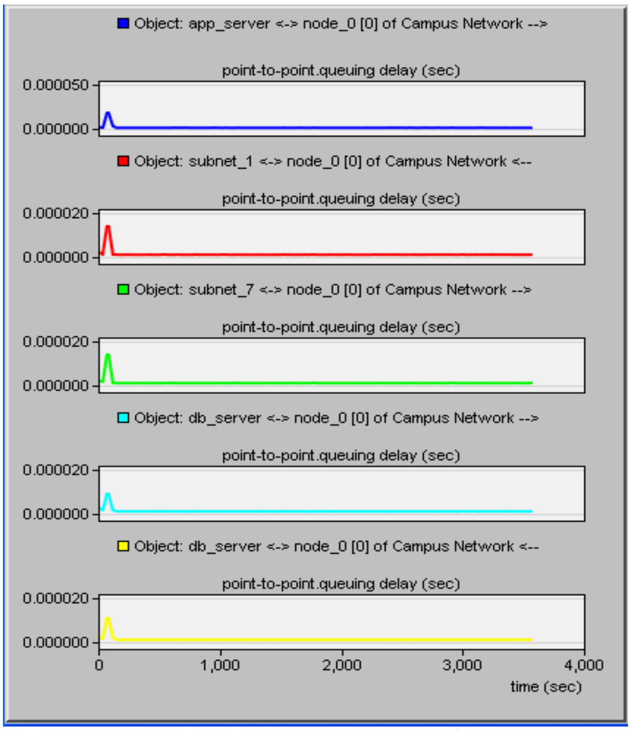

Fig. 16 Queuing delay point to point objects

G. Point to Point Link Utilization

This shows that the link with the highest utilization belongs to the database server to the ASN router of 0.244%; this is an average value as seen in Fig. 17.

	Object Name	Minimum	Average	Maximum	Std D
1	db_server <-> node_0 [0] <--	0.00011264	0.24495	0.48887	0.0481
2	db_server <-> node_0 [0] -->	0.00008221	0.24338	0.31724	0.0425
3	app_server <-> node_0 [0] -->	0.00003522	0.20905	0.42661	0.0416
4	app_server <-> node_0 [0] <--	0.00005234	0.19798	0.20691	0.0346
5	subnet_6 <-> node_0 [0] <--	0.00011010	0.05513	0.07031	0.0098
6	subnet_4 <-> node_0 [0] <--	0.00010639	0.05512	0.06500	0.0098
7	subnet_2 <-> node_0 [0] <--	0.00011010	0.05500	0.06392	0.0097
8	subnet_0 <-> node_0 [0] <--	0.00002232	0.05499	0.06205	0.0097
9	subnet_7 <-> node_0 [0] <--	0.00008318	0.05489	0.06647	0.0097
10	subnet_5 <-> node_0 [0] <--	0.00011290	0.05488	0.06644	0.0097

Fig. 17 Top ten values of point to point link average (%)

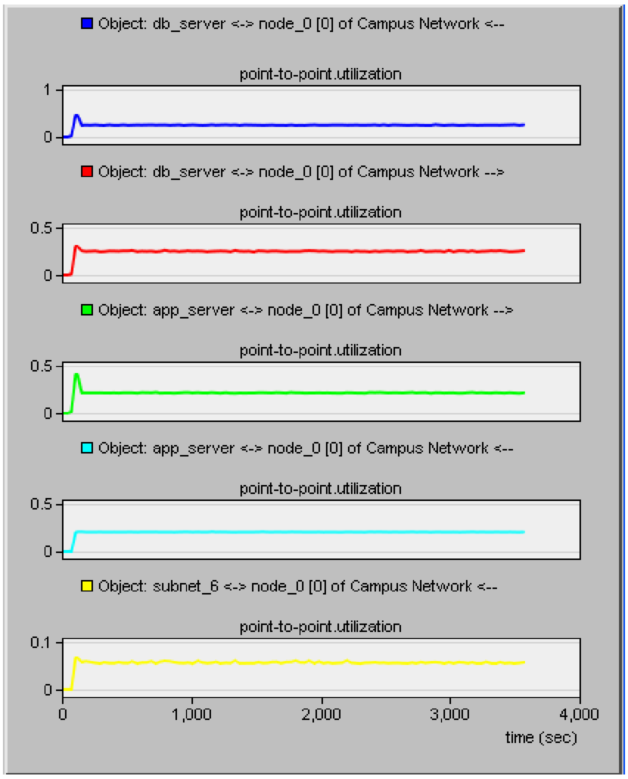

Fig. 18 Top 5 values of link utilization

The link utilization is a percentage of the bandwidth used over the total bandwidth of the link itself. In this case, the link cable used was the OCT12 which carries as much as 594.43Mbps whilst the average throughput was about 1.5Mbps. Fig. 19 below shows the peak link utilization for the database to ASN router link.

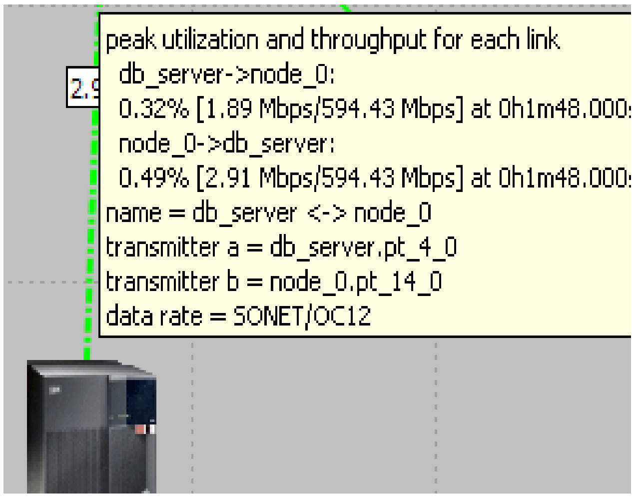

Fig. 19 Peak link utilization of the database to router link

H.Queuing Delay as Compared to WiMAX

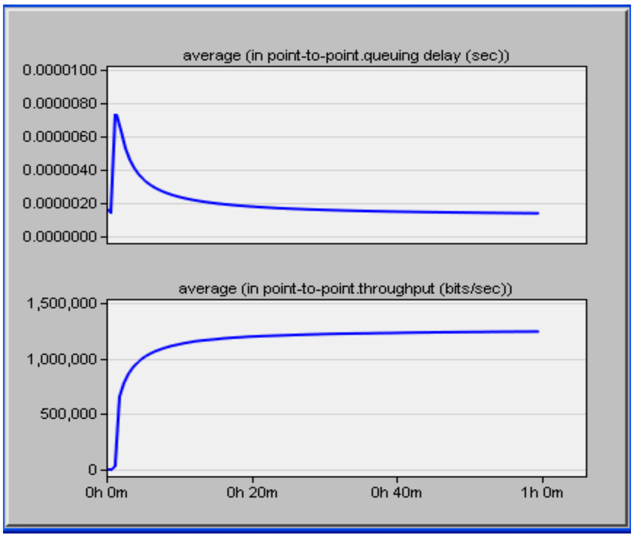

Fig. 20 Queuing delay and throughput of a Wi-Fi Network

As can be observed in Fig. 20 above the queuing delay can drop down for the Wi-Fi network to as low as 0.0000020secs between the application server node and the ASN router, when compared to the result obtained in Fig. 21 [4], there the WiMAX network has a lower queuing delay than Wi-Fi networks however from the simulation i performed one observes that when the load of the network and the throughput is increased by increasing the nature of the applications running on the network it's possible to reduce the queuing delay even in Wi-Fi based networks to as low as the values found in WiMAX like in [4].

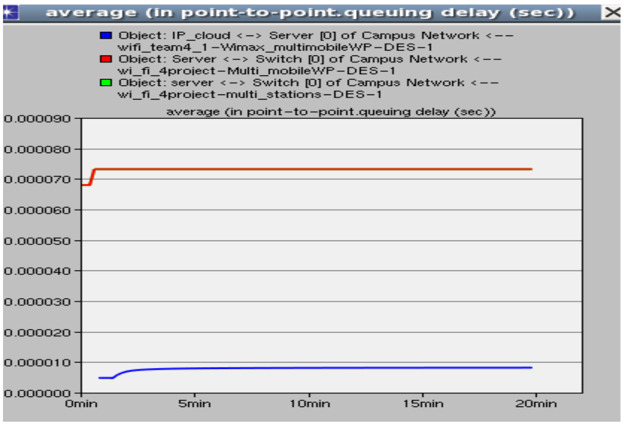

Fig. 21 Average queuing delay of the server to switch link in Wi-Fi and the IP cloud to server link in WiMAX [4]

The point to point queuing delays for WiMAX in [4] drops to 0.000010 secs, however in Fig. 22 the queuing delay for an access point WLAN router1 shown below is comparatively as low as in a WiMAX network.

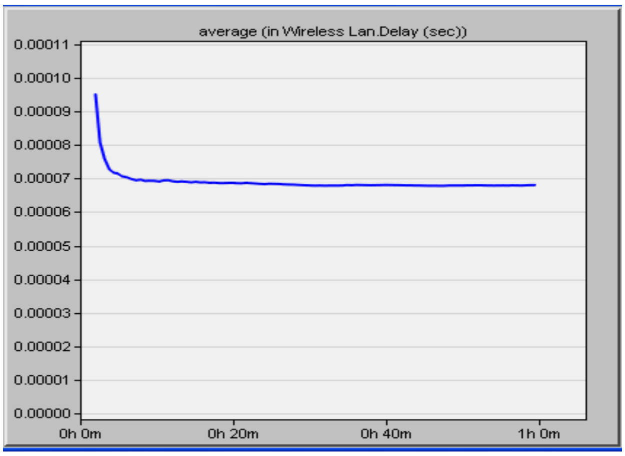

Fig. 22 Queuing delay for an access point Wlan router1 in the Wi-Fi network

IV. Conclusion

In this paper a simple network model was constructed to simulate the performance factors of a Wi-Fi network specifically the 802.11g standard. Factors such as delay, throughput and load were simulated.

From papers [3],[4] it was observed that the WiMAX standard generally is able to support a high network throughput as compared to the Wi-Fi network and has a higher utilization of bandwidth resources, although this is true, the simulation performed on the 802.11g standard shows that it is possible to load and derive a relatively high throughput (5Mbps) on the Wi-Fi network as well, by running several applications simultaneously and by using such applications as voice based applications that load the network significantly more. Of course with the 802.11n standard it's possible to load the network even more (600Mbps), however even with the 802.11n standard when a video conference application is run the network has the tendency to crash.

Finally it was observed that as the network load and throughput was increased in a Wi-Fi network the queuing delay on the point to point links decreased to significantly low values that are comparable to those in a WiMAX network of about 0.000010secs and lower.

References

[1] J.Marques-Barja, C.Calafate, J.Cano, P.Manzoni, "Evaluating the Performance Boundaries of Wi-Fi, WiMAX and UMTS using the network Simulator (ns- and wired networks, 2010.

[2] White paper, "Is 802.11a, b or g best for Industrial Wireless LAM?"

[3] M. Hammoshi,"WiMAX Simulation Model to Investigate Performance Factors," Journal of Convergence Information Technology, Volume 6, Number 1,pp. 266-276. January 2011.

[4] R. Paul, S. Lally and L.Trajkovic, "Simulation and Performance Evaluation of Wi-Fi and WiMAX using OPNET," Simon Fraser University, Vancouver, British Columbia, Opnetwork, 2011