



Design of an Inter Campus Wide Area Network - Based Exchanged Point for Optimal Routing

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Abstract: Availability of stable internet link in institution of learning has become a thing of concern in developing nations like Nigeria. Exchange Point Network approach were used in this study in designing an Inter- Campus Wide Area Network-Based for Optimal Routing. The internetwork system connected five (5) campuses in Imo State Nigeria which includes Federal University of Technology Owerri, Federal Polytechnic Nekede, Imo state Polytechnic Umugawo, Alvan Ikoku Federal College of Education and Imo State University Owerri. They institutions have challenges ranges from the cost of internet subscription, maintenance of network facilities, electricity challenges amongst others. This work makes use of the internet exchange point (IXP) technology to design and simulate a typical exchange point network for tertiary institution in Imo state Nigeria and to establish the best routing protocols. Five institutions were considered and their networks modeled. Three routing protocols RIP, EIGRP, and OSPF were considered during the simulation and it was established that RIP provided a convergence time that is within 3 and 4 seconds, with slightly varied spikes of not up to 10 seconds. OSPF and EIGRP also tries to maintain a time of between 3 and 4 seconds but is plagued with so much spikes of up to 20 seconds for EIGRP and 17 seconds for OSPF.

Keywords: Network, Internet Exchange Point, Routing Protocol

1. Introduction

Computer Network have become a critical component of organization infrastructure as it provides the platform for easy information flow. Network can be localized or globalized, the internet is a global network while a network that runs within an organization is local [1, 13]. Internetworking is the communication between two or more network of systems, which encompassed every aspect of connecting computers together for the purpose of sharing resources [2, 10]. Internetwork have grown to support vastly desperate end- system communication requirements. An internetwork requires many protocol and features to permit scalability and manageability without constant manual intervention [3, 11].

An Internet exchange point (IXP) is a physical location through which internet infrastructure companies such as Internet service providers (ISP) and contents delivery

network (CDNs) connects with each other. IP routing is the process of moving packets from one network to another network using routers. The essence of IP routing is to create communication between devices and network. It is also used to find updates of routes in the network. [4, 9]. This study discuss in details the Inter-campus Network system (ICNS), IXP and IP routing to determine the best routing protocol for an IXP network of five campuses located in eastern Nigeria.

The use of IXP network has become necessary due the challenges institutions are facing managing their internet links. The challenge of cost of internet subscription, equipment failure and government policies has over the years affected the way internet links are managed in institutions in Nigeria. Having a network that will integrate campuses within same geographical location to share their collected facilities has become an option to consider thus the impulse of this work.

2. Conceptual Overview

With the advent of Internet of Thing (IOT) today, there is need to design networks that support future expansion in a scalable, secure and reliable manner [5, 12]. Designing a network that support the end user’s expectation is not just a simple task because of the nature applications are becoming more immersive and band width intensive [6]. CISCO has defined a hierarchical model know as the hierarchical internetworking model. This model simplified the task of building a reliable, scalable, and less expansive hierarchical internetwork, rather than focusing on packet construction; it focuses on the three functional areas or layers of your network [7].

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Related Works

Several researchers have proposed Inter-campus network system topology models, and routing protocols exchange

point for Inter- Domain topology and route stability. However the summary of the researcher empirical framework, three studies were reviewed, two studies have attempted to explain the importance of exchange point in any network design. One of the studies that were reviewed which gave the researchers a spring board was the plan Design and simulation of university network a case study of Federal University of Technology Owerri FUTO [8]. Some of the weaknesses of the proposed network plan include the fact that the network does not support Voice over IP (VOIP) and video conferencing. The network does not also have any link backup plan when there is a failure of the main link.

3. IXP Campus Wide Network Design Methodology

An prototyping model was used to design the Inter-Campus Network System Exchange Point (ICNS-IXP).

Figure 1 show the steps to be adopted in the design process for the ICNS-IXP.

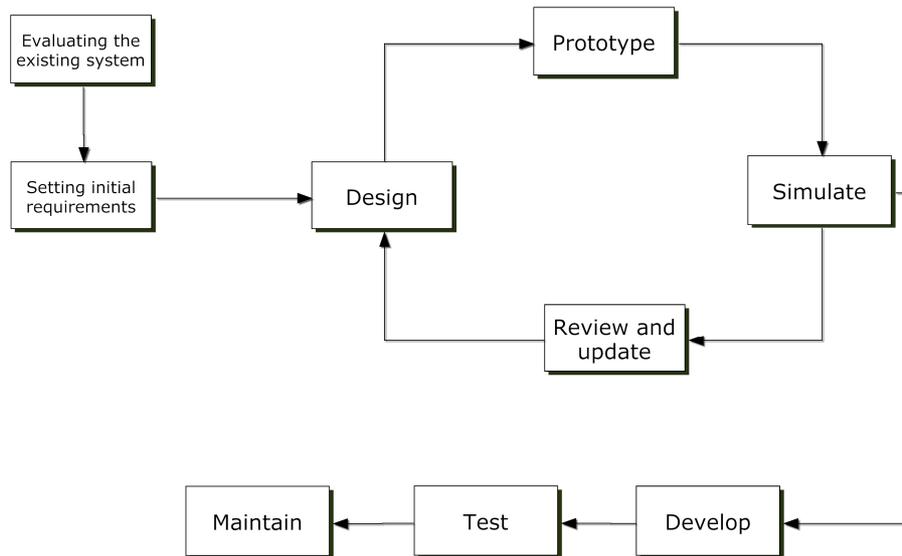


Figure 1. Steps to Design the ICNS-IXP.

4. Operational Test Metric

The existing networks for the five (5) campuses where analysed using selected metrics as shown in table 1. Due to the type of network designs available for each campuse, it is there for necessary to model the network and determine the best protocol fit to use for IXP integration.

Table 1. Summary of network description of the five (5) campuses.

Measurement metric	SCHOOL				
	FUTO	IMOPOLY	FEDPOLY	IMSU	ALVAN
Presence of visible data network	Yes	Yes	Yes	Yes	Yes
Functional subscription	Yes	Yes	Yes	Yes	Yes
Backup link	Yes	No	No	No	No
Bandwidth subscription	5Mbps/ 155Mbps Dedicated	Not disclosed	Not disclosed	Not disclosed	5Mbps Dedicated
Available to student	Partially	Partially	No	Partially	Partially
Management	Internal	Internal	Contracted	Internal	Internal
Media type	Twisted pair/fibre	Twisted pair/fibre	Twisted pair/fibre	Twisted pair/fiber	Fiber

Measurement metric	SCHOOL				
	FUTO	IMOPOLY	FEDPOLY	IMSU	ALVAN
Traffic volume possible	Not defined	Not defined	Not defined	Not defined	Not defined
Equipment vendor	Cisco/Dlink	Cisco/TPlink/Mikrotic	Cisco	Cisco/TPlink	Mikrotic
Link provider	MTN/Airtel/Glo	Microwave	Microwave	MTN/Glo	Airtel
Availability of skilled personnel	Not adequate	Not adequate	Not adequate	Not adequate	Not adequate
Network type		LAN/WAN			LAN/WAN
Network topology	Nil	Nil	Nil	Point-to-point	Hybrid star/point-point
Edge equipment	Regular Router	Regular Router	Cisco switch	Mikrotic router	Airtel microwave
Network provider					Airtel
Network architecture	None	3-layer	3-layer	None	None

All the campuses had a visible data network and subscription at the time of investigation while some do not have any defined network architecture or topology. It was also discovered that, the major challenge these campuses are Network unavailability and inadequate bandwidth for network users.

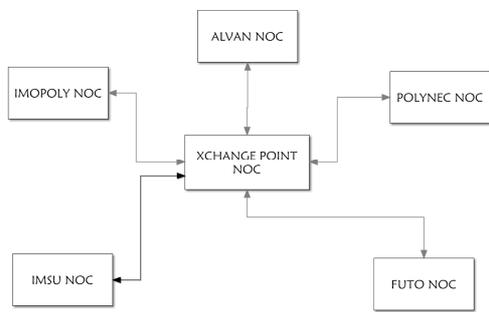


Figure 2. Block diagram of the exchange point network.

5. Network Block Diagram

The ICNs is made up of two basic modules, [1]. The exchange point and the campus unit. The exchange point serves as a connection points for all the campuses subscribed

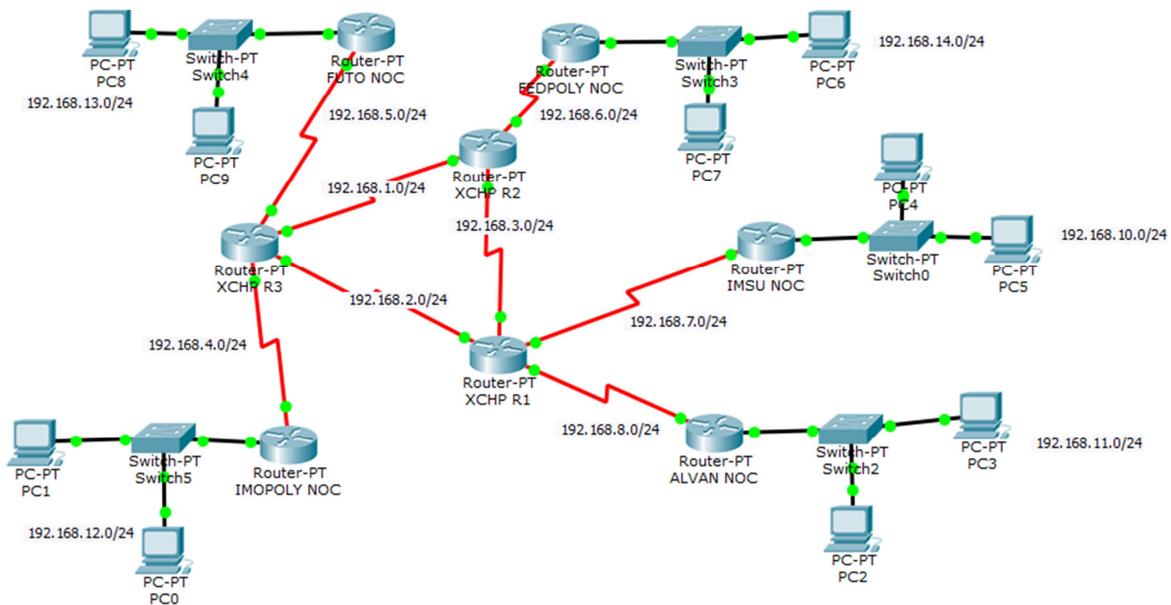


Figure 3. Network Design for Simulation.

Table 2 shows the IP configuration table of the network in figure 3. Private class C address where used between 1 and 14. Each interface of the router was assigned a whole block of IP for easy administration.

to the exchange point service. For this pilot design, the five campuses in Imo state eastern Nigeria is uses (FUTO, IMSU, POLYNEK, IMO POLY, and ALVAN).

Figure 2 is a block diagram showing how the campuses are connected. Each campus network is connected directly to the exchange point.

From the diagram, the exchange point exchange traffic between each campus NOC and allow for these campuses to also exchange traffic between each other via the exchange point NOC.

6. Implementation and Testing of the Evaluation

The network topology is a star-star hybrid topology due to the spatial nature of the locations of the campuses. The campuses are connected using radio devices or physical cables as the case may be. For the purpose of the simulation model, cable (straight and serial) are used. Figure 3 shows the network topology of the design showing edge routers at each location of a campus NOC and three routers at the exchange point for purpose of load balancing and redundancy.

Table 2. IP Configuration Table.

Device	Interface	IP address	CIDR value	Subnet mast
XCHP R3	Se 2/0	192.168.1.1	24	255.255.255.0
XCHP R2	Se 2/0	192.168.1.2	24	255.255.255.0
XCHP R3	Se 3/0	192.168.2.1	24	255.255.255.0
XCHP R1	Se 2/0	192.168.2.2	24	255.255.255.0
XCHP R1	Se 3/0	192.168.3.1	24	255.255.255.0
XCHP R2	Se 3/0	192.168.3.2	24	255.255.255.0
XCHP R3	Se 7/0	192.168.4.1	24	255.255.255.0
IMOPOLY NOC	Se 3/0	192.168.4.2	24	255.255.255.0
XCHP R3	Se 6/0	192.168.5.1	24	255.255.255.0
FUTO NOC	Se 2/0	192.168.5.2	24	255.255.255.0
XCHP R2	Se 6/0	192.168.6.1	24	255.255.255.0
FEDPOLY NOC	Se 2/0	192.168.6.2	24	255.255.255.0
XCHP R1	Se 7/0	192.168.7.1	24	255.255.255.0
IMSU NOC	Se 2/0	192.168.7.2	24	255.255.255.0
XCHP R1	Se 6/0	192.168.8.1	24	255.255.255.0
ALVAN NOC	Se 2/0	192.168.8.2	24	255.255.255.0
IMSU NOC	Fa 0/0	192.168.10.1	24	255.255.255.0
ALVAN NOC	Fa 0/0	192.168.11.1	24	255.255.255.0
IMOPOLY NOC	Fa 0/0	192.168.12.1	24	255.255.255.0
FUTO NOC	Fa 0/0	192.168.13.1	24	255.255.255.0
FEDPOLY NOC	Fa 0/0	192.168.14.1	24	255.255.255.0

Private IP class C was used to configure the network on a default subnet basis. All five campus sub network where assigned blocks of IP ranging from 1-14 on the third octet of the class block. This is clearly shown in table 2.

Table 3 shows the simulation output for TTL.

Table 3. Simulation output of connection for RIP, EIGRP and OSPF.

Simulation time	Time (ms) [@ TTL=24 and PKT=32]		
	RIP	EIGRP	OSPF
6	5	20	3
12	4	3	9
18	3	4	4
24	3	3	5
30	3	3	13
36	3	4	10
42	5	3	3
48	4	3	3
54	3	4	4
60	7	12	3
66	3	3	17
72	3	11	3
78	3	4	3
84	4	17	16
90	3	5	7
96	3	3	5
102	3	10	4
108	3	10	3
114	6	3	11
120	3	3	3

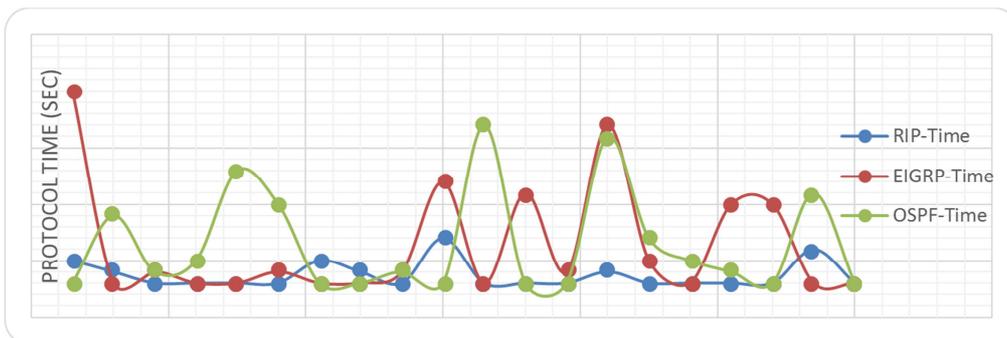


Figure 4. Graph showing the Protocol time for RIP, EIGRP and OSPF.

Form the results gotten from the simulation process, the following can be deduced:

- a. RIP as a routing protocol to be used for the exchange point network provides a convergence time that is within 3 and 4 seconds, with slightly varied spikes of not up to 10 seconds (see figure 4).
- b. OSPF and EIGRP also tries to maintain a time of between 3 and 4 seconds but is plagued with so much spikes of up 20seconds for EIGRP and 17seconds for OSPF.
- c. Form the graph, it can be clearly deduced that with a routing protocol like RIP connections between the campuses via the exchange point will converge faster.

7. Conclusion and Recommendation

From the results gotten it is clear that to get the best out of an inter campus network system connecting campuses with limited number of nodes, RIP is the best bet, with a convergence time ranging mainly between 3 and 4 seconds. Institutions that rely heavily on data communication, internetworks must provide a certain level of reliability. This is an unpredictable world; so many large internetworks include redundancy to allow for communication even when problems occur.

Redundancy provided could be an additional link or a special kind of link as proposed in this work; the internet exchange point. The internet exchange point is a reliable, easy to set up and cost effective redundant link for institutions. The exchange points simply help the various campuses share resources when it is necessary and also balance load as they are funded from the same source in this case the government.

The following are the summary findings from this work:

- a. There is an urgent need for government and institution managers to look into the data need of their schools. Access to the internet is very critical for learning in our research driven world of today.
- b. Since funding the institutions is done by the government, it is very necessary to start galvanizing fund disbursement for internet facility purchase and subscription. Institutions should be able to synergize in the area of internet access.
- c. Campus networks should be designed using proper design standards and their topology properly documented. One of such standards which is also very popular is the 3-layer hierarchical structure.
- d. Network engineers will use the outcome of the routing protocol stimulation result to know the best routing protocol that suit a particular network design. This approach can be applied to any network.
- e. The use of exchange point as a backup link will increase availability of network to the users within the

campuses.

- f. The ICNS-IXP will serve as a guide to institution administrator and government to evaluate the network infrastructure being deployed by contractors in our tertiary learning environment.

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