GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL 14, NO. 4, 2008: 467 - 471
 ISSN 1118-0579

MEASUREMENTS AND ANALYSES OF KEY PERFORMANCE INDICES OF TELEPHONE TRAFFIC IN KADUNA AND KANO METROPOLISES

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(Received 21, August 2007; Revision Accepted 5, June 2008)

ABSTRACT

Measurements of key performance evaluation indices of telephone networks such as answer bid ratios, answer seizure ratios, call completion ratios, bids per circuit per hour, seizures per circuit per hour, per cent over flow, mean holding time per seizure and traffic carried in Erlang were made in Kaduna and Kano metropolises at determined peak hour periods. Their results show that there is poor quality of service as depicted from the low values of answer bid ratios, answer seizure ratios, call completion ratios and that challenges exist in service diversification, congestion, handoff, blocking and disparity in interconnection rates. This research work has also shown that although Nigeria has witnessed spectacular growth in the mobile telecommunications environment rising from one of the lowest mobile telephone markets to one of the fastest in the world, there is inadequate number of telecommunication operators and lack of sufficient transmission bandwidth and backbone infrastructure.

KEYWORDS: Key, performance, indices and telephone traffic, bids, traffic

INTRODUCTION

Communication involves the sending, processing and receiving of information which could be by electrical instruments or any other desired means in the form of voice, picture and written message. A communication system refers to the equipment used for the transmission and reception of information which may be in the form of a telephone network, radio link, satellite and optical fibres, amongst others.

Telephony is connected with the transmission of human voice to a distant place by wire or through space (radio). The normal telephone channel occupies a bandwidth of (300 - 3400)Hz, from the range of 0 - 4000Hz, which it is allocated. Signaling is done by tones within the base band of the telephone channel. A telephone conversation occurs in real time because it is a transaction of transmission taking place immediately or in an extremely short period of time.

According to Bear (1976) the expression of telephone traffic is given as

$$A = \lambda s \quad (1)$$

where A is the traffic in Erlang, λ, is the mean call arrival rate and s is the mean holding time. Erlang is the unit of telephone traffic named after Agner K. Erlang the originator of queuing theory (www.cn.wiki-pedia.org/Erlang.unit). Usually λ and s in equation (1) are mean values because in practice calls arrive at random and they are held a random length of time. The associated inter-arrival time and holding time distributions could be determined by taking measurements over a long period, and building up a pattern for these parameters.

If a telephone circuit carries one call continuously for one hour, it is said to carry one Erlang of traffic.

Theory

Rappaport (2003) suggested that the concept of trunking allows a large number of users in a limited radio spectrum and explained that trunking exploits the statistical behaviour of users so that a fixed number of channels or circuits may accommodate a large, random user community. He posited that telephone companies use trunking and queuing theory to determine the number of telephone circuits that need to be allocated for office buildings with hundreds of telephones and that this same principle is used in designing cellular radio systems. In order to determine the "quality of service" the following telephone traffic formulae were used.

Gibson (1999),Asouzu (2004) and Viswanathan (2004) calculated the key performance indices as follows:

(i) Total traffic carried in Erlang (TC):

$$TC = \frac{TTC}{10} \quad (2)$$

(ii) Total traffic per circuit in Erlang

$$= \frac{\text{Total traffic carried in Erlang}}{\text{Total number of available trunks during the busy hour}} \quad (3)$$

Note: Available trunks = connected trunks - faulty trunks

(iii) Answered bid ratio (ABR)

$$ABR = \frac{\text{answered calls}}{\text{total bids}} \times 100\% \quad (4)$$

(iv) Answer seizure ratio (ASR):

$$ASR = \frac{\text{answered calls}}{\text{total seizures}} \times 100\% \quad (5)$$

(v) Call completion ratio (CCR):

$$CCR = \frac{\text{answered + no reply + busy + number unobtainable}}{\text{total seizures}}$$

$$= \frac{\text{switch through}}{\text{seizures}} \quad (6)$$

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(vi) Mean holding time per seizure (MHTS):

$$MHTS = \frac{\text{total holding time}}{\text{total seizures}} \quad (7)$$

Where total holding time = traffic carried in Erlang multiplied by 1800s (for 30 minutes measurements), and total holding time = traffic carried in Erlang multiplied by 3600s (for 60 minutes measurements)

(vii) Bids per circuit per hour (BCH):

$$BCH = \frac{\text{bids}}{\text{available circuits during busy hour}} \quad (8)$$

(viii) Seizure per circuit per hour (SCH):

$$SCH = \frac{\text{seizures}}{\text{available circuits during busy hour}} \quad (9)$$

(ix) $$\% \text{ over flow} = \frac{\text{bids} - \text{seizures}}{\text{bids}} \times 100 \quad (10)$$

(x) Switch through = answered + no reply + subscriber busy + number unallowable + incomplete dial

(xi) Occupancy: Is the percentage of time that the circuits are utilized which is usually during one hour.

$$\text{Occupancy} = \frac{\text{total holding time}}{\text{available circuits}} \times 100 \quad (11)$$

Significance of Study

Many times we make calls without getting through due to congestion. We do not immediately know the reason. We quickly attribute this to network failure which, to some extent, is correct but the main thing is that the network cannot carry all the calls being made at that particular time. The objective of this study is to find out the key performance indices of busy hour in two metropolises in Northern Nigeria (of Kaduna and Kano). This will make it possible for one to know why the calls could not go through at particular hours.

MATERIALS AND METHODS

The following materials were used:

(i) 144 megabits per second digital carrier network carrying trunk traffic (El lines) through optical fibre transmission link to and from major cities in the North Western part of Nigeria and Secondary Centres in Kaduna.

(ii) 15000 subscribers' digital exchange (EWSD) in Kano Primary Centre and 27000 analogue local-loop network interfacing subscribers in Kano metropolis.

(iii) Telephone traffic from Kano international airport, many multinational companies, local switching centres and industries.

(iv) 20000 subscribers' digital exchange (EWSD) in Kaduna Primary Centre, 20000 analogue local-loop network interfacing subscribers, 2 EWSD secondary centres, international telephone switching centre (rTSC) in Kaduna metropolis.

(v) Functional private telephone operators, user-rD, for all the switching centres, dedicated computer with Microsoft excel, fax line, fax machine, printing materials, two technical assistants, computerized operation and maintenance terminal (OMT) with user friendly facility for telephone traffic measurements.

(vi) Telephone traffic from Zonal headquarters of parastatals of Northern Nigerian states, Nigerian Defence Academy, federal Ministries and local exchanges.

The methods used are summarized as follows:

(i) Management permission was obtained for user-ID, to access the operational maintenance terminal (OMT) software commands on call detail recorder and necessary commands to generate basic parameters on key telephone traffic events. User defined schedules were activated on all the selected switching centers.

(ii) Collation of measured raw telephone traffic data was carried out daily from 00.30 hrs to 24.00 hrs in all the selected exchanges by the stations switching managers and faxed to us. This was done for three months (May 27 - August 27, 2005.) to determine the busy hour for each route for outgoing and incoming telephone traffic in all the switching centres as well as interconnection points with PTOs.

(iii) Formats were drawn for analysis of key traffic events (bids, seizures, answers and traffic carried) for all the selected exchanges. Measurements collated after a month were used for the determination of the busy hour for the routes separately.

(iv) The busy hour for each route in all the selected exchanges was used and the software measurement commands earlier activated were modified to obtain measurements based on the busy hour only, everyday from May 27 - August 27, 2005.

(v) The switching managers faxed the measured raw data to us from Kaduna and Kano metropolises. The selected key traffic events were entered into tables for all the routes.

(vi) Monthly calculations and documentation of key telephone traffic parameters were performed in all the routes to obtain the average values of key performance indices for each route.

RESULTS AND DISCUSSION

Table I shows the analysed mean values of the telephone traffic carried during the busy hours of each interconnection point for all the measurement sites in Kaduna and Kana metropolises (May 27 - August 27,2005).

Tables 2 to 5 show the mean values of daily key telephone traffic events taken on these busy hours for all the interconnection switches. Tables 6 to 9 are the calculations of key performance indices for all the interconnection points taken during their respective busy hours from Tables 2 to 5 respectively.

From the analysed values presented in Table 2, only 368 calls were answered for outgoing traffic while 432 calls were answered for the incoming traffic. These gave poor answer-bid ratio of 19 per cent and 32 per cent for outgoing traffic and incoming traffic respectively for Kaduna primary

centre as shown in Table 6. Table 7 results also depicted poor answer-bid ratio of 26 per cent for outgoing traffic and 27 per cent for incoming traffic for Kaduna secondary centres.

Table 8 which shows the results from Kaduna international telephone switching centre gave an answer-seizure ratio of 90 per cent for outgoing traffic while the answer-seizure ratio of 45 per cent was for incoming traffic. These results for outgoing international routes are indicative of properly terminated calls. This showed good local loop network (end-users) once the international circuit was seized, while incoming traffic terminating in Nigeria had good seizure but poor termination at the end-users (poor local loop network).

Tables 6, 7 and 9 all showed poor answer-bid ratios, answer seizure ratios and call completion ratios. The low values of ABRs and ASRs observed for the various interconnection points show that there IS poor quality of services.

Table 1: Analysed mean of eight values of the telephone traffic carried during the busy hours of measurement sites in Kaduna and Kano Metropolises).

Interconnection Point/traffic direction	Scanning time (hr) traffic carried in Erlang	Scanning time (hr) traffic carried in Erlang	Scanning tine (hrs) traffic carried in Erlang	Busy hours
Kaduna PC	9.30-10.00hrs	10.00-10.30hrs	10.30-11.0hrs	10.00am to
Outgoing	12.8Erl	14.6Erl.	14.1 Erl.	11.00am
Kaduna PC	9.00-9.30 hrs	9.30-10.00hrs	10.00-10.30hrs	9.30am to
Incoming	13.1Erl.	12.2 Erl.	14.1 Erl	10.30am
Kaduna SCs	10.00-10.30hrs	10.30-11.00hrs	11.00-11.30 hrs	10.30am to
Outgoing	120.4 Erl	127.1 Erl.	121.1 Erl	11.30am
Kaduna SCs	10.00-10.30hrs	10.30-11.00hrs	11.00-11.30hrs	10.30am to
Incoming	96.0 Erl.	101.3Erl.	96.8 Erl.	11.30am
Kaduna ITSC	4.30-500hrs	5.00-5.3hrs	5.30-6.00hrs	5.00am to
Outgoing	108.8 Erl.	119.7 Erl.	119.6 Erl.	6.00am
Kaduna ITSC	4.00-4.3hrs	4.30-5.00hrs	5.00-5.30hrs	4.30am to
Incoming	101.8 Erl.	101.8Erl..	101.9 Erl.	5.30am
Kano PC	9.00-9.30hrs	9.30-10.00hrs	10.00-10.30hrs	9.30am to
Outgoing	73.8Erl.	73.4 Erl.	70.4 Erl.	10.30am
Kano PC	9.30-10.00hrs	10.00-10.30hrs	10.30-11.00hrs	10.00am to
Incoming	13.3 Erl.	13.9Erl.	11.9 Erl.	11.00am

(May 27,2005-August 27, 2005)

Table 2: Mean values of daily telephone traffic during the determined busy-hours

Mean values of key traffic events	Outgoing traffic time (hr) (10.00-11.00) am	Incoming traffic time (hr) (9.30-10.30)am
Trunks provided	2144	2144
Trunks available	2094	2094
Bids	1899	1370
Seizures	1890	1346
Switch-through	1295	1283
Busy/No. Reply	927	851
Traffic carried (DERL)	582	525
Answered	368	432

Measurement site: Kaduna primary centre
Period: Ma 27, 2005-August 27.2005
Duration: 12 weeks

Table 3: Mean values of daily telephone traffic events taken during the determined busy hour

Mean values of key traffic events	Outgoing traffic time (hr) (10.30 11.30) am	Incoming traffic time (hr) (10.30-11.30)am
Trunks provided	4759	4759
Trunks available	4475	4475
Bids	3110	2488
Seizures	2954	2363
Switch-through	2809	2248
Busy/No. Reply	2011	1564
Traffic carried(DERL)	890	760
Answered	789	684

Measurement site: Kaduna secondary centres
Period: May 27, 2005-August 27.2005
Duration: 12 weeks

Table 4: Mean values of daily telephone traffic events taken during the determined busy hour

Mean values of key traffic events	Outgoing traffic time (hr) (5.00 –6.00)am	Incoming traffic time (hr) (4.30-5.30)am
Traffic carried (DERL)	2108	1490
Bids	2005	1704
Seizures	1904	1704
Switch-through	1809	1279
Answered	1718	767
Trunks provided	567	567
Trunks available	567	567
Busy/No. Reply	91	512

Measurement site: Kaduna International Telephone switching centre.
Period: May 27, 2005-August 27.2005
Duration: 12 weeks

Table 5: Mean values of daily telephone traffic events taken during the determined busy hour

Mean values of key traffic events	Outgoing traffic time (hr) (9.30-10.30)am	Incoming traffic time (hr) (10.00-11.00))am
Bids	3168	659
Seizures	3168	659
Traffic carried (DERL)	1178	266
Trunks provided	1150	1150
Trunks available	1150	1150
Switch-through	1011	248
Answered	883	216
Busy/No. Reply	128	32

Measurement site: Kano primary centre.
Period: May 27, 2005-August 27.2005
Duration: 12 weeks

Table 6: Key performance indices showing the analysis of busy hours key traffic events at Kaduna primary centre.

Key performance Indices (KPLs)	Outgoing traffic time (hr) (10-00-11.00)am	Incoming traffic time (hr) (9.30-10.30))am
Traffic carried in Erlang	58.2	52.5
Traffic per circuit in Erlang	0.03	0.03
Answer bid ratio (ABR)	0.19	0.32
Answer seizure ratio (ASR)	0.19	0.32
Call completion ratio (CCR)	0.69	0.95
Mean holding time per seizure (MHTS)	1.85	2.3
Bids per circuit per hour	0.91	0.65
Seizure per circuit per hour	0.90	0.64
Percent over flow	0.005	0.02
Network efficiency ratio	0.69	0.95

Table 7: Key performance indices showing the analysis of busy hours key traffic events at Kaduna Secondary centre.

Key performance Indices (KPLs)	Outgoing traffic time (hr) (10-00-11.30)am	Incoming traffic time (hr) (10.30-11.30))am
Traffic carried in Erlang	89.0	76.0
Traffic per circuit in Erlang	0.02	0.02
Answer bid ratio (ABR)	0.26	0.27
Answer seizure ratio (ASR)	0.27	0.29
Call completion ratio (CCR)	0.95	0.29
Mean holding time per seizure (MHTS)	1.81	1.93
Bids per circuit per hour	0.69	0.56
Seizure per circuit per hour	0.66	0.53
Percent over flow	0.05	0.05
Network efficiency ratio	0.95	0.95

Measurement site: Kano primary centre.
Period: May 27, 2005-August 27.2005
Duration: 12 weeks

Table 8: Key performance indices showing the analysis of busy hours key traffic events at Kaduna International telephone switching centre.

Key performance Indices (KPLs)	Outgoing traffic time (hr) (5.00-6.00)am	Incoming traffic time (hr) (4.30-5 30))am
Traffic carried in Erlang	210.8	149
Traffic per circuit in Erlang	0.37	0.26
Answer bid ratio (ABR)	0.86	0.45
Answer seizure ratio (ASR)	0.90	0.45
Call completion ratio (CCR)	0.95	0.75
Mean holding time per seizure (MHTS)	2.2	5.25
Bids per circuit per hour	3.5	3.01
Seizure per circuit per hour	3.4	0.01
Percent over flow	0.05	0
Network efficiency ratio	0.95	0.75

Table 9: Key performance indices showing the analysis of busy hours key traffic events at Kaduna International telephone switching centre.

Key performance Indices (KPLs)	Outgoing traffic time (hr) (9.30-10.30)am	Incoming traffic time (hr) (10.00-11.00)am
Traffic carried in Erlang	117.8	26.6
Traffic per circuit in Erlang	0.1	0.02
Answer bid ratio (ABR)	0.28	0.33
Answer seizure ratio (ASR)	0.28	0.33
Call completion ratio (CCR)	0.32	0.38
Mean holding time per seizure (MHTS)	2.2	2.4
Bids per circuit per hour	2.8	0.6
Seizure per circuit per hour	2.8	0.6
Percent over flow	0	0
Network efficiency ratio	0.32	0.38

CONCLUSION

From the results obtained on the quality of services parameters measured during the busy hour for interconnect partners (to confirm the results above) , very poor values of answer-seizure ratios, answer-bid ratios and call completion ratios were observed in all the exchanges considered save the Kaduna international switching centre (outgoing traffic). Bassey (2006) corroborates this in a teletraffic work carried out in some towns in South Eastern Nigeria and this agrees with what Amaefule (2006) reported, that Nigerian Communications Commission (NCC) threatened to sanction mobile operators for poor call completion ratios and poor quality of services. Which can be corrected by the provision of reliable equipment with greater bandwidth)

Telecommunications has revolutionized all sectors of the economy the world over as it has not only reduced the world to a global village but has also served as a veritable instrument in the enhancement of industrial and economic development.

Nigeria is not left out in the expansion that has been witnessed in this sector though this growth is concentrated in the Urban areas with little or no penetration to the rural areas where more people reside. This growth is besieged with lack of adequate telecommunication networks (switching, transmission and local loop networks), lack of sufficient transmission bandwidth and backbone infrastructure.

ACKNOWLEDGEMENTS

We wish to express our thanks to the management of Nigerian Telecommunication Limited (NITEL) for the permission to access their systems and for the collation of data. The rest of the authors wish to appreciate the role and efforts of the first author, MOI in preparing and completing this paper before he was called to glory. May his soul rest in peace.

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