Global Journal of Computer Science and Technology: E
Network, Web & Security
Volume 17 Issue 3 Version 1.0 Year 2017
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Hybrid Topology Design for Improving Network Performance

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Keywords: hybrid topology, network simulation, statistical analysis, performance parameters.

GJCST-E Classification: C.2.1, B.4.3

HYBRIDTOPOLOGYDESIGNFORIMPROVINGNETWORKPERFORMANCE

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Hybrid Topology Design for Improving Network Performance

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Abstract- This paper is an extract of research work carried out on the computer network of Plateau State Universities Bokkos, which is located in Plateau State, Nigeria, in the western part of Africa. The existing network topology of the University was surveyed for experience of internet users and topology requirements from technical staff. Confirmed topology or layout of existing network was designed and simulated for performance outputs. This paper present the proposed topology, also referred to as the hybrid topology for improving performance. The performance output of the existing topology will be brought forward and be compared with the performance outputs of the hybrid topology for comparative purpose. In the end, the comparative result will show us if there is improvement from simulation results or not. This would help us to for-see the possibility that our new network would be better when installed.

Keywords: hybrid topology, network simulation, statistical analysis, performance parameters.

I. Introduction

Most performance of computer networks are certainly influenced by the technology, which we adopt in making network interconnections. Network topologies (Banerjee, S. et al, 1999; Cem Erosy and Shivendra PanWar, 1992; C. M. Harris, 2008; D. Bertsekas and R. Gallager, 1992) are the technology for arrangement of various computer elements like links, nodes etc. Basically network topology is the topological structure (Geon Yoon and Dae Hyun Kwan, 2006) of a computer network. In mathematics topology is concerned with the connectedness of objects which is the most basic properties of space. In simple term, network topology refers to the way in which the network of computers (Nicholas F. Maxemchuk and Ram Krishnan, 1993; Bannister, J.A. et al, 1990) is connected. Each topology is suited to specific tasks and has its own advantages and disadvantages. A most simple and good example of network topology is a Local Area Network (LAN) (F. Backes, 1988; Li Chiou Chen, 2004). A situation Where a node has two or more physical links to other devices in the network, a star topology is described. Which is the most commonly adopted topology in most campuses. In recent days there are basically two categories of network topologies: Physical topologies and Logical topologies. Physical Network Topology emphasizes the hardware associated with the system including workstations, remote terminals, servers, and the associated wiring between assets. Conversely, Logical Network Topology emphasizes the representation of data flow between nodes. This can be represented in a graph model. In this paper, we present the proposed physical topology of PSU's network.

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II. Literature Review

The existing network topology of Plateau State University Bokkos (PSU) is being investigated via interview method of survey (Datukun et al, 2016c). this has been a Local Area Network (LAN) within the Campus, also referred to as the Campus Area Network (CAN). However, CAN could interconnect LANs with geographically dispersed users to creat connectivity (Zubbair S. et al, 2012). Network Topology shows the way in which a set nodes are connected to each other by links (Qatawneh Mohammed et al, 2015), which basically is synonymous to CAN. The technology for arrangement of various computer elements like links, nodes etc describes the concept of network topologies. T1 (William, 1998), T3 (Regis, 1992), ATM (Koichi et al., 1997), ISDN (Jonathan, 2004), ADSL (Michel, 2003), frame relay (Jim, 1997), radio links (Trevor, 1999), amongst others, constitutes few of these technologies. Technologies are accompanied with various topologies and model of deployment that best suit the technology.
A network for optimal performance and meeting users' need is key in every campus, which always needs attention. Properly selecting of equipments to be deployed after considering the requirements of the users is necessary (Sood, 2007). The impact of TCP window size on application performance as against the choice of an increased bandwidth can help boost network (Panko, 2008b). the use of redundant links may also increase performance, implement load balancing and utilise links from say 92% to 55% and response time reduced by 59% (Panko, 2008; Seung-Jae, 2008). From a risk and performance point of view, it is desirable to break a larger campus networks into several smaller collapsed modules and connect them with a core layer (Robert, 1998). Distribution modules are interconnected using layer 2 or 3 core (Tony, 2002). In effect, the layer 3 switches at the server side becomes a collapsed backbone for any client to client traffic (Graham, 2010).

A Gigabit Ethernet channel can be used to scale bandwidth between backbone switches without introducing loop (Rich and James, 2008). A truncking capacity is necessarily provided into the backbone of any network design (Jerry and Alan, 2009). Hierarchical design is common in practice, when designing campus or enterprise networks (Saha and Mukherjee, 1999; Sami et al, 2002). There is no need to redesign a whole network each time a module is added or removed, provided a proper layout has being in place. But, PSU require a redesign due to topology flaws, for improving performance (Datukun et al, 2016b). the performance of the existing network was obtained, having analyzed the simulation outputs statistically as presented in Table 1 (Datukun et al, 2016d):

Table1: Values of Performance parameters

University	Parameters	Hop Count	Delay (ms)	Throughput delivered (goodput) (%)	Packets Loss (%)
PSU		103	24.0	71.8	28.1

More so, capability facilitates troubleshooting, problem isolation and network management (Damianos et al., 2002) is necessary in an ideal CAN. In a hierarchical design (Saha et al., 1993), the capacity, features, and functionality of a specific device are optimized for its position in the network and the role that it plays. The number of flows and their associated bandwidth requirements increase as they traverse points of aggregation and move up the hierarchy from access to distribution and to core layer (Awerbuch et al., 2000).

In network analysis, problems related to network mapping, characterization, sampling, inference and process can be adopted (Eric D. Kolazyk, 2009). This has to do with identifying the network components; nodes and routing system, which has to do with the analysis of the path. It could also be mathematical analysis of the network that yields explicit performance expressions (Leonard Kleinrock, 2002). This study is concerned with simulating the existing topology for proposing a better topology requirement for improving network performance.

III. Methods

The methods used for survey were interview and observation, whose questions was presented in my previous paper titled "Towards proposing network topology for Plateau State University Bokkos" with International Journal of Computer Networks and Computer Security (IJCNCS), for existing network, of which this paper is a continuation. The same questions were used to guide the collection of relevant network data by observation and further subjected to objective critism by technical staff mainly.

The paper presented the analyzed results of the survey, graph model, the physical topology, simulation outputs via simulation panel of the existing topology and further present a topology requirement for the proposed design.

In this work, we will present the topology data, the graph model, the physical design and results of statistical analysis of performance via simulation outputs for the proposed topology. The performance of the existing topology titled "Proposing minimum Performance of proposed topology in Plateau State University" published also with IJCNCS, as shown in table 1, will be brought forward to be compared for observation of performance improvement.

IV. Results

Table 2: Links and Weights of proposed Topology

Path	Descriptions	Weight (meters)
R1-S1		70
R1-S3		85
R2-S2		96
R2-S4		75
S1-S5		50
S1-S2		60
S5-S6		50
S2-S7		50
S3-S8		50
S3-S4		60
S8-S9		50
S9-S10		50
S4-S11		50
S11-S12		50
S12-S13		50

In the Table above, for every weighted link, the binary value is 1, otherwise 0. However, the Table does not include un-weighted column

Table 3: Number of nodes and links for the proposed Topology

Number of Nodes	University	Plateau State University (PSU)
Number of nodes		15
Number of links		15

The similarity in the number of nodes and links shows that the topology is not strictly "star" as it is in the existing topology were n nodes=n-1 links. From table 2 and 3, Figure 1 below is presented.

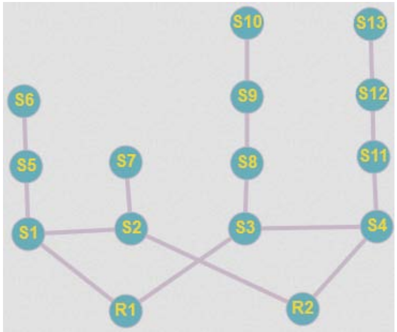

Figure 1: Graph model for PSU network

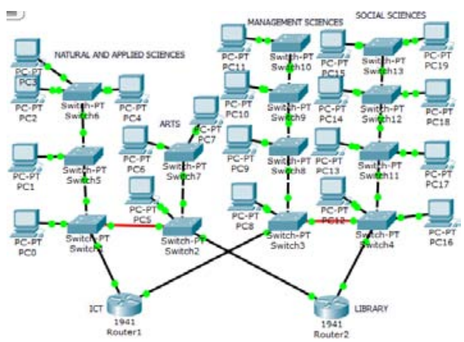

Figure 2: PSU Physical hybrid Topology

Simulation by command prompt

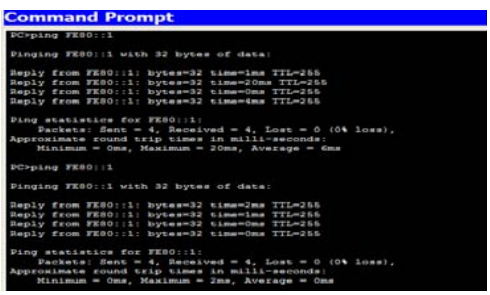

Figure3: PC 3 pings gateway

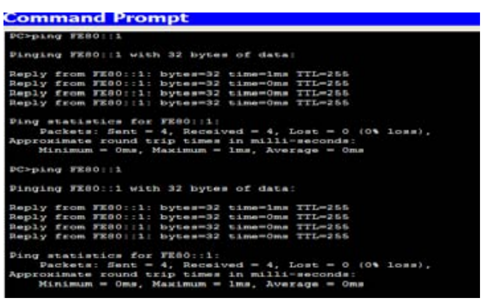

Figure 4: PC 12 Pings gateway

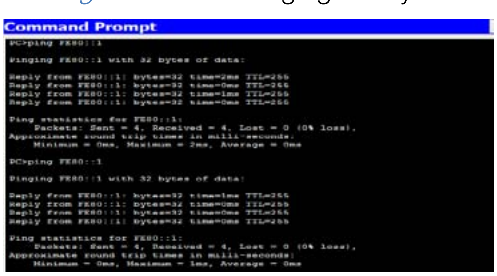

Figure 5: PC 10 pings gateway

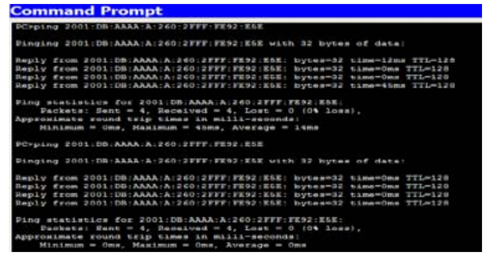

Figure 6: PC 1 pings PC 7

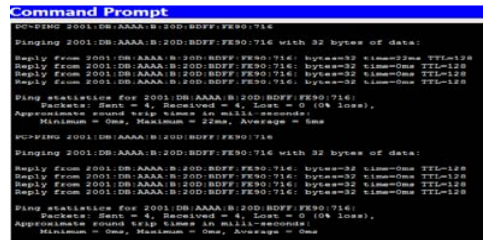

Figure 7: PC 12 pings PC 19

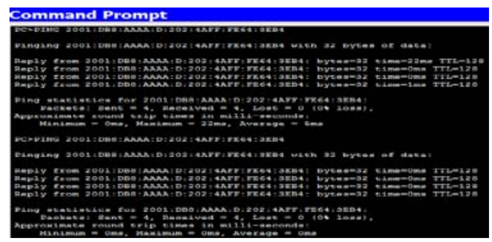

Figure 8: PC 11 pings PC 8

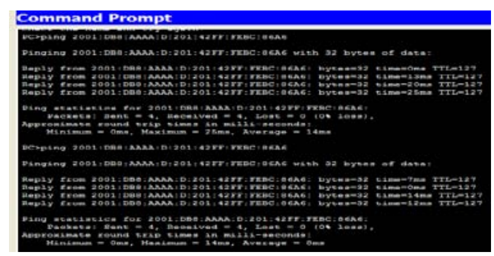

Figure 9: PC6 pings PC 9

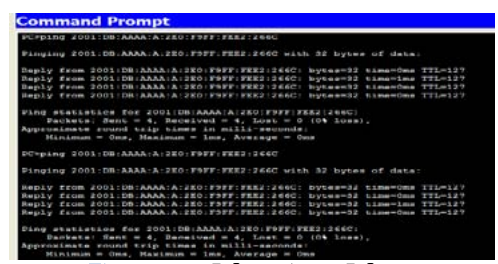

Figure 10: PC 8 pings PC 5

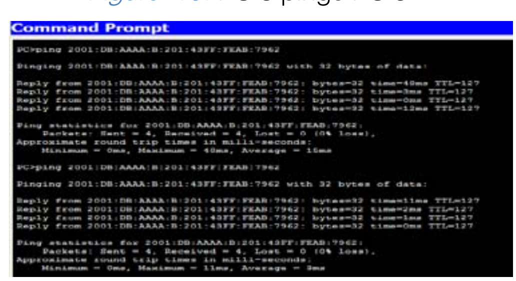

Figure 11: PC 8 pings PC 16

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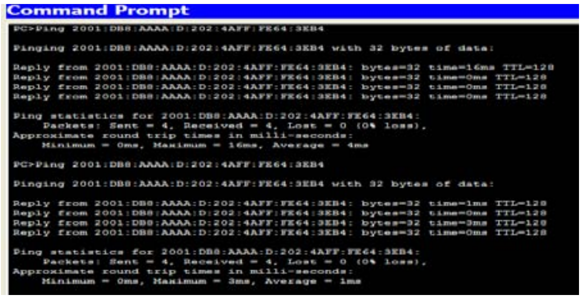

Figure 12: PC 17 pings PC 8

V. Results of Statistical Analysis

We then carry out statistical analysis as of the values obtained from Figures 3-12 as follows.

Table 4: Hybrid PSU- network Hop count

TTL	Hop Count(255-TTL) (h)	Frequency (f)	Cumulative Frequency	Hf
255	0	24	24	0
128	127	32	56	4064
127	128	24	80	3072
Total				7136

Table 4 describes the rate of hop count in the network as simulated. Average hop count $A_h = \frac{7136}{80} = 89$

Table 5: Hybrid PSU-Throughput (Packets Sent)

Packets Sent (s)	Frequency (f)	Cum. Freq.	sf
4	20	20	80
Total			80

Table 5 describes rate of packets sent as the topology is being simulated. Average packets sent $As = \frac{80}{20} = 4$. Total packets sent is 80

Table 6: Hybrid PSU-Goodput (Packets Received)

Packets Received (r)	Frequency (f)	Cum. Freq.	rf
4	20	20	80
Total			

Table 6 describes the rate of packets received (Throughput delivered). We will observe that the total packets sent in table 5 (80) is delivered in table 6 (80). Therefore the packets is 100% delivered in this simulation.

Table 7: Hybrid PSU-Packets Loss

Packets Loss (l)	Frequency (f)	Cum. Freq.	lf
0	20	20	0
Total			0

Table 6 describes the rate of packets lost as confirmed that there was no packets lost as at this simulation. Therefore, we will say that the rate of packets lost is 0% as at this simulation.

Table 8: Hybrid PSU-Transmission delay

Delay (d)(ms)	Frequency (f)	Cum. Freq	df
1	13	13	13
20	2	15	40
0	48	63	0
4	1	64	4
2	3	67	6
12	3	70	36
45	1	71	45
22	2	73	44
13	1	74	13
25	1	75	25
7	1	76	7
14	1	77	14
48	1	78	48
3	2	80	6
11	1	81	11
Total			312

Table 8 describes the rate of delay in this network simulation. Average delay

$$A_d = \frac{312}{81} = 3.85\text{ms}$$

a) Comparing Results of Hybrid Topology with Existing Topologies

Based on the specified parameters; Throuhgput, Delay and Packets Loss, we will in tabula form indicate the differences in each of the simulation results to see if there is improvement or not.

However, we also consider Hop count being a key topology determinant. It also tells how long a packet would stay on a network before it is being dropped, which contributes to the delay tendency.

Table 9: Summary of statistical analysis of Performance topology

University	Parameters	Hop Count	Delay (ms)	Throughput (%)	Packets Loss (%)
PSU		103	24.0	71.8	28.1
PSU (Hybrid)		89	3.85	100	0

VI. Discussions

We will notice that the number of nodes and links are indicated in Tables 2 and 3. For the type of topology, we will see that it is not strictly "star", since the number of nodes is equal to the number of nodes. From observation, it is clearly hybrid; semi-mesh, star and bus. Based on the given fact in tables 2 and 3, the topology was designed and simulated. The main hubs were two; located in the Library (R1) and ICT Centre(R2) connecting the four others (S1, S2, S3 and S4), the four academic faculties, being the central places of academic activities.

Here, we first consider the graph model (Figure 1), which was generated via an online graph generating platform, before subsequent physical design (Figure 2) and simulation. We further collect the values (as shown in Tables 3-8) of simulation outputs (Figures 3-12) and analyze statistically before comparing it with the previous results as shown in Table 9.

VII. Acknowledgment

I thank all the Technical staff in each University under study for being patient so far, providing me with relevant information for this research. I also thank my co-authors for all their contributions in gathering and analyzing the data of this work.

VIII. Conclusion

In conclusion, Plateau State University (PSU) would better implement the presented topology (hybrid), as this would provide the desired improvement of network performance for the Campus. This is because it has smaller hop count and delay time and no packets loss, unlike the existing network. It also has provisions for extensions, taking care of growing clients, given that the chosen main hub locations are of central academic activities and easily extensible to other areas.

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