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Performance Evaluation of the Interconnect Clearing Houses in the Nigerian Telecommunications Industry

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ABSTRACT A telecommunications Clearinghouse (CH) refers to a central exchange where calls from different mobile network operators (MNOs) are interconnected for the purpose of independently measuring how much traffic from one MNO was carried by another MNO. This enables interconnection traffic and billing to be correctly determined without dispute between concerned MNOs. There are ongoing contentions between the MNOs and the Clearing Houses in Nigeria, as to whether the Clearing houses have adequate infrastructural capacity to carry the off-net traffic routed through them by the MNOs. This paper presents the performance analysis of two out of the five licensed interconnect clearing houses in Nigeria. This was done by analyzing data obtained from the facilities. Basic parameters from this data, which was collected at Time Consistent Busy Hours (TCBH) are the carried calls (i.e. total incoming traffic), the Circuit Seizures or the CCS figures, and the congestion figures. These parameters are then used to calculate some critical exchange performance parameters such as: exchange Grade of Service (GOS), route utilization, route congestion percentage, answer-to-seizure ratio (ASR), traffic intensity (in Erlangs), as well as the number of channels the infrastructure requires to conveniently carry the measured Busy Hour traffic without terminating or delaying other lines. The data is analyzed using traffic engineering schemes. Results Obtained show that in compliance with the regulator on the 10% minimum threshold of interconnect traffic that must be routed through the interconnect exchange operators, the two CHs studied were found to have adequate capacity to conveniently carry the amount of traffic being routed through them, with a GOS of 1.38% and 0.2% respectively. Hence, the authors conclude that, at the moment, the mobile operators can conveniently route 10% of their interconnect traffic through the Clearinghouses.

Keywords: Clearinghouse, Grade of Service, Traffic, Erlang-B, Off-net

Introduction

The Interconnect Clearing House model was established and licensed by the Nigerian Communications Commissions (NCC) in 2004 to serve as a third party to Mobile Network Operators. They were also licensed to work as transit operators for receiving and distributing calls from different operators as well as to ensure appropriate revenue sharing and to ensure central monitoring of nationwide off-net calls of different operators. Part of their function is to provide systems for policing fraud and ensuring revenue/tax collection. Currently, active clearing houses in the country include: (i) Interconnect Clearinghouse Limited, (ii) Medallion Communications Limited, (iii) NicoonX Communications Limited, (iv) Solid interconnectivity Services Limited, and (v) Breeze Interconnect Limited. The figure 1 shows a clearinghouse interconnecting MNOs.

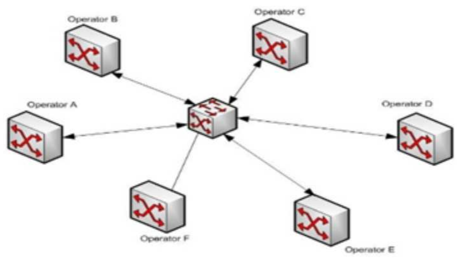


Fig.1: Network Architecture of an interconnected clearing house model (Medallioncom.com)

2. Background of Study

Since 2001, the era of the telecom industry deregulation in Nigeria, the country, inter alia, has been plagued with the issue of interconnection indebtedness. Operators are indebted to one another due to non-payment of the tariff for their traffic that passed through fellow operators' network. This is threatening the growth of the industry as the debts have been on a steady rise till date. Our research has unravelled one of the major causes of the indebtedness, inter alia, as the differentials in billing records amongst MNOs that are connected on the peer-to-peer basis. When the amount of interconnection fees payable is in dispute amongst these MNOs, the financial obligation of remittance of such fees are neglected, thus the debt piles (communications week, 2012). However, in the event that a clearinghouse (which is a third party that routes traffic that originated from one MNO and terminates on another) is involved, there is, therefore, an independent record stating "how much" traffic was exchanged between both concerned operators. Hence, the resulting interconnection fee can unanimously be agreed upon (The communicator, 2016). But in the wake of time, mobile operators have preferred to exchange traffic directly amongst themselves than through the CHs, on the grounds that the CHs, inter alia, does not have enough capacity to route 10% of the combined capacities of the MNOs as mandated by the regulator. Moreover, as at first quota of 2016, an MNO with 23% market share was the only mobile operator that did not route any percentage of its traffic through any CH (NCC, 2016). This has therefore created a miasma in the telecommunications sector in Nigeria.

Thus, there is a need to carry out a performance evaluation on the licensed clearing houses, by carrying out tele-traffic engineering analysis on them based on the current traffic they carry, in order to ascertain their current infrastructural capacity. This will enable proper determination of the capacity gap they need to fill to be able to route the requisite amount of traffic.

The rationale for the establishment of ICHs is unique and excellent (The communicator, 2016). This indicates that if properly implemented, the clearing houses in the telecommunications' scene, has the potency of propelling the sector to the next phase. However, if improperly, partially or not implemented at all, it could seriously impair the Nigerian telecommunications sector. The clearing houses are licensed to perform the following functions:

i. Accurate billing, reconciliation, and better service provision
ii. Zero debt tolerance
iii. Remove Hazards posed by peer-peer system
iv. Faster off-net calls connection
v. Eliminate congestion posed by peer-to-peer connection
vi. Provision of mobile number portability services
vii. Co-location services and single point of connectivity services to VAS providers
viii. Central monitoring of traffic for tax and security purposes
ix. To reduce money and time spent in resolving interconnection disputes amongst operators (The communicator, 2016).

Research Methodology

The method used in this work is tele-traffic engineering analysis. This is usually employed in telecommunication network dimensioning. Network dimensioning refers to processes involved in determining the minimum capacity requirements that will still allow the Grade of Service (GoS) requirements to be met. This is often achieved with traffic measured during the busy hour. To effectively dimension a telecommunications network, traffic engineering techniques must be employed (Chettinad College, n.d.). Traffic is defined as the occupancy of the server. The basic purpose of traffic engineering is to ensure that while resources are economically utilized, conditions for adequate service provision to subscribers are determined. That is, without compromising Quality of Service (QOS). Traffic engineering offers the foundation for scrutinizing the design of telecommunications networks or model, as well as the dimensioning capacity for the design of telecommunication networks (Bharat, 2007). It provides means to determine the quantity of the basic equipment needed to provide a particular level of service with respect to the given traffic pattern and volume.

For a loss system, the GOS is the probability of loss. With Traffic Engineering, it is possible to determine the ability of a network to carry a given traffic at a particular loss probability(GOS). This is achieved by balancing the following factors based on a given amount of traffic: (i) Grade of Service (GOS) and (ii) The requisite resources or Infrastructure. The following parameters are used in network dimensioning:

(i) Busy Hour: This is the 60-minute interval that has the highest call traffic in a day. Busy Hour may depend on several factors such as stock market, weather, international events and holidays. In addition to these variations, there are unpredictable peaks which could be caused by money activity, weather, sporting events, etc. Hence, it is expedient that such fluctuations be taken into account when designing switching networks. There are, therefore, three kinds of busy hours (Iversen V.B., 2015):

(ii) Average Daily Peak Hour (ADPH): In this kind, the busiest hour is determined separately for each day, with each day having different timing and then averages over a number of days.

(iii) Time Consistent Busy Hour (TCBH): This is a one-hour period, same for each day, which produces the highest traffic over specified number of days.

(Vi) Fixed Daily Measurement Hour (FDMH): This is a predetermined, fixed measurement hour, say between 19:00 - 20:00 hours; with the measured traffic is averaged over the days under considerations.

Erlang(E): It is an international dimensionless unit of telephone traffic as a measure of offered load or carried load. For calls carried, the value followed by "erlangs" is a representation of how many concurrent calls were carried by the circuits in a specified period (often one hour). One erlang traffic refers to a single channel that is in continuous use. While 1.5E, refers to two channels in which one is used to 100 percent capacity and the other, 50 percent capacity (Introduction to switching systems).

Traffic ***Intensity(TI):*** This is the measure of the traffic in terms of occupancy of the servers on the network within a specified period of time, usually a busy hour. It is calculated as:

$$A = CTh \quad Erlangs \qquad (1)$$

From the above, it is obvious that the Traffic Intensity is a Call-Time product, therefore, two parameters are involved: *Th* is the average holding time of a call while C is the average calls arrival rate. Traffic Intensity is sometimes also referred to as "Subscriber traffic" or "Trunk traffic". These, therefore, introduces to traffic viewed in two dimensions. While one is based on traffic generated by subscribers, the other focuses on the observation of busy servers in the network. There are instances when the traffic generated by subscribers overgrows the capacity of the network. When this situation occurs, either of the following happens:

i. The excess traffic is either gets discarded without being serviced or
ii. The excess traffic gets queued and wait till the busy channels are free.

These two kinds of systems listed above are the Loss Systems and Delay Systems respectively. Clearing houses, which have conventional automatic switches behave like loss systems.

A loss system is made up of two basic performance parameters, which are the Grade of Service and blocking probability.

Grade of Service (GOS) is a measure of the probability that a percentage of the offered traffic will be blocked or delayed. It is often expressed as a fraction of calls that fail to receive immediate service and ends up eventually blocked or the fraction that is forced to wait longer than a given time.

$$GOS = \frac{LostTraffic}{OfferedTraffic} = \frac{BlockedBusyHourCalls}{OfferedBusyHourCalls}$$

$$GOS = \frac{A - Ao}{A} \qquad (2)$$

where A_0 = traffic carried, A = Traffic and $(A - A_0)$ = Lost Traffic

A general standard for GOS telecom networks is 0.02 (2%). That is, 2 out of every 100 offered calls may be blocked. The smaller the GOS value, the better the QOS. The blocking probability B is defined as the probability that all the servers in a system are busy. It is a very important parameter to be considered in the dimensioning of any telephone network. However, there is a difference between GOS and blocking probability. While the GOS is from the subscribers' point of view, the blocking probability is from the network/switching point of view (Okechukwu U., 2013). Blocking probability can be calculated using techniques such as Lee graphs and Jacobaeus methods. The probability that traffic exceeds some set threshold, constitutes the basic idea of congestion theory. During which no new calls are granted access into the system. Congestion could be grouped into either Time or Call congestion. While time proportion is the percentage of the TIME that all channels on the network are busy, Call congestion is the ratio of the CALLS that arrive when all servers are busy. We can therefore also call GOS, Call Congestion and the Blocking probability, Time Congestion.

An ideal switching system is one which has the number of subscribers equal to the number of channels. If such a system exists, traffic analysis would be useless. But this is practically impossible and uneconomical. thus, the need for traffic analysis. So, in the situation where an incoming call finds all channels busy, the call would be blocked. There are two kinds of systems with different reactions to call block: (Teletraffic engineering, 2005) Loss Systems and Waiting Systems.

In these Loss systems, call-block is handled by simply refusing to service calls that arrive when the lines are all occupied. Delay system: In this system, the blocked call waits in the system until when resources are available. Conventional telephone systems are Loss-like. In this research, attention is focused on loss blocking. while for a delay system, the probability of waiting. The Erlang formula is used to determine the GOS of loss systems (that is, the blocking probability) having N channels, with offered traffic A.

The erlang formula is also useful for the determination of any of the three parameters when the other two are known. The erlang formula is based on the following assumptions:

i. Occurrence of calls are independent
ii. That calls that arrive at a switching center have a poison distribution
iii. Calls are served in the order of arrival.

Based on the assumptions above stated, there are three models of loss systems, they are:
i. Lost calls cleared (LCC)
ii. Lost calls returned (LCR)
iii. Lost calls held (LCH)

There are times we dial a number and we receive the "Network Busy" message. When this happens, it means all the lines are presently in use and there is no available line momentarily. Your call is therefore terminated until you reinitiate the process again, which is then assumed to be a new call. This is how an LCC system operates.

The first person to account fully and accurately for the effect of cleared calls in the calculation of blocking probabilities was A.K. Erlang in 1917 (Teletraffic engineering, 2005). In an Erlang loss system, three variables are involved and are constantly manipulated. When two variables are known, the third can then be seamlessly computed.
i. The number of Channels
ii. The GOS
iii. The Traffic Intensity

According to erlang, the probability of loss is given by:

$$P(N) = B(N, A) = \frac{A^N}{N! \sum_{k=1}^{n} \frac{A^K}{k!}}$$

(3)

Equation 3 above is referred to as the Erlangs formula of the first kind, the Erlang-B formula or Erlangs loss formula (Ally j,) In telecommunications network design and dimensioning, it is necessary to find the number of trunk lines needed for a given offered traffic and a specified grade of service.

Utilization or trunk occupancy, on the other hand, is the carried load per channel. This, in the data, is expressed as:

$$Utilization = \frac{MaximumBusyChannel}{TotalChannel}$$

(4)

Hence, we shall be using the Erlang-B calculator to dimension two Interconnect clearing houses in Nigeria, in order to determine the capacity (number of channels) needed to carry the busy-hour traffic with insignificant or no blocking, while keeping the QOS to standard (Teletraffic Engineering, 2005).

4. Traffic Measurement and Data Collection

Data collected from two licensed interconnect operators, named X and Y (for anonymity) were processed and computed. Traffic engineering schemes were employed to perform data and load analysis in order to determine the interconnection traffic at peak period for a service provider and the infrastructure or bandwidth needed to maintain it without terminating other lines and affecting QoS.

Data from Interconnect Clearinghouse X was taken during the busy hour period of 18:00 - 19:00 hours, from the 1st to the 28th February 2016. The summarized data, which is used for our analysis excludes the identity of all the operators involved. Only the total traffic routed into and out of the facility at the defined busy hour is here represented, for anonymity reasons, as seen in table 1 below:

Table 1: Data from clearinghouse X

				CLEARING HOUSE X							
TIME: 18:00 Hrs - 19:00 Hrs											
DATE	CC:I	CSS:I	CC:O	CSS:O	TOTAL CHANNEL	CONGESTION	CONGESTION % (GOS)	UTILIZATION %	TRAFFIC INTENSITY	ASR	
										INC %	OUTG %
2/1/2016	53761	22297	32536	13669	1522	81	0.25	30.36	813.40	41.47	42.01
2/2/2016	52251	21231	31789	13081	1522	91	0.29	25.47	794.73	40.63	41.15
2/3/2016	44837	18812	32844	13869	1522	65	0.20	28.32	821.10	41.96	42.23
2/4/2016	45204	18749	34738	14473	1522	100	0.29	28.42	868.45	41.47	41.66
2/5/2016	44921	18905	38102	15942	1522	77	0.20	29.84	952.55	42.08	41.84
2/6/2016	44332	18176	44307	18176	1522	120	0.27	32.6	1107.68	41.00	41.02
2/7/2016	39990	15897	39968	15897	1522	64	0.16	29.65	999.20	39.75	39.77
2/8/2016	43688	18536	43665	18536	1522	76	0.17	29.55	1091.63	42.43	42.45
2/9/2016	44422	18847	22227	9266	1522	49	0.22	24.86	555.68	42.43	41.69
2/10/2016	43151	18262	22321	9294	1522	43	0.19	22.95	558.03	42.32	41.64
2/11/2016	55858	23951	28674	12150	1522	51	0.18	29.49	716.85	42.88	42.37
2/12/2016	56333	24016	29011	12203	1522	58	0.20	29.02	725.28	42.63	42.06
2/13/2016	54879	21345	28998	11696	1522	54	0.19	24.77	724.95	38.89	40.33
2/14/2016	54066	21306	28049	10901	1522	31	0.11	29.23	701.23	39.41	38.86
2/15/2016	65910	27397	41467	16993	1522	75	0.18	40.6	1036.68	41.57	40.98
2/16/2016	78045	31071	51692	20729	1522	104	0.20	46.01	1292.30	39.81	40.10
2/17/2016	45447	17482	41208	15954	1522	73	0.18	39.12	1030.20	38.47	38.72
2/18/2016	52848	20281	52622	20199	1522	52	0.10	39.65	1315.55	38.38	38.39
2/19/2016	60786	23710	60565	23628	1522	48	0.08	38.97	1514.13	39.01	39.01
2/20/2016	47351	18680	47167	18608	1522	39	0.08	28.95	1179.18	39.45	39.45
2/21/2016	41441	15764	41284	15708	1522	27	0.07	27.8	1032.10	38.04	38.05
2/22/2016	46351	18490	46129	18421	1522	50	0.11	28.24	1153.23	39.92	39.93
2/23/2016	77441	28065	77335	28030	1522	387	0.50	47.74	1933.38	36.24	36.24
2/24/2016	111360	39262	107165	39260	1522	540	0.50	56.1	2679.13	35.26	36.64
2/25/2016	114536	41009	114518	41009	1522	221	0.19	55.15	2862.95	35.80	35.81
2/26/2016	109077	38165	109075	38165	1522	230	0.21	49.33	2726.88	34.99	34.99
2/27/2016	117750	41094	117746	41094	1522	142	0.12	73.31	2943.65	34.90	34.90
2/28/2016	129494	45128	129467	45128	1522	51	0.04	65.82	3236.68	34.85	34.86
SUMMARY	**63411.79**	**24497.43**	**53381.04**	**20431.39**	**1522.00**	**107.11**	**0.20**	**36.83**	**1334.53**	**39.50**	**39.54**

$$TrafficIntensity = \frac{VolumeofCalls}{CallPeriod} = \frac{C \times Th}{T}$$

(5)

For this analysis, call holding time is taken to be 90 seconds = 1.5minutes

Therefore, $Th = 90\sec s \equiv 1.5\min s$

$C = 53381$, $T = 60\min s \equiv 1hour$

$$TrafficIntensity = \frac{53381 \times 1.5}{60}$$

$$= \frac{80071.5}{60}$$

$$TrafficIntensity = 1334.525 Erlangs$$

$$GradeOfService = \frac{CallsOffered - CallsCarried}{CallsOffered}$$

.

$$GOS = \frac{LostTraffic}{OfferedTraffic} = \frac{BlockedBusyHourCalls}{OfferedBusyHourCalls} = \frac{A - Ao}{A}$$

$$AverageGOS = 0.2\%$$

Table 2: Data from Clearinghouse Y

			CLEARING HOUSE Y							
			DAILY PEAK HOUR TRAFFIC ANALYSIS			TIME: 19:00 Hrs - 20:00 Hrs				
DATE	CC:I	CSS:I	CC:O	CSS:O	TOTAL CHANNEL	CONGESTION	CONGESTION % (GOS)	UTILIZATION %	ASR	
									INC %	OUT %
4/1/2016	13856.83	5109.25	11417.38	4114.17	523.00	169.00	1.48	34.18	36.87	36.03
4/2/2016	9938.00	3606.79	10496.13	3902.92	523.00	101.00	0.96	22.70	36.29	37.18
4/3/2016	11381.21	4315.00	11448.13	4259.21	523.00	99.00	0.86	28.63	37.91	37.20
4/4/2016	10224.00	3634.58	21329.83	8241.38	523.00	132.00	0.62	22.70	35.55	38.64
4/5/2016	11905.54	3055.63	12511.33	3298.04	523.00	198.00	1.58	34.18	25.67	26.36
4/6/2016	12081.08	1720.17	13685.79	2234.08	523.00	119.00	0.87	22.70	14.24	16.32
4/7/2016	10617.71	2609.17	2163.46	1006.54	523.00	71.00	3.28	22.70	24.57	46.52
Summary	**11429.20**	**3435.80**	**11864.58**	**3865.19**	**523.00**	**127.00**	**1.38**	**26.83**	**30.16**	**34.04**

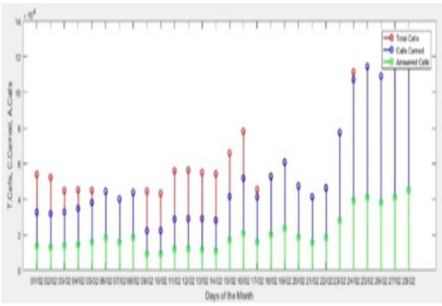
5. Results

The Erlangs-B calculator is utilized to compute the infrastructure (number of channels) needed to maintain the measured-offered traffic without termination other lines and affecting QOS. After computation, we obtain the following results for the ICN clearing house:

- In order that the facility may support an average Busy Hour Traffic Intensity of 1,334.525E
- Given a standard GOS of 2%,
- The Number of Lines/Channels conveniently required for this are 1403 lines.

Plots for Clearinghouse X

Figures 1 below shows the graphical representation of total, carried and answered calls, while Fig.2 shows the system utilization with respect to the threshold mark of 70%, set by the regulator,



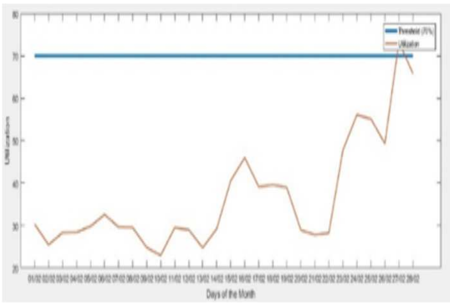
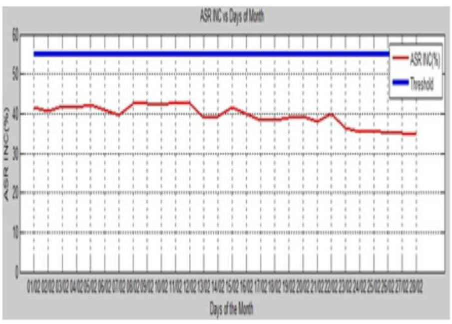


Fig.1: Total, Carried & Answered Calls *Fig.2: System Utilization*

Figures 3 & 4. below, are the graphs for Answer-to-seizure ratios (ASR) for traffic coming in and out of the exchanges, with respect to the 55% (INC threshold) and 65% (OUTG threshold) values set by the regulator.



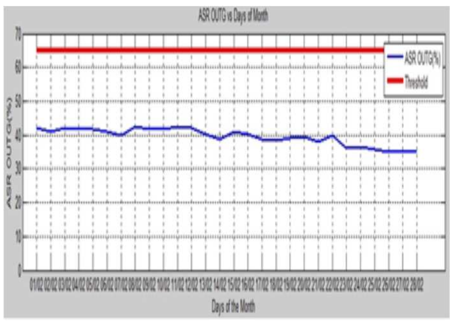


Fig.3: Answer-to-Seizure Ratio (INC) Fig.4: Answer-To-Seizure Ratio (OUTG)

Figure 5. below shows the plot for GOS obtained from the CH, with respect to the 2% standard threshold.

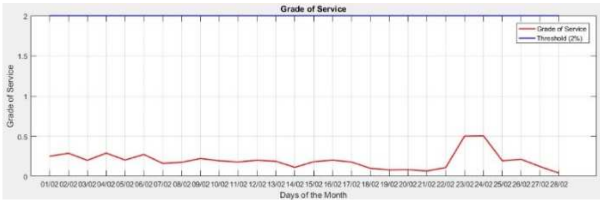


Fig.5: Grade of Service

Plots for the Clearinghouse Y

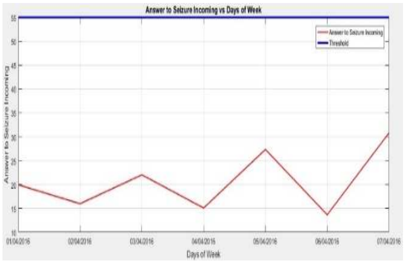


Fig.6: Answer-to-Seizure ratio (INC)

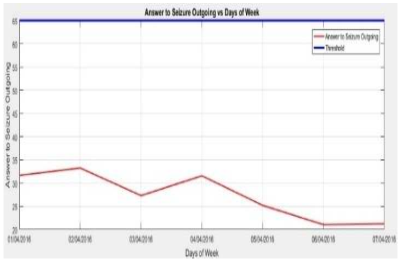


Fig.7: Answer-to-Seizure Ratio (OUT)

Fig.8: System Utilization

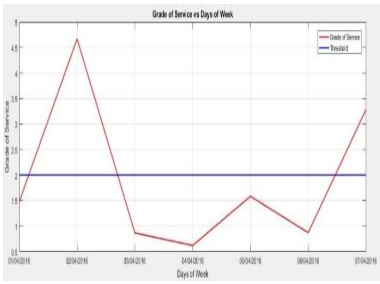


Fig.9: Grade of Service

Discussion

As can be read from the data for clearinghouse X, the average number of channels available to route the busy hour traffic for the month of February 2016 was 1,522 channels, having obtained an average of 2% GOS. On using Erlangs calculator, the ideal value needed to route the equivalent amount of traffic was obtained to be 1,403 Channels. Thus, the difference in the gap to be filled by this CH is 1,522 – 1,403= 119 channels. This means the facility has an excess of 119 unused channels that were not used to route the traffic that was passed through the facility in the whole month. To maintain the stated amount of traffic without termination other lines and affecting QOS, the facility requires 1,403 channels or more.

Similarly, for clearinghouse Y, the average number of channels available to route the busy hour traffic was 523 channels, with the GOS of the facility obtained to be 1.38%. On using Erlangs calculator, the ideal number of channels needed to route the equivalent amount of traffic was obtained to be 316 Channels. Thus, the difference in the gap to be filled by this CH is 523 – 316= 207 channels. This means the facility has an excess of 207 unused channels that were not used to route the traffic that was passed through the facility at the period data was collected. To maintain the stated amount of traffic without termination other lines and affecting QOS, the facility requires 316 channels.

6. Conclusion

Nigeria has achieved so much growth and advancement in the telecoms sector especially in the past decade, however, more effort need to be put in to ensure that as forerunners and leaders in the growth and development in this sector in Africa, are not inhibited and overtaken by other countries due to lack of vision political undertones. The regulations guiding the CHs be reviewed and the facilities constantly monitored, to enable them handle interconnect are non-discriminatory and independent manner, while carrying the confidence of both regulator and operators especially in matters relating to money. Finally, the policy implication of this study suggests that; for the CH to be fully effective, the Federal government, through the regulator should ensure that all operators are persuaded or coerced to route all their off-net traffics through these facilities (as obtained in Ghana), although this would require an equivalent increase in the capacities of the CHs.

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