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Performance Investigation of an ICT Network for Data Transmission

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Abstract

Effective network communication is thought to require a solid foundation and dependable network architecture. This is necessary for the network's many connected devices to distribute data effectively. This study took into account a well-known local area network topology with a star topology to accomplish this goal. Three architectures for the ICT Center network: ICT Centre A, ICT Centre B, and ICT Centre C were each modelled in an OPNET simulation environment using application traffic from HTTP, FTP, Email, and Database. The number of workstations in each architecture ranged from 40 to 80 to 120. Statistics like Ethernet delay (sec), load (bits/sec), and traffic received (bits/sec) were taken into consideration for each Centre. Due to a large number of workstations, the server at ICT Centre C delivered the highest traffic volume, while ICT Centre B outperformed the others in terms of Ethernet delay reduction. The server at ICT Centre C had the highest load. This demonstrates the need for a lower number of workstations to be taken into account when designing a communication network for faster data transmission.

Keywords: FTP, HTTP, OPNET, Topology, Traffic Received

1. Introduction

Data consumption and information distribution are becoming essential components of information transmission. Robust infrastructures with a standard network architecture/ topology are required as a crucial factor for network communication. Effective resource distribution and user information accessibility are the primary priorities of a computer network. When thinking about data transmission, the network topology is an important consideration. If one is proficient with awareness of the differences between them, one can construct efficient networks. Essentially, the network topology is the topological organization of a computer network, which is further segmented into logical network topology (data flow between the nodes) and physical network topology made up of workstations, servers, and links [1], [2], [3]. The choice of an appropriate topology for a constructed network is influenced by a variety of variables, including price, the multitude of terminals used, the selection of application servers, and the needed processing times [4]. Network topology is further classified into star, mesh, ring, and bus topology [5], [6], [7]. The most popular design, known as a star topology, connects to the central unit via twisted pair wire [8]. Many simulators, including NetSim, NS-2, OMNeT++, NS-3, JSIM, QUALNET, REAL, OPNET, and GlomoSim, have been developed by the academic community to lower the expense of projection due to their utility and power in enabling speedy experimentation with numerous design possibilities in the design space [9], [10], [11].

An effective network is desirable in an organization when setting up ICT Centre for usage. This provides adequate communication facilities for various employees to ensure sufficient and efficient sharing of limited resources. Most organizations considered star topology for their ICT Centre configuration because of its flexibility, adaptability and reliability. Though the problem of a central host having faults and rendering communication useless is still a major concern in this technology. To have in-depth knowledge of this most embraced local area network technology on how data is transmitted and distributed, the performance of three ICT centres was modelled, simulated and analyzed in an OPNET (Optimized Network Engineering Tools) simulator for 40, 80 and 120 workstations. Traffic across the network is generated from HTTP, FTP, Email, and Database and parameter of interest for analysis were Ethernet delay (time needed to convey data from the sender to the recipient), load (ratio between the channel's capabilities and the amount of traffic being transmitted across the network), and traffic received (total amount of traffic received on the network) [12].

Three separate network centres were modelled, simulated, and analyzed using OPNET for analysis to ascertain how a star network behaves and performs as network size increases.

Other sections of this work is prepared as follows: The relevant research on this technology is presented in Section 2. Section 3 presents the method used for implementation. The results generated were presented and discussed in section 4 and section 5 concluded the research work.

2. Related work

N. Absar et al [13], designed and evaluated a star topology model in a small Internetwork using an OPNET simulator. Several simulated graphs were generated based on

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parameters such as the number of nodes, load (bit/sec) and Ethernet delay (second). The results obtained indicated that with varied in simulated time and the number of nodes, the server loads also varied but with an almost constant delay. [14], in their work investigated Local Area Networks using OPNET to simulate different network structures, this was based on four various parameters which include throughput, network load, percentage network utilization and Ethernet delay. They concluded based on their findings that with the adoption or upgrading of the communication link of the network to 100GB, a tremendous performance was achieved in the network. This means that the performance of a network will be higher with a bandwidth link of 100GB. [15], further investigated office Local Area Networks (LAN) with an OPNET simulator by considering different scenarios using network parameters such as Ethernet delay, traffic received, collision and traffic sent. The performance of the Local Area Network was compared in both Hub and Switch. They, however, concluded that with a higher collision in the network, more packets will be lost. Therefore, the hub suffered in most of these parameters considered while the switch has better performance as compared to a hub. Different network topologies were investigated based on some factors, the advantages and disadvantages each exhibit. They observed that each topology demonstrates strong features which can make any of them the topology of choice for network design. They, however, concluded that two or more of these topologies can be chained to for hybrid topology which will be more flexible, scalable, effective and reliable. But also considered the cost of deploying the infrastructures and the design complexity of the network [16]. Furthermore, in [4], four different scenarios with different values were configured to examine ring, bus and star topologies based on different network sizes. Different values were configured for each topology in the OPNET environment. Network parameters such as Delay for global statistics, Collision, Traffic Received (bits/sec), and Load (bits/sec) for node statistics (i.e. server) were compared in each topology with various network sizes and between these three topologies. They, however, concluded that, with an increase in network sizes, performance decreases, and further stressed that ring topology outperformed the other two topologies.

3. Methodology and Procedures

This work investigates the performance of an ICT network for data transmission where OPNET was used to model, simulate and analyzed three different network centres. Each Centre consists of 40, 80 and 120 workstations. HTTP, FTP, Email, and Database were the applications selected to generate traffic for each Centre and Ethernet delay (sec), load (bit/sec), and traffic received (bit/sec) were network metrics selected for analysis.

The method was taken into consideration to explain the technique and procedure utilized to assess the performance of a well-organized star topology network in an ICT Centre for information transmission.

Three alternative situations were modelled in an OPNET platform, which was used to develop and execute the procedure. The simulation technique was thought to lower the implementation costs and, as a result, show the anticipated result in the actual application.

The setup wizard was used to create the centres' network (scale: 100 x 100 meters). Employing a simulation tool, three scenarios made up of 40, 80, and 120 workstations were quickly created. Ethernet_wkstn with client-server applications supports 10Mbps, 100Mbps, and 1000Mbps was chosen as the periphery node model, and 1000BaseX duplex links operating at 1Gbps were taken into consideration as the link model. The 3C CB9000 14s a8 ae80 fe40 ge8 model was chosen as the centre node model, which supports up to 136 ports.
For all three cases with different numbers of nodes, other properties like radius, x, and y placement held onto their default positions.

A default configuration (Application Configuration) was set up for the application definition, which provided application specifications for several parameters. The five apps that make up the Profile definition, which records user behaviour over time for this work to generate traffic, are HTTP (heavy), FTP (heavy), Email (heavy), Database (light), and Print (light).

Both the application support profile and the application support service were set up on the center's Ethernet server, which offers HTTP, FTP, Email, Database, and Print services.

Additionally, the centers' Ethernet printers were set up with application support services and profiles. The simulation was executed. On each occasion, the following statistics were gathered: Ethernet Delay (sec) for the global, Server Load (sec), and Traffic Received (bits/sec) on the Server for the object for each scenario.

A few of the parameters utilized for simulating the star network are shown in Table 1 below.

Table 1. Parameters Employed.

S/N	Parameters	Values
1	Center Node Model	3C CB9000 14s a8 ae80 fe40 ge8
2	periphery node model	Ethernet_wkstn
3	Link Model	1000BaseX
4	Application Traffic	Http, Ftp, Database, Print, Email,
5	Network Parameters	Delay, Load, Traffic Received
6	Number of Nodes	40, 80, 120

The flowchart describing the technique used the in modelling and simulation of this work in the OPNET environment is presented in figure 1 below.

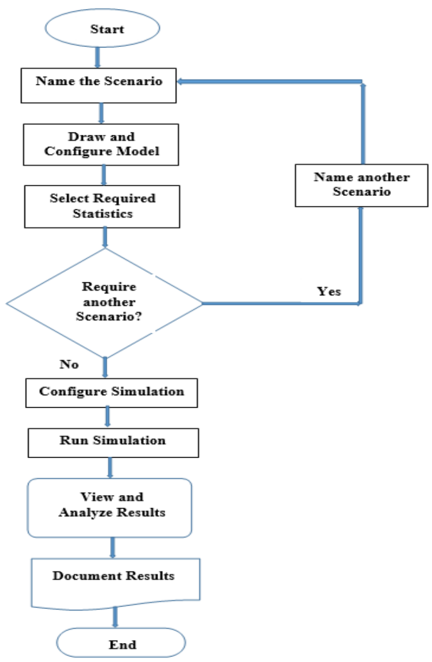

Fig. 1. Technique Flowchart.

Fig. 2, below presents a star-network system setup for an ICT Centre A, modelled with an application and profile definition, a server, printer and 40 workstations linked with 1000BaseX to a central switch to deliver data across the Centre. The required services across the network were provided from the HTTP Server, FPT Server, Email Server, Database Server and Print Server all configured on the ICT Centre Server. The scenario was simulated for 1 hour to generate the output result for the process.

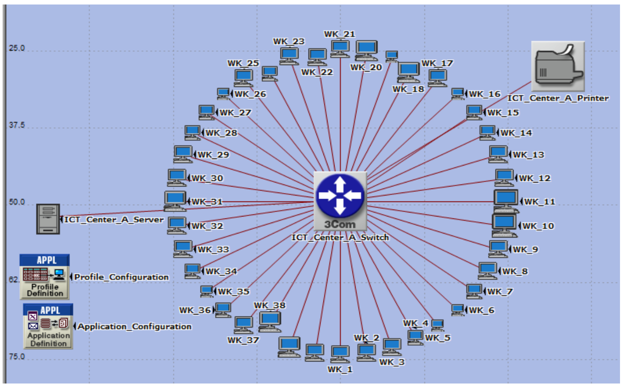

Fig. 2. ICT Centre A with 40 Workstations.

Fig. 3, below shows a setup for a star-network system with the proper infrastructures for an ICT Center B, modelled with an application and profile definition, a server, printer, and 80 workstations connected with 1000BaseX to a central switch to distribute data across the Center. The HTTP Server, FPT Server, Email Server, Database Server, and print server all configured on the ICT Center Server offered the necessary services across the network. To produce the output result for the process, the situation was simulated for one hour

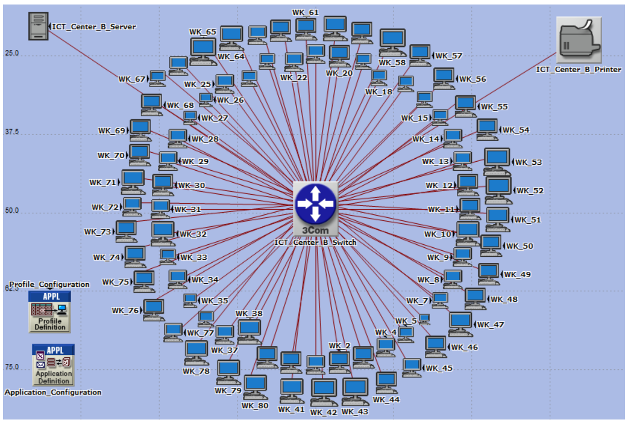

Fig. 3. ICT Centre B with 80 Workstations.

The architecture for a star-network system in Fig. 4, below includes the necessary components for an ICT Center C, designed with an application and profile definition, a server, printer, and 120 workstations linked via 1000BaseX to a central switch to disseminate data throughout the Center. Essential network services were provided via the HTTP Server, FPT Server, Email Server, Database Server, and Print Server, all set up on the ICT Center Server. The scenario was simulated for one hour to provide the final output for the operation

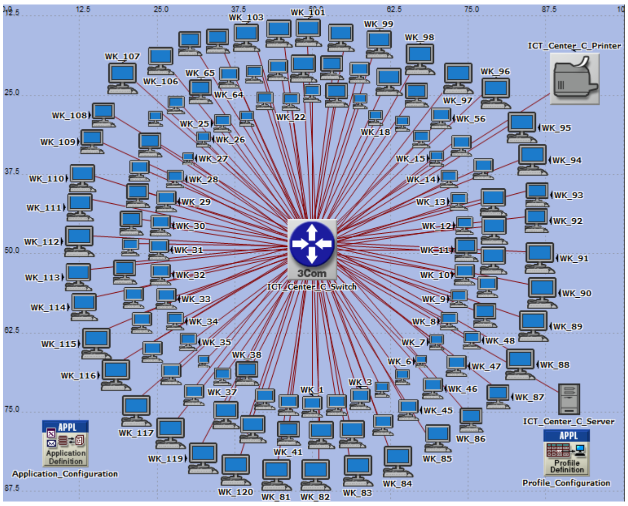

Fig. 4. ICT Centre A with 120 Workstations.

4. Results and Discussion

The expected outcomes for the three events were shown and discussed in this chapter.

Table 2 displays the outcomes of modelling a star topology with 40 workstations. For object statistics, the network characteristics taken into account were traffic received (bits/sec), load (sec), and delay (msec) for global statistics. Following an hour of simulation, the findings were attained and displayed in tabular form as seen below. Ethernet delay was low at 0 min, but it rises between 10 min and 20 min and then lowers as time increases. The load on the server was 0 sec at 0 min, peaked at 10 min, and then continued to decline over time. The server experienced the lowest traffic at 0 minutes, the highest at 10 minutes, a decline between 20 minutes and 40 minutes, and then a rise as time went on.

Table 2. ICT Centre A with 40 Workstations.

Time (min)	Delay (msec)	Loads (bits/sec)	Traffic Received (bits/sec)
0	0.003968	0	200.89
10	0.005800	92,597.90	64.268.75
20	0.005812	88,040.86	59,843.35
30	0.005767	84,472.73	57,467.74
40	0.005757	82,668.29	56,552.26
50	0.005748	80,780.39	57,340.44
60	0.005741	79,884.80	57,581.38

80 workstations were used to model a star topology, and the results are shown in Table 3. The network factors included for object statistics were traffic received (bits/sec), load (sec), and delay (msec) for global statistics. After one hour of simulation, the results were obtained and presented in tabular form as shown below. The Ethernet delay was a little at 0 minutes, but it increases after 10 minutes, though not consistently. The load on the server was zero at 0 minutes, but it peaked at 10 minutes and then gradually decreased. The amount of traffic on the server peaked at 10 minutes and then continued to diminish as time went on.

The outcomes of modelling a star topology using 120 workstations are displayed in Table 4. Global statistics were chosen to include traffic received (bits/sec), load (sec), and delay (msec) as network parameters for object statistics. The simulation took an hour to complete, and the results are provided below in tabular format. Ethernet latency was minimal at 0 minutes, but after 10 minutes, it grows, however, the increment was not steady over time. Around 0 minutes, the server had no load; nevertheless, at 10 minutes, the demand reached a peak before progressively declining. After 10 minutes, the server had its highest traffic, which then gradually decreased.

Table 3. ICT Centre B with 80 Workstations.

Time (min)	Delay (msec)	Loads (bits/sec)	Traffic Received (bits/sec)
0	0.003902	0	392.89
10	0.005553	159,455.32	122,387.58
20	0.005543	153,121.58	111,085.11
30	0.005594	149,664.60	110,928.17
40	0.005630	149,943.26	110,661.78
50	0.005622	147,284.86	109,850.13
60	0.005612	146,304.44	108,014.13

Table 4. ICT Centre C with 120 Workstations.

Time (min)	Delay (msec)	Loads (bits/sec)	Traffic Received (bits/sec)
0	0.004543	0	577.78
10	0.005739	232,11.75	190,136.73
20	0.005720	227,310.93	172,406.79
30	0.005699	225,752.95	170,844.69
40	0.005688	221,181.04	167,798.14
50	0.005694	220,297.54	166,084.24
60	0.005675	219,507.47	163,267.99

Based on the provided network characteristics, a comparative study of the three situations in tabular form was performed to determine how well this architecture performed. The results are graphically represented in Fig. 5-7.

Table 5 lists the delay (sec) for each case, and Fig. 5, displays a graphic illustration of this table.

Table 5. Delay (msec) for the Three ICT Centres.

Time (min)	Delay (msec) for Centre A	Delay (msec) for Centre B	Delay (msec) for Centre C
0	0.003968	0.003902	0.004543
10	0.005800	0.005553	0.005739
20	0.005812	0.005543	0.005720
30	0.005767	0.005594	0.005699
40	0.005757	0.005630	0.005688
50	0.005748	0.005622	0.005694
60	0.005741	0.005612	0.005675

The graph for each of the delays (sec) taken into account for the three scenarios is shown in Fig.5. It was evident that a star topology with 120 workstations had the most delay (msec) at the beginning and later dropped as compared with topology with 40 workstations. Furthermore, a topology with 80 workstations had the lowest delay (msec), during the process of data transfer in the ICT Centers. Although there were very few differences in the three scenarios' delays

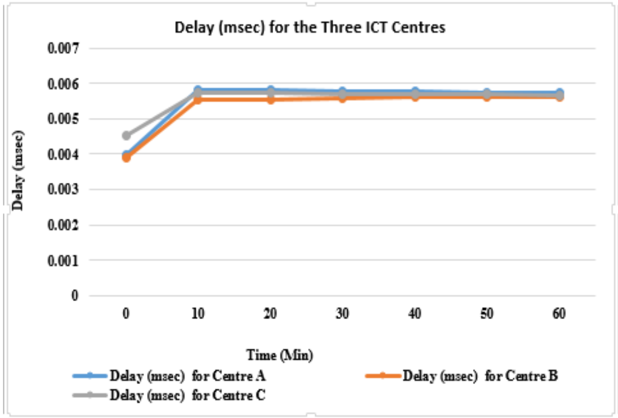

Fig. 5. Delay (msec) for the Three ICT Centres.

Table 6 lists the load (bits/sec) for the three cases, and Fig. 6, displays a graphic illustration of this table.

Table 6. Loads (bits/sec) for the Three ICT Centers.

Time (min)	Loads (bits/sec) for Centre A	Loads (bits/sec) for Centre B	Loads (bits/sec) for Centre C
0	0	0	0
10	92,597.90	159,455.32	232,11.75
20	88,040.86	153,121.58	227,310.93
30	84,472.73	149,664.60	225,752.95
40	82,668.29	149,943.26	221,181.04
50	80,780.39	147,284.86	220,297.54
60	79,884.80	146,304.44	219,507.47

The load (bits/sec) graph for each of the three scenarios is present in Fig. 6. It is abundantly evident that when transmitting data, a server connected to 120 workstations has the highest load (measured in bits/sec), followed by a server connected to 80 workstations, and the lowest loads experienced by a server connected to 40 workstations.

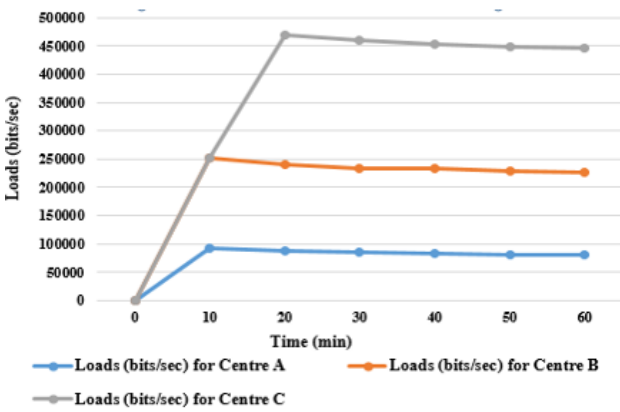

Fig. 6. Loads (bits/sec) for the Three ICT Centres.

The traffic received (in bits/sec) for each of the three situations is listed in Table 7, and Fig. 7, shows a graphical depiction of this table.

In Fig. 7, the traffic received (bits/sec) graph is shown for each of the three scenarios. It is plain to see that a server connected to 120 workstations received the most data traffic (measured in bits/sec), followed by a server connected to 80 workstations, and a server connected to 40 workstations received the least.

Table 7. Traffic Received (bits/sec) for the Three ICT Centers.

Time (min)	Traffic Received (bits/sec) for Centre A	Traffic Received (bits/sec) for Centre B	Traffic Received (bits/sec) for Centre C
0	200.89	392.89	577.78
10	64.268.75	122,387.58	190,136.73
20	59,843.35	111,085.11	172,406.79
30	57,467.74	110,928.17	170,844.69
40	56,552.26	110,661.78	167,798.14
50	57,340.44	109,850.13	166,084.24
60	57,581.38	108,014.13	163,267.99

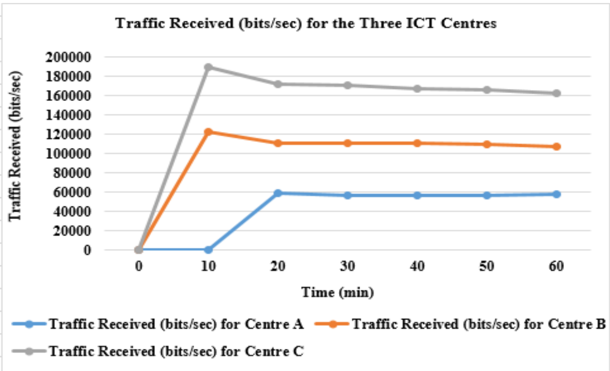

Fig. 7. Traffic Received (bits/sec) for the Three ICT Centre.

5. Conclusion

The star network performance evaluation of basic internetwork utilizing software techniques is presented in this article. A scenario including 80 workstations was deemed more relevant because the network delay, in this case, was smaller and hence indicated faster data transmission when comparing the three centres. Contrary to predictions, an 80-workstation scenario had a lower Ethernet delay than a 40-workstation scenario would have. Because there were more workstations (120 workstations) connected to the central switch, the single server on the network suffered the highest load (bits/sec), which was caused by the higher number of workstations. Additionally, ICT Center C also saw high traffic (bits/sec) levels as a result of having the most workstations linked to the central switch. This shortcoming could be attributable to the use of a single server to support five separate applications (HTTP, FTP, Database, Email and Print). Different servers might be recommended for use in real-world deployment to handle these various applications. Researchers might investigate this element to make it even better while also considering various network characteristics.

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