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Optimizing an Efficient Use of Internet Bandwidth for Higher Learning Institutions in Ghana

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ABSTRACT

This paper examines the availability of Internet services in Higher Learning Institutions (HLIs) for developing countries such as Ghana, with respect to the cost and usage. We looked at the source of Internet services and the bandwidth package for some Higher Learning Institutions in Accra, Ghana. One of the key objectives of this study is to design and simulates an efficient Internet bandwidth usage for Higher Learning Intuitions. We examined the cost of bandwidth package offered by the Internet service providers to these higher institutions. In looking at the cost we also included the bandwidth packages offered, the type of Internet connection and the service level agreement with the ISPs. In the study, we looked at how the Internet is distributed to these institutions and the equipment used in the distribution of the Internet services. Ipswich Whatsup Gold software was used to monitor the network infrastructure for one of the institutions in the study. We went further to monitor the bandwidth consumption for Ghana Technology University College, one of the institutions in the study, to monitor their bandwidth consumption and traffic flow in the network. In designing an efficient bandwidth management for the Higher Learning Institution, we model and configured a network in Packet tracer using a proxy cache box. This technique allows for an efficient bandwidth planning capacity to manage the bandwidth consumptions. At the end of the study, we modeled a network using cache box to restrict and minimize bandwidth usage and thus making it less expensive for the Higher Learning Institutions.

Keywords : Internet, Bandwidth, Efficient, Higher Learning Institutions, Cache box

I. INTRODUCTION

The Internet can simply be described as a global network that connects several small networks together for the purpose of communication and the sharing of information. The Internet provides a platform for connecting computer networks together which uses the protocol suite (TCP/IP) to link billion of devices. The growth of the Internet has been steadily, making it more accessible and available to users. The Internet is used across several fields such as the manufacturing sector, health sector, governance and the educational sector just to mention a few. In the present era of information technology space, the Internet is the most important source of current information. The Internet at most is the first place where students and academic staff tend to look for information for their academic activities. The Internet generally makes a wider volume of information available, which is easily accessible and reliable. Higher Learning Institutions (HLIs) are connecting to the Internet which makes it easier for students to access academic materials such e-journals, e-books and other online study platforms for their research. Electronic libraries are gradually taking over from the traditional libraries for accessing information that is usually within a confined area. The access of information on the Internet is beyond

boundaries and therefore it is essential to have a reliable Internet connection to academic institutions. Higher Learning Institutions (HLIs) like universities, polytechnics and colleges of educations play a unique role to serve as a conduit for the flow of Information and technology transfer between academia and the industry. There is therefore the need for well resourced ICT labs with reliable high-speed Internet services that will facilitate the work of academic institutions. Information produced and consumed from HLIs will heavily depend on their ICT infrastructure and a very good Internet bandwidth.

Internet bandwidth describes the amount of data that can be sent over the Internet in a given time. It measures the speed of data packets sent and received in seconds. A very low bandwidth will mean poor Internet service. Ghana a middle-income country is developing at a fast space, the use of information communication technology to accelerate its development is more than ever needed. There is the need to invest more in ICT infrastructure development and make the Internet very accessible to the urban and rural areas. The Internet explosion in developing countries has changed the cost of communications among African countries and the rest of the world. Ghana was among the first countries in the sub-Saharan region to connect to the Internet [1], where access to the Internet services was quite unreliable and very limited. The Internet has become much more pervasive in Ghana recently with many ISPs coming into the market and more subscribers having access to the Internet services for both public and private use. The Internet has evolved more quickly in Ghana than its West African neighbors in the sub-region. By the year 1996, they were only three (3) ISPs in Ghana with each ISP having its own satellite connections to the Internet. [2] These satellite connection services allowed ISPs to connect directly to the Internet without a telephony company. In some other Africa countries, they required the access to the Internet through Post Telephone, and Telegraph (PTT) [2,3]. In general there are a number of ISPs currently operating in Ghana that offer good Internet access to academic institutions to support the ICT labs across various universities campuses.

This study is divided into five sections; the first section looks at a brief background of the Internet in Ghana, section two looks at other related works, a review of Internet connectivity to Higher Learning Institutions (HLIs). Section three describes the methodology we adopted for our study and the fourth section deals with the analysis of the results and simulation. The fifth section is the discussion and conclusion of the results.

1.1 Problem Formulation

The Internet is very essential for academic research in Higher Learning Institutions (HLIs), where the cost of Internet bandwidth for these Institutions is becoming more expensive. Some academic institutions cannot a afford a bigger bandwidth, thereby confining them to a low bandwidth for their academic work. Again the source of Internet connectivity from the ISPs in Ghana is also a challenge for some HLIs. The paper looks at issues of reliable Internet connection for Higher Learning Institutions in terms of cost, bandwidth usage and the equipment for Internet distribution. Another problem of the study is to examine the various bandwidth packages provided by the ISPs namely MTN, Vodafone and Surfline and the Service Level Agreements (SLAs) with these institutions. Finally, the study will also address the issues of Internet bandwidth management and the equipment required to minimize bandwidth usage for the institutions.

1.2 Motivation of the study

This study looks at the source of Internet connectivity for higher learning institutions in Accra, the cost and bandwidth packages offered by the various ISPs to these institutions. One of the objectives is to look at the source of Internet

connectivity among Higher Learning Institutions (HLIs) in Accra. We shall explore the cost and the availability of Internet bandwidth to these Higher Learning Institutions (HLIs). Another aim is to examine Internet bandwidth packages for these institutions from their ISPs and their Service Level Agreements (SLAs). In this study, we shall also look at the equipment for network distribution and simulate a network to monitor the bandwidth usage for that network capacity. Finally, we will design an efficient network that will reduce Internet bandwidth consumption and thus making the Internet faster. An efficient Internet bandwidth usage will be beneficial for the academic institution to reduce the cost on bandwidth packages for the HLIs.

II. BACKGROUND STUDIES

Internet access for developing countries at a relative low price is very important where governments need to adopt bold measures to address the challenges affecting Internet penetration such as pricing, network infrastructure and policy framework for ISPs operation. In a World Bank report (2001) [4] emphasized the need to address the issues of Internet pricing structure, controlling the monopoly of Internet access and the licensing charges for ISPs on the African continent. The report further suggests the need for liberation in the provision of Internet service and telecommunication network at a lower cost that will facilitate the economic growth in the continent. A reliable Internet access to academic institutions is very important in view of the role academic institutions play in the transfer of knowledge to the industry for economic growth of a country. In Ghana, the premier international computer network for forwarding emails and providing Bulleting Board System (BBS) with computers in a network were connected via short dial-up calls. [3] By the year 1989, the Fidonet connection was set-up between the Ghana National Scientific and Technology Information Network (GHASTINET) and Greenet in London as well as the Association of African Universities (AAU) and the Technology Transfer Centre (TTC) [5] This project was established as a pilot of the Pan African Development Information System. (PADIS) The University of Ghana Balme Library later became the Fidonet central hub for extensive networks that supported upto 50,000 users. [Osiakwan 2000]. According to the findings of Osiakwan [5], some of the Unix Copy Protocol (UUCP) that was built by the African Universities (AAU) built a more robust and email-store system to provide email connection to organizations and three major universities. The AAU's email system and the AAUnet allowed subscribers in the network to forward email traffics to the global Internet where TCP/IP connectivity was provided for commercial system Interrogator and Network Computer Systems (NCS). The AAUnet later extended other web services to users of the network.

2.1 Internet Service Providers (ISPs) in Ghana

In the year 1992, the Network Computer Systems (NCS) applied for the rights through the Ministry of Communication [6] to give an additional value service such as emails, newsnet and other services where the NCS allowed its subscribers to be able to dial-in to its computers for a duration 4 to 6hrs in a day to access the Internet when it's Pipex connection were up. The NCS at the time were able to acquire a 14.4kbps leased used that could establish a TCP/IP from Ghana Telecom by August 1995. This made it possible for NCS to offer its customers the E-mail, Telnet, FTP and other web services on a 24/7 basis. In June 1996, Internet Ghana a 2nd ISP was established in the country by Eletromod an indigenous company, where for international connection the Internet Ghana (ISP) connected MCI Internet backbone in the United States via a dedicated leased line from Ghana Telecom. [Tamakloe, 2003][7]. Internet Ghana later through its partnership with Ghana Telecom to

provide Internet access to cooperate customers through ISDN and its customers share in the market increase steadily for the years. By the year 2002, Internet Ghana upgraded its connection to the global Internet backbone to accommodate a large number of subscribers where it acquired a 2mbps of connectivity via SAT-3 submarine cable. [8] The numbers of ISPs in the country have since increased. According to a report from the National Communication Authority, between a period of 1999 and 2003, the NCA has registered over 52 ISPs out of which 16 are already operating which is illustrated in a in the table below. [6]

Table 1 : ISPs in Ghana, 2003

ISP	Dail-up Subscriptions	Leased Line/Wireless	International Bandwidth
NCS	6000	120	8Mbps up/ 2Mbps down
Africa On-line	3000	105	3Mbps
Internet Ghana	4000	250	2 E1 + 2 Mbps (SAT-3)
IDN	4000	200	1E1
TIN-IFA	0	20	512Mbps up/ 512Kbps down
ITS	5000	35	?
3rd Rail	0	50	3Mbps up/ 512Kbps down
GS Telecom	0	70	1 E1
Natal	0	40	?
Nas Global	0	20	128 Kbps/128 Kbps
USB Ghana	300	15	?
Africa Express	500	40	?
Afripa Telecom	0	25	?
Africanus	0	15	?
Total	~ 23,000	~ 1000	~ 25Mbps

2.2 Internet Cost and Tariffs

The basic elements for Internet pricing from service providers will normally depend on the infrastructure access fee, the connection fee and the fee for usage. The Internet pricing mechanism can be based on whether a fixed flat monthly fee, usage-based on data bundle consumed and an agreed bandwidth package with the ISPs. The volume of data consumed by the subscribers is common among the ISPs where the cost per megabyte or gigabyte of data used is charged. Internet pricing can be used for the network efficiency where the utilization of resources such as buffer space, bandwidth as well as the economic efficiency which is the value of the user satisfaction and a maximized revenue for service providers. [9] A limited network infrastructure will directly translate in the high cost of Internet service for subscribers. The cost of Internet connectivity and bandwidth has considerably reduced compared to the early years when the Internet came to Ghana. Broadband and dial-up access is quite cheaper in 2006, compared to the year 2001. [10] Table 2 sourced from the Ministry of Communication gives a comparative analysis of the years 2001 and 2006 below;

Table 2 : Internet and International service in 2001 and 2006

		2006	2001
I	Local call cost	US$0.054	US$0.21
II	Call to US cost	US$0.5	US$1.5
III	Internet access cost	Dial-up US$25-35 per month/ US$100-120 per year. Broadband: Average Installation fee: US$120 Plus Subscription fee of US$65per month	X 3
IV	Average cost of 20 hours of Internet use (cyber-cafe)	US$20	US$60
V	Price of full circuit (to US/UK) SAT-3/WASC	Non- GISPA- US$8,000 Non-ISP-US$12,000 GISPA members – US$4,010	US$120
VI	Average satellite	US$5,500	US$15,000

	price (1Mb/s)-duplex		

Table 2 : Internet and International service
Source: Ministry of Communications,
http://www.nca.org.gh

From the table above, the costs of Internet bandwidth in the year 2001 and that of 2006 indicates a downward trend in the cost of accessing the Internet and other communication services. The average cost of the Internet services for 20hours as at 2006 was $20, which is a decrease from $60 from the year 2001. Over the years as the number of subscribers increased in the country, the cost of Internet services for customers has declined and more accessible to consumers. The simple reason that can be attributed to the reduce cost in the Internet tariffs is the improvement of network infrastructure that has increased the number of leased landlines and expansion of the national fibre optic backbone to connect urban and rural areas together. Another reason is as the number of ISPs increase there is competition in the market to provide cheaper Internet service to subscribers.

Some service providers have entered the Ghanaian market to provide dedicated and reliable Internet services to customers at a relatively cheaper cost. Some of the ISPs in Ghana have built their own network infrastructure to provide connectivity to regional capitals with the combination of VSAT. The ISPs are now focused on providing Internet services to both private and public organizations as well as academic institutions. The Internet has become more pervasive among users in HLIs for their academic work. Over the years, government has put in place measures with the necessary funding to build a national fibre optic backbone for the country. Ghana's national fibre optic backbone is very limited and the infrastructure does not exist in the rural areas of the country and that compounds the issues of HLIs to tap into the national fibre optic backbone for high speed Internet connectivity. According to the National Communications Authority (2009), Ghana's fibre optic network only covers a distance of 1315 kilometers from the approximated 238,533 square kilometers. [11] This is woefully inadequate and Governments are making more interventions to expand the national fiber optic backbone. ISPs in the country therefore continue to build their own network infrastructure to expand the Internet access to consumers in rural areas in which the cost is passed on directly to the subscribers. Currently the big ISPs in the country that provide competitive Internet bandwidth packages for both public and private institutions include; Surfline, Busy, Vodafone, MTN and Airtel-Tigo. These ISPs are providing competitive Internet bandwidth packages for academic institutions in the country. The Internet service connectivity price "war" among the service providers is very good according to the industry players, because it will give subscribers the flexibility to choose which ISP best meets their organizational needs with cost and availability as the key factors to consider. It is in view of this, that one of the aims of this paper is to look at the source of Internet services among Higher Learning Institutions (HLIs) in Accra, the Internet bandwidth packages offered as well as the Service Level Agreements (SLAs) with the ISPs. This paper will also look at the equipment required for Internet service distributions to the HLIs.

III. RELATED WORKS

The Internet has become the most important source for accessing information where it offers users the ability to communicate in the network and also to retrieve updated information. High Learning Institutions (HLIs) in developing countries like Ghana, serve as a resource pool to provide the human resources in the economic development of the country. University libraries that act as a centre for

academic research activities will require reliable Internet connection to remain relevant in a fast changing ICT environment. Well resourced libraries in HLIs will normally depend on the quality of the Internet service connection to the ISPs that will link these libraries to a global research network. In a study by Kichinji, [12] on designing a bandwidth manager prototype in order to achieve an efficient bandwidth utilization for tertiary institutions in Kenya. The aim of the study is to adopt a bandwidth utilization strategy by using traffic controls that is available in Linux kernel. With this method of traffic control in bandwidth management, Linux is programmed to allow borrowing an interclass borrowing of bandwidth for users uploading and downloading in the Internet with the optimal use of bandwidth resources and thereby reducing wastage. The results obtained from the simulation proved that using Linux as bandwidth managing tool can achieve an efficient bandwidth utilization for tertiary institutions. There is the need for academic institution to have a reliable Internet connectivity to the digital information space and help link institutions to their satellite campus. The advantage of Internet connectivity with a high-speed bandwidth for HLIs cannot be over emphasized since its benefits are enormous with some institutions currently making the appreciable effort to set up ICT labs. However, the high cost of Internet bandwidth and the lack of Internet connectivity for the some institutions still pose as a challenge for HLIs to join the digital information world. Access to academic resources such as e-journals, e-library, e-books in the web which are essential for academic research, is severely challenged and academic institutions need to invest more in this sector. There are different modes of Internet connection to private and public organizations that are provided by the Internet service providers. Academic institutions in the Africa cotenant have different mode of connectivity to their ISPs. Some HLIs have an agreeable fee charged by the ISPs for Internet connection based on a Service Level Agreement (SLA) with the institutions that need the services. In a study carried out by ATICS (2006), it was found out that the mode of connectivity to the Internet for some universities in Africa from their ISPs where namely by; dial-up (7%) leased line fibre (16%), leased line wire (32%), link wireless (16%) and VSAT (29%). [13] From the study carried out it is indicate of that most HLIs rely on a leased line wires and VSAT for the Internet connectivity to their service providers. Some developing countries in the cotenant have made tangible effort to improve Internet connectivity for academic institutions. One country that has made the effort is Ghana, where the Ghana Research Network (GARNET) attracted the Danish Group to complete a VSAT to the University of Ghana (UG) to provide 128kbps and 512kbps. [14] The support from the Danish Group was to allow the UG connect Internet via VSAT to the university community. A study by Rosenberg (2005),[15]on establishing the digital status of university libraries in the African continent, pointed to the fact that VSATs is the most popular mode of connectivity to service providers because it widely available and cheaper, where an example cited by the OSIWA project in Nigeria that connected many libraries via VSATs. According to the findings by Rosenberg, it was further revealed that the use of fibre optic can reduce the cost of Internet bandwidth by approximately 80% compared to the use of terrestrial services infrastructure. Although VSATs is very popular among libraries on the continent, its main challenge has to do with the low speed connection that makes the bandwidth smaller. Several higher academic institutions continue to make strives to connect to ISPs that will provide them with reliable high bandwidth for academic research. Some academic institutions' Internet bandwidth is quite poor for the institutions to fully benefit from multi-media services and other academic resources on the web. Therefore the use of electronic classrooms in the Internet and online discussion platforms is greatly challenged. According to a study by Kyalo (2005) [16] in Kenya

noted the formation of Kenyan Education Network (KENET) with the goal of providing high speed and sustainable Internet connectivity for education Institutions will enhance teaching and learning among institutions and as well support electronic communication. The institutions connected to the KENET, later served as a hub where other universities connected to them to obtain Internet service. The KENET platform was able to support several institutions that connected to it for their academic libraries. According to research findings by Aluoch (2006)[17] Internet connectivity is relatively poor, unreliable and expensive among some universities in Africa where some institutions on the average pay as much as $40.50 per kilobits per second for a month whilst other institutions pay $36 per kilobits per second for a bandwidth compared to subscribers in North America that pay a little as $10 per month for 3mbps using DSL link. The findings of the study supported the claim that HLIs in African pay a very high cost of Internet bandwidth compared to other academic institutions in North America. The high cost of Internet bandwidth can be attributed to the lack of network infrastructure such as leased lines and a national fiber optic backbone that can be linked to an International optic backbone. The findings of another study conducted by Gakio (2006) [18] among 54 tertiary institutions from some twenty-seven (27) countries indicated that the Internet bandwidth capacity for both uplink and downlink were 706Kbps and 1254Kbps respectively for African universities, where in Africa HLIs paid US$4.58 per month. The study further reveals that the cost of Internet bandwidth is expensive compared to other universities in Europe. Ghana has made some significant gains in the provision of affordable Internet service through submarine cables. Ghana's capital, Accra has been connected to three (3) submarine cables namely; Mainone, SAT-3, and GLO1 that originates from Portugal in Europe. [19] Some Higher Learning Institutions (HLIs) are looking at the options of expanding their Internet bandwidth where Institutions are entering into an agreement with various ISPs in the country. The University of Ghana (UG) went into an agreement with Vodafone (ISP) to quadruple their Internet bandwidth where in February 2010, UG paid US$2.43 per kps that will sum up to US$27.75 per month. [19] It is expected that the bandwidth price will reduce with the arrival of the submarine MainOne cable. In May 2010, Vodafone (ISP) entered into partnership with Kwame Nkrumah University of Science and Technology (KNUST) to provide a 45mbps network to the university community [20] where the ISP was able to provide a higher bandwidth at a subsidized rate of 50% for the institution. This partnership was a good one that made KNUST as one of the universities in Ghana with the fastest Internet connection for their academic activities. Even though the bandwidth has improved considerably on the KNUST campus, more interventions still need to put in place to improve the Internet services within the university community and it's surrounding for students and staff. Internet Service Providers (ISPs) will normally price the cost of Internet service connection depending on the bandwidth an organization will like to subscribe. The cost of connectivity is a major factor in the pricing and the bandwidth packages agreeable with the organization. Larger educational institution will subscribe to bigger bandwidth that can accommodate a big number of users that may come at a higher cost to the institution. For Higher Learning Intuitions (HLIs) the objectives of the Internet bandwidth management are to minimize the cost of Internet bandwidth consumption as well as ensure a good performance of the Internet for key application within intuitions. They may be certain important applications that require the Internet to operate and therefore an efficient bandwidth management will support key applications to run. Another reason for bandwidth management is to ensure that there is no use of illegal applications online as well prevent the users from visiting prohibited websites on the Internet. This will allow network administrators to

closely monitor the type of application that consume Internet bandwidth and filter out websites that may be harmful.

3.1 Equipment for Internet distribution in Higher Learning Institutions

DSL Modem: A DSL modem is used to convert signals from digital to analog via a fixed telephone line connection. The DSL modem is suitable for sending and receiving signals using the telephone line to provide Internet connectivity to the subscriber. A DSL modem is usually built into an Internet broadband router and may not come as a separate component. The DLS can also serve as a broadband filter that will filter the signals in a telephone line to allow users to access both the Internet and other network services.

Router: A router is a network device that is responsible for forwarding and receiving data packets in a network. The routers will direct data packets that are being sent in a network platform. There are different types of routers for Internet connection to organizations. Some of the common routers like cisco router, lynx router that can be used in the Internet distribution to other computers in a network.

Network Hub: A hub is a device that connects two or more computers in a network. The network hub has multiple ports that allow it to connect physical cables. Some hubs can also serve as a switch where it has many Ethernet ports to distributed the network to other computers.

Wireless access point: A wireless access point is a network device that provides wireless signals to the devices in a Wi-Fi network to access Internet services. The wireless access point will normally connect to an Ethernet port on wired network, where it is configured to propagate wireless signals within an access point area. Users in a network will then connect to WI-FI to access the Internet. In some cases repeaters are required to boost wireless signals to cover a wider geographical area.

3.2 Internet Bandwidth Management Methods

Internet bandwidth management describes the efficient use of bandwidth for individuals or institutions. The goal of network administrators is to ensure that the bandwidth an organization subscribes to is available for usage. Network administrators will normally perform a cost effective analysis on which bandwidth packages best serves the institutional needs. The most common Internet bandwidth management techniques include the following;

Internet Restriction Usage: In this technique of bandwidth management the bandwidth is restricted by a network administrator for user groups or the type of application to be used online. With this technique, the bandwidth can be restricted to users, whereby users are allocated bandwidth quota monthly or weekly. This is usually common among academic institutions where students may be allocated a certain bandwidth to use for a specific period. Bandwidth can also be restricted based on specific applications in the web. Restriction can also be put on certain websites online based on the institutional policies.

Internet Time-shift Usage: This method can be used to manage and ensure the efficient use of Internet bandwidth in a time-shift process. In this technique the network administrator observes the peak and off-peak period of Internet usage within an organization and then put in place the necessary measures to allocate more bandwidth resources during the peak periods. This is seen to be efficient in a way that a smaller bandwidth is assigned to active users online during off-peak hours. Some traffic in the Internet are time-critical while others are not, thus more bandwidth resources can be allocated to web

resources and application that are time-critical during peak periods to ensure users have access to them.

IV. METHODOLOGY

The research methodology adopted for this study will be in two phases: Phase 1: In phase one we will gather data of some Higher Learning Institution (HLIs) in Greater Accra. We will look at their source of Internet, the bandwidth package offered by the ISP and their SLAs. We will analyze the bandwidth capacity offered by the ISPs of these institutions and the SLAs they have with these institutions.

Phase 2: In the second phase, we monitor and analyze the network for one of the HLIs in the study to view the Internet bandwidth consumption and Netflow of traffic. We will use a bandwidth simulation tool called Ipswich Whatsup Gold that can help to monitor the bandwidth consumption of users for both uplink and downlink. The goal is to view the bandwidth consumption of users hub on the network and to perform a bandwidth capacity planning. We will design and configure a network that also use proxy cache box to achieve the purpose of minimizing bandwidth usage.

4.1 Sample Population and Technique

The sample population for this study comprises of some private Higher Learning Institutions (HLIs) in Greater Accra Region, the capital of Ghana. We conducted the study among private Higher Learning Institutions because these institutions use their own internally generated funds to subscribe to their ISPs with no external support from the central government. Private academic institutions run on their own budget and they play an important role in absorbing a sizable number of students who seek to acquire university education. The study employed a simple random sampling technique involving private university colleges in Accra. In all, a total of (6) private universities colleges in Accra participated in the study namely;

Catholic Institute of Business and Technology (CIBT)
Methodist University College of Ghana (MUCG)
Ghana Technology University College (GTUC)
The Institute of Charted Accountants, Ghana. (ICAG)
Kings University College, Ghana (KUCG)
Zenith University College, Ghana (ZUCG)

4.2 Instrument for Data Collection

The main instrument used to collect the important data was mainly questionnaire. Questionnaires were used in this study because it was the most appropriate technique to achieve the objectives of the study. The data gathered from the fieldwork of the study is analyzed and presented in tables and graphs. In the data analysis, after the questionnaires have been collected, the results are then discussed and deduction done based on the results obtained.

4.3 Empirical Findings and Analysis

In the study, the data analysis and presentation of results are in a table and a graph. The results are then explained using appropriate tools. The table below indicates the relevant data obtained;

Table 3 : Data collected from HLIs in Accra

Name of Higher Learning Institution (HLI)	Internet Service Providers (ISPs)	Bandwidth from	Cost of Internet Bandwidt	Service Level Agreement with ISPs	Approximate number of users at peak periods

		ISPs	h package		
Methodist University College of Ghana (MUCG)	Vodafone (GH)	6mb/s	8718.50	Monthly subscription which includes maintenance	250 users
Ghana Technology University College (GTUC)	Vodafone (GH) DS3 Fiber Optic	80mb/s	¢ 40,000	Monthly subscription which includes monitoring, support services and maintenance of routers	1000 users
Institute of Chartered Accountants, Ghana (ICAG)	Vodafone (GH) DS3 Fiber Optic	20mb/s	¢ 16,880	Monthly subscription that includes Priority 1 support and dedicated services.	500 users
Catholic Institute of Business and Technology (CIBT)	Vodafone (GH)	4mb/s	¢ 1600	Monthly subscription and service	70 users
Zenith University College of Ghana (ZUCG)	Surfline (GH)	10mb/s	¢ 12,000	Monthly subscription, network support service and hardware maintenance	300
Kings University College Ghana (KUCG)	MTN (GH)	8mb/s	¢ 9,500	Monthly subscription which includes network support services	350

Table 3 shows the data collected in the fieldwork for participating universities in the study. The information is categorized into the following; the Internet Service Providers (ISPs) for the institutions in the study, the bandwidth from the ISP, the cost of Internet bandwidth packages and the approximate number of users the network can support during peak periods as well as the Service Level Agreement (SLAs) from their ISPs. From the table 2, the dominant ISP for Higher Learning Institutions (HLIs) in the study is Vodafone (GH). Vodafone provide Internet services to these HLIs either via a D3 fiber optic cable connection or using dedicated Vodafone landlines for their Internet services. The ISPs that also provide Internet services to other institutions in the study are Surfline and MTN (GH). From the data collected we note the cost of Internet bandwidth packages the ISPs provide to the HLIs. Big institutions with a huge population of students and staff will turn to go for a bigger bandwidth to accommodate huge numbers

that hub into the Internet for their academic activities. From table 2 above, GTUC subscribes to a bandwidth of 80mb/s at a cost of ¢ 40,000 ($8340) per month; ICAG has a bandwidth of 20mb/s at a cost of ¢ 16,880 ($3520) per month. It is important to note that both GTUC and ICAG use Vodafone D3 fiber optic service that is quite expensive. MUCG subscribes to bandwidth package of 6mb/s at a cost of ¢ 8718.50 ($1816) whilst CIBT subscribes to a bandwidth of 4mb/s at ¢ 1,600 ($335), where the institutions connected to the Internet from their ISP via a dedicated landline service. ZUCG has Surfline as

their Internet service provider with an agreeable bandwidth of 15mb/s at a cost of ¢ 12000 ($2500) per month. Kings University Collage of Ghana has MTN (GH) as their ISP that gives them a bandwidth of 8mb/s at a cost of ¢ 9,500 ($1980). A graphical representation in a pie chart is illustrated below as a percentage of the total bandwidth the institutions subscribe to their service providers in **figure 1.**

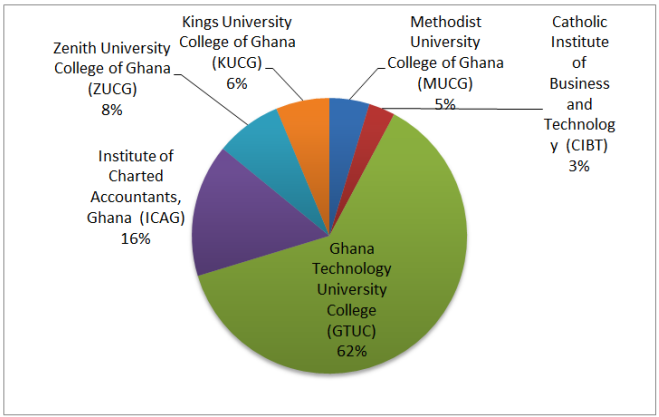

Figure 1 : A graphical representation of bandwidth capacity among HLIs

From figure 1 above we view the Internet bandwidth capacity for the Higher Learning Intuitions (HLIs) that participated in the study in percentages. In figure 1, the information represented in a pie chart for the HLIs in the study shows that GTUC has 62% of the bandwidth capacity, ICAG has 16%, ZUCG has 8%, KUCG has 6% and MUCG has only 5%. CIBT has the lowest bandwidth capacity that is 3%. With these information HLIs need to put place adequate measures to increase the bandwidth capacity and reduce the cost. There is need for an efficient network configuration to reduce the Internet bandwidth consumption for users in the academic space. An efficient bandwidth management will reduce the consumption of bandwidth resources for the HLIs and allow them to go for a relative cheaper bandwidth package at a reduced price from their ISP.

4.3 Type of Internet Connection and Service Level Agreement with ISPs.

The types of Internet service connection to the academic institutions are; using DSL cable, fibre optic cable Internet service and 4G wireless access services. Institutions such as CIBT, MUCG use dedicated Vodafone landline cables to provide Internet service to the academic Institution. With this type of Internet connection the institution uses Vodafone router to transmit and provide Internet service signals to the institution. GTUC and ICAG, uses Vodafone D3 fiber optic cable that provide fast Internet connection to the academic institutions. This type of Internet connection is very fast and quite expensive at the same time. The Vodafone fiber optic cable is an ultrafast broadband service that provides Internet. ZUCG and KUCG use 4G wireless access services to access the Internet service that is quite fast as well. With these ISPs are able to transport and send the signals to all users in the network to access the Internet within the signal coverage area. They type of Services Level Agreement (SLA) from the ISPs to the institutions is to provide general network routine maintenance services. The SLA simply looks at the contract between the service providers and the subscriber. The ISPs in the study provide periodic maintenance of network equipment such as routers, modems and wireless access points to the institutions when they are damaged. The also resolve network failures and denial of service attacks to restore Internet services to the institutions.

4.4 Ipswich Whatsup Gold Monitoring Software

Ipswich Whatsup Gold is a monitoring software used to monitor an entire network infrastructure. Whatsup Gold automatically discovers all network devices in a network, gives a report and an alert of the network performance. A key feature of Whatsup Gold is that it can allow users to measure and determine how much bandwidth the network actually requires. This will give network administrators the ability to perform a bandwidth planning capacity for the growth of a network. The flow monitor in Ipswich Whatsup Gold can also be

used to monitor the traffic as well as identify traffic trends in a network. We selected GTUC, one of the HLIs in the study to monitor their network. GTUC was selected for the network simulation and monitoring because from the data collected, the university college has the biggest bandwidth capacity at a high cost compared to the other institutions. In the Whatsup Gold simulation, we configured and discovered all devices in GTUC wireless network called Hotspot. Figure 2 shows all the devices that are discovered in GTUC Hotspot. All the client computers discovered in the Hotspot are connected to the main wireless router (access point) where each device has an IP address. Figure 4 shows the devices found in Hotspot are then ping to see how they respond from the monitoring device. Some devices in the Hotspot network respond when ping while others devices do not in the network.

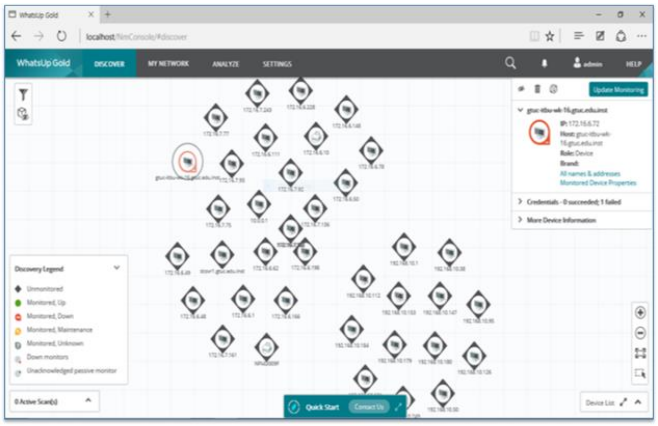

Figure 2 : Whatsup Gold discovery of GTUC Hotspot Network

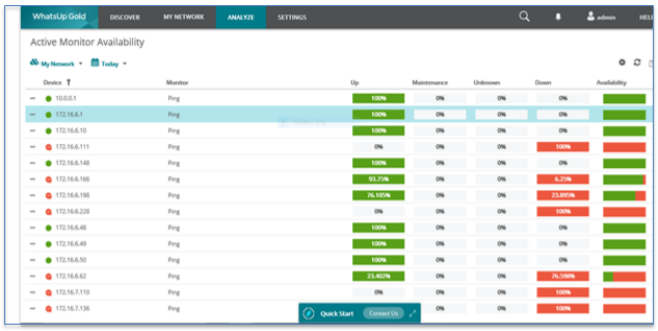

Figure 3: Ping discovered devices in GTUC Hotspot

Figure 4 : Response of client devices being ping in Hotspot

When we monitor the bandwidth usage graph for the nodes in Hotspot, we are able to view the flow data rates for users on Hotspot network in both uplink and downlink. With the downlink we have an average speed of 20kb/s whilst the uplink gives an average speed of 4kb/s. This shows the speed in which users in the network are able to send and receive data packets.

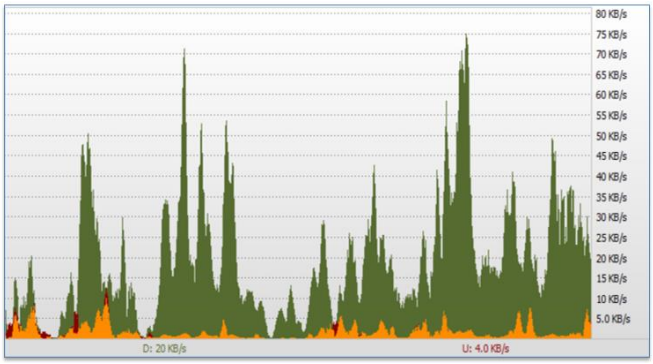

Figure 5: Graph of bandwidth usage of device in Hotspot

In the bandwidth simulation we view the usage report of data packets sent and received in a day. Figure 6 shows that data packets received on 11/2/2018 is 145MB whilst packet sent is 9.00MB for client users on Hotspot network. Comparatively, on the 11/1/2018, the data packets sent and received is 147MB whilst the data packet sent is 9.37MB for users on the Hotspot network.

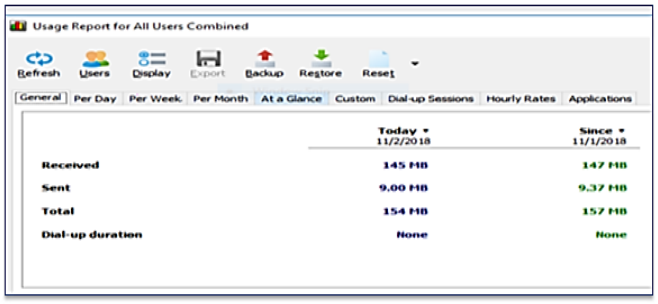

Figure 6: A Usage report for all users on Hotspot

In figure 7 the hourly rates of bandwidth consumption for all users in Hotspot, where network flow shows the bandwidth consumption within specific hours in the day and the average hourly bandwidth consumption in Hotspot network. The hourly rates of bandwidth consumption for all users is indicated in figure 7 and the bandwidth within specific hours.

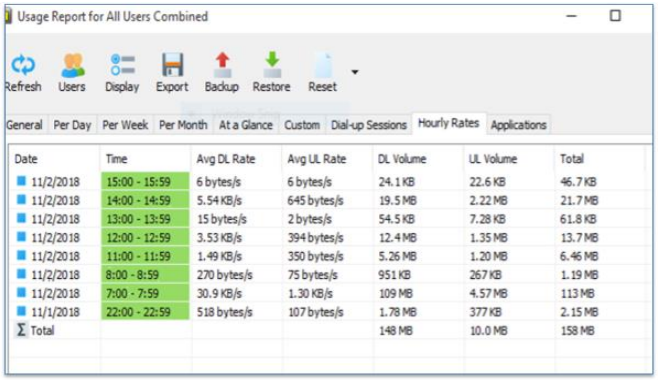

Figure 7 : Hourly bandwidth usage in Hotspot

In summary the simulation carried out in GTUC Hotspot enable us view the traffic flow and the bandwidth consumption capacity of devices hub to the network. This gives network administrators an opportunity to plan an efficient bandwidth capacity and make bandwidth resources available for key applications during peak periods.

4.5 Managing Bandwidth Network Configuration and Simulation

In this section, we examine the environment for the network configuration and the platform for the simulation. Packet tracer is used for the simulation because it allows us to see the metrics of data packets sent and received from the configured devices in the network. This gives a conceptual view of the flow of data packets among the configured devices in the simulation. In setting up the simulation, the network devices used in the packet tracer environment are namely; client computers, switch, router, DNS server, web server, a proxy cache box and a private mail server. The devices are connected via straight cable. Each device is then configured and assigned static IP address to connect with the other devices in the network. In the simulation in packet tracer we used bandwidth management technique via cache boxes. With this technique of bandwidth management a network is configured using proxy cache boxes to manage bandwidth consumption. The web client is configured in such a way that it allows the client browsers request to pass through the cache box automatically to access the web server. The proxy cache box will in turn host and retain the frequently visited web contents in the configured network. The proxy cache box when configured will obtain frequently accessed web pages from a main web server that will make it easily accessible from a web client end. Web caching allows proxy cache boxes to store copies of recent or frequently web pages access in the main web server. The copies that are stored in the cache box deliver the content to the user at the web client when it is requested again. This in a way will reduce the network traffic and resources required to access the previous visited web content. This will considerably reduce the bandwidth consumption in the network by using a proxy cache box. A model diagram of a network simulation using cache boxes is illustrated below;

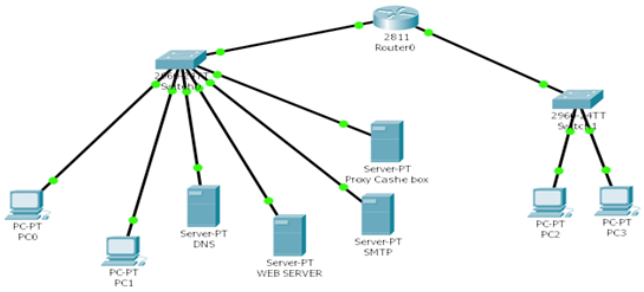

Figure 8 : Network configuration setup for simulation

The client computers are connected to a switch in the network. The name server, web server, private mail server and the proxy cache are configured with static IPs to connect and share information among the devices. The simulation set up is indicated in figure 8, where client computers send request passes through the proxy cache and then to the main server.

Table 4 : IP address for devices in the simulation

Network Device	Port	Link	IP Address	MAC address
P_{C0}	Wired	UP	10.0.0.6	00E0.A3A1.C801
P_{C1}	Wired	UP	10.0.0.7	00E0.A3A1.C802
P_{C2}	Wired	UP	192.168.0.2	00E0.A3A1.C803
P_{C2}	Wired	UP	192.168.0.3	00E0.A3A1.C804
DNS server	Wired	Down	10.0.0.1	00D0.97B7.CA59
Web server	Wired	Down	10.0.0.2	00D0.97B7.CA60
SMTP server	Wired	Down	10.0.0.3	00D0.97B7.CA61
Proxy Cache Box	Wired	Down	10.0.0.4	00D0.97B7.CA62

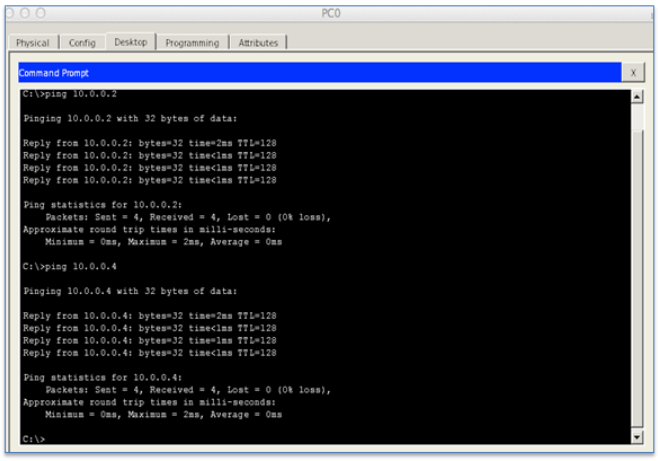

Figure 9 : Pinging Web server to test for connection.

When the web server is ping in figure 9 above from client computer $P_{CO,}$ we are able to test the connection of the device configuration in the network and view the data packets sent and received. The ping statistics show that the total packets Sent = 4, Received = 4 and Lost = 0. This clearly shows the number packets sent is the same as the number of packets received. The simulation in Figure10, shows the data packets send from the source to its destination. Client computers are able to receive and send the data packets as well as the servers in the network. When a user browser sends a request to access information from the web servers, data packets is captured as it moves from to its source to the main web server. Automatically the cache box will keep a copy of the web content access, when the client browser sends request to access the same information again, then the cache box will releases the information to the web browser. This process is displayed in the auto PDU play of data packets sent and received in the network.

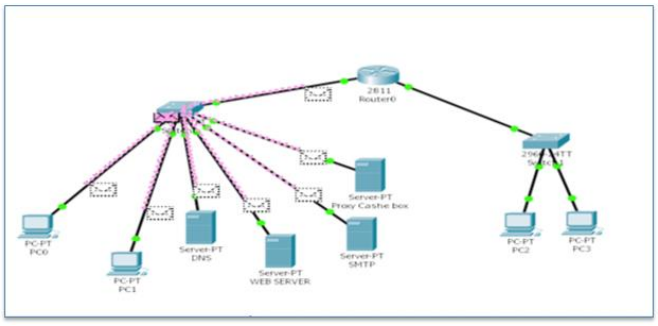

Figure 10 : Data packets send to destination

The Figure 10 shows the conceptual flow of data packets from the sources to its destination. The data packets received by the individual configured devices in the network. As the data packets arrive in to their destination, the colour of the packet changes to pink to signify the successful arrival of the data packets to its destination. Figure 11 shows the successful arrival of the data packets to their destination.

This network configuration done is Packet tracers when implemented will allow for the efficient management of bandwidth resources. With this network configuration we are able to manage the bandwidth consumptions from the client browsers end in accessing information in the main web server. Once the contents from the main web server is buffered at the proxy cache box, the client browser is configured to automatically pass through the proxy cache box. This will reduce the traffic and resources required to reach the main web server. It also creates an allusion that the network is fast from the client computers end. An efficient management of bandwidth resource using this network configuration will allow bandwidth to be used by only key applications. In summary the above network configuration and simulation done in packet tracer can be used to manage the bandwidth consumptions drastically and thus allow HLIs to subscribe to smaller bandwidth from their Internet service providers at a reduced cost.

V. CONCLUSION

In this study we successfully carried an analysis on the cost of Internet bandwidth for some Higher Learning Institutions (HLIs) in Accra and their source of Internet services. We then monitored the network bandwidth usage for GTUC, one of the institutions that participated in the study. In this paper, we designed and simulated a network that will allow for an efficient management of bandwidth resources. One of the main aims of the study is to look at the source of Internet services for HLIs, the cost of bandwidth packages and how to efficiently optimize the bandwidth usage for the HLIs. An efficient management of bandwidth resources will allow for the HLIs to go for smaller bandwidth that meets the needs of the HLIs at a reduced cost. In the related works, we look at the source and bandwidth packages for some HLIs in sub-Sahara Africa. An analysis of the bandwidth service packages are done in the study and we then proceeded to examine the early ISPs in Ghana providing Internet services to academic institutions in the country. In the first part of the study we gathered empirical data from the participating HLIs in the study to determine their source of Internet services, the bandwidth package the institutions subscribe to and the services level agreement with their ISPs. Institutions with a huge population of academic staff and students will go for a bigger bandwidth package at a higher cost to accommodate the needs of users in the academic environment. We then analyzed the empirical data from the HLIs and did a comparative analysis of the Internet bandwidth packages the institutions are currently using. It is important to note that some institutions with bigger financial muscle are able to afford D3 fibre optic services that is quite expensive. In the study, we monitored the traffic and bandwidth consumption for the GTUC network called Hotspot. Whatsup Gold was used to monitor GTUC Hotspot and it gave us a view of the bandwidth consumptions of all devices in the network as as well as network flow traffic. In monitoring Hotspot, we discover the entire devices hub to the network, the traffic flow and bandwidth consumptions of devices in the network. In the second part of the study we designed and configured a network that will allow for the efficient management of bandwidth resources that can be used by the HLIs. Cisco Packet Tracer was used for the network simulation to optimize the bandwidth usage in a network. The network configuration set makes used of clients, servers and

proxy cache box to achieve the aim of managing scarce bandwidth resources. In the simulation done in packet tracer we ware able to have conceptual view of data packets flow in the network. In conclusion, the network design when implemented will efficiently help manage the bandwidth resources in a network. This will reduce the network traffic and the bandwidth required to access the main web service since most of the content can easily be accessed from the proxy cache box that has been buffered. This is a novel procedure when adopted by HLIs to manage their Internet bandwidth consumption from the client computers in a network. An efficient bandwidth management will allow HLIs to go for a smaller bandwidth to meet the academic needs of institutions at a reduced cost. This will make an efficient bandwidth optimization a good value for money for HLIs.

VI. REFERENCES

[1]. Ignatius Fosu, "Exploring the potential of wireless technologies to accelerate universal Internet access in Ghana" Elsevier Telecommunications_ Policy 35_ (2011) 494–504 Available on: www.elsevierbusinessandmanagement.com/locate/telpol

[2]. William Foster, Seymour E. Goodman, Eric Osiakwan "Global Diffusion of the Internet IV: The Internet in Ghana " Communications of the Association for Information Systems Volume 13, 2004) 654-681

[3]. William Foster, et al "Global Diffusion of the Internet IV: The Internet in Ghana" Communications of the Association for Information Systems Volume 13, 2004) 654-681

[4]. A world bank report (2001) on Africa ICT Infrastructure Buildings, siteresources.worldbank.org

[5]. Osiakwan, E (2000) on Ghana's Internet Industry Available on: chanzocapital.com

[6]. Ministry of communication, Ghana, National Communication Authority. Available on: http://www.nca.org.gh

[7]. Tamakole, L. "The Internet in Ghana" Personal Communication (July 2003)

[8]. https://www.researchgate.net/Global_diffusion_of_the_Internet_IV_The_Internet_in_Gh

[9]. Eric Osiakwan " The Case for "Open Access" Communications Infrastructure in Africa: The SAT-3/WASC cable Ghana case study " ASSOCIATION FOR PROGRESSIVE COMMUNICATIONS (APC) APC-200805-CIPP-R-EN-PDF-0047 ISBN 92-95049-49-7

[10]. Burkhard Stiller, Peter Reichl, Simon Leinen "Pricing and Cost Recovery for Internet

[11]. Services: Practical Review, Classification, and Application of Relevant Models"

[12]. Computer Engineering and Networks Laboratory TIK, ETH Zu ̈rich, Available on:

[13]. https://www.researchgate.net/Pricing_and_Cost_Recovery_for_Internet_Services

[14]. Internet and International services, National Communication Authority, Ghana. (July 2007) Available on: http://www.nca.org.gh

[15]. NCA, R.W. "Public consultation on the selection and award procedure for licenses in the 2500—2690 MHz band" National Communications Authority (July 2009) http://www.nca.org.gh/consultations/Wireless_Broadband_Access_Public_Consultation_Rev_2_11_2009.pdfS.

[16]. Kithinji Joseph " Internet Bandwidth Management for Tertiary Institutions" International Journal of Computer Application Technology and Research, ISSN: 2319-8656 Available on: www.ijcat.com

[17]. African Tertiary institution connectivity survey (2006). ATICS 2006 Report. Available: http://biotrade.aauorg/renul/docs/ATICS2006.pdf

[18]. Echezona, R.I. and Ugwuanyi, C.F., "African University Libraries and Internet Connectivity: Challenges and the Way Forward" (2010). Library Philosophy and Practice (e-journal). ISSN 1522-0222 Available on: http://digitalcommons.unl.edu/libphilprac/421

[19]. Rosenberg, D. (2005). Towards the digital library: Findings of an investigation to establish the current status of university libraries in Africa. Oxford: INASP.

[20]. Kayla, V. (2005). Kenya education network. AAU Newsletter 11 (3): 6-7.
[21]. Aluoch, A.A. (2006). " The search for affordable quality Internet connectivity for African universities " AAU Newsletter 12 (3): 8.
[22]. Gakio, K. (2006). Africa tertiary institutions connectivity survey (ATICS) 2006 Report.
[23]. Botswana: Cyberplex Africa. Available: http://www.aau.org/renu/docs/ATICS 2006.pdf
[24]. Omollo, Kathleen Ludewig "Information and Communication Technology Infrastructure Analysis of Kwame Nkrumah University of Science and Technology and University of Ghana" http://hdl.handle.net/2027.42/85731
[25]. Ghana News Agency (10 May 2010). Vodafone to establish high speed Internet bandwidth at KNUST. Retrieved 15 May 2010 from http://www.businessghana.com/portal/news/index.php? op=getNews&id=126875.