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Performance Analysis of Shared and Switched Ethernet LANs through Using OPNET Simulation

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Abstract: In this paper, performance analysis of Shared and Switched Ethernet LANs under Different Scenarios through simulation has been attempted using OPNET as simulating tool. The first scenario was comes under Hub Only scenario. The environment of the network is in an office, which covers an area of 100m X 100m. The hub used is a 16 port hub in an Ethernet environment with the following configurations- Center Node Model = ethernet16_hub, Periphery Node Model = ethernet_station, Link Model = 10BaseT, Number=16, X=50, Y=50, and Radius = 42. The traffic generated by each workstation have the following configurations: ON State Time = constant (200), OFF State Time = constant (0), Interarrival Time = exponential (0.02), Packet Size = Constant (1500).
The second scenario was comes under The Hub Low Load; this scenario used the following values for the traffic generated by each workstation: Interarrival Time = exponential (0.08). The average traffic that each workstation will generate followed by the total traffic in the network. The time average for the traffic sent in both Scenarios has been analyzed as well.
The third Scenario comes under Scenario comes under Hub and Switch scenario. The Ethernet collision count, count the number of collision count, the traffic received , and the delay for both the Hub Only and Hub and Switch scenarios has been analyzed. The Comparison for the difference in performance in terms of collision count between the selected scenarios (Hub Only, Hub and Switch) has been discussed.

Keywords: Shared Ethernet LANs; Switched Ethernet LANs; OPNET.

I. Introduction

Network uses the combination of computer hardware, cabling, network devices, and computer software together to allow computers to communicate with each other. The purpose of any computer network is to permit multiple computers to communicate. Recently, for the most companies the network infrastructure has been the most important part to define big business success. To be up-to-date with new technologies and systems, and to go with the competitive in the business aspects; the network has to be upgraded continuously [1]
Many of simulation tools are available such as NetSim, NS-2 and OPNET for the purpose of modeling and simulation. [2].
Recently OPNET has gained a considerable popularity in both academia and industry. The paper presents a detailed description of simulation models for network topology and elements using OPNET. [3]
OPNET simulation software was the choice for this research because its features such as the statistical analysis of data for network planning and design operations.

This study has focused on the performance analysis of Shared and Switched Ethernet LANs through Using OPNET Simulation. In addition to that, this study has been produced a report that contained the graphs produced by the OPNET simulation runs requested for each model. Therefore, substantial critical analysis and justification for of the results was provided. This paper has been organized as follow: In Sect. II, relatedwork. In Sect. III, modelling and opnet simulation. In Sect. IV. The Ethernet LANs based scenarios. The conclusion in Sect. V.

II. RELATEDWORK

Generally, LANs have two hardware layers: the data link layer and physical layer; each layer performs specific function. The data link layer performs three functions, which are message delineation, medium access control and error control. [4].

Ethernet could be used to detect and correct errors; errors are rare in modern LANs therefore error connection was uncommon. Shared Ethernet LANs contains three components in addition to the computers which are Network interface Cards, Cables and Hubs. While switched Ethernet uses switches instead of hubs, switches used to make switching decisions based on data link layer addresses that called layer-2 switches or workgroup. While a hub broadcasts frames to all ports, the switch reads the destination address of the frame and only sends it to the corresponding port.Managing LAN traffic using switches differ from hubs; switches send an incoming frame out the port corresponding to its destination computer. While hubs broadcast incoming frames out all the ports of the hub. This greatly reduces network traffic and prevents most collisions. Switches use a store-and-forward approach to managing LAN traffic. If two frames arrive at a switch at the same time, the second frame is temporarily stored in memory until the switch is done processing the first frame. The Ethernet means multiple-access network, that a set of nodes sends and receives frames over a shared link. While Switched LANs is a set of local area network interconnected by switches.

In the Switched LANs, there is a limitation of how many hosts can be attached in the single network and how size of a geographic area can serve. The switches are used in the computer network to enable the communication between hosts. In addition, switches can be used when no direct connection exists between those hosts. However, the core job of switch is to take the packets that arrive on an input and forward them to the right output so that they will reach their appropriate destination.

The main point that has to be noted, as a key problem is that the switch must deal with is the finite bandwidth of its outputs. Example of that if packets destined for a certain output arrive at a switch and their arrival rate exceeds the capacity of that output, that means there is a problem of contention. Here the switch will buffer, packets until the contention subsides but if the packets discarded too frequently, the switch will be in congested state. [5].

III. MODELLING AND OPNET SIMULATION

A model is a mathematical representation of a system, an entity, process, or phenomenon. The network designer analyzed these models to predict how these networks would perform in real-time. The adoption of simulation helps to overcome expenses and design an accurate network model. Models are two types; static and dynamic, the dynamic models that called simulations are much effective than static models for changing environment. Optimized Network Engineering Tools (OPNET) is one of important simulations available among the various simulators; however, the Simulation can be used to evaluate the pros and cons of the network designs, to model the ideas, and to make alternatives and finally choose a better configuration. [6]. The OPNET simulator is a very powerful software to simulate heterogeneous network. It has several distinct methods of creating topologies. [7].

IV. THE ETHERNET LANs BASED SCENARIOS

The Ethernet LANs has been setup up sing two different devices: hubs and switches. A hub forwards the packet that arrives on any of its inputs on all the outputs regardless of the destination of the packet. On the other hand, a switch forwards incoming packets to one or more outputs depending on the destination(s) of the packets. In addition to that, how the throughput and delay of packets in a network are affected by the configuration of the network and the types of switching devices that are used.

4.1 The First Scenario.

The current scenario comes under HubOnly. The environment of the network is in an office which covers an area of 100m X 100m. The hub used is a 16 port hub in an Ethernet environment with the following configurations- Center Node Model = ethernet16_hub, Periphery Node Model = ethernet_station, Link Model = 10BaseT, Number=16, X=50, Y=50, and Radius = 42.

The traffic generated by each workstation have the following configurations: ON State Time = constant (200), OFF State Time = constant (0), Interarrival Time = exponential (0.02), Packet Size = Constant (1500).

Result (1) shows the average traffic that each workstation will generate followed by the total traffic in the network.

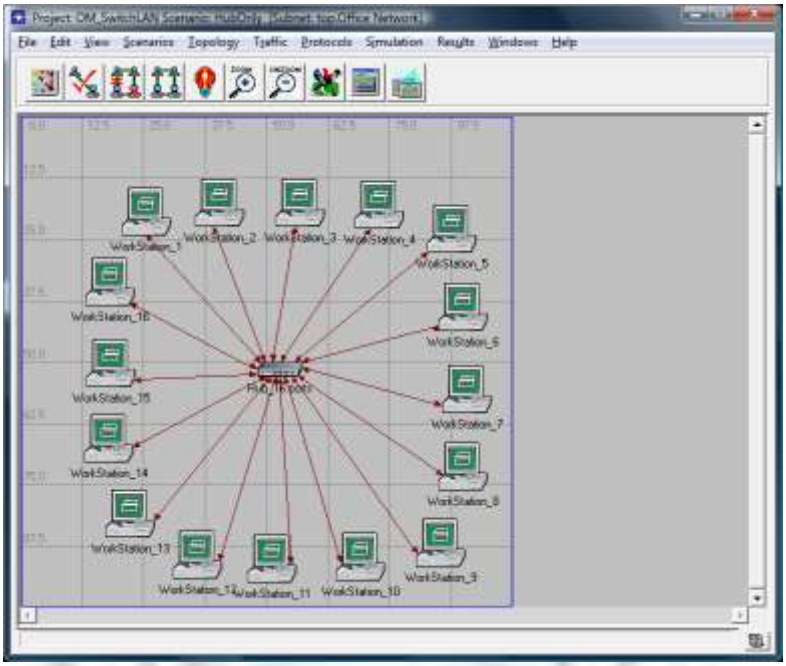


Figure (1): Hub Only scenario network diagram

Result 1

The formula below will be used to calculate the average traffic generated by each of the (16) Workstations in the network.

Average traffic = (Packet Size * 8) / Interarrival Time

Average traffic per workstation = (1500 * 8) / 0.02 = 600000 (bit/sec)

To get the total traffic that generated by the network, just multiply the average traffic per workstation by the number of the workstations in the network as shown in the following formula:

Total traffic = Average traffic * No. of Workstations

The total traffic generated by network = 600000 * 16

= 9600000 (bit/sec)

Since there is a high load in the hub, it's obviously that the total traffic for the Hub Only scenario is a little bit high. So the offered load to the hub (link load) will be affected by increasing or decreasing the interarrival times value. Based on that, the delay and loss of packets will be also depends on the interarrival times and the packet lengths. The value 9600000 (bit/sec) is the total traffic generated by the network.

4.2 The Second Scenario

This scenario uses the following values for the traffic generated by each workstation: Interarrival Time = exponential (0.08). The average traffic that each workstation will generate followed by the total traffic in the network.

Result (2) shows the average traffic generated by the sixteen workstations for the Hub Low Load scenario,

Result 2

To calculate the average traffic generated by the sixteen workstations for the Hub Low Load scenario, the same formulas that had been used in the Hub Only scenario will be used and also to calculate the total traffic generated by the network. As shown below:

Average traffic = (Packet size * 8) / Interarrival Time

Average traffic per workstation = (1500 * 8) / 0.08 = 150000 (bit/sec)

Total traffic = Average traffic * No. of Workstations

The total traffic generated by the network =150000 * 16 = 2400000 (bit/sec)

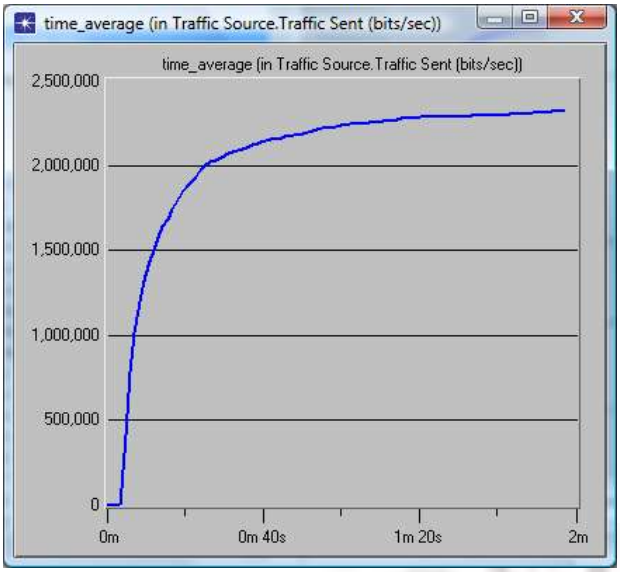


Figure 3: Time average for the Traffic Sent

Figure 4: Time average for the Traffic received in the Hub Low Load scenario in the Hub Low Load scenario

In the above two figures, figure (3) shows the time average for the traffic sent in the Hub Low Load scenario and in figure (4) shows the Time average for the Traffic received in the Hub Low Load scenario. When it comes to compare the time average between the two figures will notice there is no much difference between them in this scenario. Based on the calculation that has been done earlier, (2400000 bit/sec) is the total traffic generated by the network.

When it comes to compare this value with the value of total traffic for the low load will find it is a little bit low and reasonable because of the interval time value has been changed in this scenario. So, as the author mentioned earlier changing the interarrival time value (increase or decrease) will affect on the total traffic and also on the delay time value.

Result 3

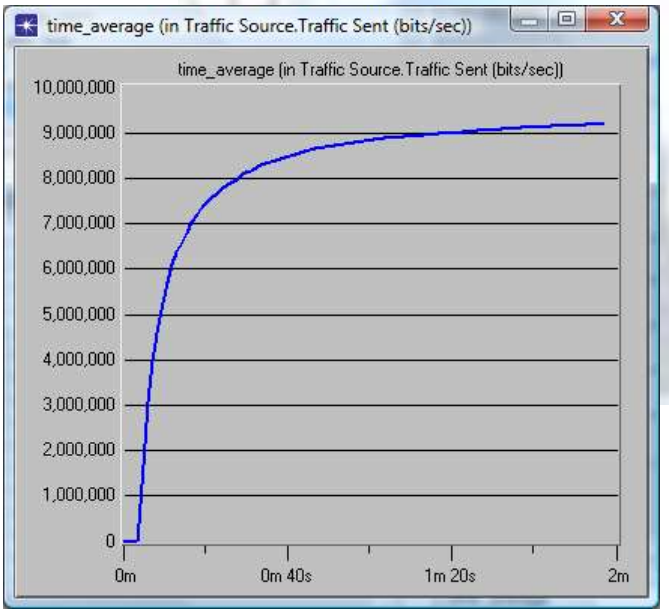


Figure (5) Time average for the traffic sent

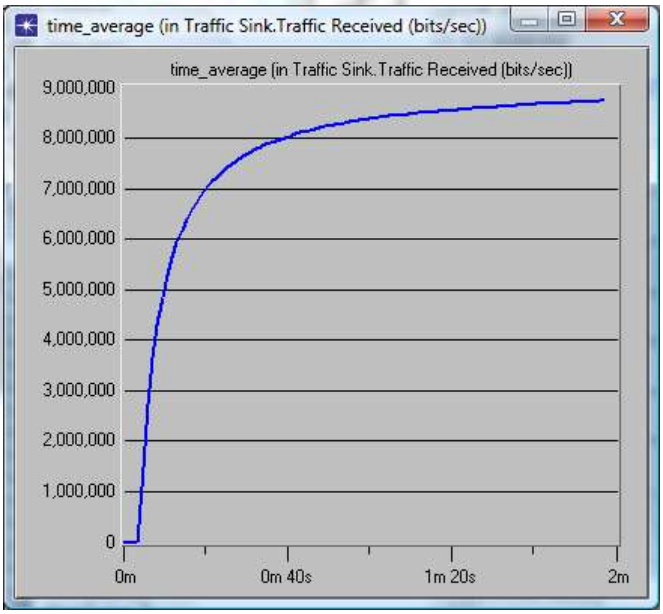


Figure (6) Time average for the traffic received in the Hub Only scenarioin the Hub Only scenario

In the above two figures, figure (5) shows the time average for the traffic sent in the Hub Only scenario and in figure (6) shows the Time average for the Traffic received in the Hub only scenario. When it comes to compare the time average between the two figures will be noticed there is much more traffic was sent than was received in the hub only scenario. However, the hub has become overloaded and cannot deliver all the traffic that it receives. But when it comes to compare the hub only scenario with Hub Low Load scenario will find there is a huge difference between the total traffic between them. For the Hub Low Load scenario is much better than Hub Only scenario. This difference because of the different in the interarrival times value that has been given for both scenarios as the author explained earlier.

Result 4

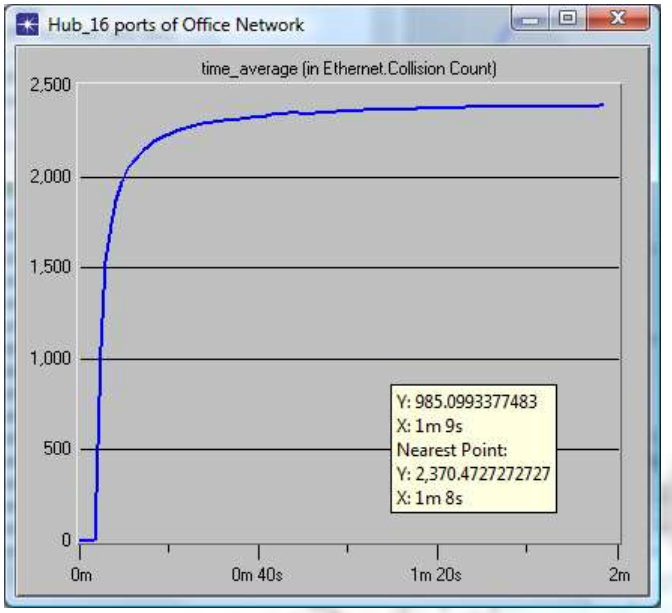


Figure (7) Time average for the collision count

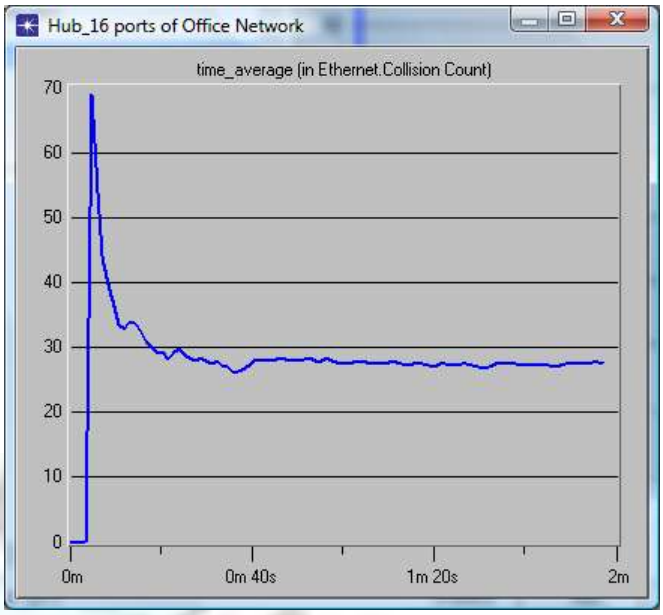


Figure (8) Time average for the collision count in the Hub Only Scenario in the Hub low load scenario

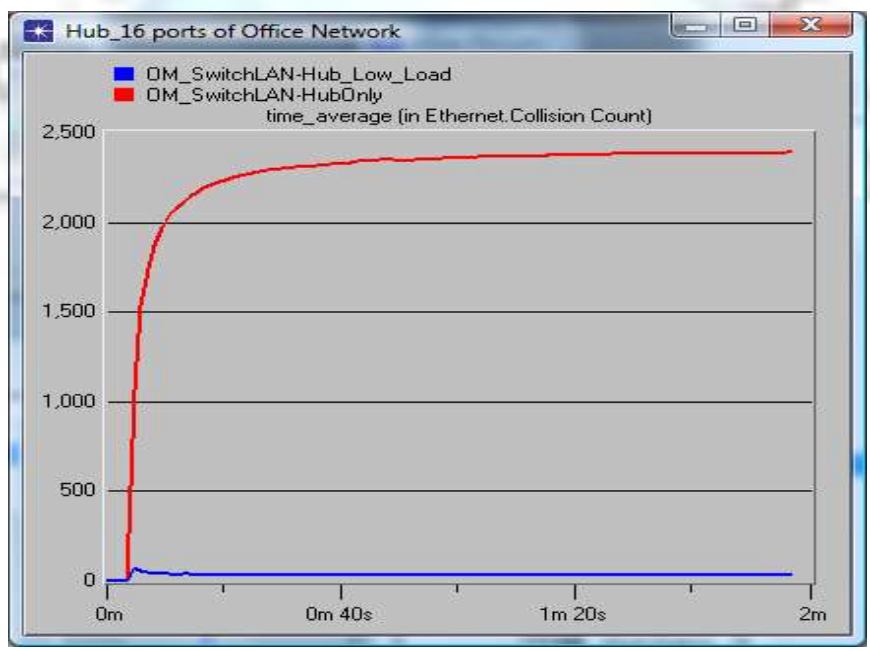


Figure 9: A comparison between Hub Only and Hub Low Load scenarios that show the time average for the Ethernet collision count.

In the above three figures, figure (7) shows time average for the collision count in the Hub Only scenario, in figure (8) shows Time average for the collision count in the Hub low load scenario and in figure (9) comparison between the time average for the Ethernet collision count in the Hub Only and Hub Low Load scenarios. Figure (9) shows that there is a high different in the statistic for the collision count in the Hub Only and Hub Low Load because of the different in total traffic for both. In addition to, the total traffic in the Hub Only scenario is higher than others that leads to the hub becomes overloaded and cannot deliver all the traffic that it receives. For that reason, the collision count for the hub only is much higher.

The following simulation results that has been taken for both scenarios:

Hub low load scenario: highest collisions count = 80, after 1minute and 39 sec
Hub Only scenario: highest collisions count = 2534, after 1 minute and 20 sec
Hub low load scenario: Lowest collisions count = 2, after 42 sec
Hub Only scenario: Lowest collisions count = 2234, after 1 minute and 3 sec

Result 5

To explain the difference between the traffic sent and received values for both scenarios (Hub Only and Hub Low Load), it can be conclude the difference between them from the above statistics. This difference in values caused because the different in the interarrival time value that had been given for the both scenarios. Based on that difference in values that affect the collision count value, as a result when it comes to compare the collision count in Hub Low Load scenario with collision count in Hub Only scenario will find the collision count in Hub Low Load scenario is very low. In conclusion, some of the packets that were sent collided required to retransmissions and reducing the throughput.

Result 6

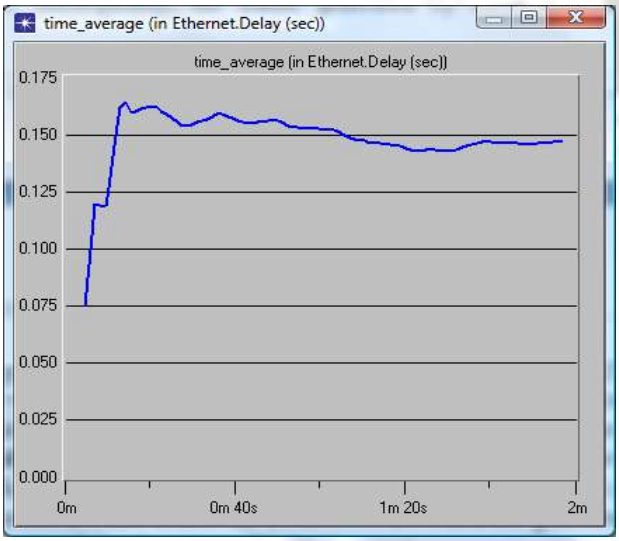


Figure (10) The delay statistic for the Hub Only scenarios

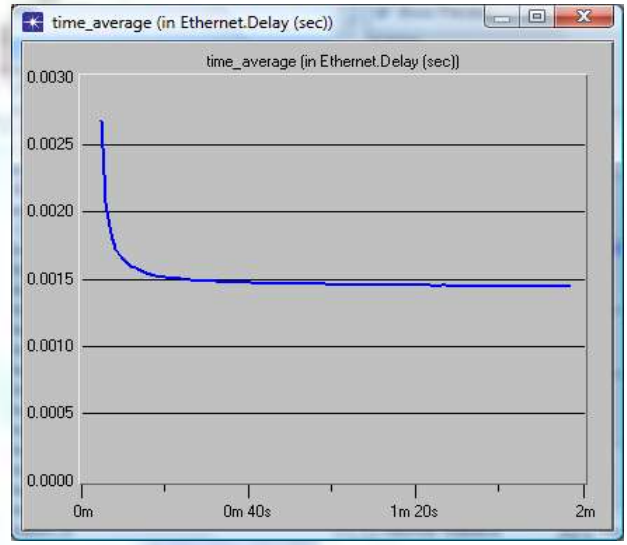
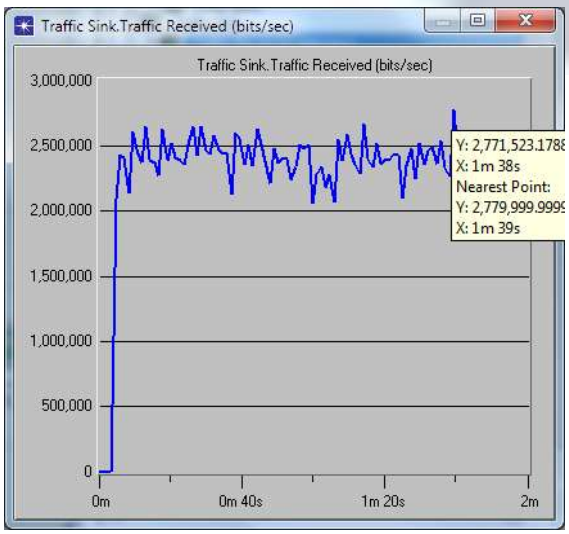
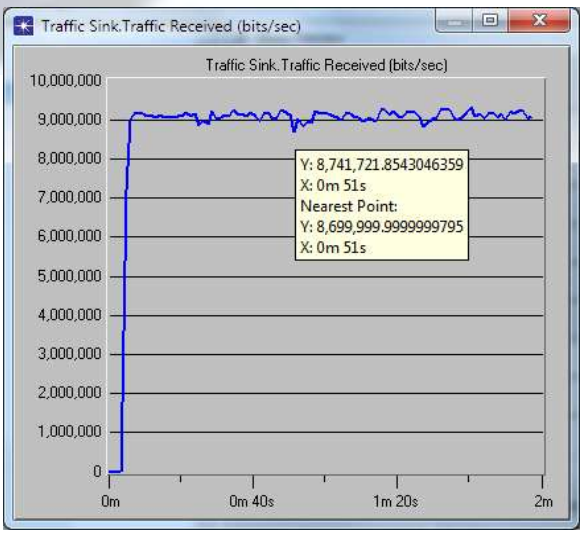


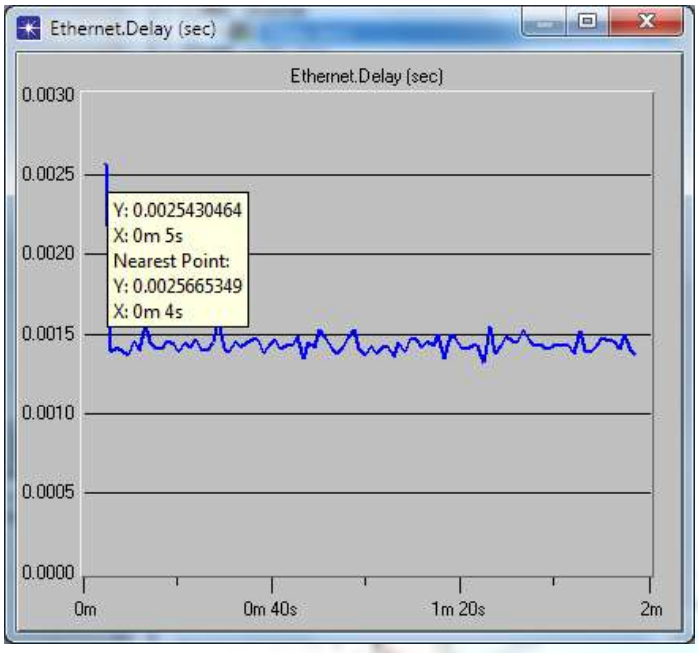
Figure (11) The delay statistic for the Hub low load scenarios

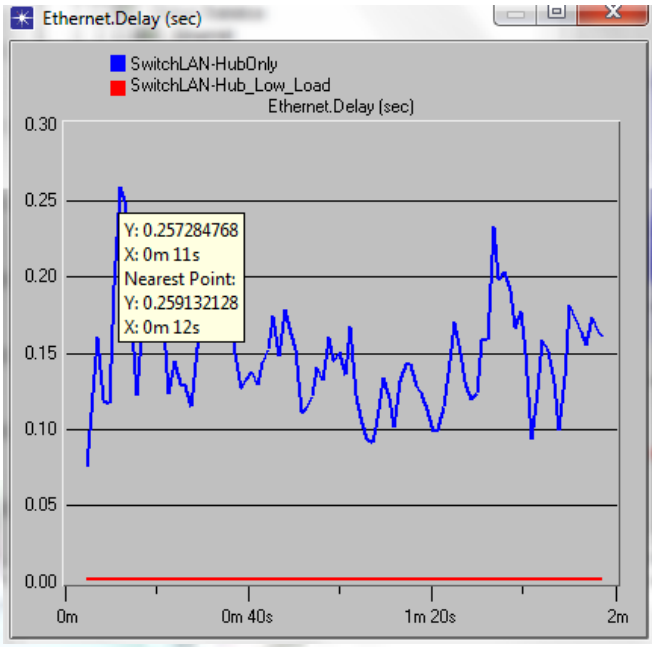
In the above two figures, figure (10) shows time average for the delay statistic for the Hub Only scenarios and in figure (11) shows time average for the delay statistic for the Hub low load scenarios .
To calculate the Expected delay for a packet transmission will be according to the formulae below.
The expected delay = highest value of delay / highest value of traffic received. The result will be shown below:





Expected delay of packet transmission for hub would be as 0.257284768 / 8741721.85 = 2.943181e-8.





Hub Low Load Delay: Value = 0.002543

Hub Low Load Traffic received 2771523.17

So the Expected delay of packet transmission for hub low load would be as = 0.002543/2771523.17
= 9.17546e-10

Figure (12) shows the delay experienced by all packets which have been delivered successfully. It's shown that the delay is fairly consistent in the Hub Low Load scenario, but that the high level of traffic which is 9600000 bit/sec causes growing delays in the Hub Only scenario.

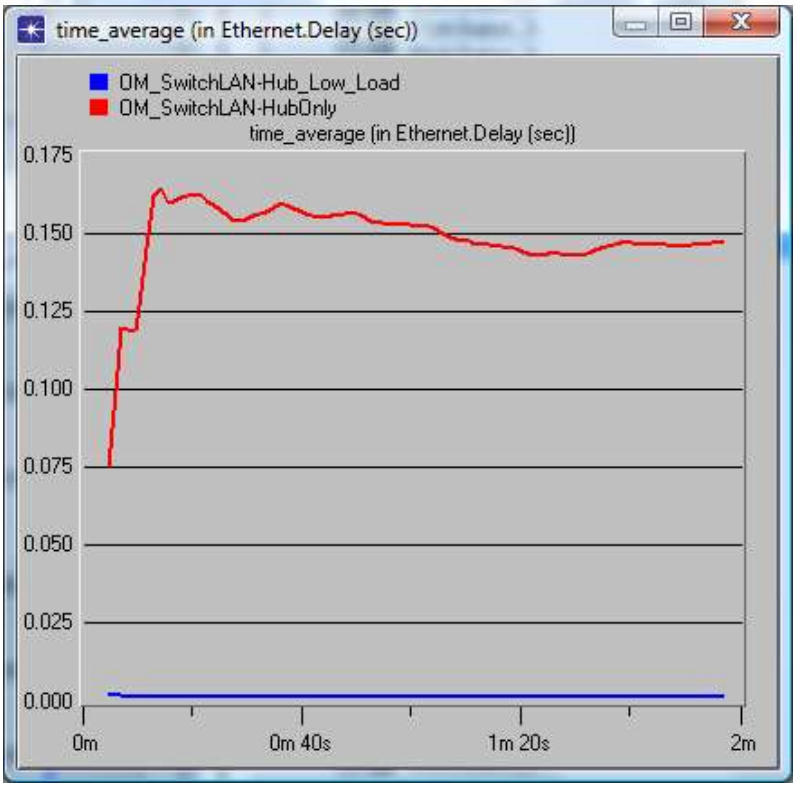


Figure 12: The delay statistic for both the Hub Only and Hub Low Load scenarios.

4.3The Third Scenario is Hub and Switch Scenario

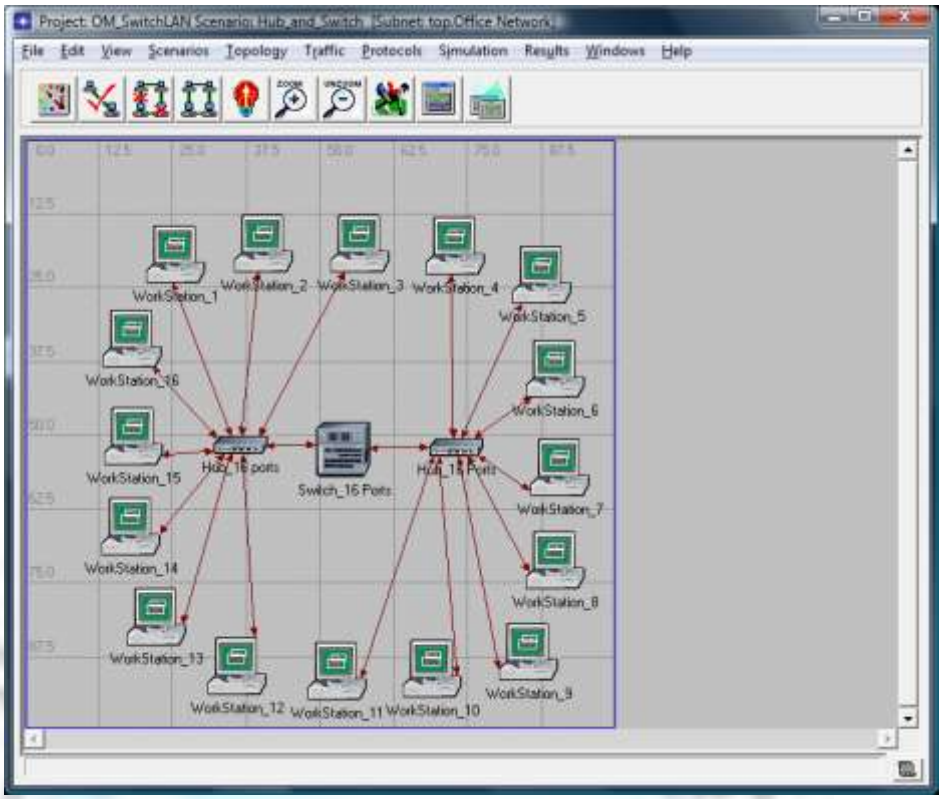


Figure 13: Hub and Switch scenario network diagram.

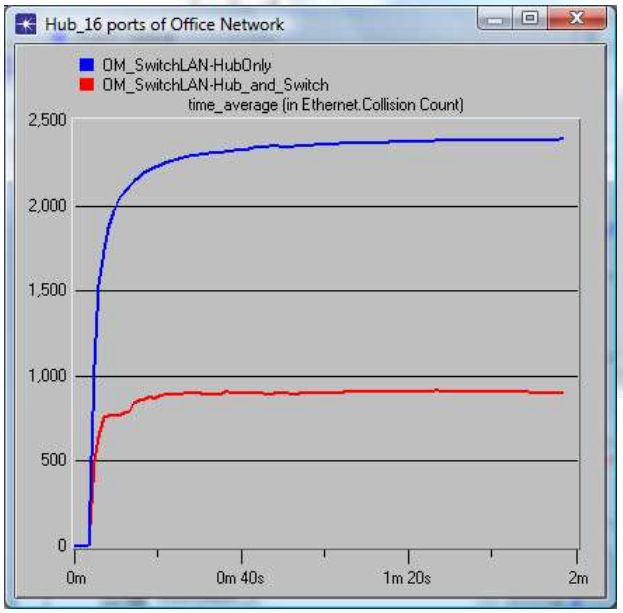


Figure 14: The Ethernet collision count for both the Hub Only and Hub and Switch scenarios.

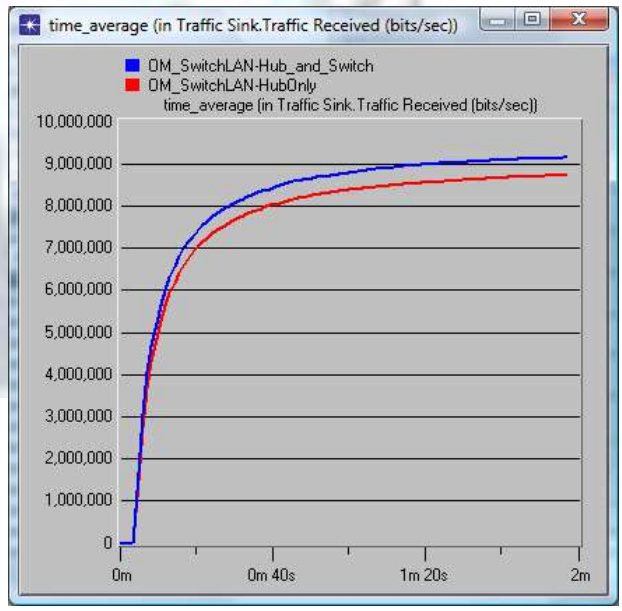


Figure 15: The traffic received in bit/sec for both the Only Hub and Switch scenarios.

The above figure (14) shows Ethernet collision count for both the Hub Only and Hub and Switch scenarios. When it comes to compare the collision count between them will notice the collision count for the Hub and Switch scenario is much lower than the collision counts in the Hub Only scenario. The statistic shows the number of collisions count that occurred at the hub during the simulation which is close to 2500 collisions per second occurred. This is due to the heavy overloading of the hub.

Result 8

The number of collision count in the Hub only and Hub and switch scenarios will conclude the number of collision count For the Hub Only scenario it contains only one collision domain while the Hub and Switch scenario each connected port of the switch considered as collision domain, so two switch ports connected, that mean two collision domains. So in total with the 2 hub that each one has one collision domain, the whole scenario has four collision domains.
No. of collisions domain for the Hub Only scenario = 1 collision domain
No. of collisions domain for the Hub and Switch scenario = 4 collision domain

Result 9

The above figure (15) it shows the traffic received in bit/sec for both the Hub Only and Hub and Switch scenarios. When it comes to compare the results will find that the traffic received in the Hub and Switch scenario is more than the traffic received in the Hub Only scenario, so that mean the network throughput increased because of using the switch device to connect the two hubs.

Result 10

The above figure (16) shows the delay for both the Hub Only and Hub and Switch scenarios. When it comes to analyze the result between them will find the value for the hub and witch scenario is much lower than the value in the hub only scenario that because of using of the switch. The improvement of using the switch, the switch gives reducing the collision count and that lead for the transmission delay to become low.

Result 11

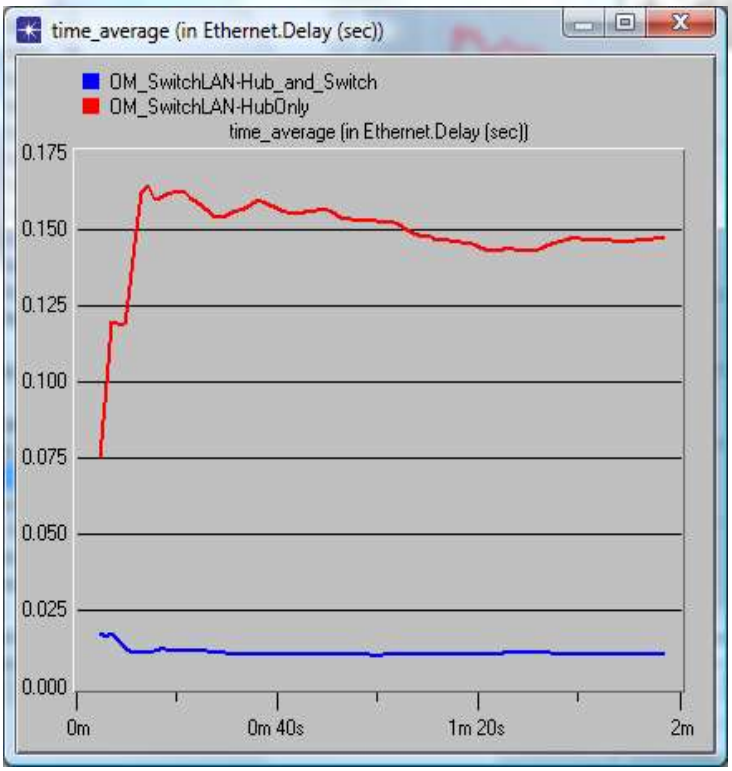


Figure 16: The delay in seconds for both the Hub Only and Hub and Switch scenarios

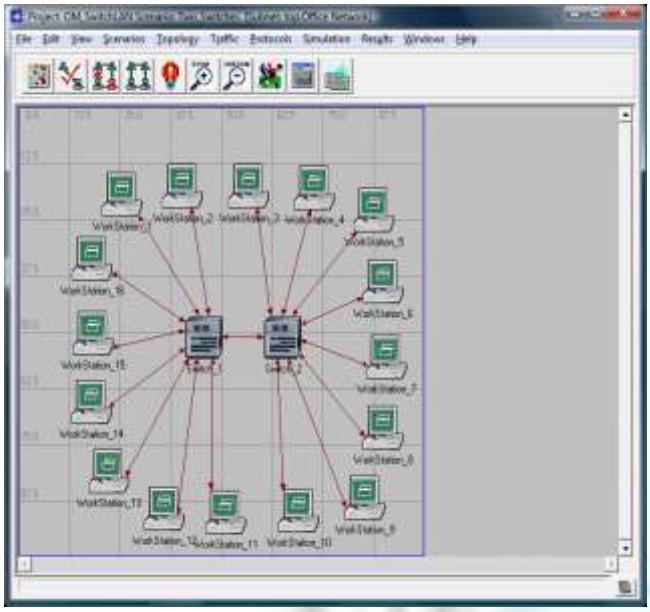


Figure 18: Two Switches scenario network diagram.

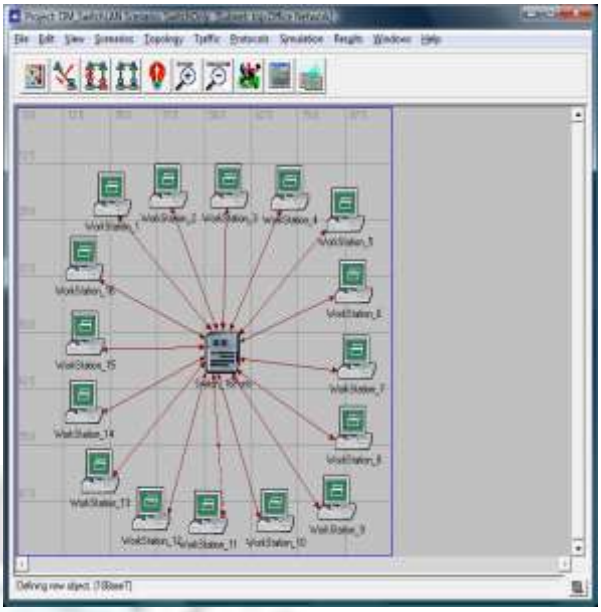


Figure 17: Switch Only scenario network diagram

Result 12

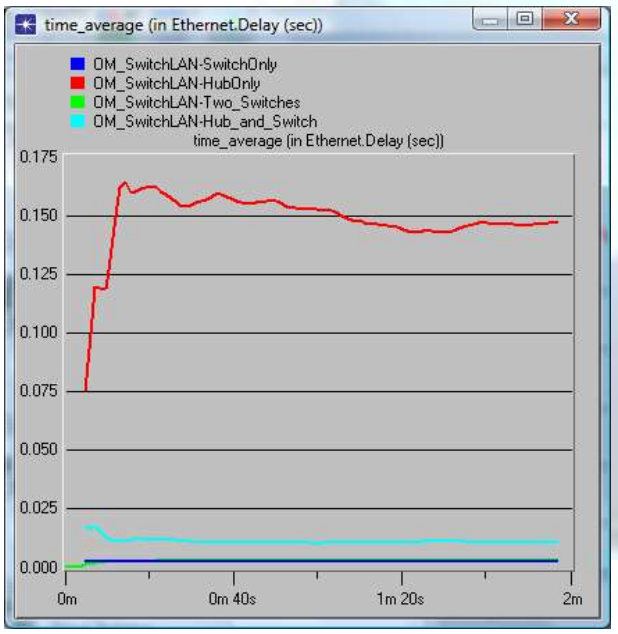


Figure 19: Comparison for the difference in performance in terms of delay between theselected scenarios (Hub Only, Hub and Switch, Switch Only and Two Switches)

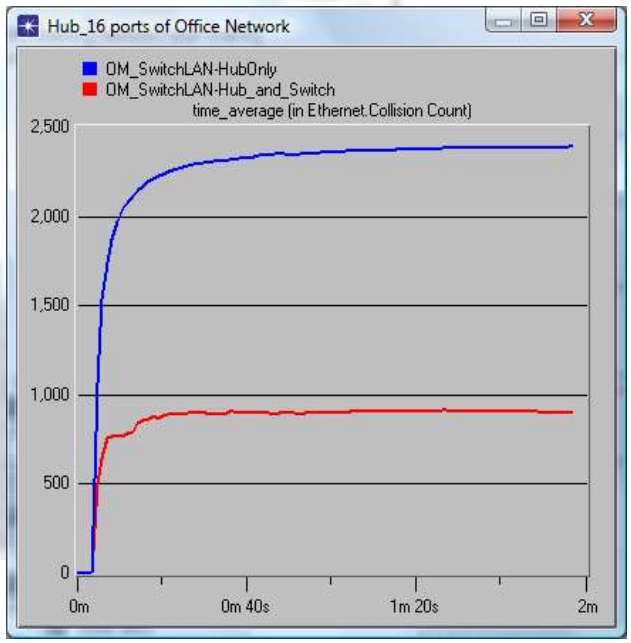


Figure 20: Comparison for the difference in performance in terms of collision count between theselected scenarios (Hub Only, Hub and Switch)

The above figure (19) it shows Comparison for the difference in performance in terms of delay between the selected scenarios (Hub Only, Hub and Switch, Switch only and Two Switches). When it comes to analyze the result will find the delay for the two switches and switch only scenarios is small and constant while the delay for the for the Hub Only scenario and the switch and hub scenario is growing without bound. The collision domain in each scenario will get 18 collision domains for the Switches scenario, one collision domain for each connected switch port which increase the network throughput and reduce delay and collisions count, 16 collision domains for the Switch Only scenario and this lead to lower delay comparing with the two other scenarios (Hub only, and Hub and switch) this is because each port of

the switch creates collision domain, reduces the collision counts and increase the traffic sent/received. While for the two scenarios (Switch only and the Two Switches scenario) there is no collision count as each port in the switch count as a collision domain. The delay and collisions in all network scenarios have been inspected. It's compared the performance and effect of all networks in case of sending and receiving frames. Delay, Traffic Sink, Traffic Source, Collision and Frame Size are the performance parameters. The throughput is improved and delay is decreased as the network was implemented by switches. As conclusion from that, the use of switches in network has more advantages than using Hubs.

Similar to result6; the value for Delay are:

Hub Only: 0.002543/2771523.17= 9.17546e-10
Hub and Switch: 0.037/9932432.43= 3.725e-9
Switch only: 0.00257/102364863.48= 2.510e-10
Two Switches: 0.0034437/9729729.7= 3.539e-10

V. CONCLUSION

The Ethernet LANs has been setup up sing two different devices: hubs and switches. A hub forwards the packet that arrives on any of its inputs on all the outputs regardless of the destination of the packet. On the other hand, a switch forwards incoming packets to one or more outputs depending on the destination(s) of the packets. This study has been investigated the Performance Analysis of Shared and Switched Ethernet LANs through Using OPNET Simulation and how the throughput and delay of packets in a network are affected by the configuration of the network.

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