OPTIMIZING LOCAL AREA NETWORK PERFORMANCE: INSIGHT FROM RIVEBED MODELLING

ABSTRACT

Designing and deploying an efficient and cost effective network that will satisfy end users requires a careful consideration of the different network devices that are available and selecting network parameters that will guarantee optimum performance. In this study, Riverbed modeling software was used to simulate and study the effects of varying different network parameters and devices on the performance of a local area network (LAN).Starting off with the designated Simple Network and Busy Network, the network parameters were varied for other scenarios to investigate the effects of network background utilization, link type, as well as the number of servers. Results from the simulation show that for a local area network, the web server demonstrated the highest CPU utilization. While increasing the background utilization of the network increased the remote server access time, FTP get download time, and HTTP request page response time, replacing the three servers with a single server did not have any significant impact on the CPU utilization. Further results from the simulation show that using cables enhanced the data transmission rate, andrather than deploying multiple servers, effective selection and distribution of network services can be used to achieve optimum network performance using a single server. This is achieved by striking a balance between frequently utilized network services and non-frequently utilized network services

Keywords: **design, devices, network, parameters, simulation**

I. INTRODUCTION

Designing and deploying an effectivelocal area network that will provide users with high performance calls for careful planning. It is critical to run a simulation to reveal thenetwork's performance before acquiring and deploying the necessary hardware. This will provide insight on how the network will perform in real life.

Riverbed simulation software can be employed to simulate networks using a variety of devices, including routers, switches, servers, links, and workstations. Users can also modify the network's parameters to examine the performance of the network as a function of changes in bandwidth, utilization, latency, and other factors.

This workaimed at designing a network with different number of users, hosts, and services usingthe local area network (LAN) model.

II. RELATED WORKS

A simulation analysis of the Zigbee standard was conducted using the Riverbed academic edition 7.5 for star, tree, and mesh topologies using 3, 5,10,15,20,25,30,35 and 40 nodes. The performance of the network was observed for parameters like throughput, end to end delay (ETD), and number of hops. Forthe 40 nodes network, the ETD was 0.98 seconds for star topology while it was 0.1 seconds for the tree and mesh topologies. Throughput for the 40 nodes network was observed to be very high (75000bits/sec) for the mesh topology as against those of star and tree topologies. Results show that the mesh topology provides better network performance in terms of ETD and throughput while tree topology is more suited fora scenario of increased nodes as it provides greater number of hops [1].

The performance of IPv6 network for real time applications was evaluated using IS-ISv6 routing protocol on Riverbed. End to End delay (ETD), packet delays for voice and video applications, IPv6 traffic dropped, and jitter in voice were investigated. Results from the work show that whereas throughput of video applications in IPv6 network is enhanced by the IS-ISv6 routing protocol, less end to end delay and packet variations can be used to achieved average performance for voice application.In summary, IS-ISv6 routing protocol can be efficiently implemented to achieve high performance in real time application networks[2].

A performance analysis of different network topologies supported by IEEE802.15.4/ZigBee standard was conducted using Riverbed modeler simulation. Comparisons were made based on throughput, sent and received data traffics. Different topologies of Wireless Personal Area Network (WPAN) such as cluster-tree, mesh and star topologies with single coordinator wereused.Results from the research show that for EEE802.15.4/Zigbee standard, the cluster tree topology provides greater efficiency when compared with the mesh and star topologies[3].

OPNET 14.5 Modeler was employed to perform an evaluation and enhancement of VLAN using wireless networks. Web browsing applications and file transfer in heavy traffic were used to investigate delay and average throughput. Simulation results show that while using VLAN through wireless network improves network performance by reducing traffic hence minimizing delay, network throughput is reduced by VLAN implementation as the transmitted and received traffic is related positively with the throughput [4].

“A Performance evaluation of campus network involving VLAN and broadband multimedia wireless networks using OPNET modeler was carried out by simulating a campus network involving wired and wireless environments with and without virtual local area network (VLAN) technology.Four scenarios involving heavy-loaded File transfer protocol (FTP) and web browsing applications with two logical groups of users were investigated. Results from the simulation show that VLAN outperforms LAN networks in terms of bandwidth and security, which was achieved by reducing the throughput in both sending and receiving levels to the confidential servers and also reducing the broadcast domain thereby achieving greater power efficiency. With regards to file and packet transfer, VLAN showed lower delay and increased throughput over LAN providing advantages in terms of installation flexibility and configuration speed”[5].

“The performance of WLAN in enterprise wireless area network (WAN) was estimated using OPNET modeler. Three scenarios were considered, which are the FDDI scenario, the FDDI Hybrid

Star scenario, and the FDDI hybrid ring scenario using web browsing (HTTP) and file transferprotocol (FTP). For all the scenarios, both the hardware objects and software configurations were kept the same. Different types of links and topologies were applied among WLAN subnets while the gateway was changed to measure quality of services (QoS) parameters for the different scenarios investigated. Findings from the study reveal that in terms of WLAN delay, WLAN load, FTP download response time, as well as HTTP object response time, the FDDI hybrid ring scenario produces better performance than the FDDI Hybrid Star Scenario"[6].

"Effort geared towards helping researchers use OPNET as a tool for network research and development was made and simulation was also performed with Riverbed Modeler for the design of a network topology and configuration of OSPF routing protocol to investigate how much time it takes for the routers in the network to reach convergence with and without configuring areas in OSPF routing protocol"[7].

"Focus was on four different routing protocols and their functionality in MANET with the analysis to be observed on Optimized Link State Routing Protocol (OLSR) in Proactive RoutingProtocol (PRP), Dynamic Source Routing (DSR) and Ad Hoc On-Demand Distance Vector (AODV)in Reactive Routing Protocol (RRP), and Gathering based Routing Protocol (GRP) in Hybrid Routing Protocol (HRP) which are worn for efficient routing. Using Riverbed modeler, the efficiency of the routing protocols were assessed based on routing overhead(ROH), end to end delay (E2E delay), routing traffic sent (RTS), routing traffic received (RTR), network load, data dropped, throughput, retransmission attempts, and media access delay (MA delay)"[8].

"An assessment of the Performance of LAN, MAN, WAN, and WLAN Topologies for VoIP Services Using OPNET Modeler was executed. Using Riverbed modeler academic version 17.5 to evaluate voice quality in VoIP experiments, these different scenarios were studied by simulating a VoIP network and its performance was studied and analyzed under the different scenarios. This is to guide researchers and designers to design and deploy a network for VoIP services and also guide network operators to choose speech compression techniques that will provide better voice quality"[9].

"Performance analysis of wireless sensor networks for nuclear medicine applications was carried out by investigating the performance of IEEE802.15.4 Zigbee based WSN using OPNET Modeler. To check for network coverage, the star, tree, and mesh topologies were used for the study, with the introduction of a reliable integrated remote sensing solution based on Zigbee technology for nuclear medicine practices. Results from the simulation were based on Quality of Service (QOS) parameters such as; end to end delay (ETD), throughput, load, as indicators of network performance to serve as guide for selecting the most suitable combination out of the proposed network architectures. From the simulation results, network performance for end to end delay and routing overhead were degraded by fading. While star topology is best for small networks, mesh topology is best suited for networks that have fixed and mobile nodes in large numbers. Furthermore, the research established that for the purpose of nuclear medicine monitoring, WSNs provides a more realistic practical solution”[10].

Virtual local area network in a wireless network with three ad hoc routing protocols in a number of different scenarios was investigated using the Riverbed Modeler simulation. Results show that adopting VLAN technology could reduce delay and data of the network and considerably lower throughput. Routing methods with VLAN were tested across the WLAN to obtain the best throughput gain performance. The findings also revealed that these ad hoc routing protocols improved the Wireless Sensor Network performance as an additional investigation for the improvement of any network’s delay and throughput [11].

A network prioritization framework for enabling smart environments to determine an appropriate WLAN standard or a combination of standards that best supports a specific set of smart network applications in a specified environment was presented. Furthermore, a number of IEEE 802.11 technologies was ranked by using the proposed network optimization technique with separate case studies for the circular, random, and uniform geographical distributions of smart services. The performance of the proposed framework is validated using a realistic smart environment simulation setting, considering both real-time and best-effort services as case studies with a range of metrics related to smart environments [12].

Simulation modelingwas used to analyze structured network geometries and evaluate their network performance by Riverbed Modeler. Simulation results show that the cross polytope (CP) and triangular pyramid (TP) topologies have better results than the unstructured network in response time and network delay under a high-load configuration. Also, the plane CP structure exhibits superior performance compared to the other three network designs examined [13]

Using OPNET simulation to highlight the impact of link capacity on network performance, it was revealed that higher capacities links led to lower HTTP response times while lower capacity links struggled with simultaneous traffic leading to delayed responses. In terms of QoS, FIFO exhibited the highest data traffic drop, followed by Priority Queuing (PQ), while Weighted Fair Queuing (WFQ) boasted the lowest drop rate. Furthermore, LAN delay increased as user volume accessing the network within the LAN segment grew. WFQ proved most effective in receiving video traffic, followed by First in First Out (FIFO) and PQ. Finally, PQ demonstrated superior handling of Voice Traffic [14].

A simulation model (using OMNET++) was developed and the quality-of-service parameters, such as end-to-end delay, throughput, and packet loss for various network scenarios and configurations was measured. Simulation results show that increasing wireless video clients in the subnets have significant system performance drawbacks (i.e., reduce throughputs up to 93% and increase end-to-end delays up to 99%) [15].

III. METHOD

For the purpose of this study, the following were used in the design of the network:

1. Local area network (LAN) with ten (10) workstations connected via the 10baseT link as shown in figure 1(a).
2. One (1) subnet with three (3) servers connected to 16-port Ethernet switch through the 10baseT link. Three servers were designated as: web server (that supports Web-browsing, e-mail, and Telnet services), a FTP server (that supports FTP and file print services), and a database server (that supports database access) as shown in figure 1(b).
3. Four (4) subnets with 16-port Ethernet switches, dedicated to Research, Engineering, E-Commerce, and Sales applications as shown in figure 1(b).

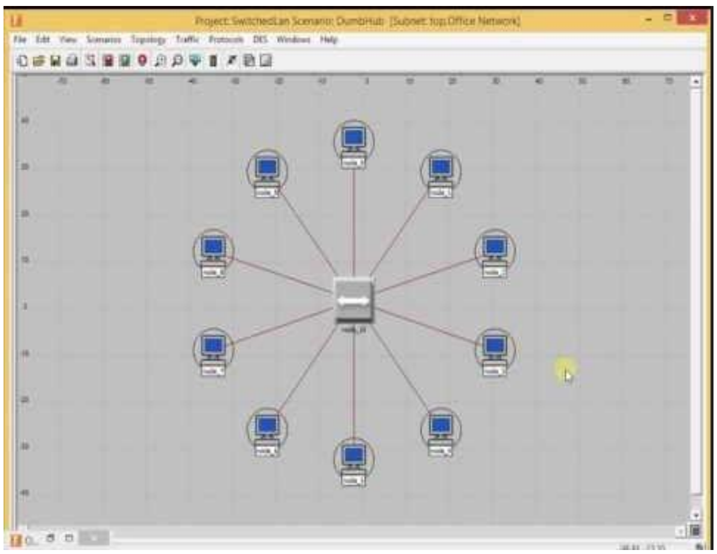

Fig. 1(a): The Network Layout

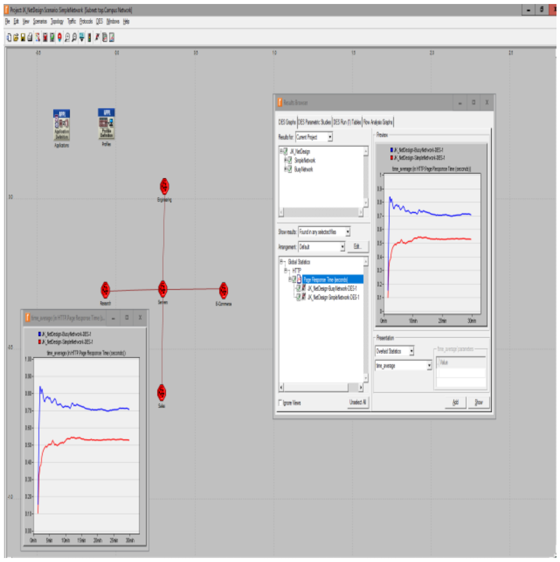

Fig. 1(b): Layout showing the Subnets

IV. RESULTS and Discussion

SCENARIO 1: The result obtained regarding the HTTP page response time was analysed. Four other statistics were collected and the simulation of the **Simple** and the **Busy** network scenarios were rerun. The graphs that compare the collected statisticswere plotted.

RESULT: When the background utilization of the network was increased to 99% of the page response time of HTTP request, the database query response time, email download time, FTP get download time, remote server access time all increased as shown in figures 2, 3, 4, 5, and 6.

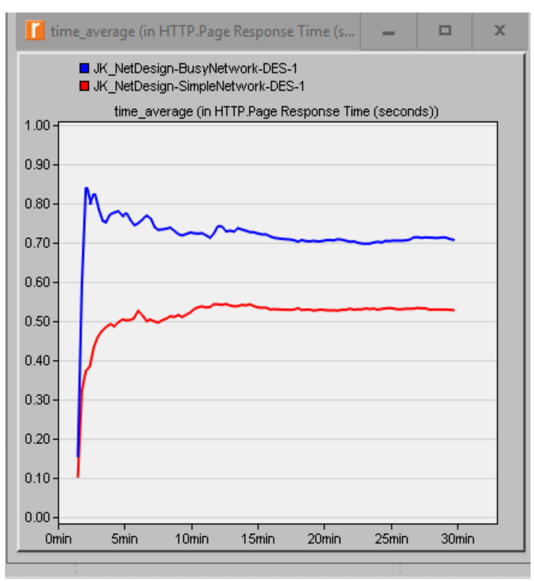

Fig. 2: Time Average comparing the HTTPpage response time for the two networks i.e. BusyNetwork and SimpleNetwork.

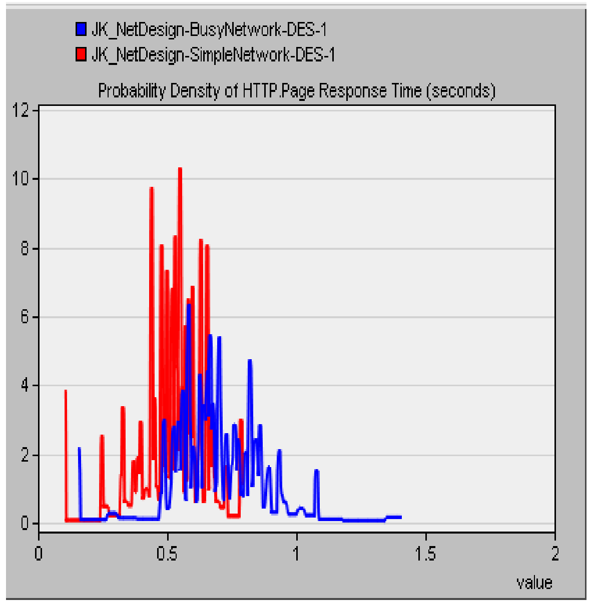

Fig. 3: Probability Density of HTTP page response time (sec) comparing the HTTP page response time for the two networks i.e. BusyNetwork and SimpleNetwork.

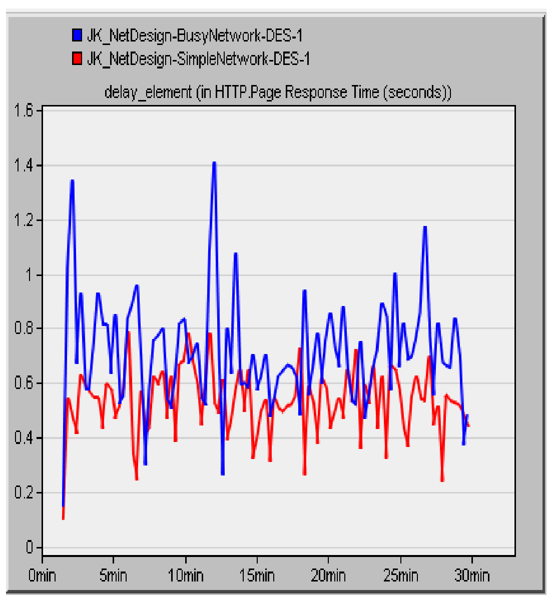

Fig. 4: Delay Element of HTTP page response time (sec) comparing the HTTPpage response time for the two networks i.e. BusyNetwork and SimpleNetwork.

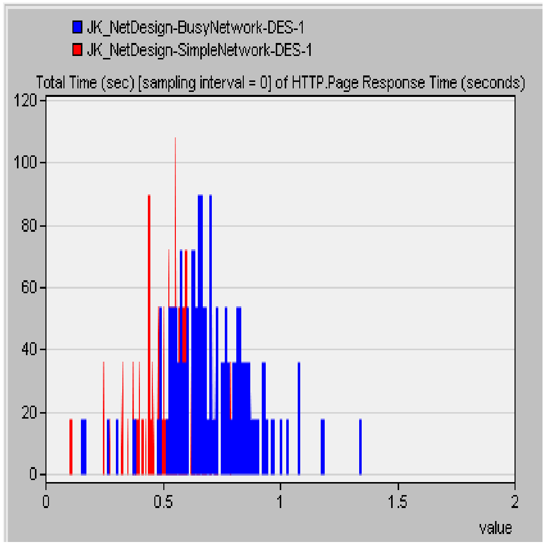

Fig. 5: Total Time (sec) (Sampling interval=0) of HTTP page response time (sec) comparing the HTTP page response time for the two networks i.e. BusyNetwork and SimpleNetwork.

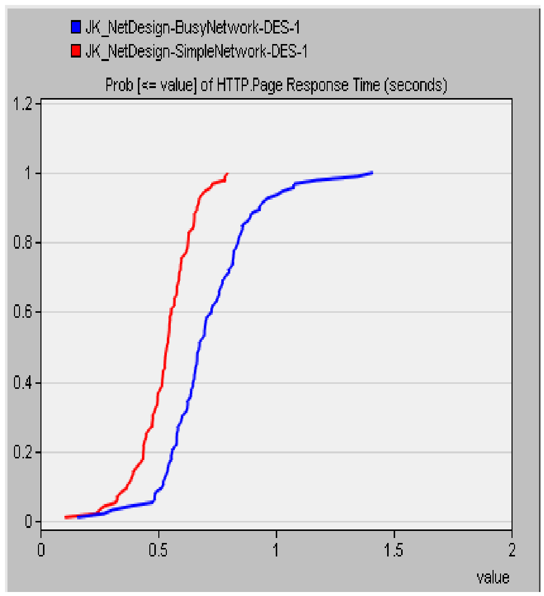

Fig. 6: Prob (<= value) of HTTP page response time (sec) comparing the HTTP page response time for the two networks i.e. BusyNetwork and SimpleNetwork.

SCENARIO 2: In the BusyNetwork scenario, the percentage utilization of the CPUs in the servers was studied.

RESULT: It was observed that the Web server has the highest CPU utilization. This is because while the other servers handle lesser services like file transfer and printing, the Web server processes much more requests coming in from other services, like E-mail, Telnet, and Web browsing. This is shown in figures 7 and 8.

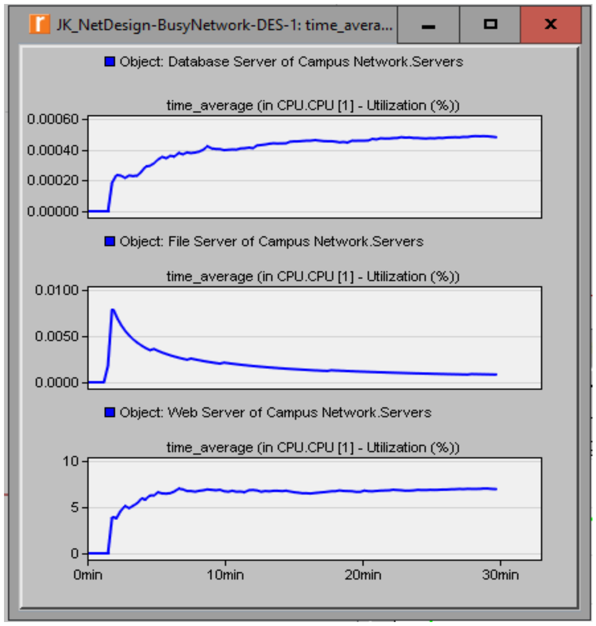

Fig 7: comparing the percentage CPU utilization for the three servers i.e. Database Server, File server, Object server, and Web Server.

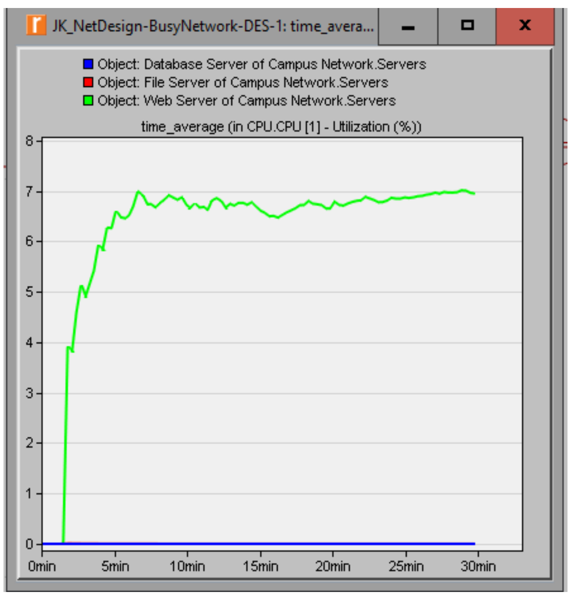

Fig 8: comparing the percentage CPU utilization for the three servers i.e. Database Server, File server, Object server, and Web Server.

SCENARIO 3: A new scenario was created as a duplicate of the BusyNetwork scenario and was namedscenario Q3_OneServer. In this new scenario, the three servers were replaced with only one server that supports allrequired services. The utilization (%) of the server's CPU in this scenario was studied and this was compared with that of the three CPU utilizations obtained previously.

RESULT: Simulation results show that when the three servers are replaced with only one server that supports all the required services, the CPU utilization becomes almost same as that for one server i.e. the Web server. This is because the services responsible for the higher utilization are Web browsing and e-mail. FTP, file print, and database access requests does not have much impact on the percentage of CPU utilization. This is shown in figure 9 below.

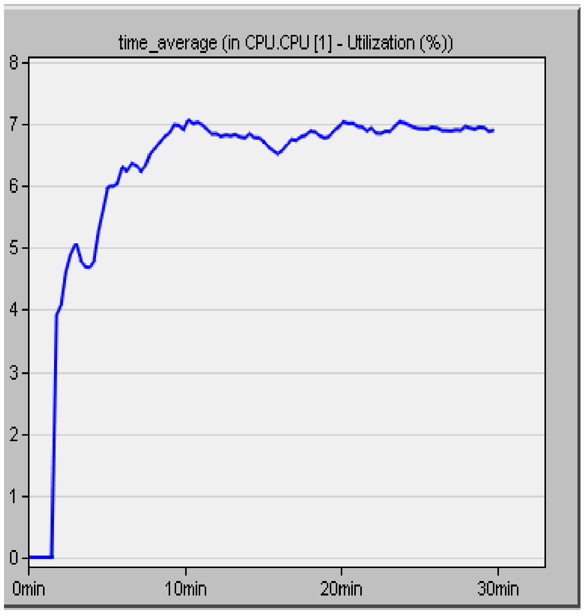

Fig 9: Showing the percentage CPU utilization for one server that is used to replace the initial three servers.

SCENARIO4:A new scenario was created as a duplicate of the BusyNetwork scenario and this new scenario was named scenario Q4_FasterNetwork. In the Q4_FasterNetworkscenario, all the 100BaseT links in the network were replaced with 10Gbps Ethernet links and all the 10BaseT links were equally replaced with 100BaseT links. This is to study the impact of increasing the bandwidth of the links on the performance of the network using the new scenario (e.g., comparing the HTTP page response time in the new scenario with that previously observed in the BusyNetwork).

RESULT: The faster network has higher bandwidth as compared to the busy network. This is because the faster network uses cable which has a higher transmission rate. Even though both networks have the same utilization (99%), the page response time of HTTP is lower in the FasterNetwork due to the higher bandwidth thereby making it much faster to process request and do things like downloads and browsing of the net. This is shown in figure 10 below.

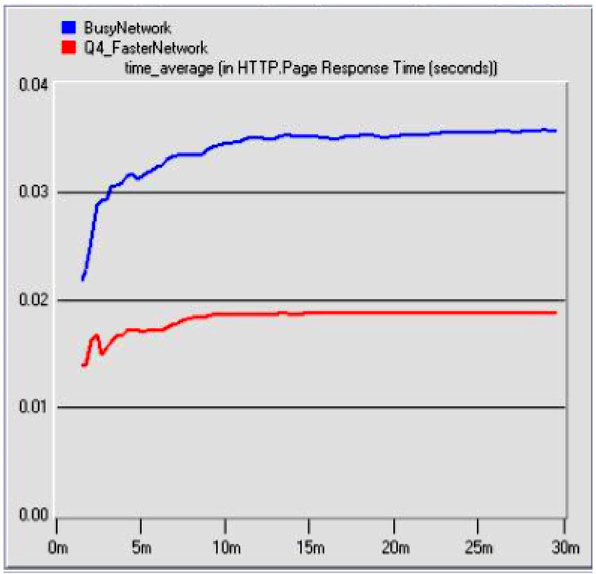

Fig 10: Q4 FasterNetwork. The graph shows how an increase in link bandwidth impacts on network performance

A summary of the simulation results from the four scenarios is shown below.

TABLE 1. SUMMARY OF THE SIMULATION RESULTS FOR THE FOUR SCENARIOS

SCENARIO	ACTION	RESULT
1	1. LAN with ten (10) workstations were used, connected with 10BaseT link. 2. One (1) subnet with three (3) servers connected to 16-port Ethernet switch through the 10baseT link..3. Four (4) subnets with 16-port Ethernet switches, dedicated to Research, Engineering, E-Commerce, and Sales applications.	Increase in background utilization of the network to 99% increased the page response time of HTTP request, database query response time, email download time, FTP get download time,and remote server access time.
2	BusyNetwork scenario. The percentage utilization of the CPUs in the servers was studied.	Web server has highest CPU utilization. Web server processes much more requests coming from other services, like E-mail, Telnet, and Web browsing. Other servers handle lesser services like file transfer and printing.
3	BusyNetwork scenario was duplicated and was named scenario Q3_OneServer. The three servers were replaced with only one server that supports all required services. The utilization (%) of the server's CPU in this scenario was studied and compared with that of the three	With the three servers, the CPU utilization is almost same as that for one server i.e. the Web server.
4	BusyNetwork scenario was duplicated and named scenario Q4_FasterNetwork. All 100BaseT links were replaced with 10Gbps Ethernet links and all 10BaseT links were equally replaced with 100BaseT links.	The faster network has higher bandwidth as compared to the busy network. . Even though both networks have the same utilization (99%), the page response time of HTTP is lower in the FasterNetwork.

V. CONCLUSION

This work demonstrates that during network design, selection and distribution of the various services to be handled by either a single server or multiple servers are critical factors that should be taken into consideration. These factors greatly affect the CPU utilization and overall performance of the network. There should be a balance between those services that are frequently utilized and those that are not frequently utilized. Once this balance is achieved, there will be no need to deploy more than one server to support different services within the same network. If this is achieved, it will lead to reduction in capital expenditure and give the network or business owner a competitive advantage.Using Riverbed simulation and varying several network parameters for four different scenarios provided insight into how variations in different parameters impacts on network performance. From evidence derived from the simulation, using a single server for non-frequently utilized servicesin place of multiple servers is cost effective approach as it does not impede on network performance, provided the network link and background utilization is such that guarantees reasonable response times for the server. However, further research should be conducted to investigate how other network parameters other than link type, number of servers, and network background utilization affects network performance. This will provide further insight into how different parameters can be concurrently varied in a more more efficient way so as to attain optimum network performance.

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