Available online at http://jurnal.ahmar.id/index.php/asci

Journal of Applied Science, Engineering, Technology, and Education

ISSN 2685-0591 (Online)

Journal of Applied Science, Engineering, Technology, and Education Vol. 1 No. 2 (2019)
https://doi.org/10.35877/454RI.asci12100

Extending Campus Network Via Intranet and IP-Telephony For Better Performance and Service Delivery: Meeting Organizational Goals

Arnold Adimabua Ojugo[a,*], Andrew Okonji Eboka[b]

[a]*Department of Computer Science, Federal University of Petroleum Resources, Effurun 32001, Delta State, Nigeria, ojugo.arnold@fupre.edu.ng*
[b]*Department of Computer Science Edu., Federal College of Education (Technical), Asaba 32001, Delta State, Nigeria, ebokaandrew@gmail.com*

Abstract

The adoption of information and communication technology (ICT) tools and medium in today's business, is geared to advance data processing tasks, timely exchange of data, easy access to Internet at increased speed, extended memory to house large volumes of data and better communications etc. Businesses grow in lieu of advancing the services they offer; But, they require as a matter of urgency, a corresponding need for effective communication to grow exponentially. The Intranet provides an option to advance such via its many feature (not limited to) collaborative communication channel, ease in business processes etc. We posit that many businesses lacks a clear strategy to implement an effective Intranet design. This often leads to investment profit loss, loss of time, unproductivity and complete failure in achieving its set goals. Extending Ojugo and Eboka (2020) via a multi-service intranet, the study outcomes an infrastructure that allows the effective integration of data solutions via an open-source protocol, application, hardware and software. Three common issues observed therein includes: packet loss, jitters, and latency. Jitters and packet loss can be resolved via increased bandwidth allocation; while, latency is minimized via upgrade in the infrastructure. Thus, our proposed solution seeks to provide users with mobility, resilience, economy, flexibility, and productivity with improved service delivery and performance. The study recommends that to harness the full benefits of Intranet and improve communication within businesses and organizations today, there is the need for a constant knowledge update is imperative, which will in turn improve effective communication in the implemented infrastructure.

Keywords: IP telephony; jitters; resilience; redundancy; quality of service, network performance

1. Introduction

Networks have today become effective and efficient means to communicate. Networks have become veritable tools to aid organizational successes irrespective of their area of interest. They have proven successful with the impression they seek to create [1]. A network (or net) is a collection of autonomous devices connected together for the purpose of sharing resources that may include files, audio, voice, video, software/hardware resources [2, 3, 4, 5, 6, 7, 8, 9]. Networks differ in forms and sizes within an organization. They have proven to be very helpful and insightful, giving the organizations and businesses that effectively employ and utilize them, a strategic and competitive advantage along with its range of benefits. With proper articulation of the needs of the various stakeholders in an organization, an

* Corresponding Authors
E-mail address: ojugo.arnold@fupre.edu.ng (Arnold Adimabua Ojugo)

efficient and cost-effective, intelligent, scalable and robust network will be the result of this study. This will in turn yield its secondary deliverable/solutions to other concerns and issues that will be raised therein [9].

1.1. Intra-Nets And Effective Communication

The foundations of a converged network is in its capabilities and tools that allows for user flexibility, cost effectiveness and secure data transfer services (in combination of data, voice and video) packets across the same transmission links via the same switching, routing and gateway platforms. Thus, the converged-network is more secure, more fault tolerable, flexible, scalable, resilient and with easy manageability of resources [10, 11, 12]. For its applications, it employs an intelligent network within that ensures data transfer service quality, availability, reliability and security [13]. With the proliferation of electronic systems on every frontier, access becomes increasingly bothersome to have users tethered with wires. Thus, the need for wireless devices whose merits include: low-cost deployment, broadcast the same data to many locations simultaneously, deployment ease in hostile environ, and mobile communication. However, its demerits includes lesser data rates, lesser reusable frequencies, and they are more susceptibility to interference [14]. IP telephony is the process that uses signal technology built on Open IP-standards to provide users with end-to-end communication / data transfer (file, data, voice and video) – to aid data transfer services for public carrier networks and Internet users in general with an inter-operable networks [15, 16].

[16] IP telephony involves large family of communication standards to deliver voice and video services via open packet network and uses the H.323 protocol to setup, control and manage sessions. The many benefits of IP-network as easily deployed services over legacy PSTN includes: (a) It allows call services to be located anywhere on network and use packet networks rather than TDM, (b) allows service delivery so that dual cabling and network equipment for PBX or IP-PBX connections is not required, (c) carry traffic across various areas and various vendors across various countries – interfacing a variety of Internet and telephone technologies more flexibly, with greater benefits at reduced cost of implementation and operation. Thus, a converged network helps extend capabilities of such an intelligent IP network over or into a PSTN network (when built to use underlying network) protocols and are based on server or network appliance [17, 18, 19, 20, 21].

1.2. Intranet Structures, Design and Strategies

An intranet is a network that is limited to its organization providing collaborative communication to its users that are located in different geographical locations [22]. Intranet services include e-mail, content management system, calendars, project management etc. With its extensive range of benefits, organizations have become interested in implementing intranet(s). Managing data with intranet is of great benefit [23] as a stable, efficient, cost-effective, flexible, productive alternative. As businesses comprehend its value, they consistently develop a communication tool to aid data exchange and resource sharing that ultimately blossoms into new collaborative workplace areas. [24] conceptual model identified the effects of collaborative workplaces and suggested that intranet usage is highly driven by organizational culture and by perspective towards blogging.

With communication and information as integral of business today, an intranet is very productive in socializing and finding data. Developing a great intranet framework will enhance socialization in newcomers faster and better. In the information point of view, newcomers are slow in obtaining information from intranet but in communication point of view they are effective in finding information from intranet [25]. An intranet utilizes Internet to provide security, expandability, and openness. It concentrates on security issues in connections between an intranet and the Internet. Furthermore, there is inadequate technical support for intranet security. Thus, intranet security is a critical issue. Besides requirements for intranet and internet security are dissimilar. The Internet concerns about secure transmission of information between systems. While, intranet security limits within the system inside organization [26, 27, 28].

Intranet are typically a large information system, which is meant to be flexible, robust and can evolve. However, such robustness and flexibility requirement will require a constant update and ever-changing policies to implement. Also, it is quite hard to design a system that is quite flexible to handle the needed changes. Thus, [28] there are nine (9) well-known intranet design strategies to include (not limited to): (1) Determine Goal and Promotion, (2) Roles and Responsibilities, (3) Communication and Governance, (4) Info Architecture, (5) Branding (6) Picking the Right tool, (7) Consistent Design, (8) Periodic Assessment, and (9) Remote Accessibility as in fig. 1 below. [29] All these are geared towards ensuring that both internal/external factors responsible for the design of such system is met. Some of

the external factors that have affected the ease of intranet usage and its usefulness includes task interdependence, task equivocality, and web experience.

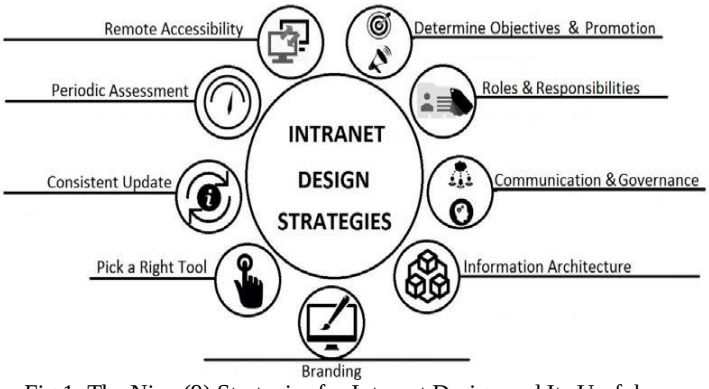

Fig 1: The Nine (9) Strategies for Intranet Design and Its Usefulness

1.3. Rationale For Designing Of An Intranet

In pursuance and furtherance of business ideas, technology will continue to harness the many benefits therein, for the converged intelligent network. These are derived from its fundamental capabilities to provide these advantages:

1. Economy – The advent of the Internet has birthed effective data sharing. It has mitigated challenges experienced with the traditional public switched telephone network (PSTN), which employed expensive legacy systems as connecting elements, applications and technologies like DS1/DS0 line cards, trunk cards and digital signalling technologies. Conversely, the advent of the Internet has and continues to advance the use of IP networks allow users to build data services via Ethernet economics and Moor's law for rapid advances in computing performance. A merit of IP-network is its cost in connecting enterprise PBX system to PSTN via ports, cards and circuits. Thus, cost is lesser to provide connections to other sites and to other apps [11, 30].
2. Flexibility – PSTN element(s) are mostly proprietary, monolithic and restrictive. Whereas IP network connections are made from virtual reach with resources distributed on demand to anywhere needed, and economies are gained via centralized gateway and server resources. Use of many types of media and applications to be brought together to facilitate communication. It supports broadband voice, front and back office integration and apps, outsourcing operation, mobility, centralised management, telecommuting, desktop integration, automation etc. It leverages on a plethora of emerging web services such as mobility, instant messaging and presence [31].
3. Security – Achieving a higher degree of security for data transfer that is vastly superior over legacy technologies; while deploying and integrating wireless LAN apps, video surveillance, IP video on demand, streaming and rich media conferencing applications [31, 32].
4. Resilience - With business continuity and disaster recovery high, resiliency of connectivity and abilities provided by IP network keeps an organization connected make it an ideal candidate for survivable services. Its redundancy is built into intelligent layer technologies and apps. Clustering and hot standby technologies, fault tolerant storage technologies like RAID, dual power supply are now common. IP offers superior failover, self-healing and redundant abilities that are easy to deploy, open-standards based, and supports an organization's communication needs via feats of reliability, availability and superior alternatives than PSTN [33, 34].
5. Productivity – Its focus, shifts from cost savings to enabling users become more productive with apps to help accomplish higher quality communications more quickly and easily, has yielded a network of apps that uses any existing web or enterprise database on an IP network. Users leverage on web innovations, enterprise directories, e-mails, voice mail, fax, and general tools for programming communication rules. Voice recognition and soft-phone support via user desktops are added to IP-communications environment. While, some of these feats exist in legacy PSTN, they are more expensive, less scalable, and more difficult to deploy [35, 36, 37].

1.4. Motivation For The Study

The study seeks to deploy intranet strategies on [9] to promote resource sharing, provide unlimited opportunities for collaboration amongst staff (locally and globally) via design of an intelligent, scalable and robust network that will improve communication and data management. It hopes to achieve with the following objectives:

1. Identify the requirement needs of all stakeholders therein.
2. Analyze the existing network with a view to identifying the initial condition of the network.
3. Determine the physical architecture of the existing network, its inherent limitations, bottlenecks and demerits
4. Generate a requirements list of resources and estimate expected data flow for the proposed network.
5. Recommend appropriate security measures for the safety of devices and the infrastructure.
6. Run simulations of both the proposed network systems making use of OPNET IT Guru, Academic Edition.

The study seeks to address the upgrades of the network infrastructure as implemented in [9], implement an IP-telephony to fully harness the benefits of intranet via the strategies of [28].

2. Materials And Methods

2.1. The Federal College of Education Technical, Asaba

Educational institutions thrives on the quality of its products, data sharing and management, and communication processes. The Federal College of Education Technical Asaba has its mission as, to train teachers in different fields of endeavour – making them agents of change in the lives of others, their communities, the nations and the world at large. As a staff of the organization, the quality of technological education (with respect to teaching and learning) and the quality of technology education (with respect to technology integration as means of alternative delivery) were lacking as opposed to international best practices. Also, communication processes and record keeping abilities currently utilized, are inefficient. A resultant effect therein, is the absence of a system to efficient communication and keep records. These challenges the study seeks to address via an intelligent, scalable and robust network infrastructure that accounts for requirement needs of the stakeholders, boosts communication among its users, improve the research capabilities of staff within the institution and improve overall efficiency via the many benefits of IP telephony.

Currently, most students' records are computed and stored manually. This leads to misplaced academic records during final computation of results. Staff communication is quite inefficient – often resulting in missed appointments as memos from Institution's Management that are manually disseminated can often be misplaced in transit [9]. Here, a network was set to enhance communication and research capabilities of staff, which collapsed only few weeks later. We opine that the principles of network design and management were not effectively employed – resulting in its collapse. Also, management, staff and students find it difficult to establish effective communication to inform each other of changes in scheduled meetings, lectures and examinations. Access to online materials for students preparing for examinations, undertaking their research is quite a daunting task – resulting in poor performance and poor quality research on a regular basis. This has necessitated the researchers' need for a robust network with implemented IP telephony to help tackle issues raised therein; While, also offering stakeholders improved quality of service, better mechanism for conducting its daily activities and a greater channel for reaching out to a larger number of potential student population (locally/globally). The study extends [9] by analysing existing network, identifies devices, apps and upgradable technologies in the existing network, implements the improved network and up-scales the network capability with IP telephony to ensure its ability to fully harness the potentials therein.

2.2. Network Structure: Pre-Planning and Feasibility Study

A critical, structured analysis of the existing network was indicates that these must be addressed before effective implementation namely [31, 32, 33, 34, 35, 36, 37]:

1. Difficulty to accommodate differences in disparate technologies existent within the existing network infrastructure
2. Difficulty to traverse the geographic boundaries
3. Ability to manage the various campuses (as sites) centrally
4. Change the way resources are used on a network
5. Traverse regulatory boundaries

6. Deliver such new communication services using different media types
7. Provide level of integration, ease of use, access and management found in IP telephony systems.

2.3. Network Structure: Pre-Planning and Feasibility Study

Study seeks to modify an existing network infrastructure at Federal College of Education (Technical), Asaba. A breakdown of the community population size is listed in the Table 1.

Table 1. Dataset Fact-Sheet for User Population

No	Population	Number	Expertise	Training Required
1	Management Staff	12	Little-None	Yes
2	Academic Staff	348	Little-None	Yes
3	Non-Academic Staff	775	Little-None	Yes
4	Student(s)	2364	Little-None	Yes
5	Technical ICT Team	14	Little-None	Yes

Table 2. Dataset Fact-Sheet: Breakdown of Existing Network Components

No	Population	Number
1	Internet services provider: Cyberspace Nigeria Limited	Wide coverage at 3Mbps speed is ideal.
2	10Base-T Connectivity between network devices	Upgrade Required
3	100Base-Tx Ethernet Tech Connectivity between servers	Upgrade Required
4	Category six cabling	Still useful
5	3-CISCO ME 3640 24CX Series Ethernet Access Switches	Still useful
6	1-CISCO 7000 Series Router, reached end-of-life	Still useful for backup purposes
7	1-CISCO Aironet Wireless 1800 Access Points in ICT Unit	More Required

Table 3. Fact-Sheet of Available Servers and Devices

No	Hardware	Status
1	HP Pro-Liant DL560 Gen8 Servers with Server, two 750 GB HDD Working on RAID	More Server machines required
2	Workstation (50 pieces)	Additional Required
3	Network Printers Available (4)	More Required

Table 4. Fact-Sheet of Available Servers and Devices

No	Software	Status
1	MS Secured Safe Server	Upgrade to Microsoft Visual Studio Team System Server
2	MS SQL Server 2008	Upgrade Required to SQL Server 2012
3	Active Directory	Still Useful
4	MS Exchange Server 2010	Still useful
5	Web Server (Microsoft IIS/8.5)	Still useful
6	MS SQL Server 2008 R2 RTM	Still useful
7	MS Virtual Machine Server 2008 R2	Still useful
8	DHCP Server	Still useful

Tables 2, 3 and 4 respectively shows the available hardware and software applications present in the existing network.

2.4. Limitations of Existing Network

The following limitations and bottlenecks were observed:

1. Single Router poses the risk of a single point failure, in the event of a malfunctioning router. This will crash the entire network. An ideal situation is to introduce some resilience via use of a backup router using the appropriate technology to recover in the event of a failure in the main router.

2. Absence of Backup Servers is also a drawback.
3. Network Topology does not support efficient scalability and will obviously not be able to integrate the ever-growing user and application requirements.
4. Single Internet Service Provider is an issue to availability and has been so, subject to the budgetary provisions.
5. Absence of Redundancy with use of a single main Switch is not healthy. In event of an upgrade, redundancy would have to be introduced to ensure resilience in the network.
6. Apps Location: Office and antimalware apps are located on individual user systems in the ICT unit. This is an expensive both to the network and the applications. Each application would require upgrades and patches individually. This would cumulatively lead to an increase in network traffic.

3. Proposed Experimental Framework

After the identification of the applications and devices in the existing network, a proposal was drawn by the researcher to reflect network requirement in terms of application, devices and user requirements. This is to ensure that the proposed network withstands the challenges expected by its potential users. Tables 5 and tables 6 is breakdown of these various requirement specifications.

3.1. The Layout Architecture of The Proposed Network

With fig 1, network topology is quite essential in system analysis. It greatly influences and is responsible for and in determining the overall performance of the network [38]. There are two types of topologies: physical and logical. Physical topology consists of the device and their cabling layout. The logical topology deals with the pathways data signals undertake as routes in the network from one point to another [39]. The logical is an offshoot of the physical topology. Thus, we seek to analyse the physical topologies of existing network [40, 41]. The logical architecture for the existing network employed a flat network topology – from simplicity of network operation and functionality. Basic operations allow for online integration as alternative delivery and result storage system. Thus, course registration forms were accessed from the Web server; while, completed forms are stored back into the database server. The traffic generated in the network was periodic. Thus, the network has few challenges at peak periods. This can no longer be the case incorporating new applications and user groups.

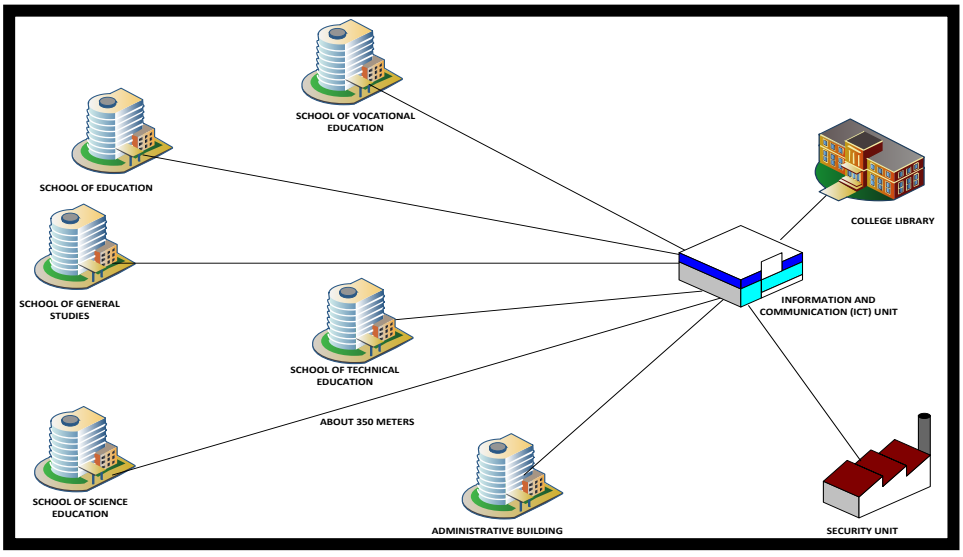

Fig 1: Site map of Buildings to Implement the Proposed Network

Table 5. Fact-Sheet of Proposed Network Specification(s)

No	Type	Description (and Quantity)	Gathered At	Location	Status	Priority

1	Device	Cisco ASR1002-X Chassis Router (1)	Initial Condition	ICT unit	Core	High
2	Device	Cisco Aironet 3600 Series (9)	Initial Condition	See Map	Core	High
3	Device	New HDD for VM Server	Management	ICT unit	Core	High
4	Device	HP Pro Liant DL560 Gen8 Servers with 1.5TB each to add to existing server (4)	Initial Condition	ICT unit	Core	High
5	Device	Cisco Catalyst 6500 Series Switches for distribution layer (2)	Initial Condition	ICT unit	Core	Critical
6	Device	CCTV to enhance physical security in ICT unit	Management	See Map	Core	Critical
7	Device	Swipe cards for authentication	Management	ICT unit	Core	High
8	Network	10GB Category five-e cables for patch panels	Management	See Map	Core	High
9	Network	10GB Category Six cables for host to Servers	Management	See Map	Core	High
10	Network	1GB multimode fibre server/network backbone	Management	See Map	Core	High
11	Network	Cisco ASA 5550 Adaptive Security Appliance	Management	Server Room	Core	Critical
12	Users	Training of various categories of staff	Management	TBD	Core	Critical
13	Business	Minimal Budget (btw £300,000 - £400,000)	Management	Info	Core	High
14	Business	Minimal disruption of organizational activities	Management	Info	Core	High

Table 6. Fact-Sheet of Proposed Network Application Services

No	Type	Description (and Quantity)	Gathered At	Location	Status	Priority
1	Application	Active Directory and Domain Controller is installed on main and backup servers	Management	Server Machine	Core	Critical
2	Application	SQL Server 2012 to link Database Server	Management	Server Machine	Core	Critical
3	Application	MOSS SharePoint 2008 for data and protocol centralization	Management	Server Machine	Core	Critical
4	Application	MS Office 2013	Management	Server	Core	High
5	Application	NovaBack16: Disaster Recovery Backup	Management	Server Machine	Core	Medium
6	Application	Antivirus Software	Management	Server	Core	Critical
7	Application	Payroll Software	Management	Dedicated Syst.	Core	High
8	Application	Microsoft Virtual Server 2012	Management	Server	Core	Medium
9	Application	DNS Server	In. Condition	Server	Core	Critical
10	Application	DHCP Server / Solar Wind Suite	In. Condition	Server	Core	Critical

With the requirement document as in tables 5 and 6 respectively implemented, we have the network of [9] implemented. Further implementing and integrating the intranet strategies as listed above in Section 1.2 and figure 1, we have the proposed IP-telephony implementation with the modified network infrastructure as figure 2.

3.2. Discussion of Findings

Using the Riverbed simulator, we measured the flow analysis for the proposed network. The flow analysis seeks to characterize the flow of data through a network. It considers areas of convergence and performance needed by helping a network designer to characterize traffic (individual, composite and critical) flow, flow models and identify data sources/sinks. We considered various requirements, locations, user behaviours, apps and protocol overheads (that cannot be actually computed). The critical applications moves bi-directionally to/fro client and server. The estimated network flow is computed to determine the bandwidths required to accommodate them. This involves determining the available network capacity and average utilization of specific applications critical to the network. The app utilization is captured via network analyser with values in table 7. Our proposed network utilizes a 10Gbps multimode fibre that supports a bandwidth of about a billion-byte (1,000,000,000 bytes/sec). With protocol overhead and others, the proposed network will work optimally. We compute average network utilization via network analyser, and compare its value with bandwidth of cable for data traffic. Cable bandwidth is computed by determining the amount of available bandwidth and computing the average utilization required by the specific applications.

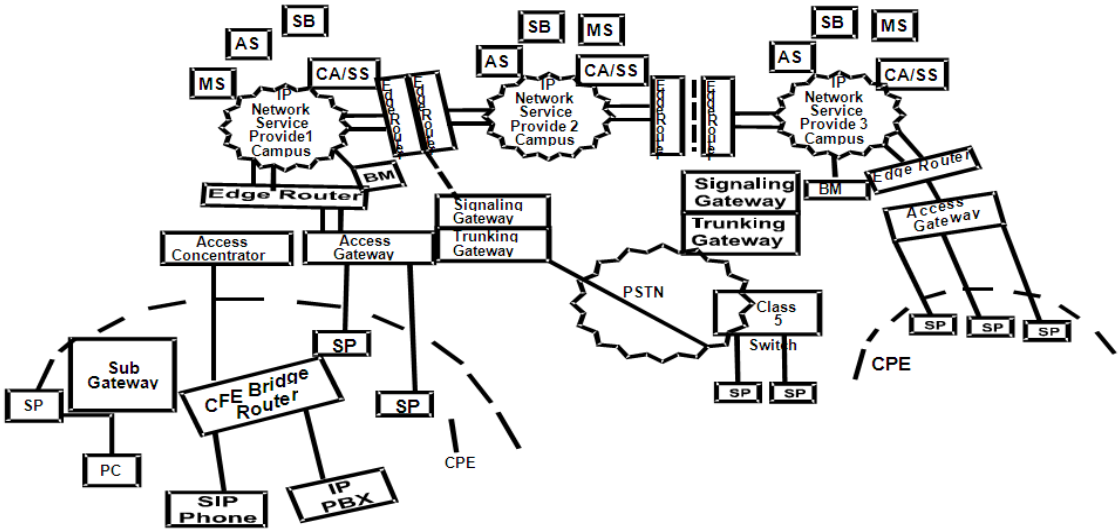

Fig. 2: Proposed IP-Telephony Implementation on Modified Network Infrastructure

Table 7. Capacity Flow Analysis of Major Applications (in bytes/secs)

No	Type of Application	Bandwidth in Bytes/secs	Estimated Users
1	Email Service	1,200,000	3153
2	Web Utilization	1,800,000	3153
3	File Transfer	10,800,000	3153
4	Database Query	500,000	3153
Total Bandwidth Utilization		14,300,000	3153

4. Summary, Recommendation and Conclusions

From the logical architecture of the new system, it was observed that the existing system had poor network design that resulted in scalability issues, jitters, packet loss, latency, redundancy etc. These challenges can be attributed to the absence of the DMZ, the non-provision of an Intrusion Prevention System and/or firewall, amongst other feats such as virtual LANs – all of which posed both security and management issues. However, our proposed system addressed the constraints via different strategies namely [42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52]:

1. Improved Security: Introduction of a firewall and Intrusion Prevention System was achieved via Cisco ASA 5550. Also, implementing a virtual LANs on the main switches, virtual private network (VPN) at the core and a Demilitarized Zone (DMZ) at distribution layer will improve the security.
2. Improved Resilience: To improve network redundancy, additional routers were placed at the core support the main linking them with the Hot Standby Router Protocol. Also, redundancy was introduced in the distribution layer to add resilience to the network. Finally, backup servers were introduced to aid network data recovery in case of crash.
3. Improved Performance and Availability: Use of multimode fibre for upload/download at distribution layer. Also, three wireless access points will be placed at strategies locations in each of the floors and extensions of the various buildings – to boost network access apart from cablings in building. To improve availability, Cisco Express Forwarding (CEF), Low Latency Queuing (LLQ) and Committed Access Rate (CAR) will also be used to boost the network performance.

References

[1] Dye, M., McDonald, R., and Rufi, A. (2008) *Network Fundamentals: CCNA Exploration Companion Guide*. 1st edn. ed. by

Ray, M. Indianapolis, Indiana, USA: Cisco Press

[2] White, C. (2011) *Data Communications and Computer Networks: A Business User's Approach*. Boston, USA: Course Technology Publications

[3] Derfler, F.J. (2000) *Practical Networking*. Indiana: Que

[4] Comer, D. (2008) *Computer Networks and Internets*. 5th edn. London: Addison-Wesley

[5] Beasley, J. (2008) *Networking*. 2nd edn. USA: Prentice Hall

[6] Tanenbaum, A. and Wetherall, D. (2010) *Computer Networks*. 5th edn. USA: Prentice Hall

[7] Ojugo, A.A., Yoro, R., Oyemade, D.A., Eboka, A.O., Ugboh, E., Aghware, F., (2013). *Robust cellular network rural telephony in Southern Nigeria,* American J. of Net. Comm. 2(5): 125-132 www.article.sciencepublishinggroup.com/html/10.11648.j.ajnc.20130205.12.html

[8] Ojugo, A.A., Abere, R., Orhionkpaiyo, B., Yoro, R., Eboka, A., (2013). *Technical issues for IP-based telephony in Nigeria,* Int. J. Wireless Comm. & Mobile Comp., 1(2): 58-67, [web]: www.article.sciencepublishinggroup.com/html/10.11648.j.ajnc.20130102.14.html

[9] Ojugo, A.A., Eboka, A.O., (2020). *Mitigating technical challenges via redesigning a campus network for greater efficiency, scalability and robustness: logical view*, Int. J. Modern Edu. Comp. & Sci., 10(1): pp126-132 [web]: http://ijmecs.com/20403

[10] Eung-Ha, K., Cho, K.S and Ryu, W., "Amendment to MSF whitepaper on personalized converged services: network-to-network", [online]: www.msforum.org/techninfo/reports.shtml, last accessed March 2013.

[11] Stallings, W and Van Slyke, R., *Business data communications*, 6th Ed., 2010, Prentice Hall Int. Ed., ISBN – 1-13-761230-3, pp316-340.

[12] Kurose, J. and Ross, K. (2013) *Computer Networking: A Top-Down Approach*. 6th edn. ed. by Hirsch, M. and Snider, E. Boston: Pearson Education Limited

[13] Ojugo, A.A., R.E. Yoro., A. Eboka., M. Yerokun and I. Iyawa., (2012). *Implementation issues of VoIP to enhance rural telephony in Nigeria,* Journal of Emerging Trends in Computing & Information Systems, 4(2): pp113-120, [web]: cisjournal.org/journalofcomputing/Archive_Feb_2013.aspx

[14] Garg, V., Smolik, K and Wilkes, J., "CDMA application in wireless communications", 1997, Prentice Hall publications, New Jersey: Upper Saddle River.

[15] Helgert, H., "Integrated services digital net: Architecture, protocols and standards", 1991, Readings: MA: Addison-Wesley.

[16] Brennen, R and Dipak, G., "Secure IP telephony via multi-layered protection", 2009, Technical University of Denmark report, Centre for ICT, Denmark: Lyngby

[17] Martins, J.A.H., "Telecommunications and the computer", 1990, Prentice Hall publications, New Jersey: Upper Saddle River

[18] Rosa, J., "Rural telecommunications via satellite", Journal of Telecommunications, 2005, 3(2), pp 75 – 81.

[19] Ojugo, A.A., F. Aghware., R. Yoro., M. Yerokun., A. Eboka., C. Anujeonye., F. Efozia., (2015a). *Dependable community-cloud framework for smartphones*, American J. of Networks and Communications, 4(4): pp95-103, [web]: article.sciencepublishinggroup.com/html/10.11648.j.ajnc.20150404.13.html

[20] Conte, R., "Rural telephony: new approach via mobile satellite communication", Proceedings of Pacific telemmunication conf., 1994, Hawai: Honolulu

[21] Ojugo, A.A., D. Oyemade., D. Allenotor., R.E. Yoro., C.N. Anujeonye., (2015b). *Immunization problem for Ebola virus in rural Sierra-Leone,* African J. of Comp. & ICT., 8(1): pp1 –10: [web]: www.afrjcict.net/

[22] V. S. Lai, "Intraorganizational communication with intranets," *Communications of the ACM,* vol/issue: 44(7), pp. 95-100, 2001.

[23] M. Edenius and J. Borgerson, "To manage knowledge by intranet," *Journal of Knowledge Management,* 7(5), pp. 124-136, 2003.

[24] P. Raeth and S. Smolnik, "Antecedents and consequences of corporate weblog usage in the intranet: A process perspective," *System Sciences (HICSS), 2010 43rd Hawaii International Conference on. IEEE*, 2010.

[25] L. E. Chang and S. P. Lin, "Newcomers' Socialization by Intranet System," *Computer and Information Science (ICIS), 2011 IEEE/ACIS 10th International Conference on. IEEE*, 2011.

[26] Neill, W. D. and James E. R., "Intranet portals: marketing and managing individuals' acceptance and use," *Australasian Marketing Journal* (AMJ), vol/issue: 20(2), pp. 147-157, 2012.

[27] S. Lee and B. G. Kim, "Factors affecting the usage of intranet: A confirmatory study," *Computers in Human Behavior*, vol/issue: 25(1), pp. 191-201, 2009.

[28] D.R. Roshan and K.S. Rao., *Intranet design strategies*, Int. J. Elect. & Comp. Eng., 2016, 6(3): 936 - 944

[29] R Hall, "Agile Design on Your Intranet," http://www.intranetconnections.com/blog/ agile-design-on-your-intranet/, 2014.

[30] R.E. Yoro., Ojugo, A.A., (2019). *An intelligent client-trusted and dependable security framework to ease smartphone portability on community cloud computing*, J. of Network and Communication, 4(3): pp79-90

[31] A.A. Ojugo., R.E. Yoro., A. Eboka., M. Yerokun and I. Iyawa., (2012). *Implementing VoIP on a campus network*, Technical report of Federal University of Petroleum Resources Effurun (TRON-3201), pp113-120

[32] Ojugo, A.A., Eboka, A.O., (2014). *Social engineering detection model for mobile smartphone clients*, African J. of Computing & ICT, 7(3): pp91–100. [web]: www.africanjournalofcomputingict1.files.wordpress.com/2017/08/vol-7-no-3-september-2014.pdf

[33] D.A. Oyemade., J. Akpojaro., A.A. Ojugo., R. Ureigho., F. Imouokhome., E. Omoregbee., (2016). *A three tier learning model for universities in Nigeria*, Journal of Technologies in Society, 12(2): pp9-20, [web]: https://jts.cgpublisher.com

[34] Ojugo, A.A., O.D. Otakore., (2018a). *Mitigating social engineering menace in Nigerian Universities*, J. of Comp. Sci. & Application, 6(2): pp64–68, doi: 10.12691/jcsa-6-2-2, [web]: www.sciepub.com/jcsa/content/6/2

[35] Ojugo, A.A., D.O. Otakore., (2018b). *Redesigning academic website for better visibility and footprint: a case of Federal University of Petroleum Resources Effurun website*, Network & Communication Technologies, 3(1): pp33 –44, https://doi.org/10.5539/nct.v3n1p33, [web]: www.ccsenet.org/journal/index.php/nct/

[36] Ojugo, A.A., A.O. Eboka., (2018). *Assessing user satisfaction and experience on academic websites: a case of selected Nigerian Universities websites*, Int. J. Tech & Comp. Sci., 10(7): pp53-61, doi: 10.5815/ijitcs.2018.10.07

[37] Subramoni, H., Kandalla, K., Vienne, J., Sur, S., Barth, B., Tomko, K., Mclay, R., Schulz, K., and Panda, D.K. (2011) "Design and Evaluation of Network Topology-/Speed- Aware Broadcast Algorithms for InfiniBand Clusters". *2011 IEEE International Conference on Cluster Computing* [online] 317–325. available from <http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=6061150> [8 June 2014]

[38] Kumar, H. (2013). *Physical vs. logical topologies* [online] available from http://egyaan.in/2013/04/22/physical-vs-logical-topologies/

[39] Sun, X. and Xie, G.G. (2013) "Minimizing Network Complexity through Integrated Top-down Design". *Proceedings of the ninth ACM conference on Emerging networking experiments and technologies - CoNEXT '13* [online] 259–270. available from http://dl.acm.org/citation.cfm?doid=2535372.2535376

[40] DiNicolo, D. (2007) *Advantages and Disadvantages of Different Network Design Approaches* [online] available from <http://www.2000trainers.com/ccda-study-guide/comparing-network-design-approaches/> [2 June 2014]

[41] Huynh, M., Goose, S., and Mohapatra, P. (2010) "Resilience Technologies in Ethernet". *Computer Networks* [online] 54 (1), 57–78. available from <http://linkinghub.elsevier.com/retrieve/pii/S1389128609002692> [1 June 2014]

[42] Iqbal, R. and Xingang, W. (2014) *Network Planning and Management* [online] Coventry. available from http://cumoodle.coventry.ac.uk/course/view.php?id=10062

[43] Lanxiaopu, M. (2012) *An Investigation and Comparison on Network Performance Analysis* [online] UNIVERSITY OF OSLO. available from https://www.duo.uio.no/bitstream/handle/10852/9087/MxMT.pdf?sequence=1

[44] McCabe, J. (2008) *Network Analysis, Architecture and Design*. 3rd edn. London: Morgan Kaufmann

[45] Rouse, M. (2010) *Network Topology* [online] available from <http://whatis.techtarget.com/definition/network-topology> [23 May 2014]

[46] Duboc, L., Letier, E., and Rosenblum, D.S. (2013) "Systematic Elaboration of Scalability Requirements through Goal-Obstacle Analysis". *IEEE Transactions on Software Engineering* [online] 39 (1), 119–140. available from http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=6152130

[47] Oppenheimer, P. (2011) *Top-Down Network Design*. 3rd edn. Indianapolis: Cisco Systems Inc.

[48] Derbel, H., Agoulmine, N., and Salaün, M. (2009) "ANEMA: Autonomic Network Management Architecture to Support Self-Configuration and Self-Optimization in IP Networks". *Computer Networks* [online] 53 (3), 418–430. available from <http://linkinghub.elsevier.com/retrieve/pii/S138912860800354X> [13 June 2014]

[49] Ergu, D., Kou, G., Shi, Y., and Shi, Y. (2014) "Analytic Network Process in Risk Assessment and Decision Analysis". *Computers & Operations Research* [online] 42, 58–74. available from <http://linkinghub.elsevier.com/retrieve/pii/S0305054811000785> [11 June 2014]

[50] Kizza, J.M., (2013) *Computer Communication and Networks: A Guide to Computer Network Security*. 2nd edn. London: Springer

[51] Roy, S., Ellis, C., Shiva, S., Dasgupta, D., Shandilya, V., and Wu, Q. (2010) "A Survey of Game Theory as Applied to Network Security". *2010 43rd Hawaii International Conference on System Sciences* [online] 1–10. available from

http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=5428673

[52] Miaji, Y. and Ph, D. (2014) "Novel Performance Enhancement of University ' S Network Exploiting Cisco Network Design Model : Study Case on IUKL Network". in *International Conference on Computer Security and Digital Investigation* [online] held 2014 at Malaysia. 36–41. available from http://sdiwc.net/digital-library/novel-performance-enhancement-of-universitys-network-exploiting-cisco-network-design-model-study-case-on-iukl-network