Investigation on Quality of Service Provided by Third Tier Internet Service Providers in Nigeria: Akure Cybercafés as case study

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***Abstract*—This paper presents an investigation into the quality of service (QoS) of cybercafés networks in Nigeria using five different cybercafés in Akure metropolis as a case study. The study was carried out in three stages. In the first stage, Distributed Internet Traffic Generator (D-ITG V. 2.4) was used to measure the QoS metrics such as packet loss, average jitter, bandwidth and delay standard deviation on the five cybercafés networks investigated. The second stage, involves the administering of questionnaires to users of studied cybercafés in order to obtain primary data on some of the users' QoS metrics such as reliability and efficiency of the networks. The final stage involves visitation to the cybercafés considered to obtain onsite data on specifications of computers using for browsing in the cybercafés. The result of the study shows that all the networks considered were inefficiency, congested and unprotected. It was also found from the study that, there is direct correlation between the bandwidth, number of terminals and the efficiency of the network. The paper was concluded with suggestions on how to improve the QoS of internet cybercafés in Nigeria in order to enhance teaching and research through internet facility in the country.**

Keywords- *Cybercafé; Internet service providersg; Tiers of internet service providers; Quality of service metrics*

I. INTRODUCTION

With the explosive demand for the right information at the right time, Internet, corporate intranets, and business-chain extranets, web-based networks have been replacing the conventional local area networks (LANs) and wide area networks (WANs) as the mainstream of computer information technology [1]. The usage of Internet worldwide today, is not just another marketing channel neither it is just another advertising medium nor just a way to speed up transactions but it is the foundation for a new industrial order [2]. This has led people, companies as well as government and non-government organisations across the globe to adopt Internet as a new means of disseminating and retrieving information. As a result of the effectiveness of Internet in information dissemination and retrieval, it has become an indispensable tool in academic research, commerce and health delivery to mention a few.

The Internet is a global system of interconnected computer networks that use the standardized Internet Protocol Suite. It is simply defined as the network of networks that consists of millions of privates and public, academic, business, and government networks of local to global scope that are linked by copper wires, fiber-optic cables, wireless connections, and other technologies [3]. It is a mechanism for information sharing and means of collaboration and interaction between individual and computer without the barrier of distance or geographical location [4]. Its communication potential has reduced the gap between the developed and the developing nations in their access to information, which is vital for addressing the nation's socio-economic problems [5].

In Nigeria, like other nations of the world, the use of Internet is gaining momentum. However, unlike other technologically advanced countries, Internet connections exist only in urban locations. Likewise, the percentage of the citizenry having access to the Internet from home is minima. Hence, majority of the people that access the Internet do so from Internet café or shop popularly referred to as either Cybercafés or boutique Internet Service Providers (ISPs) in the cities.

Generally, there are three distinct tiers of ISPs with each being characterized and differentiated in a number of ways including: Customer base size, Internet backbone accessibility, Wholesale/retail sale capabilities, Service offered and Physical connectivity. For instance, the Tier 1 ISPs comprised of the larger ISPs and Telecommunication companies and organizations with direct, multiple connection to the Internet backbone. This makes it most reliable connection and serves only the Tier 2 ISPs. Tier 2 service providers are connected to the Internet via a Tier 1 ISPs. They primarily serve large companies and Tier 3 ISPs. The Tier 3 ISPs are those carriers that solely purchase Internet protocol (IP) transit from other carriers, ISPs or networks (typically Tier 2 providers) in order to reach the majority of the Internet. Tier 3 ISPs generally service a selected group of customers from within a localized geographical area such as within the confined of a single metropolitan area. They serve primarily medium and small companies and homes. They are therefore being looked upon as

"boutique" ISPs or "retail" ISPs. They are called "retail" ISPs because they provide Internet in little quantity to the end-users. They are the readily available Internet access point in Nigeria where various categories of Internet users patronize.

Within the last few years, there had been a widespread of these "retail" ISPs popularly called Internet cafes or cybercafés in Nigeria. However, with the widespread of cybercafés all over the places, the expectations of the Internet users in terms of qualitative QoS are not met. For instance, in Federal University of Technology, Akure (FUTA) and Akure metropolis, the complaints of all the Internet users are the same. It is mainly on the poor QoS experiencing in all the cybercafés within the metropolis. Though QoS as a generic performance measure has different meaning and definition to different people, the unique thing is that they all point toward the same meaning. While some defines QoS from technology side of view, others define it from users' experience and expectations. For instance, while [6] defines QoS as a collection of technologies, which allow network-aware applications to request and receive predictable service levels in term of data throughput capacity (bandwidth), latency variations (jitter) or propagation latency (delay), [7] advocate for a distinctly user-focused interpretation on the way in which a service performs to a level that satisfies the user of that service.

Since users are not concerned about how a service is provided, but only the resulting quality they receive, it is therefore reasonable to understand parameters users use in their evaluation of network QoS. Although such approach has traditional retail origins, service providers have little to offer customers if QoS is low. From users' point of view, four main factors were discovered to have direct linkages to the user perception of network QoS [8]: reliability, efficiency, predictability and satisfaction. While the underlying rationale behind each factor has been consistent, the manner in which it has been assessed for the different applications varies [6].

In generic terms, 'reliability' examines how important and useful it is to know in advance the level of network performance. 'Efficiency' represents a measure of how quickly the system responds to requests, or the perceived speed of network performance. 'Predictability' is concerned with the degree to which the user experience followed the expectations of the user, and 'satisfaction' probed to what degree the user was satisfied with each experience. Assessments of these factors afford service providers with valuable insight into user-perceived network performance requirements [6] and means of enhancing their QoS.

Following this introduction, the rest part of the paper is organized as follows. Section II gives a brief review of Internet history in Nigeria and the challenges that motivate this study. Section III, presents the methodology used in carrying out the study. In section IV, the results obtained from section III were presented and discussed in a way to meet the objectives of the study. Lastly in section V that concludes the study, suggestions on how to improve the QoS provides by cybercafés in developing counties like Nigeria were made.

II. HISTORY OF INTERNET IN NIGERIA AND STUDY MOTIVATION

The first Information and Communication Technology (ICT) initiative in Nigeria started in the 1950s with the focus on print and electronic media. However, no major outcome or benefit of ICT was achieved until the exit of Military rule in 1999. After the exit of Military rule, the Obasanjo administration established the National Information Technology Development Agency (NITDA) in 2001 to serve as a bureau for the implementation of National Policy on Information Technology. The establishment of NITDA exploded the Internet penetration level in Nigeria [9].

By 2002, the usage of ICT in governance started gaining momentum when some state governments embarked on e-government [10]. In the same way, by 2002, banks in their bids to deliver quality services and expand their operations started e-banking in Nigeria [11]. The same trend in usage of Internet facility spreads to the Nigerian educational sectors, with establishment of cybercafés in some Nigerian universities' campuses such as Obafemi Awolowo University (OAU), Ile-Ife, in 2002 and FUTA in 2004.

Globally, as the world educational system today is increasingly becoming the information and knowledge base for the transformation of the world through qualitative teaching and research outputs, it is obvious that Internet has become an invaluable tool for teaching, learning, and research [12]. Therefore, for research outputs of any institution to be relevant, it must base on reliable and update information. Hence, scholars involve in teaching and research need quick and easy access to relevant and update information which Internet has been observed as the enabling tool.

A review of the literature shows that students and lecturers are the regular users of the Internet, which they use mostly for research and educational purposes. For instance, in a survey conducted by [13] at University of Calicut, Kerala, India, revealed that students, research scholars, and teachers used the Internet for the purpose of study, research and teaching respectively. In a similar study conducted by [14], it was found that the Internet is used by academic staff as a tool for teaching preparation, research, and academic work. Outcome of [14] further revealed that, the use of Internet and knowledge of its advantages are significantly correlated with the age of the academic staff as well as their knowledge, skills, and experience in using computers and the Internet.

Similarly, in a study at the Engineering Colleges of Orissa, India conducted by [15], the result revealed that majority of the colleges use the Internet to provide online demonstrations. At Science and Technology community of Lucknow city, India, a related survey was carried out [16] to access the level of awareness and demand of web based learning among Science and Technology information seekers. The result of the survey showed that 36.6% of the users consulted e-journals regularly on the Internet, 40.4% used Internet for consulting technical reports, 24.8% used the Internet to find online databases and 10.4% used the Internet for Telnet service. Likewise in Nigeria, [17] conducted a study on internet usage with particular reference to OAU, Ile-Ife. The study revealed that the respondents used Internet to access research materials and for e-mail. The study concluded that the use of Internet for academic activities would improve significantly if more

Internet access is provided in academic departments. This has certainly geared up Institutional Management in most Nigerian higher institutions to embark on provision of Internet facilities on their campuses to aid teaching and research.

However, for the Internet provided in Nigerian schools to be relevant to teaching and research, QoS must be ideal while users (students and members of staff) are equipped with the right tools of exploiting the potentials of the Internet. This will invariably enhance the quality of both the Nigerian Universities research outputs and graduates. This study therefore addresses the issue of poor QoS in FUTA own Cybercafé and some privates Cybercafés in Akure metropolis where both the lecturers and the students of the institution are using for teaching and research. The study becomes imperative because the author is of the opinion that good QoS of Cybercafés in Akure and her environs will indeed improve the teaching and research output of the institution.

In order to achieve this aim, the study was embarked upon with the following objectives. Firstly, to determine the technological QoS metrics (e.g. packet loss, jitter and delay variation, efficiency, reliability, etc.) effects on wired local area networks and offer necessary suggestions of reducing their negative effects. Secondly, to determine the effects the specifications of computer using for browsing has on uploading and downloading of data as well as the effects of bandwidth on uploading and downloading of data.

III. RESEARCH METHODOLOGY

A. The study Area

The study was carried out in Akure, the capital of Ondo State, Nigeria. Akure lies on Latitude 7^0 15′ and Longitude 5^0 12′ of the equator. The city is in the South-West geo-political zone of Nigeria. The city has a population of 360,268 [18] with 49.6% (178,672) male and 50.4% (181,596) female. Akure was chosen as a true representative model for this study because all categories of Internet users (students, lecturers, businessmen, government officials and civil servants) reside in the city. There are two higher institutions (FUTA and Federal College of Agriculture, Akure) and two research institutes (Engineering Materials Development Institute, Akure and Technology Incubation Centre, Akure) within the city where members of staff and students use Internet for teaching and research. These and the availability of cybercafés within one of these institutions and around the city make the city suitable for the study.

Five different cybercafés (FUTA Café, Lan Computers Café, Soft Designs Café, System Plus Café and WellSpring Café) within the city were used. Brief details about each cybercafé are as follows:

- FUTA Café is located within the premises of the FUTA. The café was commissioned in 2004. There are 50 computers in the cybercafés for the users. The computers are arranged in such a way that it provides little privacy among the users. At every point in time, the number of end-users on this network can not be ascertained as the university members of staff use it in their offices as well as those in the café. There are always 5 members of staff of the cybercafé on ground to attend to users' complaints and enquires. The café uses a very small aperture terminal (VSAT) connection and paid for a bandwidth of 256/128kbps.

- Lan Computers Café is located along Oba Adesida Road after the Oja-Oba Market. It has 15 computers and two staff are on duty at all times. The café also uses VSAT connection with bandwidth of 64kbps full duplex.

- Soft Designs Café is located at Lafe Shopping Complex, Lafe Junction along Oba Adesida Road. It has 15 computers. The arrangement of the computers gives no privacy for users. Soft Designs Café also uses VSAT with 64kbps full duplex.

- System Plus Café is located at Ricabin House also along Oba Adesida Road in the city. There are 40 computers in the café with two staff on duty to handle customers' complaints. VSAT connection is equally used in the café with 64kbps full duplex bandwidth.

- WellSpring Café is located at Atolagbe Shopping Complex beside FUTA South Gate. It started operation in 2006 and has 20 computers for the customers. The arrangements of the computers also do not give privacy to the customers. It has either 2 or 3 staff on duty at a time to attend to customers. The café uses VSAT connection with 128kbps full duplex bandwidth.

B. The study stages

Stage I: In this stage, an open-source Distributed Internet Traffic Generator (D-ITG V. 2.4) computer program [19] was installed on two computers in each of the five cybercafés used for the study. The detail on the generator was presented in [19]. The generator was used to determine the technological parameters (bandwidth, jitter and delay) for determining the studied cybercafés networks QoS. One of the two computers, on which the generator was installed, was used for sending of the traffic flow and logging purposes while the second computer was for receiving and decoding. Application program in C++ was written to instruct the computers to send data or packets from the sender to the receiver. The results captured by the receiver were decoded, stored and tabulated. The obtained data are presented and discussed fully in section IV.

Stage II: The prepared well structured questionnaire was administered to customers of the studied cybercafés. The questionnaire was divided into two sections. The first section is the introductory part, where the aim of the study was stated for the respondents. The section also contains words of assurance and encouragement, assuring respondents that the information provided by them would be treated with utmost confidentiality.

The second section of the questionnaire consists of a total of 13 questions on objectives of the study. The section was divided into four subsections:

- the first subsection deals with the background information about reliability assessment parameters relevant to the study. Total of four questions were asked in this subsection by which the reliability worth of each of the cybercafé considered was determined.
- the second subsection extracts information on the efficiency of each of the cybercafé considered. Three questions were asked in this subsection on how fast the systems on the network respond to requests.
- the third subsection contains two questions on how the consumers' experiences followed their expectations. In addition, two other questions on users' satisfactions in each of the cybercafés understudied were asked. Total of four questions were asked also in this subsection.
- in the fourth subsection, two questions were asked on the network security.

One thousand four hundred (1,400) copies of the questionnaires were prepared and distributed in the studied cybercafés. The distribution of the questionnaires was based on the number of computers on the network of each of the considered cybercafés. Ten questionnaires were allocated to each computer on the network. The administering of the questionnaire in cybercafés outside FUTA campus was targeted mostly on users that were students and teachers of all categories that use Internet for teaching and research, though other categories of users were considered as members of FUTA non-teaching staff were considered. The administering of the questionnaires took almost a month. Table I shows the detail on the questionnaires distribution and amount retrieved that was used for the study. The response from the survey is presented and discussed fully in section IV.

Stage III: The selected cybercafés studied were visited by the author. During such visitations, specifications of few of the computers in each of the five cybercafés studied were inspected. This was to randomly determine the specifications of each of the computers used in those cybercafés. Some of the specifications recorded are: the computer processor speed, the size of hard disk and the memory capacity of the computer using. The data gather on the field study is presented and discussed fully in section IV.

TABLE I. QUESTIONNAIRE DISTRIBUTION DETAILS

Cybercafé	Questionnaire		
	Number Distributed	Number Retrieved	Percentage Retrieved
FUTA	500	500	100.0
Lan Computers	150	142	94.7
Soft Designs	150	147	98.0
System Plus	400	368	92.0
WellSpring	200	200	100.0

IV. RESULTS AND DISCUSSION

The results of the test carried out on each of the cybercafé network using D-ITG V. 2.4 software to determine the technological QoS metrics of each of the five cybercafés' networks is presented in Table II. The result of the study shows that FUTA cybercafé has the highest percentage packet loss value (17.97%) followed by WellSpring cybercafé (5.39%) while Lan Computer cybercafé has the lowest percentage packet loss value of 0.43%. This indicates that the level of congestion on FUTA network is the highest. The congestion at the WellSpring cybercafé, which is the closest to FUTA campus is the next follows in rank while congestion on the other cybercafés located farther from the university are relatively low. This observation buttresses [12] finding that Internet has become an invaluable tool for teaching, learning and research nowadays. Similarly, the result of the test shows that the delay experience over time called jitter, in all the cybercafés considered were bearable. The jitter effect will be undetectable since the value is low. Jitter effect becomes noticeable when it is as higher as 40ms which is not applicable in any of the cybercafés' networks considered.

TABLE II. D-ITG V. 2.4 TEST RESULTS

Cybercafé	Packet Loss (%)	Average Jitter (ms)	Bandwidth (kbps)	Delay Standard Deviation (ms)
FUTA	17.97	0.80	40.43	25.63
Lan Computers	0.43	0.68	48.95	3.04
Soft Designs	0.57	0.50	48.89	25.57
System Plus	3.05	1.03	47.65	4.29
WellSpring	5.39	1.40	39.34	14.60

Also from the test, the delay standard deviation which is the sequence of time that passes between packets sent and received for the 5 cybercafés was obtained. The result shows that delay experience at FUTA and Soft Designs cybercafés were the highest followed by WellSpring cybercafé. On the other hand, the delay in System Plus and Lan Computers cybercafés were relatively low with that of the Lan Computer cybercafé the lowest. This shows that FUTA Internet network is inefficient enough for teaching and research. In addition, the result of the test revealed low bandwidth values for FUTA and WellSpring cybercafés while others are relatively higher. This means that the amount of information that can be transmitted in a given time, usually a second, on FUTA and WellSpring cybercafés' networks are very low compare to other cybercafés considered. This account for low connecting speed of the two cybercafés' networks compare to other cybercafés considered. This test also reveals that, the quality of service in both FUTA and WellSpring cybercafés' networks are poor compare with others three cybercafés investigated and that the two networks, though in academic environment are not ideal for teaching and research.

Table III shows the customer's or user's QoS metrics considered in evaluating the five cybercafés investigated. From the Table (i.e. Table III), Lan Computers cybercafé was justified the most reliable and most efficiency by the respondents while FUTA cybercafé's network was rated worst. In addition to the four regular parameters (reliability, efficiency, predictability and satisfaction) normally use by

customers or end-users of the network to determine the QoS on the network, the study included network safety in this study. Respondents were asked to rate the probability of virus attack on each of the cybercafé investigated. It was discovered that the probability of contacting virus on the WellSpring network is the highest while chance of contacting virus on Lan Computers network was again the lowest.

TABLE III. CUSTOMER QoS PARAMETERS OBTAINED

Cybercafé	Reliability	Efficiency	Predictability	Satisfaction	Network Safety
FUTA	80 (26.7%)	62 (20.7%)	42 (14.0%)	38 (12.6%)	78 (26.0%)
Lan Computers	104 (36.6%)	80 (28.2%)	27 (9.5%)	44 (15.5%)	29 (10.2%)
Soft Designs	86 (29.3%)	67 (22.8%)	58 (19.7%)	31 (10.5%)	52 (17.7%)
System Plus	79 (28.6%)	64 (23.2%)	30 (10.9%)	47 (17.0%)	56 (20.3%)
WellSpring	84 (28.0%)	75 (25.0%)	20 (6.7%)	30 (10.0%)	91 (30.3%)

The data gathered from the third stage of the study is presented in Table IV. By considering the number of terminals in each of the cybercafé, it was found that the number of terminals, the bandwidth and the specification of computer using for Internet browsing by the end-users have direct correlation. For instance, the Lan Computers that was justified the most efficient and reliable from the study has only 15 terminals while System Plus café with the same bandwidth value and better computers configuration is not as reliable as Lan Computers cybercafé (see Table IV) because of larger numbers of terminals (40) on System Plus network per time. The same reason accounts for the poor performance experience in FUTA cybercafé network, despite its high bandwidth value and better specifications of computers being used on this network because of highest numbers of end-users on the network per time. This shows that efficiency of the network has direct relationship with both the bandwidth and the number of end-users on the network per time.

V. CONCLUSION AND RECOMMENDATION

The result of this study reveals that all the cybercafés investigated were over utilizing their bandwidths with the exception of Lan Computers cybercafé. It was also discovered that all the operators of the cybercafés investigated did not protect their computers and the end-users removable storage media from viruses and other malicious programs (spyware). This also has direct impact on their computers and server leading to ineffectiveness of their networks. Above all, this investigation has buttressed previous studies [12,17] that had established the fact that Internet is essential tool for quality teaching and research. Also, the study as open up steps to be taken in order to enhance the QoS of computer network most especially Internet cybercafé network for effective teaching and research in developing nations of the world like Nigeria. It is based on these observations, that the following suggestions were made:

- Cybercafés operators should limit the number of terminals on their networks to ideal numbers corresponding to their bandwidth.

TABLE IV. TERMINAL DEVICE CONFIGURATION IN EACH CYBERCAFÉ

Cybercafé			RAM Size	Hard Disk	Processor Speed
Name	No. of Terminals	Bandwidth (kbps)			
FUTA	50	256 (Uplink) 128 (Downlink)	(i) 256 MB (ii) 96 MB	(i) 38.4 GB (ii) 37.2 GB	(i) 400 MHz (ii) 796 MHz
Lan Computers	15	64 Full Duplex	96 MB	37.2 GB	766 MHz
Soft Designs	15	64 Full Duplex	(i) 224 MB (ii) 512 MB	(i) 75 GB (ii) 76.3 GB	(i) 2.6 GHz (ii) 1.2 GHz
System Plus	40	64 Full Duplex	128 MB	31.4 GB	533 MHz
WellSpring	20	128 Full Duplex	(i) 128 MB (ii) 128 MB	(i) 9.3 GB (ii) 9.3 GB	(i) 548 GHz (ii) 450 GHz

- FUTA cybercafé bandwidth especially should be increased to enhance teaching and research in the institution. Similarly, the private own cybercafés should either increase their bandwidth or reduce the number of their terminal in order to cater for their ever increasing customers.
- the computers in the cybercafés networks should be well protected against viruses and other malicious programs by using anti-virus and other defender programs as this will enhance the efficiency of the networks and their networks' QoSs.

It is believed that if the above suggestions can be observed and put into practice, it will not only enhance the QoS on the network, but will indeed increase the profit margin of the private cybercafés owners. Finally, if the suggestions can be observed, it will enhance the quality of both the graduates and researches in Nigeria universities and contribute greatly to the socio-economic development of the nation.

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