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PRIMARY RESEARCH

Effective management of handover process in mobile communication network

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Abstract— This paper presents the effective management of handover process in mobile communication networks, aims to determine effective utilization of signaling channels in mobile communication network to avoid incessant of handover drop calls in the mobile network. Data were obtained from the Operation and Maintenance Centre (OMC). Analytical method known as Markovian chain analysis of continuous time and discrete space was used in the modeling, of handover blocking probability in mobile communication network. In addition, it was validated using MATLAB software. The causes of handover calls failure were analysis in network B. It was observed that handover blocking probability increases as the number of offered traffic load in erlang increases with a given number of transmission channels (V+g). Handover call blocking probability traffic model performance of the system is function of offered traffic in erlang and number of transmission channels (P_b = f(A,(V+g)). The handover blocking probability decreases, as both number of transmission channels (V+g) and traffic load in erlang increase. In order, to obtain satisfactory handover blocking probability the number of channels must be increased in proportion to offered traffic load in erlang.

I. INTRODUCTION

Mobile telephony technology has witnessed rapid development in recent years. The present mobile communications systems offer much more than just telephoning and text messaging. Presently it delivers e-business, e-banking, e-sport activity, e-conference, e-library, social activities etc. The mobile multimedia services rendered by mobile communication system contributed positively to man activities, such as to get connected with friends and relatives, sharing information and pleasantries, also increasing the level of Social activities among the youth.

The unique characteristic about mobile communication system is the mobility attribute possessed by the mobile network. This gives room for subscribers to embrace this mobile technology. In recent times, subscribers witnessed incessant drop calls in the mobile communication system in Nigeria. Drop calls probability is one of the major factors used to determine the quality of service. Technically, there are differences between Drop calls and block calls. Drop calls are calls that originally (initially) granted access to the network channels (switches), but due to technical error the calls are truncated during conversation. While block calls are calls that are rejected due to lack of transmission channel's capacity [1].

The major cause of drop calls experienced in mobile network is the technical error in handover process. Handover is the procedure that transfers an ongoing call from one cell to another as the users move through the coverage area of cellular system [2]. Handover (handoff) is a process of changing the channel (frequency, timeslot, spreading code or combination of these) when moving from one cell to another, during conversation. It's often initiated either

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by crossing a cell boundary or when the signal quality of the call's current channel goes below the design or dedicated signal threshold network [3]. This handover process technology helps to maintain subscriber's call continuity and good signal quality in call's conversation in the mobile communication system. Poorly designed handover schemes will result in heavy signaling traffic load and high number of drop calls, leading to decrease in Quality of Service (QOS). In mobile communication system, handover process plays a critical role in frequency management design which helps to obtain and minimize frequency usage [3]. In GSM network, there are different types of handover processes; these include [2].

Intra cell-intra BSC handover:
The smallest of the handover process is the intra-cell handover process where the subscriber is handed over to another traffic channel (another frequency) within the same cell.

Inter cell-intra BSC handover: When a subscriber moves from one cell to another cell (cell 1 to cell 2). In this case, the cell's handover process is controlled by the same BSC.

Inter cell-inter BSC handover:
The subscriber moves from one cell to another cell (cell 1 to cell 2). In this case, the cells are controlled by two different BSC. The handover process is carried out by the MSC, but the decision to make the handover is still done by the first BSC. The connection with the first BSC is released when the connection with the new BSC is set up successfully.

Inter-MSC handover:
The subscriber moves from a cell controlled by one MSC/VLR (anchor MSC) to another cell in the domain of MSC/VLR called (target MSC). This makes use of handover process number [3] and [4].

A. Handover is Performed due to Two Basic Reasons

Handover process occurs when the quality or strength of the radio signal falls below a specific radio threshold parameter. In handover process, measurement is carried out by the means of the Mobile Station (MS), when the signal strength goes beyond a recommended threshold level, it automatically connects the MS to another stronger radio signal within or outside the cell [5]. The handover process can also be triggered due to traffic reasons, this occurs when the traffic capacity of a cell has reached its maximum capacity. In such a case, the subscribers (mobile stations) near the edges of the cell may be handed over to neighboring cells with less traffic load [2] and [6].

Handover calls must have strategies for priorities request, over call initiation request when allocating unused channels. Handover process must be successful to minimize drop calls experienced in the network. It must be as fast as possible, and imperceptible to the users. In order to meet these requirements in handover process, the mobile communication system designer must specify an optimum signal level at which to initiate a handover once a particular signal level is specified as the minimum usable signal for acceptable voice quality at the base station receiver (normally taken is between -90Dbm and -100Dbm), a slightly stronger signal level is used as a threshold at which a handover is made [7] and [8].

C. Handover (Handoff) Technology in both GSM Network and CDMA2000 Network

There are hard handover and soft handover processes in mobile communication networks; the hard handover process occurs in GSM networks, while soft handover process occurs in CDMA2000 networks. The Soft handover process in CDMA2000 network is usually a preferable situation for a Mobile Station (MS) as it improves the quality of connection. The soft handover is referred to as "make before break" as it increases the overall system interference level and decreases the system capacity by consuming more signaling traffic (data transmission) in the network [9] and [10] and [11]. The hard handover occurs in GSM system. Hard handover is referred to as "break before make". The problem associated with hard handover are calls dropped due to lack or limitation of free channels or timeslots and time delay, because preliminary measurements must be made for precise determination of high power signal level before decisions are made by the mobile station [11].

D. Handover Modeling Parameters

Modeling handover process involves the issues of channel holding time, call holding time and mobility of the subscribers that are considered for proper modeling. The channel holding time is determined by the cell residence time (cell dwell time). The cell residence is affected by the mobile moving speed, geographical location and direction (or other factors such as fading). Channel holding time is the time a Mobile Station (MS) remains in the same cell during a call, while call holding time is the total time spent by MS during call. It may involve MS moving from one cell to another new cell; that process is referred to as handover

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process [12], [13] and [14]. Channel holding time, call holding time and inter-arrival time of a call are all assumed to be exponential distribution. From research work, the assumption of exponential distribution in traffic situation is based on simple means of evaluating the network performance [15], [16] and [17]. [2] developed a handover prioritizations scheme involving cell overlap and load balancing scheme to enhance the GSM cellular capacity using an overlapping coverage area while, [3] proposed TDMA-based dynamic channel allocation along with bandwidth window in heavy load conditions. In this study, handover call traffic model is developed based on the unique feature of the mobile communication network i.e. subscriber mobility on the network.

III. METHODOLOGY

The Effective management of handover process in mobile communication network's investigation is carried out by considering the causes of handover failure. Data were collected from Network B OMC for a period of one year, from March, 2014 to February, 2015. The Markovian chain analysis of continuous time and discrete space was deployed to model handover channel utilization in mobile communication network. The handover modeling parameters are highlighted and are used to determine the performance of the mobile communication network.

TABLE 1
CAUSES OF DROP CALLS IN MOBILE COMMUNICATION NETWORKS

Handover Drops call causes	Occurrence percentage (%)
Electromagnetic causes	49.4
Causes from mobile station end	36.9
Technical error from equipment	7.6
Natural disaster	6.1

Source :(Network B)

A. Data Presentation

The data were obtained from OMC-counter of NETWORK B Company in Nigeria, presented in Table 1 for duration of one year.

TABLE 2
HANDOVER MODELING PARAMETERS ASSOCIATED WITH MOBILE COMMUNICATION NETWORKS

S/No.	Parameters of Handover
1	Channel holding time
2	Call holding time
3	Mobility of the subscribers
4	Mobile moving speed
5	Geographical location and direction
6	Arrival process
7	Number of traffic channel
8	Number of subscriber utilization
9	Discipline (method of deployment of handover strategy)

B. Modeling of Handover process in Mobile Communication Networks

The proposed handover traffic model is on queue theory, which is based on Markov chain analysis of continuous time and discrete space. This queuing model is characterized by the Poisson arrival process, independent exponential service times and independence between the

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arrival process and the service times. It is denoted by M in the first two positions (i.e., M /M/. /.). Because of the memoryless property of Markovian chain, which is used as a modeling tool, to develop the proposed handover traffic model, the following assumptions were made:

1) The arrivals of handover calls follow a Poisson probability distribution which implies exponential distribution of call inter-arrival time

2) It is also assumed that all handover calls are served on a First-Come, First-Served (FCFS) basis by any of the servers (channels)

3) All handover calls requests are memoryless, implying that all users, including dropped calls (users) may request a channel at any time

4) All free channels are fully available for servicing handover call until all channels are occupied

5) Inter-arrival time of handover call requests is independent of each other.

6) The assumed total numbers of channels are shared into two segments: V channels are used for voice calls and handover call, while g channels are used for handover calls only.

The handover call arrival pattern is assumed to be random, the blocked call cleared, number of channels shared on FCFS basis and holding time is assumed to be exponentially distributed.

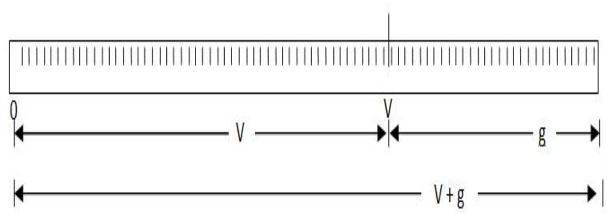

Fig. 1 . Total channels in a cell system

The N represents a hard limit on the number of simultaneous users that are served in the proposed traffic model.

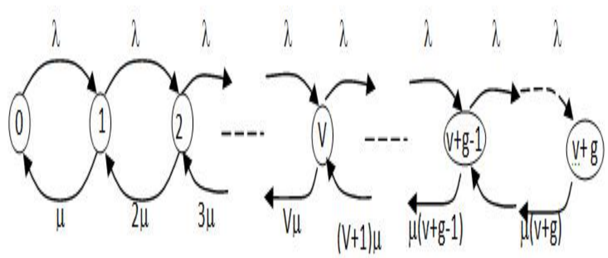

Fig. 2 . The transition steady state diagram of Markov chain

The setup state transition diagram for M/M/V+g/N blocking system is shown in Fig. 2. The state K in the system defines the number of busy channels. Where K (K = 0, 1, 2, 3 - - -) is a discrete random process representing the number of occupied or busy channels at discrete time. In Fig. 2, all the states of the system are represented as circles, and the rate by which the traffic process changes from one state to another state is shown with the arcs of arrows between the states. The change is restricted to only the neighboring states. The system is assumed to be in statistical equilibrium, and when the system will be in state (K) and the proportion of time μ, where P(K) is the probability of observing the system in state [k] at a random point of time. When the process is in state [K], it will jump to state [K + 1]λ times per time unit, and to state [K - 1] kμ times per time unit; λ is the arrival rate, while μ is service duration. The process will leave state (k) at the moment there is a state transition. The future development of the traffic process only depends upon the present state, not upon how the process comes to this state (the Markov-property).

The Fig. 2, describing the state of the system under the assumption of statistical equilibrium can be set up in two ways, either by Node Equations and Cut Equations.

The basic parameters deployed in this modeling analysis are:

K- Represents discrete number of occupied or busy channels.

P_k - Represents the probability of observing the system in state [k] at a random point of time.

λ - Represents the total average number of call arrival rate

μ - Represents the total service time or average holding time per call

A- Represents the total offered traffic load. The total arrival rate λ is

$$\therefore \lambda = \lambda_v + \lambda_g \tag{1}$$

λ_v= new arrival voice call

λ_g handover voice call

The total service time μ

$$\therefore = {}_v + {}_g \tag{2}$$

${}_v$ service time for V channel calls

${}_v$ service time for g channel calls

The total offered traffic:

$$A = A_v + A_g \tag{3}$$

$$A = \frac{\lambda_v}{\mu_v} + \frac{\lambda_g}{\mu_v} \tag{4}$$

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Derivation of state probabilities (P) from Fig. 2

C. Handover Blocking Probability Traffic Model

The handover blocking probability modeling put into consideration the mobility of subscribers from one cell to another. The probability that a call will fail during conversation or (experienced drop call), while moving from one cell to another is referred to as handover blocking probability (phb). This implies, that there are no free channels in the destination cell. The developed handover blocking probability Equation is presented in Equation 6 and 7

$$P_{hb} = \frac{(\frac{\lambda}{\mu})^{v+g}}{(v+g)!}.P(0) \qquad (5)$$

Where $\frac{\lambda}{\mu}$ is the total offered traffic load in erlang (A):
$\therefore A = \frac{\lambda}{\mu}$, Substituting A into 6
Equation

$$P_{hb} = \frac{\frac{(\frac{\lambda}{\mu})^{v+g}}{(v+g)!}}{\sum_{k=0}^{v-1}(\frac{\lambda}{\mu})^k \frac{1}{k!} + \sum_{k=0}^{v+g}(\frac{\lambda}{v\mu})^k \frac{1}{k!}\frac{1}{k-1!}} \qquad (6)$$

$$P_{hb} = \frac{\frac{(A)^{v+g}}{v+g}}{\sum^{v-1} \frac{A^k}{k!} + \sum^{v+g}(vA)^k \frac{1}{(k-1)i}} \qquad (7)$$

The Equation 7 is used to determine and predict the handover blocking probability of handover calls in a V+ g channel in mobile communication system.

The basic performance parameter deduced from the queue traffic model is the handover blocking probability (see Eq. 7), which is used to determine the channels (cell) utilization and average (expected or mean) number of subscribers in the system. Through the proposed handover blocking probability traffic model as in Equation 7, the number of blocked calls experienced during handover process can be estimated. This handover blocking probability traffic model Equation is designed based on the assumptions that the total number of channels is (V+g) (number of channels V is used by both voice calls generated from the cell and handover calls, while g is used for handover calls only, the calls are exponentially distributed; outgoing and incoming from one cell to another are equal).

D. Data analysis and Result

Based on the handover calls failure rate data obtained from OMC, the data were categorized into percentage in Table 1, presented in Fig. 3.

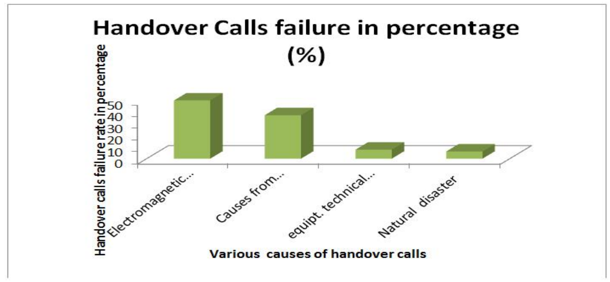

Fig. 3 . Handover calls failure rate in percentage against various causes

The Equation 7 was tested in MATLAB environment. In order to assess the behavior of the tested traffic model, plots of handover blocking probability against traffic load are presented as shown in Figs. 4 and 5, for lower and higher number of transmission channels respectively.

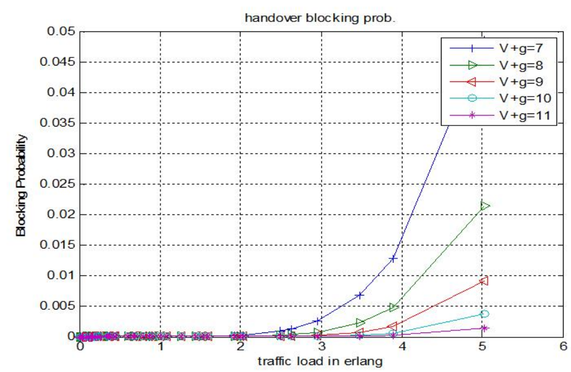

Fig. 4 . Handover calls failure rate in percentage against various causes

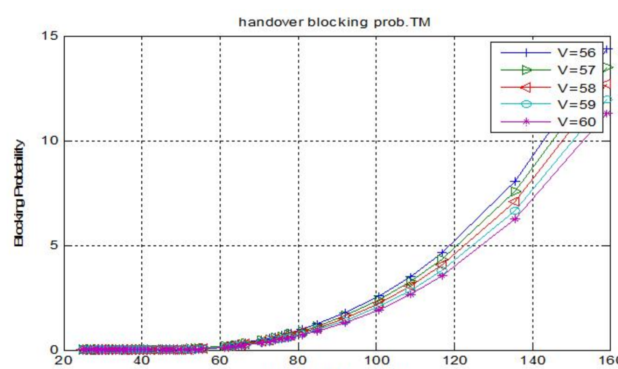

Fig. 5 . Handover calls blocking probability with higher number of channels (V+g)

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It was observed that handover blocking probability increases as the number of offered traffic load in erlang increases with a given number of transmission channels (V+g) for Fig. 4 and Fig.5 to Fig 8. The impact of offered traffic load on the mobile network performance was also illustrated with Figs. 6 and 7.

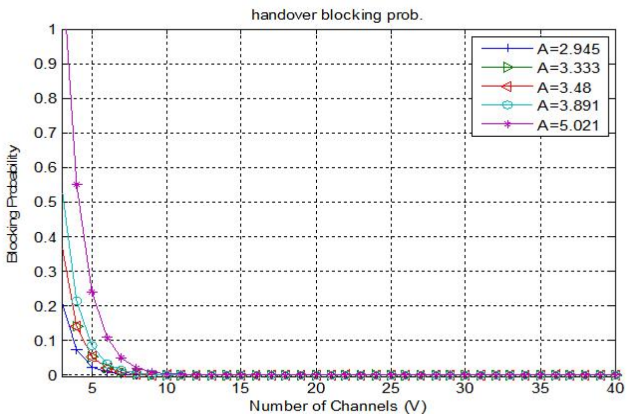

Fig. 6 . Handover calls blocking probability with lower offered traffic load in Erlang (A).

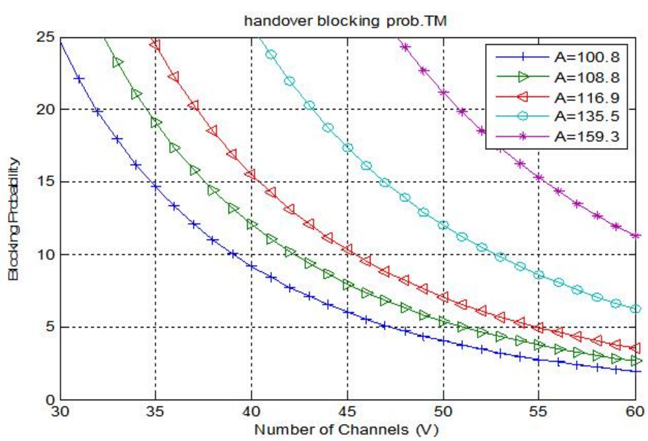

Fig. 7 . Handover calls blocking probability with higher number of traffic load in Erlang (A).

In Fig. 6 and Fig. 7, low number of offered traffic load in erlang and high number of offered traffic load in erlang were used respectively to determine the handover blocking probability with increase in the number of transmission channels provided. It was also observed that at any given offered traffic load (in erlang) (A), the system experienced high number of handover blocking probability, and blocking probability reduces as the number of transmission channels increases in the mobile network.

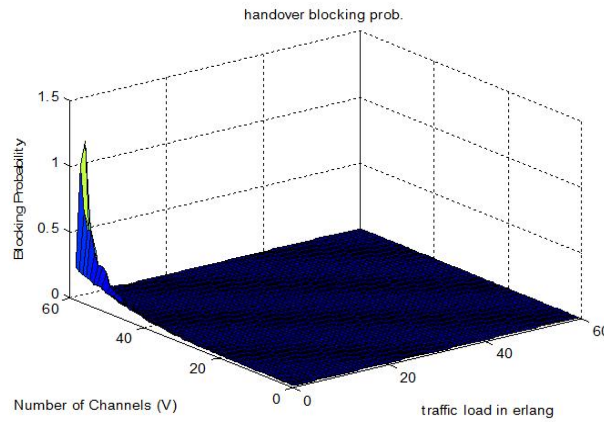

Fig. 8 . 3D Handover calls blocking probability

In Fig. 8, the 3D plot shows handover calls blocking probability (P_b) on Z-axis, number of channels (V+g) on y-axis and offered traffic load in Erlang (A) on x-axis. It can be deduced from the Figure that handover blocking probability traffic model performance of the system is function of offered traffic in erlang and number of transmission channels (P_b = f(A,(V+g)). The handover blocking probability decreases, as both number of transmission channels (V+g) and traffic load in erlang increase. In order to obtain satisfactory handover blocking probability the number of channels must be increased in proportion to offered traffic load in erlang.

III. CONCLUSION

This handover traffic model is developed based on the unique feature, such as subscriber mobility associated with mobile communication network. The mobile network subscribers often experienced handover failure calls or handover dropping calls during handover process in the mobile network. However, handover process occurs based on two basic reasons, which are whenever the quality or strength of the radio signal falls below a specific radio recommended threshold level, it automatically connects the MS to another stronger radio signal within or outside the cell. Secondly, the handover process occurs due to traffic reasons, when the traffic capacity of a cell has reached its maximum capacity. In such a case, the subscribers (mobile stations) near the edges of the cell may be handed over to neighboring cells with less traffic load. It was observed that handover blocking probability increases as the number of offered traffic load in erlang increases with a given number of transmission channels (V+g).

Handover call blocking probability traffic model performance of the system is a function of offered traffic in er-

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