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Optimization of Computer Network for Efficient Performance

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ABSTRACT

Network centralization is an act that promises enormous paybacks in education, it centralizes data access and replaces many individual systems and unique processes with common management procedures resulting in potentially dramatic improvement in equipment utilization and lower operating costs. It has other benefits among them are: Greater availability, Better and more responsive service level, Flexibility to rapid response to change, Cost effective computing, Better security, Quality education, Organizational efficiency, improved administration. In this paper, OPNET IT Guru Academic Edition modeling software was used to perform capacity planning study. The application was used to predict the impact the application deployed over the network will have on the network resources and the impact the network itself will have on the application performance.

Keywords: *Network Optimization, WAN, OPNET, Computer network.*

1 INTRODUCTION

Network simulation is a method used for network performance analysis. Network simulation software is a valuable tool for networks with complex architectures and topologies. A simulator can provide the programmer with the necessary information on how to control and manage the performance of a computer network (Xinjie, 1999). With the development of the computer technology, simulation plays an important role in analyzing and designing complex systems, such as computer network. Since the development of network simulators they have been use as a tool for network performance, management and prediction.

Optimized Network Engineering Tools (OPNET) is a powerful network simulator. Main purposes are to create networks and optimize cost, performance and availability (Aboelela, 2003).

It enables one to create a virtual network consisting of relevant hardware, protocols, and application software (OPNET Technologies, 2004). This network is a purely software entity that can run on an individual workstation. Routers, switches, web servers – almost anything found in real networks – can be duplicated in an IT Guru virtual network. It can be scaled from just a network of two workstations to one representing tens of thousands running in a WAN. Once a virtual network is created it can be manipulated in various ways – for instance routers can be added or subtracted, protocols switched around or altered, web servers added or discarded – any permutation imaginable. The effects of various alterations and diverse configurations can then be usefully and quantifiably examined and analyzed. Importantly IT Guru allows one to study and gather useful statistics about a virtual network built from it.

Many colleges of education in Nigeria currently are using independent networking platform, each of which are incurring direct cost. There are duplicate network management functions across these networks including technical support. A centralized enterprise solution can ensure a more efficient use of network resources.

Okeke (2007) defines network centralization as the act of centralizing network infrastructure and activities in order to improve services and reduce operational cost. Network centralization is an act that promises enormous paybacks in education, it centralizes data access and replaces many individual systems and unique processes with common management procedures resulting in potentially dramatic improvement in equipment utilization and lower operating costs.

In this work a Wide Area Network (WAN) was created to connect all the Federal Colleges of Education in Nigeria. The network was simulated using OPNET IT GURU to link and that it will be able to handle the loads on the network and to also ensure that the total delay across the network is acceptable.

2 NETWORK OPTIMIZATION

Optimization traditionally has a strict mathematical characterization and there are fundamentally four major types of optimization related problem in a networked systems. They are as follows:

1) Structural Optimization: Finds a graph $G(V, E)$ where V is the set of nodes and $E$is the set of edges that extremize a given structural function $F[G]$.
2) Dynamics Optimization on Static Graphs: for a graph $G(V, E)$ and dynamic system on ϕ on G,
   $\phi(x, x \ldots \{\alpha\}, t) = 0$ (1)
   The equation finds the values of the parameters $\{\alpha\}$ that extremize a global functional $F[\Phi]$ of the dynamics Φ. The variables **x** are quantities associated with properties of the nodes and edges in the network..
3) Structural Optimization for Dynamics: Given the dynamical system as in equation (1) and a set of parameters $\{\alpha\}$, this finds a graph $G(V, E)$ for which a global functional $F[\Phi]$ of the dynamics Φ is extremized.
4) Dynamics Driven Network Optimization: If the graph of the network evolves in time $[i.e\ G(V, E) = G(V, E, t)]$, either through an independent dynamics or through coupling to the dynamics in (1). find the values of the parameters $\{\alpha\}$ for which a global functional $F[G, \Phi]$ of the dynamics Φ *and* of the graph $G(V, E, t)$ is extremized.

The first type is purely a graph theoretical problem in that it looks for structures that have some specified properties. For example, given a fixed number sequence on *N* nodes, one can construct a graph that minimizes the diameter. Problems involving optimal assignment of edge-weights and –directionality also belong to this class.

The second type is a “flow extremization” problem. For example, given a roadway network, what should be the speed limit for cars on every street such that jamming is minimized? The type three commonly occurs in design problems: given a flow dynamics, such as packet flow in packet switched networks, find the graph structures optimal for information throughput. Other important examples include the optimization of synchronous and coherent behavior.

The fourth type is also common, though sometimes very difficult to solve because properties of both graph structure and dynamics are allowed to change. This is also the most relevant case to the study of emergent properties in evolving systems.

3 RELATED WORKS

This brings together contributions on network structure and dynamics, with emphasis on optimization problems and their applications to infrastructure.

Danila et al (2007) in their work considered routing optimization in network transport, Dobson et al(2007) discussed how competition between efficiency and robustness leads to a SOC-based model for the power-grid dynamics, Guclu et al (2007) study how fluctuations and synchrony in distributed processing networks relate to the network structure, Gulbahce (2007) addresses the optimization of jamming on gradient networks, while Teuscher (2007) analyzes the impact of performance metrics in network-on-chip designs.

This shows that the optimization of performance and robustness is a common property of most computer network systems and is a desirable property in most man-made systems. There is now increasing evidence that the proper functioning of complex computer network systems lies in the properties of underlying complex networks. This evidence has generated increasing interest on dynamical processes in complex networks and on how the interplay between these processes and network structure influences the performance and robustness of the system.

4 NETWORK ANALYSIS

Many types of networks exist, but the most common types are Local Area Networks (LANs) and wide Area Network (WANs). In LAN, computers are connected together within a local area (for example, an office or home). In WAN, computers are farther apart and are connected via telephone/communication lines, radio waves or other means of connection.

Networks are usually classified using three properties: Topology, Protocol and Architecture. Topology specifies the geometric arrangement of the network. Common topologies are a bus, ring, and star. Many WANs use a star topology (the branches are connected to the head office producing a traditional star topology. The start and end points are sometimes cross connected to create a mesh or partial mesh topology. This provide for many possible combinations for interconnection. When designing a WAN, a topology that meets the design requirements must be selected. In a layout, there are several factors to consider. More links will increase the cost of the network services, and having multiple paths between destinations increases reliability. Adding more network devices to the data path will increase latency and decrease reliability.

Protocol specifies a common set of rules and signals the computer on the network use to communicate. Most network use Ethernet, but some networks may use IBM's token ring protocol. For this work we are to use Ethernet. Ethernet is a contention media access method that allows all hosts on a network to share the same bandwidth of a link. Ethernet is popular because it's readily scalable, meaning that it is comparatively easy to integrate new technologies, such as fast Ethernet, gigabit Ethernet into an existing network infrastructure. It's also relatively simple to implement in the first place and with it, troubleshooting is reasonably straight forward.

Architecture refers to one of the two major types of network architecture: peer-to-peer or client/server. In peer-to-peer networking configure-tion, there is no server, and computers simply connect with each other in a workgroup to share files, printers and internet access. This is most commonly found in home configurations, and is only practical for workgroups of a dozen or less computers. In client/server network, there is usually a NT Domain controller, which all the computers log on to. This can provide various services, including centrally routed internet access, mail (including e-mail) file sharing, printer access, as well as ensuring security across the network. This is most commonly found in corporate configuration where network security is essential. In this work the client/server architecture is chosen, thus all the Federal Colleges of Education are centrally connected to the NCCE head office in Kaduna to share resources including internet access. The topology to be used for this work is star topology as shown in figure 1.

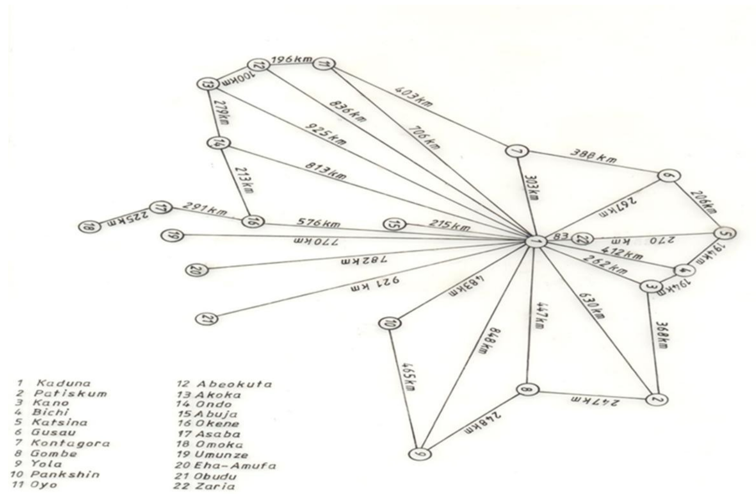

Fig. 1. The Geographic representation of the proposed Network based on distance

Table 1: Default EIGRP Values for Bandwidth and Delay (Bruno and Kim, 2004)

Media Type	**Delay**	**Bandwidth**
Satellite	5120 (2 secs)	5120 (500Mbps)
Ethernet	26600 (1 ms)	256,000 (10 Mbps)
T1 (1.544 Mbps)	512,000 (20 ms)	1,657,856
64 Kbps	512,000 ,,	40,000,000
56 Kbps	512,000 ,,	45,714,176

Source: Todd(2005:35)

Users of interactive applications expect minimal delay in receiving feedback from the network. In addition, users of multimedia applications require a minimal variation in the amount of delay that packets experience. Delay must be constant for voice and video applications. Variations in delay, called jitter, cause disruptions in voice quality and jumpiness in video streams.

4.1 Things to be considered while Chosen a WAN, they include

- Availability: Is the technology available in the area?
- Bandwidth: How much do we need, and how much do we get for that type of WAN connection?
- Cost: Is there a cheaper connection type that still takes into account future growth?

- Ease of management: Is the initial configuration as well as normal operation easy or difficult to maintain?
- Quality of Service (QoS): How critical is the actual data itself, and is there a way to ensure low or no data loss with this WAN type?
- Security: What measures need to be in place to provide security of company data, while still allowing users and customers to access the data they need?
- Reliability: Is the WAN link a critical link, and do we need an additional link in the event of failure?
- Application traffic: What is the primary type of data being sent across the WAN, and can this WAN handle that type?

5 METHODOLOGY

To build a network model using the OPNET, the work flow centres on the project editor. This is used to create network models, collect statistics directly from each network object or from the network as a whole, execute a simulation and view results.

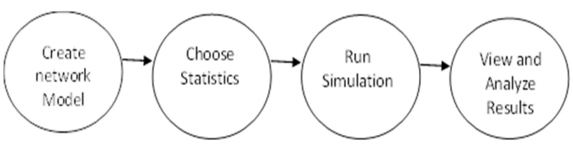

Fig. 2. Workflow diagram

5.1 Wan Creation

OPNET IT Guru was use to generate 30 workstations linked in star shape to a Switch as shown in figure 3. This subnet was use to replicate the other subnets that represents the different Colleges of Education being modeled. The modeled 30 workstations which represent the LANs were connected to a router.

The profiles and applications that will be used by the LANs (i.e. the traffic to be carried by the network) were defined. The created profile was applied to the network. This profile supports E-mail, Database, Browsing and File sharing application. The LAN will send traffic that models these applications.

Bichi subnet was created. Because the subnets are identical, the Bichi subnet was copied and placed appropriately.

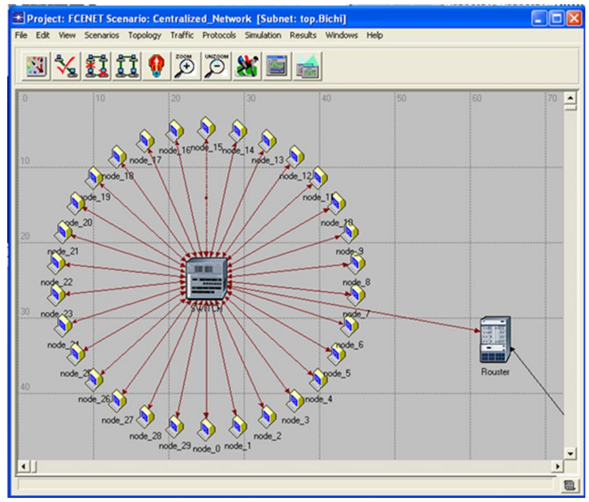

Fig. 3. Bichi LAN connected to a router.

The subnets were connected to the NCCE Head office using three different approaches:

- Layered approach with single point connection to the internet
- Interconnection through the internet
- Virtual Private Network

The first network was created using a link downloading at 1.544Mbps to connect all the twenty Federal Colleges of Education hierarchically using the geographic zones.

The second network was created using a link downloading at 1.544Mbps to connect the Colleges through the internet.

The third network was designed using a Virtual Private Network (VPN) with a link downloading at T1 (1.544Mbps) speed. The networks for the three different approaches are as shown in the figures below.

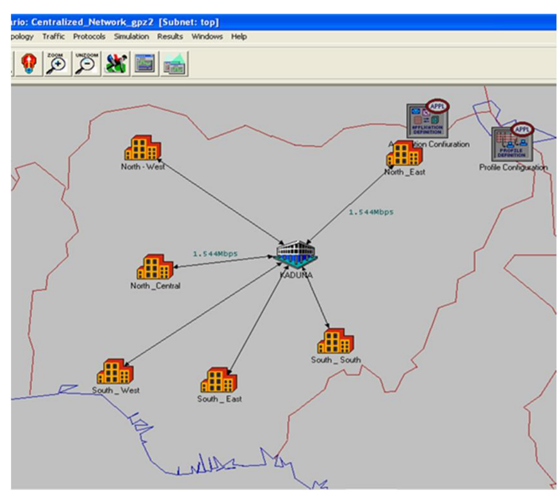

Fig. 4A. layered Approach with single point Connection to the Internet

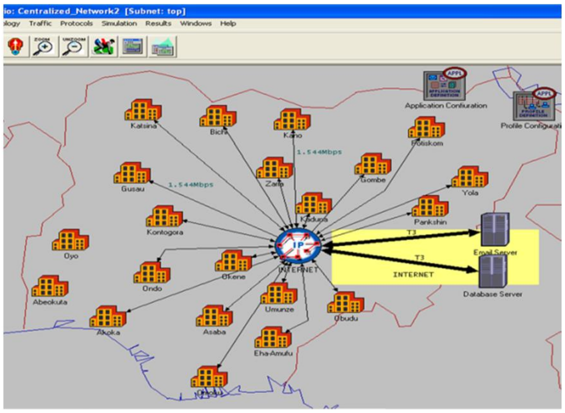

Fig. 4B. Interconnections through the Internet using 1.544Mbps link

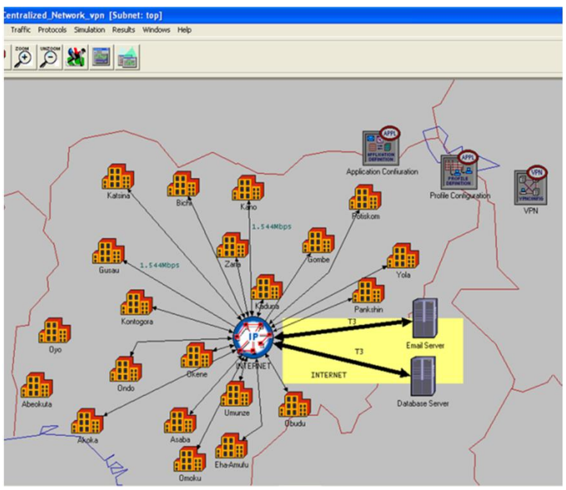

Fig. 5. Interconnections Using Virtual Private Network (VPN)

5.2 Collecting Statistics

After network Creation Statistics were collected to in order to evaluate the network performances. Global statistics can be used to gather information about the network as a whole in order to find out the delay for the entire network. This was the statistic used to evaluate the three networks. The global network delay for the three scenarios is as shown in figure 6.

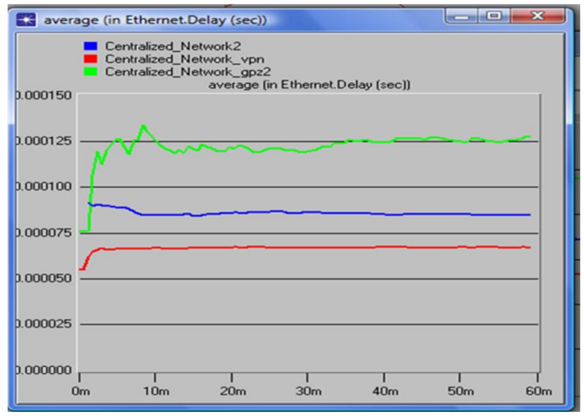

Fig. 6. Global Network Delay for the Three Scenarios

The Global Network Delay with the interconnection via the Virtual Private Network is the lowest. The delays experienced is in the range of 0.00006 to 0.000150 seconds (0.075 – 0.15 milliseconds), which is Ok according to the internationally accepted bench mark for network delay. This equally shows that the Network is not actually overloaded. This type of connection is secured and faster because traffic is still carried through the internet, thus, it can be said to be the best connection.

6 CONCLUSION

Education quality will be enhanced through the interconnection and savings could be realized also. The emphasis throughout this work is an effort to address the issue of independent LANs being operated by the various Federal Colleges of Education.

A complex network design can be financial drain and a resource drain on an organization. It is necessary to demonstrate that the design meets the project requirements. This work has provided this “trial run” with the capability to demonstrate almost all the functionality of the network, resulting in a prototype. Thus, it has proved that the design works.

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