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Performance Analysis of the Bus Topology Network for Effectual Data Distribution

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Abstract- **Stability, reliability, efficiency, and dependability necessitate a higher performance feature-based system in Ethernet LAN to meet the prevalent emergent technology of 5G and beyond 5G in the domain of networking. LAN technology has experienced the most progression since it came to reality. Despite its ability to achieve promising performance, the technology still keeps some topology characteristics that have a greater influence on its performance. This paper, therefore, addresses the high packet loss experienced in bus topology by investigating the performance of bus topology in four practical scenarios consisting of 10, 20, 30, and 40 nodes. In some applications, traffic was cautiously selected and configured in the application configuration to generate traffic for the modeling. These include HTTP, FTP, email, and databases before they were finally defined in the profile configuration. Substantial global and object statistics such as delay (sec), traffic-sent (bits/sec), traffic-received (bits/sec) for global, and throughput (bits/sec) for global were considered as network metrics for simulation in the OPNET environment. The results obtained proved that as the number of nodes increased, more traffic (bits/sec) were sent and received, more messages were delivered (bits/sec), the delay (sec) was lowered, but greater bit errors per packet were experienced in the network, thus making the bus topology not very suitable for a larger network.**

Keywords- Bus Topology, Global Statistics, LAN, OPNET, Packet Loss.

I. INTRODUCTION

In our present-day communication, networks play an imperative role in effective data distribution as it is applied to every sphere of life, ranging from education to banking, commerce, industry, and entertainment. The use of Local Area Networks (LANs) in propagating appreciable information to people is necessary, especially in an academic setting where the use of modern networking technology is required [1]. The LAN is classified into topology, architecture/design, and protocols [2]. The work aims to achieve the best topology using the most suitable links and several nodes, so that, the network can experience better data-flow-rate in terms of speed [3]. Various types of topologies are available in computer networking. These include star topology, which requires a central host for node connection, bus topology, which requires a common medium for transmission, ring topology, which requires point-to-point connection of the nodes to form a closed path, and mesh topology, which also requires connection of each node to every other node in the network [2, 4].

Several simulation tools like packet tracer, OMNet++, NS-2, NS-3, OPNET, Netsim, and Glomosim are available to properly model and analyze topology in a network environment to lower the cost of evaluation and deployment [5]. The OPNET simulator was preferred because of its flexibility, ease of use, user-friendliness, availability in a Graphic User Interface (GUI), excellent documentation, fastest simulation, and the greatest scalability, freely and commercially available. OPNET also allows the investigation of bit errors, packet losses, data message flows, and link failures [6].

Several performance metrics are available in the OPNET environment to serve as performance pointers and to determine the behavior of network topology. The following performance metrics were considered for maximum efficiency: The delay (sec), which is regarded as the time taken for data to travel from source to destination (the lesser the delay, the higher the performance); throughput (bits/sec), is the average message successfully delivered over a transmission link (the higher the throughput, the higher the performance) [7]. Also, traffic sent (bits/sec) from the source to all available nodes, traffic received (bits/sec) sinks to all available nodes [8], and bit error per packet.

The aim of this work is based on investigating the performance of bus topology to tackle high packet loss for effectual data distribution using simulation approaches. In this paper, four scenarios were modeled by considering different sizes of nodes to cater to network applications: FTP, HTTP, email, and database. The simulation metrics in this paper include: delay (sec), traffic sent (bits/sec), traffic received (bits/sec), throughput (bits/sec), and bit errors per packet. The metrics were implemented and a comparison of each of these metrics was considered for various sizes of LAN networks to achieve optimum performance.

The remaining part of this work is structured as follows: Section I, explained the introductory part of the research work. Section II reviewed the work of different researchers. Section III discussed the techniques used to implement the research work. Section IV discussed and presented the results obtained from the bus topology implementation. Section V serves as the concluding part of the research work.

II. RELATED WORK

This phase of the research briefly discussed various ideas presented by different researchers on network topology and the best techniques deployed to achieve their desired goal. [9], according to this paper, computer networks and the recent developments in the field of computer networks were explicitly examined. Accordingly, keystream network topology configurations were discussed; the basic advantages and disadvantages of nearly eight configurations were also presented in their work. Based on their investigation, different architectural characteristics were studied to assist in developing innovative networks that are in practice. According to their findings, an innovative idea will help engineers advance the subsequent generation of the network. In [10], analytical research on different existing topologies to have a fleeting knowledge of each topology and its characteristics was carried out. In their work, both the advantages and disadvantages of each topology were presented. They, however, observed that two or more of these topologies with their characteristics can be combined to form a hybrid topology. This topology proved to be more effective, reliable, flexible, and scalable as advantages, but it required expensive infrastructure and design complexity. Researchers in [11], also carried out the analytical investigation on different categories of network topologies that were based on their advantages, disadvantages, and other differentiating factors that segregate them. A comparison table was prepared to determine how data flow in the topologies. They presented their work as a great tool for dealing with any problem related to network topology. In [12], a topology for improving performance for their campus, called hybrid topology was proposed. This required the comparison of the output performance of the existing topology with the output performance of the hybrid topology. They concluded that this method produced better and required advancement in network performance for their campus after properly implementing their proposed approach in a simulation environment.

This was based on the fact that there was no packet loss; their work was faced with a smaller delay time and had a lower hop count. They stressed that this network can be extended to handle increasing user numbers. According to the work in [8], performance evaluations on bus topologies using a simulation approach were carried out. Their method was based on various network parameters such as delay in (sec), throughput in (bits/sec), traffic-sent in (bits/sec), traffic- received in (bits/sec) for 10 Ethcoax stations. An OPNET software was considered the simulation of choice for the implementation and thus simulated for 1 hour.

They concluded that using the simulation approach is far easier than the real-time execution strategy. And they further stressed that as the number of nodes increases, the network performance decreases and thus experiences little differences in delay (bits/sec), but there was not much difference in end-to-end delay. [13], considered three main topologies to include bus, ring, and star for various numbers of workstations using software methods. Four different scenarios were examined for each topology, and each scenario consisted of 5, 10, 15, and 20 workstations. They based their analysis on four different parameters, which include the number of collisions experienced on one server, delay in (sec) for global statistics, load in (bits/sec), and traffic received in (bits/sec) on object statistics. Each topology was compared distinctly and also compared for an equal number of linked devices. They came to the conclusion that as the number of linked workstations grows, the network's performance declines, and that the bus topology outperforms the other two topologies.

In this research work, bus topology was investigated with different sizes of four modeling scenarios: 10 nodes, 20 number nodes, 30 number nodes, and 40 numbers nodes. This method was used to examine how the bus topology behaved in the presence of high packet loss when the number of nodes in the network grew. The metrics used to generate network traffic were HTTP, FTP, email, and databases, which were compared in the OPNET simulation environment to achieve a reasonable result.

III. Methodology and Procedures

This aspect describes the method and procedure deployed to appreciate the performance of well-organized network topology (Bus Topology) for maximum data communication. The process was designed and implemented in an OPNET simulation environment where different scenarios were modeled. The simulation approach was considered to ease the cost of execution and, thus, demonstrated the expected outcome in the real-life exploitation.

The office scale (100 x 100 meters) was designed using the startup wizard, and the ethcoax model family was selected. Different sizes of bus topologies (10, 20, 30, and 40) were generated in the rapid configuration of the OPNET, where ethcoax_station was chosen as the node model, eth_coax as the link model, and eth_tap as the tap model, and other attributes remained in their default position. The bus attributes were adjusted with the name changed as eth_coax_adv, the data rate of 500,000bps was fixed and the delay of 0.05 seconds was considered. Application configuration, profile configuration, and nodes were configured with (HTTP, FTP, email, and the database) to generate traffic. The simulation was set up, and the global statistics (Delay in (sec), traffic-received in (bits/sec), and traffic-sent in (bits/sec)), and also object statistics (Throughput in (bits/sec), Bits Error per Packet), were obtained.

Application configuration (default), profile configuration (configured with four (4) selected network parameters), and a server configured to provide required services such as HTTP server, FTP server, email server, and database server to ten nodes connected to the eth_coax backbone are shown in Figure 1. The model was simulated for 1 hour (60 min) for optimal results.

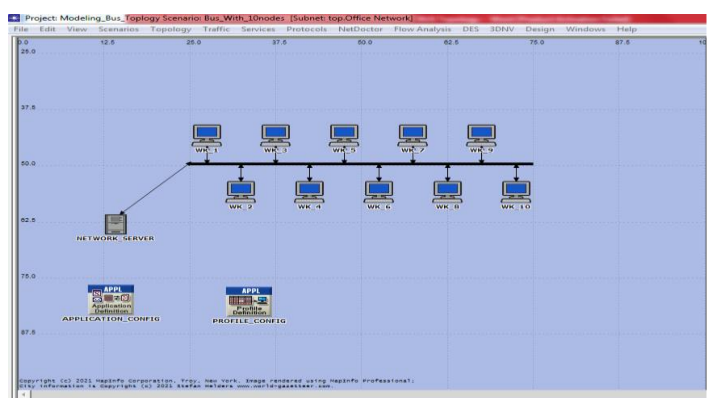

Figure 1. Bus Topology Modelled with 10 Nodes

Figure 2 shows a server configured to provide the required services which are HTTP Server, FTP Server, Email Server, and Database Server to the 20 nodes connected to the eth_coax backbone. The model was simulated for 1 hour (60 min) for optimal results.

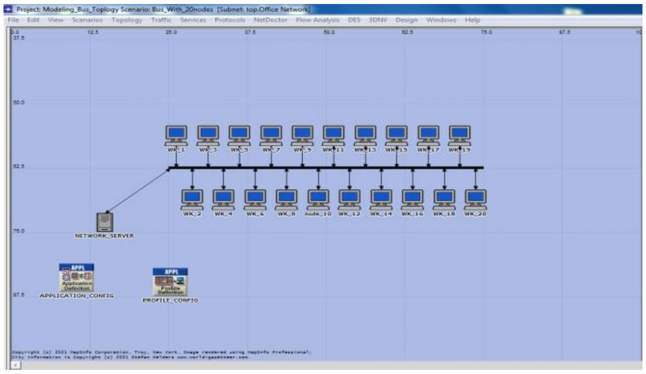

Figure 2. Bus Topology Modelled with 20 Nodes

Application configuration (default), profile configuration (configured with four (4) selected network parameters), and a server configured to provide required services such as HTTP server, FTP server, email server, and database server to 30 nodes connected to the eth_coax backbone are all shown in Figure 3. The model was simulated for 1 hour (60 min) for optimal results.

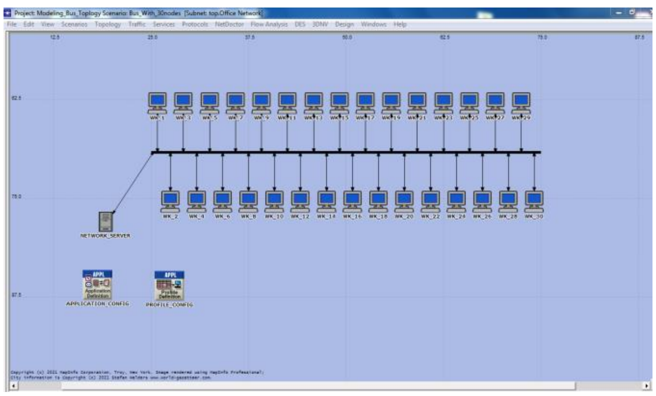

Figure 3. Bus Topology Modelled with 30 Nodes

Figure 4 shows a server configured to provide required services such as HTTP server, FTP server, email server, and database server to 40 nodes connected to the eth_coax backbone, as well as profile configuration (configured with four (4) selected network parameters). The model was simulated for 1 hour (60 min) for optimal results.

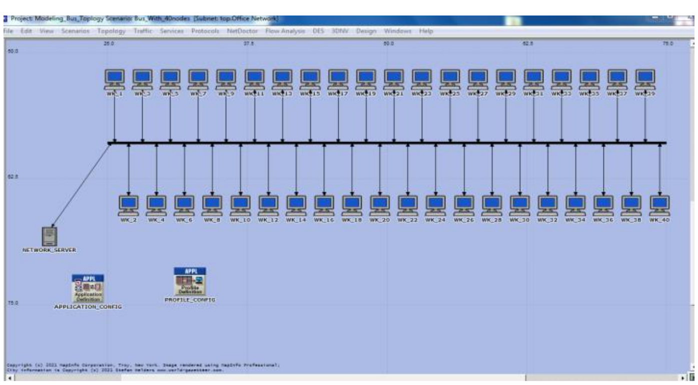

Figure 4. Bus Topology Modelled with 40 Nodes

Figure 5 depicts the bus topology modeling of the discrete encryption system (DES) execution manager for four scenarios, each of which was simulated for one hour.

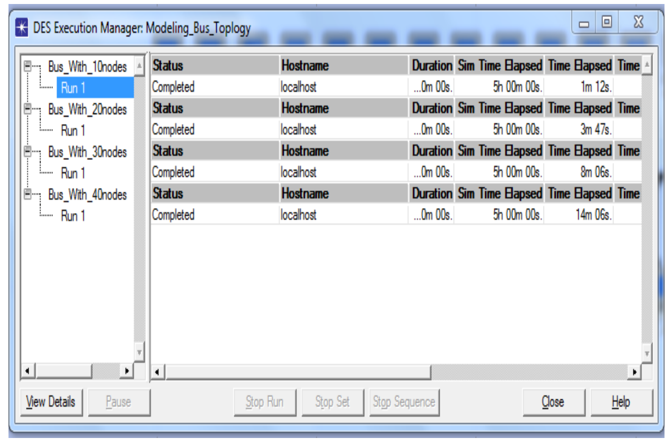

Figure 5. DES Execution Manager Modelling for Bus Topology

Some of the parameters selected for modeling the bus topology in a simulation environment are registered in Table I.

TABLE I. PARAMETERS USED

S/N	Parameters	Values
1	Application Traffic	HTTP, Ftp, Email, Database
2	Network Parameters	Delay, Traffic Sent, Traffic Received, Bits Error per Packet
3	Number of Nodes	10, 20, 30, 40
4	Link Model	Eth_Coax
5	Node Model	Ethcoax_Station
7	Tap Model	Eth_Tap
8	Data Rate	500,000bps
9	Delay	0.05 Second

IV. RESULTS AND DISCUSSION

The simulated results were presented for various scenarios. The results for a bus topology modeled with 10 nodes are shown in Table II.

TABLE II. BUS TOPOLOGY WITH 10 NODES

Time in (sec)	Delay in (sec)	Traffic Received in (bits/sec)	Traffic Sent in (bits/sec)	Through put in (bits/sec)	Bits Error Per Packet
0	0.2889	68,039.11	76,231.11	77,233.33	25.30
10	0.2872	73,201.03	82,122.27	83,598.15	38.55
20	0.2886	72,804.78	82,050.03	83,413.33	50.34
30	0.2884	72,874.67	82,055.66	83,290.85	55.61
40	0.2912	73,302.00	82,753.25	84,027.45	56.36
50	0.2912	73,350.53	82,843.61	84,140.00	56.00
60	0.2921	73,425.35	82,880.28	84,168.00	56.07

The network parameters of consideration were delay in (sec), traffic-sent in (bits/sec), traffic-received in (bits/sec) for global statistics, throughput in (bits/sec), and Bits Error per

Packet for object statistics. The results were obtained and presented in tabular form as shown in Table II after simulating for one hour. From Table II, the lower delay was observed between 0-30Secs, more traffic received between 40-60secs, greater traffic sent, and higher throughput experienced from 10-30sec, and error increases as simulation time increase.

Table III represents the results obtained for a bus topology modeled with 20 nodes. The network parameters of consideration were delay in (sec), traffic received in (bits/sec), and traffic sent in (bits/sec) considering global statistics, throughput in (bits/sec), and Bits Error per Packet for object statistics. After one hour of simulation, the results were obtained and presented in tabular form as shown below. From Table III, the higher delay was observed at 0 sec and decreased with time, greater traffic was received at 10 sec and then, from 40–60 sec, higher traffic was sent at 10 sec, higher throughput was experienced at 110 sec, and errors increased on the network as simulation time linearly increased.

TABLE III. BUS TOPOLOGY WITH 20 NODES

Time in (sec)	Delay in (sec)	Traffic Received in (bits/sec)	Traffic Sent in (bits/sec)	Throughput in (bits/sec)	Bits Error Per Packet
0	0.2748	135,623.11	151,779.56	152,366.67	88.69
10	0.2731	152,737.68	166,229.33	166,959.65	116.83
20	0.2723	151,961.60	165,114.31	165,653.33	125.71
30	0.2722	151,788.48	164,846.50	165,357.05	128.83
40	0.2715	152,161.05	164,954.35	165,416.18	129.86
50	0.2721	152,470.25	165,333.84	165,853.33	128.76
60	0.2721	152,023.04	164,998.26	165,358.67	133.05

Table IV represents the results obtained for a bus topology consists 30 number nodes. The network parameters of consideration were delay in (sec), traffic received in (bits/sec), and traffic sent in (bits/sec) based on global statistics, throughput in (bits/sec), and Bits Error for object statistics.

TABLE IV. BUS TOPOLOGY WITH 30 NODES

Time in (sec)	Delay in (sec)	Traffic Received in (bits/sec)	Traffic Sent in (bits/sec)	Throughput in (bits/sec)	Bits Error Per Packet
0	0.2650	198,428.44	222,549.33	512,600.00	260.33
10	0.2670	228,609.50	249,221.24	246,215.79	218.12
20	0.2673	227,999,66	247,905.52	245,100.00	208.76
30	0.2673	228, 540.17	248,678.07	245,547.44	214.35
40	0.2672	228,813.80	248,684.76	245,720.59	213.27
50	0.2670	228,805.77	248,656.65	245,661.57	213.08
60	0.2670	228,859.42	248,715.95	245,765.33	213.03

After one hour of simulation, the results were obtained and presented in tabular form as shown in Table IV. From this Table, the higher delay was observed from 20 sec to 30 sec and decreased with time, greater traffic was received from 40 sec to 60 sec, greater traffic was sent at 10 sec, higher throughput was experienced at 10 sec, and more errors per packet were observed at 0 sec and decreased on the network as simulation time increased.

Table V represents the results obtained for a bus topology modeled with 40 nodes. The network parameters of consideration were delay in (sec), traffic received in (bits/sec), traffic sent in (bits/sec) for global statistics, throughput in (bits/sec), and Bits Error for object statistics.

TABLE V. BUS TOPOLOGY WITH 40 NODES

Time in (sec)	Delay in (sec)	Traffic Received in (bits/sec)	Traffic Sent in (bits/sec)	Throughput in (bits/sec)	Bits Error Per Packet
0	0.2677	259,640.89	295,367.11	284,666.66	306.28
10	0.2635	303,834.57	332,458.67	325,229.83	265.19
20	0.2647	303,286.04	331,561.45	324,360.00	269.67
30	0.2639	303,016.47	331,039.79	323,674.51	272.20
40	0.2635	303,492.18	331,665.57	324,158.33	274.79
50	0.2641	303,272.66	331,310.18	323,968.24	272.71
60	0.2638	302,785.42	330,870.33	323,456.00	273.76

The results were obtained and presented in tabular form as shown above after being simulated for one hour. Table V shows that the higher delay was observed at 0 sec and varied time, that more traffic was received at 10 sec, that greater traffic was sent at 10 sec, that higher throughput was observed at 10 sec and varied time, and that more errors per packet were observed and varied time as the simulation time increased.

The delay (sec) for each scenario is listed in Table VI, and the graphical representation of this Table is shown in Figure 6.

TABLE VI. DELAY IN SECS FOR ALL SCENARIOS

Time in (sec)	Delay (sec) in for 10 Nodes	Delay (sec) in for 20 Nodes	Delay (sec) in for 30 Nodes	Delay (sec) in for 40 Nodes
0	0.2889	0.2748	0.2650	0.2677
10	0.2872	0.2731	0.2670	0.2635
20	0.2886	0.2723	0.2673	0.2647
30	0.2884	0.2722	0.2673	0.2639
40	0.2912	0.2715	0.2672	0.2635
50	0.2912	0.2721	0.2670	0.2641
60	0.2921	0.2721	0.2670	0.2638

A comparative analysis of various scenarios in tabular form was carried out based on the given network parameters to obtain the effective performance of this topology. Figures 6–10 show the graphical representation of the findings.

Figure 6 shows the graph for all of the delays (sec) considered for different nodes. During the data transmission process, it was clear that a bus topology with 10 nodes had the highest delay (sec), while a topology with 40 nodes had the lowest delay (sec).

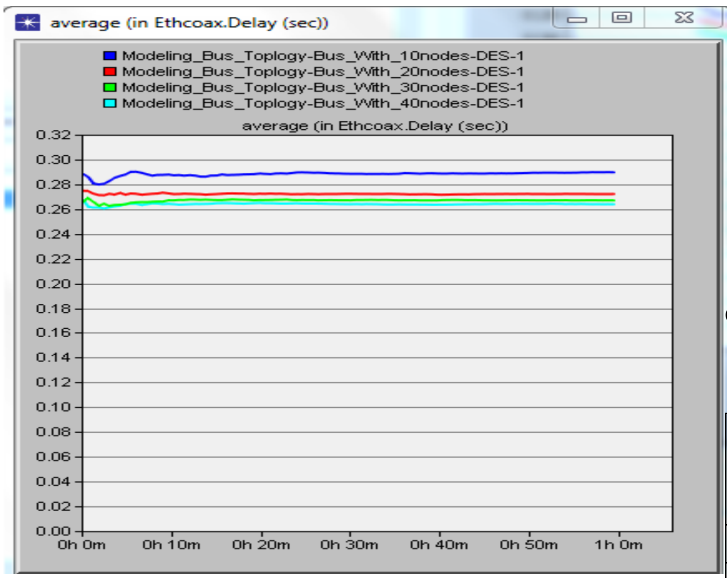

Figure 6. Delay in sec for all Scenarios

The traffic received in (bits/sec) for all scenarios is listed in Table VII, and a graphical representation of this Table is shown in Figure 7.

TABLE VII. TRAFFIC RECEIVED IN BITS/SEC FOR ALL SCENARIOS

Time in (sec)	Traffic Received for 10 Nodes in (bits/sec)	Traffic Received for 20 Nodes in (bits/sec)	Traffic Received for 30 Nodes in (bits/sec)	Traffic Received for 40 Nodes in (bits/sec)
0	68,039.11	135,623.11	198,428.44	259,640.89
10	73,201.03	152,737.68	228,609.50	303,834.57
20	72,804.78	151,961.60	227,999,66	303,286.04
30	72,874.67	151,788.48	228, 540.17	303,016.47
40	73,302.00	152,161.05	228,813.80	303,492.18
50	73,350.53	152,470.25	228,805.77	303,272.66
60	73,425.35	152,023.04	228,859.42	302,785.42

The graph for all the traffic received (bits/sec) is presented in Figure 7. It is crystal clear that a bus topology with 40 nodes received the most traffic (bits/sec), while a topology with 10 nodes experienced the lowest traffic (bits/sec) during the data transmission process.

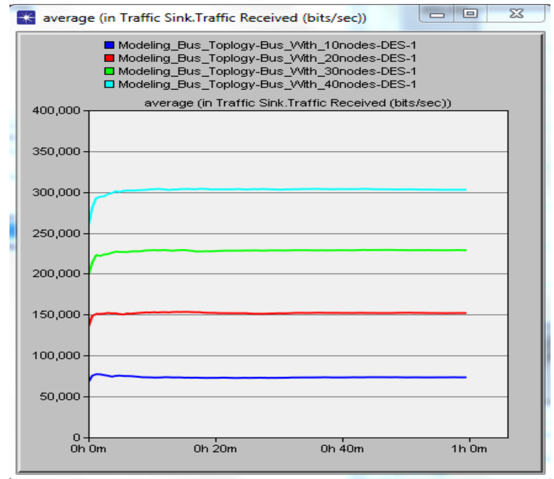

Figure 7. Traffic Received in Bits/Sec for all Scenarios

Table VIII, which shows the traffic sent in (bits/sec) for each scenario, is represented graphically in Figure 8.

TABLE VIII. TRAFFIC SENT IN BITS/SEC FOR ALL SCENARIOS

Time in (sec)	Traffic Sent for 10 Nodes in (bits/sec)	Traffic Sent for 20 Nodes in (bits/sec)	Traffic Sent for 30 Nodes in (bits/sec)	Traffic Sent for 40 Nodes in (bits/sec)
0	76,231.11	151,779.56	222,549.33	295,367.11
10	82,122.27	166,229.33	249,221.24	332,458.67
20	82,050.03	165,114.31	247,905.52	331,561.45
30	82,055.66	164,846.50	248,678.07	331,039.79
40	82,753.25	164,954.35	248,684.76	331,665.57
50	82,843.61	165,333.84	248,656.65	331,310.18
60	82,880.28	164,998.26	248,715.95	330,870.33

Figure 8 shows that during the data transmission process, a bus topology with 40 nodes sent the most traffic (bits/sec), while a topology with 10 nodes experienced the least traffic (bits/sec).

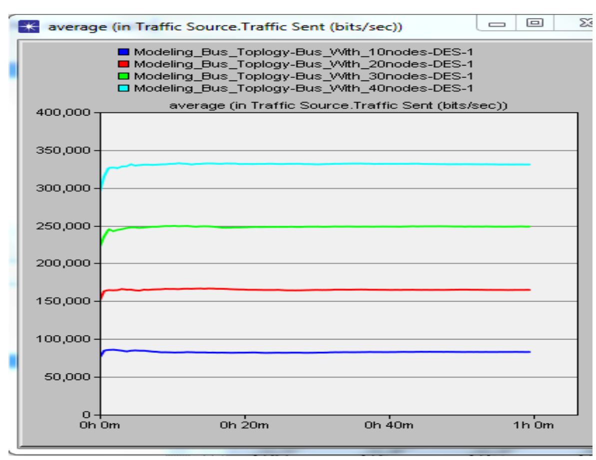

Figure 8. Traffic Sent in Bits/Sec for all Scenarios

Table IX shows the throughput (bits/sec) for all of the scenarios, and Figure 9 shows the graphical representation of this Table.

TABLE IX. THROUGHPUT IN BITS/SEC FOR ALL SCENARIOS

Time in (sec)	Throughput for 10 Nodes in (bits/sec)	Throughput for 20 Nodes in (bits/sec)	Throughput for 30 Nodes in (bits/sec)	Throughput for 40 Nodes in (bits/sec)
0	77,233.33	152,366.67	512,600.00	284,666.66
10	83,598.15	166,959.65	246,215.79	325,229.83
20	83,413.33	165,653.33	245,100.00	324,360.00
30	83,290.85	165,357.05	245,547.44	323,674.51
40	84,027.45	165,416.18	245,720.59	324,158.33
50	84,140.00	165,853.33	245,661.57	323,968.24
60	84,168.00	165,358.67	245,765.33	323,456.00

Figure 9 shows that during the data transmission process, a bus topology with 40 nodes experienced higher throughput (bits/sec), while a topology with 10 nodes experienced the lowest throughput (bits/sec).

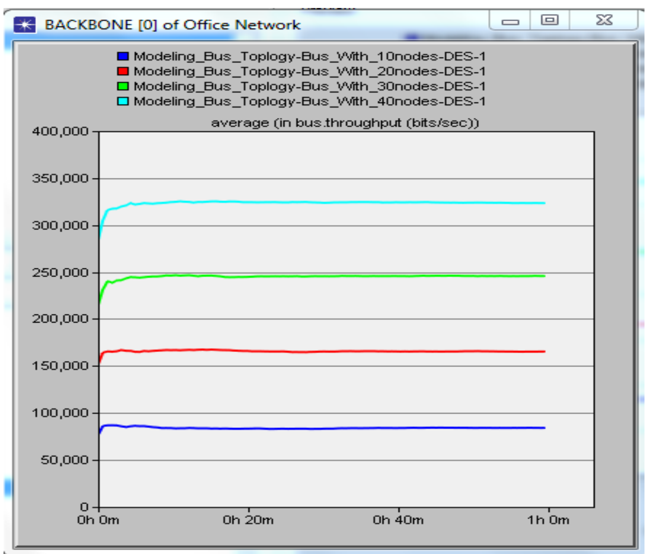

Figure 9. Throughput in Bits/Sec for all Scenarios

The Bits Error per Packet for all of the scenarios is presented in Table X below, with a graphical representation in Figure 10.

TABLE X. BITS ERROR PER PACKET FOR ALL SCENARIOS

Time in (sec)	Bits Error Per Packet for 10 Nodes	Bits Error Per Packet for 20 Nodes	Bits Error Per Packet for 30 Nodes	Bits Error Per Packet for 40 Nodes
0	25.30	88.69	260.33	306.28
10	38.55	116.83	218.12	265.19
20	50.34	125.71	208.76	269.67
30	55.61	128.83	214.35	272.20
40	56.36	129.86	213.27	274.79
50	56.00	128.76	213.08	272.71
60	56.07	133.05	213.03	273.76

Figure 10 shows that a bus topology with 40 nodes had higher bit errors per packet during the data transmission process than a topology with 10 nodes, which had the lowest bit errors per packet.

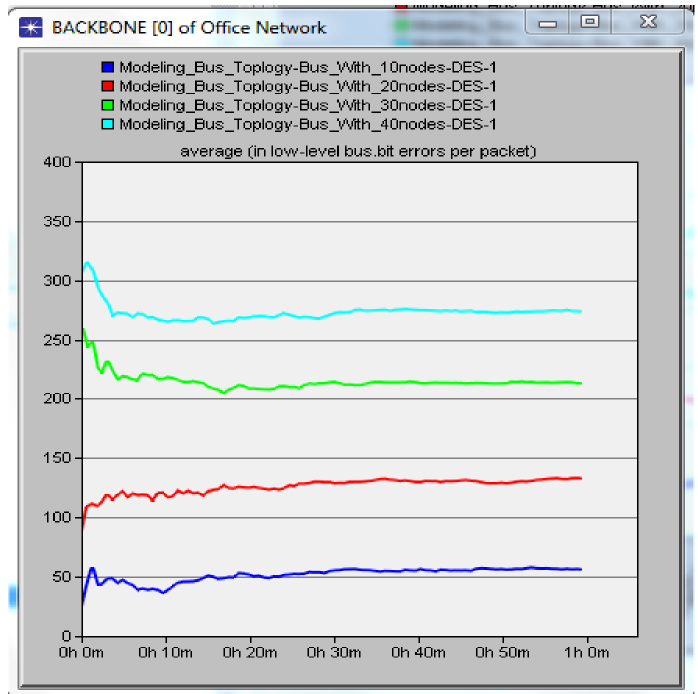

Figure 10. Bits Error per Packet for all Scenarios

V. CONCLUSION

Considering the vital and prevalent concern of distributed computers with the ability to provide great performance at a moderate cost, different computers were linked to provide effective data distribution. However, based on the results obtained from the simulation environment, it is crystal clear that delays were higher in scenarios with lower nodes. But this result was contrary to the presumption that scenarios with fewer nodes would experience little or no delay. Furthermore, the scenario with higher nodes sent and received more traffic than those with lower scenarios. The scenario with a larger number of nodes experienced higher throughput as a result of the longer backbone (eth_coax) and also encountered the problem of higher bit errors per packet because of the high collision rate experienced in the network with larger nodes. In the nearest future, more research into the performance of this topology could be done by taking into account, a variety of other network parameters to learn more about the bus topology performance.

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