Reliability Analysis of Fixed Wireless Networks in Nigeria.

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ABSTRACT

The purpose that a system is required to serve determines the level of reliability required for the operation such a system. In telecommunication systems, it is generally assumed that a high level of reliability is required, particularly in systems as important as national security telecommunication systems. Since it may be uneconomical for private telecom operators to provide even close to 50% redundancy networks, it is of necessity to install highly reliable devices, equipment, and infrastructure.

(Keywords: reliability, analysis, fixed wireless, Nigerian, Nigeria)

INTRODUCTION

In general terms, reliability may be said to be the ability of a person or system to perform and maintain its function in routine circumstances, as well as hostile or unexpected circumstances [5]. It is the ability of a system or component to perform its required functions under stated conditions for a specified period of time. The reliability challenge for legacy services is more than just perceptual. For instance, fixed wire-line telephony and cable TV are designed to deliver high-availability services.

The design standard for telephone circuit switches is two hours of downtime every 40 years, and analysis of cable TV designs shows 41 minutes downtime per year for the hybrid fibre-coax plant. Service availability is very important here since a subscriber will expect their television to work whenever it is switched on for news or any other program. Likewise, the same consumer expectations are present for internet and voice systems. For this service to make the required impact, it has to be an "always on" service.

COMMONLY USED TERMS IN FIXED WIRELESS NETWORKS ASSESSMENT

(a) **Erlang -** An *erlang* is a basic unit for measuring traffic volume. It is important to note that an erlang is dimensionless. However, the industry norm is to reference 1 erlang of usage to one hour or 60 minutes of use for the circuit or facility. Depending on the grade of service and the probability model used—Erlang B, Erlang C, or Poisson—the number of facilities or circuits can be determined from knowing the number of erlangs used.

(b) **Lost, or dropped call -** A *lost*, or *dropped*, *call* with respect to traffic engineering is another name for the Erlang B model for mobility traffic. Specifically, a call is lost from a traffic perspective when it tries to gain access to the network and is denied. For a lost call, the subscriber does not enter into a queue for potential assignment.

(c) **Queue -** A *queue* is another name for *waiting* in a telephony system. When someone refers to a queue or to "a subscriber's entering a queue," he or she means the subscriber who requested a facility—that is, a radio channel—and is denied, he or she is put on a waiting list for assignment when a facility becomes available.

(d) **Busy Hour (Peak time) -** The *busy hour* refers to the time period, one hour, in which, during the course of a 24-hour day, there is the most amount of traffic either for the system, the cell site, or even a sector of a cell site. The cell site is normally a fixed time of day.

(e) System Busy Hour - This is the one-hour period that the wireless system as a whole will have the highest traffic load. The system busy hour is usually a fixed hour, usually 4:00 to 5:00 P.M. or 5:00 to 6:00 P.M.

(f) Cell site busy hour – This is the time one-hour period when the cell site experiences the highest amount of traffic in comparison to the remaining hours of the day. For example, cell 1, sector A, may have a busy hour between 8:00 and 9:00 A.M. while sector B of the same cell may have a busy hour between 4:00 and 5:00 P.M. It is common for different sectors of a cell site to have different busy hours; however, on the whole, the system should be designed to support the system busy hour.

(g) Erlang, or Traffic density – This is the amount of erlangs per square kilometer (or square mile) that applies to a wireless system or a subpart of a wireless system. For example, if a system has 100 km^2 of area and has 10 erlangs of usage, then the erlang density = 10/100, or 0.1 E/km^2.

(h) Radio Utilization ratio – This ratio is used to express the relationship of the existing traffic load to the offered traffic load at the defined grade of service. The radio utilization ratio is a planning parameter that is used as a trigger for adding new radios to the wireless network.

(i) Cell site growth – This is the process of expanding the wireless network by adding cell sites.

(j) Radio Channels – These are physical radios that are used in transmitting and receiving wireless communications. The radio channels can be of any technology platform. Typically, a radio channel will be associated with a specific frequency that is used for transmitting and receiving.

(k) Traffic Channel – This term refers to time slots used in digital wireless systems. For example, an IS-136 wireless system has six time slots used for conveying voice information. Of those six time slots, two slots are assigned to particular communication and are referred to as a *traffic channel*.

(l) Registration - A process used in a wireless system for determining at a periodic interval where the subscriber is within the network. The purpose of registration is to relieve the paging channel from congestion by being more efficient in directing the in-coming call, or page, to where the subscriber was last located instead of paging the entire network.

(m) Grade of Service (GOS) - With respect to telephony, GOS refers to the blocking probability that is expected for any given trunk or member size. A typical GOS value used for wireless systems is 1 and 2 percent. This refers to a 1 or 2% chance that the caller will be denied a facility, that is, a radio channel, when he or she wants to use the system. The GOS used for a system is different for the radio and switching environments. For example, the radio (mobile) environment may have a GOS of 2% while the landline, PSTN connection, may be designed for a 1% GOS because there is a facility concentration at the landline side of the wireless system [1].

MEASURING RELIABILITY OF A NETWORK

Reliability engineers rely heavily on statistics, probability, and reliability theory. Several of engineering techniques are used in reliability engineering ranging from reliability prediction to reliability testing.

The reliability of wireless networks, as a whole, should be reviewed at every quarterly engineering design review. Some of the metrics used to measure the network reliability are given below [1]:

1. Description and size of the network outage including duration of the outage and causes for the outage

2. Number of system swaps taken place (use of backup redundant systems or facilities)

3. Life-cycle performance tracking data for the network equipment and facilities

4. Plans to improve current network reliability performance.

RELIABILITY ANALYSIS OF NIGERIAN FIXED WIRELESS NETWORKS

Presently, Nigeria's GSM operators have inadequate records systems, and this is partly because there was serious infrastructure decay from inception and until present. Just building this record base has lead to hoarding information amidst stiff competition among GSM operators in hopes of gaining a competitive advantage over other firms. Because of the difficulty in accessing this information, an alternative means of collecting this data for reliability assessment is necessary.

The data provided for analysis was extrapolated from wireless subscribers through the use of questionnaires and periodic random phone call sampled data from selected towns in each of the thirty six states of the federation. Requirements were specified using reliability parameters and the most common reliability parameter is the mean-time-between-failures (MTBF), which can also be specified as the failure rate or the number of failures during a given period [5].

These parameters are very useful for systems that are operate on a continuous basis, such as mobile operators. In the context of telephony, failure rates may be measured by attempt failures, drop call rates, and handover failures.

From this collated data (as shown in Table 1), the level of reliability of each of the sampled mobile operator may be deduced. It may be noted that a system with 5%, 10%, and 5% attempt failure, congestion, and call drop rates respectively is assumed to possess a reliability of 100%.

Table 1: Operator Reliability Assessment.

Fixed Operator	Attempt Failure (%)	Congestion Level	Call-drop rate	Deduced reliability (%)
Starcomms	26.5%	72.8%	74%	8.04%
Multilinks-Telkom	16.5%	58.3%	63%	2.99%
Reltel	19.5%	64%	69%	1.27%
Standard	5%	10%	5%	100%

To calculate the reliability of the networks,

$$[R = e^{-\lambda_T t}] \qquad \textbf{(1)}$$

Where T = the total duration of the call (24hrs),
λ_T = total failure rate.

Since a standard system with call-drop, congestion, and attempt failure of 5%, 10% and 15%, respectively, is specified by National Communication Commission (NCC) to have 100% reliability, it therefore means the probability to establish a successful call one the first attempt and to have the link sustained for a period of 24 hours is 100%.

The total failure rate:

$$[\lambda_T = n\lambda w_E w_T w_R] \qquad \textbf{(2)}$$

which indicates the acceptable call-drop, congestion, and blocking levels. For convenience, the weighting standard factors of 95%, 90%, and 95% will be appropriate. This is obtained by deducting the call-drop, congestion, and attempt failure values from a percentile. Therefore,

$$K = n\lambda = -2.36232687\text{E-}7$$

where

K = constant of proportionality for which the condition holds.

For a standard network,

$$R = \text{Exp}\,[-(-2.3623*10^{-7}*95*90*95*24h)] \approx 100\%$$

The actual values of reliability of these networks over the test period of 24 hours may vary from the calculated values (less) due to the inaccuracy of subscriber data. Such errors must be cared for in calculations (i.e. by introducing a constant).

QUALITY OF SERVICE

The percentage call-drops is one of the most important Quality of Service (QoS) indices used to monitor the performance of wireless networks all over the world, including in Nigeria. The prevailing consensus is that every single provider in the country is either careless about service or has failed in their responsibility to subscribers. It is been argued that Nigerian providers have the highest incidence of droped calls and the lowest inclination to Quality of Service of their counterparts elsewhere [10].

The fixed wireless market is now an aggressive and changing environment. Customer retention is critical to the success and growth of the business. All of the operators have worked hard to increase their customer base, but not hard enough on their service packages and network performance. Customer support is an indispensable issue. Network coverage has not improved greatly and we are nearing total coverage. However the biggest problem is still call drop-out and is often the most visibly frustrating quality of the service issues customers have encountered.

OTHER QOS PROBLEMS

Common problems with the performance of mobile wireless networks are evident in the form of [4]:

- Interference
- Speech quality (Call clarity)
- Coverage
- Channel load (congestion)
- Call drop

An illustration of QoS problems reported in the data questionnaires used in this research are represented in Figures 1-4.

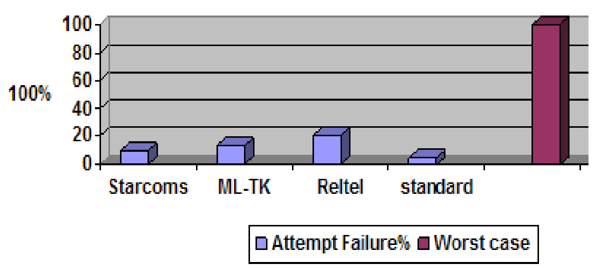

Figure 1: Attempt Failure of Sampled Fixed Wireless Networks in Nigeria.

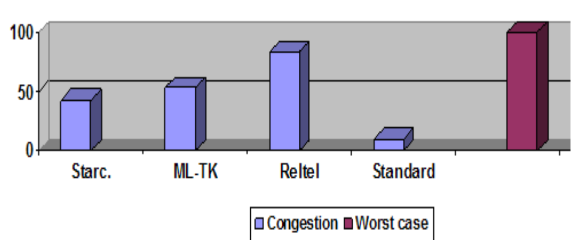

Figure 2: Congestion Level of Sampled Nigerian Fixed Wireless Operator Networks.

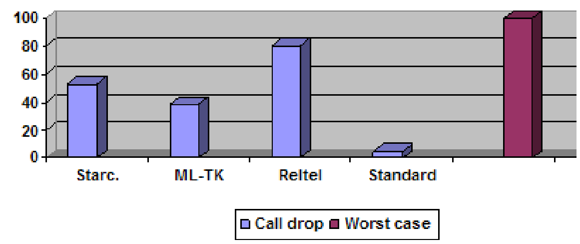

Figure 3: Call Drop Rate of Sampled Fixed Wireless Operators in Nigeria.

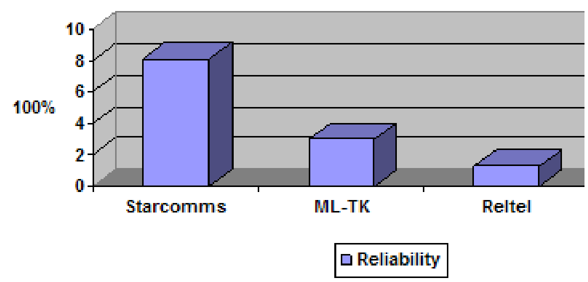

Figure 4: Reliability of Sampled Fixed Wireless Networks in Nigeria.

CONCLUSION

For a developing company to remain competitive, as established in Table 1, the probability for a subscriber of Starcomms (fixed) to make a successful call (on-first-try) and keep the connection for the next 24 hours without experiencing drop is just over 8%. This analysis shows that it is not probably for Nigerian fixed wireless operator networks to provide a once dial, mean holding time of 24 hour phone service. In reality, most subscribers never need such excellent service but the higher the reliability the better. Of all the sampled fixed wireless networks in the country, Reltel provides the least reliability (1.27%). This reliability assessment is based on the results obtained from measured congestion level, call-drop, and blocking rates provided by the operator subscribers.

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Seyi Stephen Olokede attended St. Mary/Nicholas Catholic Primary School for his primary education between 1974 and 1980, and continued his secondary education at Anglican Grammar School, both at Otan Ayegbaju, under Boluwaduro local government of the Osun State of Nigeria. He completed his secondary education at Ipetu Ijesha Grammar School, Ipetu Ijesha, Osun State in the year 1986. He proceeded to the University of Ilorin from 1988 through 1993 where he obtained a Bachelor of Engineering (honors) degree in Electrical Engineering with specialization in Communication & Electronic Engineering. He also earned a Master of Engineering degree from the same department in 2001. Currently, he is doctoral student at the University of Benin, Edo State, working on multiple-in multiple-out correlation modelling & optimization for future MIMO wireless communication.

He is a corporate member, Nigeria Society of Engineers (MNSE). In 2001, he was certified to practice engineering in Nigeria by the Council Of Regulation of Engineering in Nigeria (COREN) with registration number R.08999.

He has formerly lectured at Oladoke Akintola University, Ogbomoso, Oyo State; University of Ilorin, Ilorin; Covenant University, Ota, Ogun State; before joining the Olabisi Onabanjo University, Department of Electrical & Electronic Engineering of the College of Engineering & Technology, Ibogun, Ogun State, Nigeria. He his happily married and has two children.

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