Development Of Inter Cell Handover Deflection Mechanism For Mobile Telecommunication Networks In Nigeria

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***Abstract*— In this paper, development of inter cell handover deflection mechanism for mobile telecommunication networks in Nigeria is presented. The main aim of the mechanism is to enhance the call handover performance of the telecommunication networks. The relevant mathematical models and flow diagrams for the inter cell handover deflection mechanism are presented. A simulation program was developed for the handover deflection mechanism using JAVA and PYTHON programming languages. The simulation program was implemented with the deflection time set at 0.080 ms and the maximum number of calls a base station can handle was set at 20 calls. Then, a number of simulations were executed for cases with no call in the network, with 20 calls, with 40 calls, with 60 calls, and with 80 calls in the network. The results show that for cases with less or equal to 20 calls in a base station, all the calls were handled effectively without any deflection. However, for the cases where the number of calls in a base station exceed 20, the dynamic handover deflection mechanism distributed the calls (above 20) to the other nearest Base Transceiver Station (BTS) in the vicinity of the base station with a specified handover time of 0.080ms. Specifically, for 40 incoming calls to a base station, 20 calls are deflected; for 60 incoming calls to a base station, 40 calls are deflected and for 80 incoming calls to a base station, 60 calls are deflected by the handover deflection module. In all, the use of the dynamic handover deflection mechanism help to reduce congestion, drop calls and handover failure in the network.**

Key words: Global System for Mobile Communications (GSM), Inter Cell Handover, Mobile Telecommunication Networks, Handover Deflection Mechanism

1. INTRODUCTION

One of the elements crucial to GSM (Global System for Mobile communication) network Quality of Service (QoS) and customer satisfaction is an efficient handover procedure [1,2,3]. Mobile Subscribers (MSs) are provided with telephone service within a geographical area of a cellular system [4,5]. The service area is separated into several cells that are adjacent to one another. MSs communicate with Base Transceiver Stations (BTS), one for each cell, via radio links. When MS crosses a cell boundary, the old BS's channel is released, and an idle channel in the new BS is required; otherwise, the BS's connection is lost, and the call is dropped [4,6,7]. As a result, if the caller or the person being called is moving, the caller's Mobile Station (MS) must remain connected to a BS in order to sustain connection. Each BS, however, has a set area of coverage, so if either of them leaves his or her BS's coverage range, the call is transferred to another BS. The term "handoff" or "handover" refers to this procedure [8,9,10]. The process of transferring an ongoing call to another channel or cell is known as handover ([11,12,13]. It is crucial to wireless cellular system mobility management and has an impact on resource allocation [13].

In Global System for Mobile communication (GSM) networks, there are two types of handoffs: soft handoffs and hard handoffs [14,15]. Before the connection to the source BS is broken, the connected BSs smoothly move the call to the new channel. Call loss is infrequent when soft handoffs are used. When the communication channel is first released before the MS acquires a new channel, it is considered to be a hard handoff. This frequently happens when the BSs are separated by a large distance or are occupied (no available channel in the BS). Ongoing calls may be lost, and incoming calls may be blocked, due to the time lag. The Nigerian telecommunications business has been harmed by call losses due to handoff [4].

Within any cellular system, the procedure of handover is critical. It's a crucial step that, if done incorrectly, might result in a loss of calls. Dropped calls are highly irritating to consumers, and as the number of dropped calls increases, so does subscriber unhappiness, which may lead to a change of service provider [16,17]. Failed handover forcibly terminates established connections, resulting in dropped calls. Call losses due to handoff are common and have a negative impact on Quality of Service (QoS) of the Nigerian telecommunications industry. High inter-cell handover requests considerably increase traffic and deteriorate Quality of Service (QoS); they also increase call setup time, call dropping and call blocking rates in a crowded metropolis. Therefore, the focus in this work is to present the development and evaluation of a mechanism that can be used to enhance the call handover performance of telecommunication networks by sharing the call traffic among adjacent base stations to avoid congestion, call drop and handover failure. The details of the mechanism are presented in terms of mathematical expressions and flow diagrams along with simulations using some sample numerical data.

2. METHODOLOGY

The focus in this work is to present the development and evaluation of a mechanism that can be used to enhance the call handover performance of the telecommunication networks considered in the study. The relevant mathematical models and flow diagrams for the inter cell handover deflection mechanism are presented.

2.3 DEVELOPMENT OF THE HANDOVER DYNAMICS DEFLECTION MECHANISM

In order to lower the rate of handover failure, a performance improvement module is presented, and it is called handover dynamics deflection module or mechanism. The module depicts a cell containing 'Ch' channels, which include open access channels ($\boldsymbol{Och_{\_Blue}}$) and deflection channels ($\boldsymbol{Dch_{\_Red}}$), which is expressed mathematically as;

$$Ch = Dch_{\_Red} + Och_{\_Blue} \quad (1)$$

$$Och_{\_Blue} = Ch - Dch_{\_Red} \quad (2)$$

The operation of handover dynamics deflection mechanism with respect to the channels allocation to handover calls and new calls are presented in Figure 1 and Figure 2 respectively. By design, the open channels are less than the total channels by a number termed deflection channels, according to Equation 1).

When there is a heavy traffic load demand during handover, deflection channels are allocated to handover calls. This prevents channel resources from being wasted because deflection channels are only used for handover calls. Handover requests are given deflection by allocating a variable number of channel(s) ($Dch_{\_Red}$) just for handover requests among the total number of channels 'Ch' in a cell. Both new and handover call requests compete for the remaining channels, referred to as open access channels ($Och_{\_Blue}$), which are equal to ($Ch - Dch_{\_Red}$). A handover request is accepted as long as a channel is available; however, when channels are occupied, the request is deflected. When available access channels are fully utilized, a new call is accepted.

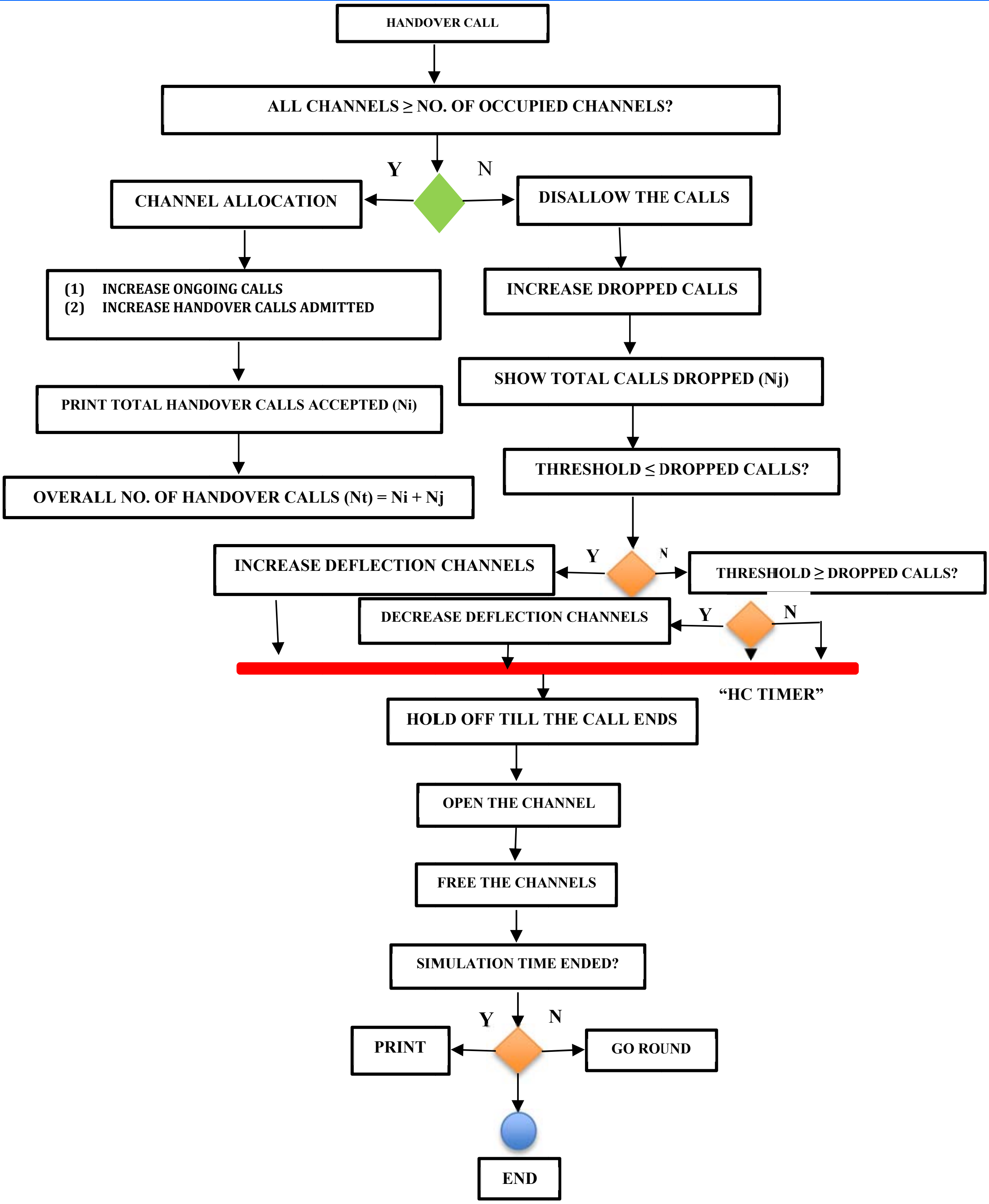

Figure 1: Flow diagram for Handover Calls

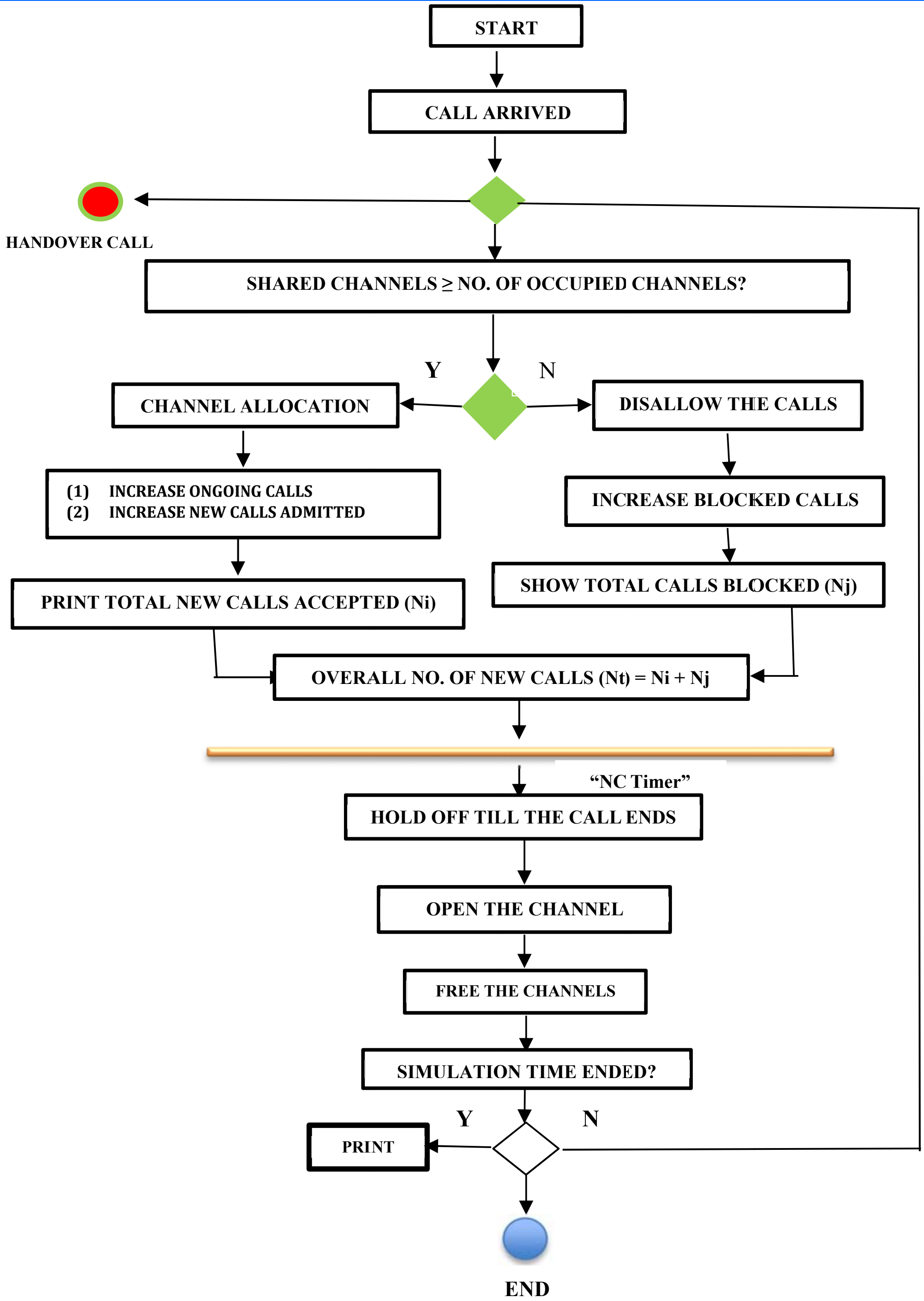

Figure 2: Flow diagram for New Calls

2.4 MODEL FOR HANDOVER ARRIVAL RATES WITH RESPECT TO HANDOVER DYNAMICS DEFLECTION MECHANISM

In a cellular network, an active terminal can travel from one cell to another. A successful handover from the previous cell to the new cell is required to maintain service to the mobile terminal in the new cell. If the appropriate resources are available and allocated for the mobile terminal, the handover is successful.

The terminal interfaces are Base Transceiver Station (BTS), Base Station Controller (BSC) and Mobile Switching Centre (MSC) is the number of call after reaching the maximum threshold to the number of deflected module. Mathematically:

$$Base\ Transceiver\ Station\ (BTS) = \frac{Number\ of\ calls_{After\ Max}}{deflected\ Module} \quad (3)$$

$$Base\ Station\ Controller\ (BSC) = Number\ of\ call * Number\ of\ BTS \quad (4)$$

$$Mobile\ Switching\ Centre\ (MSC) = Numberof\ Calls * Number\ of\ BSC \quad (5)$$

Handover Speed is the rate of the number of call load to the total deflected time. To calculate the measurements of the handover speed of these network.

$$Handover\ Speed\ (HOS) = \frac{Number\ of\ Call\ Load}{Total\ \ Deflected\ Time} \quad (16)$$

3. RESULTS AND DISCUSSIONS

A simulation program was developed for the handover deflection mechanism using JAVA and PYTHON programming languages. The simulation program was implemented with the deflection time set at 0.80 ms. Also, the maximum number of calls a base station can handle was set at 20 calls. Then, a number of simulations were executed for cases with no call in the network, with 20 calls in the network, with 40 calls in the network, with 60 calls in the network, and with 80 calls in the network.

3.1 THE RESULTS FOR THE HANDOVER SPEED AND TOTAL DEFLECTION TIME

The results for the handover speed and total deflection time for the Base Transceiver Station (BTS), the Base Station Controller (BSC) and the Mobile Switching center (MSC) are presented in Table 1. The results in Table 1 show that the number of call load is from 20 bytes at the beginning to 400 bytes at the end. Also, Table 1 shows that it takes a total deflection time of 0.080 milliseconds (ms) at the handover speed 0.250 bytes/ms from the beginning and handover speed of 5.000 bytes/ms at the end.

Table 1: Handover speed and total deflection time for BTS, BSC and MSC

S/N	Number of Call Load (Bytes)	Total Deflected /Handover Time (ms)	Handover Speed (Bytes/ms)
1	20	0.080	0.250
2	40	0.080	0.500
3	60	0.080	0.750
4	80	0.080	1.000
5	100	0.080	1.250
6	120	0.080	1.500
7	140	0.080	1.750
8	160	0.080	2.000
9	180	0.080	2.250
10	200	0.080	2.500
11	220	0.080	2.750
12	240	0.080	3.000
13	260	0.080	3.250
14	280	0.080	3.500
15	300	0.080	3.750
16	320	0.080	4.000
17	340	0.080	4.250
18	360	0.080	4.500
19	380	0.080	4.750
20	400	0.080	5.00

3.2 THE RESULTS OF THE HANDOVER DEFLECTION MECHANISM FOR CASE WHERE THERE IS NO CALL IN THE NETWORK

The results of the handover deflection mechanism for case where there is no call in the network are shown in Figure 1. In this case, the handover deflection mechanism PYTHON scripts detected that there was no call made at that particular time across the network. As a result, the system is free from congestion, the system experiences no call drop, no waiting call and any call made at this time would easily be propagated across the telecommunication system.

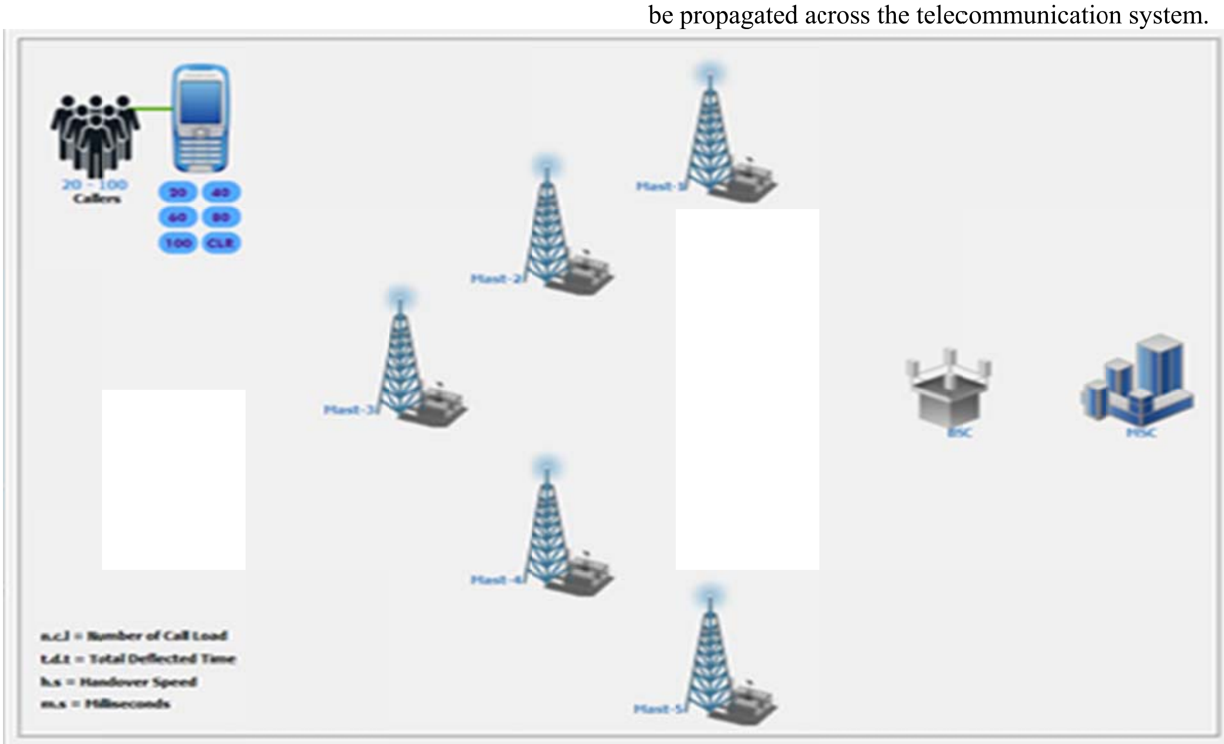

Figure 1 The PYTHON simulation model for the case where there is no call in the network

3.3 THE RESULTS OF THE HANDOVER DEFLECTION MECHANISM FOR CASE WHERE THE TOTAL NUMBER OF CALLS IN THE NETWORK IS LESS THAN 20

The PYTHON simulation model for the case where the total number of calls in the network is less or equal to 20 is shown in Figure 2. From the simulation model in Figure 2, 20 calls were seen propagated across the network. However, in the case study network, the maximum calls that should be handover at a particular time is 20 calls at 0.800ms. These 20 calls can be handled effectively without any deflection as observed from the simulation model.

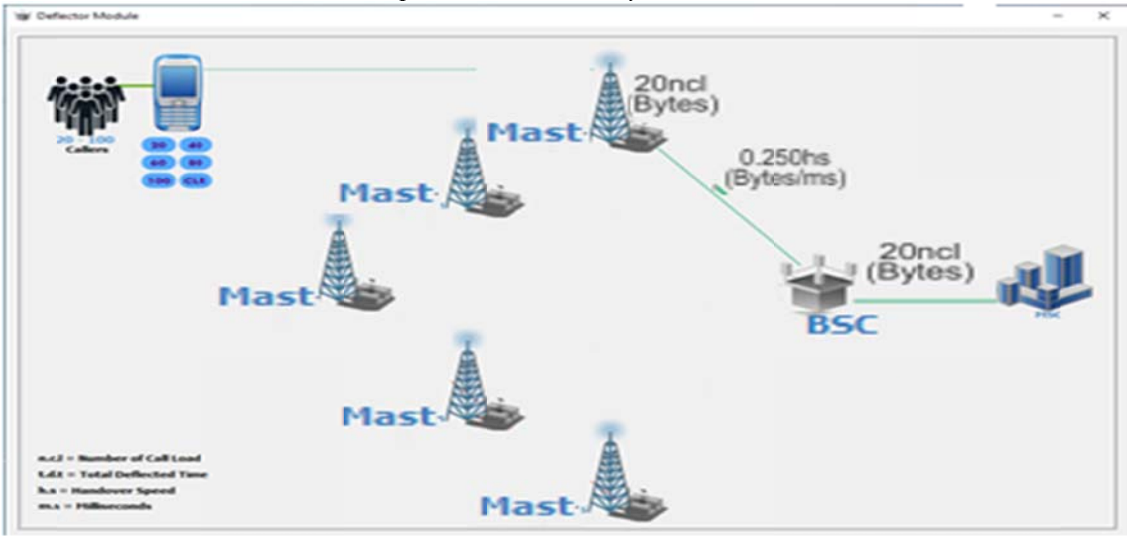

Figure 2 The PYTHON simulation model for the case where the total number of calls in the network is less or equal to 20

3.4 THE RESULTS OF THE HANDOVER DEFLECTION MECHANISM FOR CASE WHERE THE TOTAL NUMBER OF CALLS IN THE NETWORK IS GREATER THAN 20 BUT LESS THAN 40

The PYTHON simulation model for the case where the total number of calls in the network is greater than 20 but less than 40 is shown in Figure 3. In Figure 3, it is observed that 40 calls have entered the network. However, the maximum number of calls a base station can handle is 20 calls at a time but as seen in Figure 3, the calls entering the network has exceeded the maximum calls stipulated by the network. At this point, the handover deflection module will simply deflect the other 20 calls to the nearest Base Transceiver Station (BTS) in that vicinity with a specified handover time of 0.800ms to the Base Station Controller (BSC) then to the Mobile Switching center (MSC) and then re-routed to their different destinations. This help to reduce congestion and drop calls.

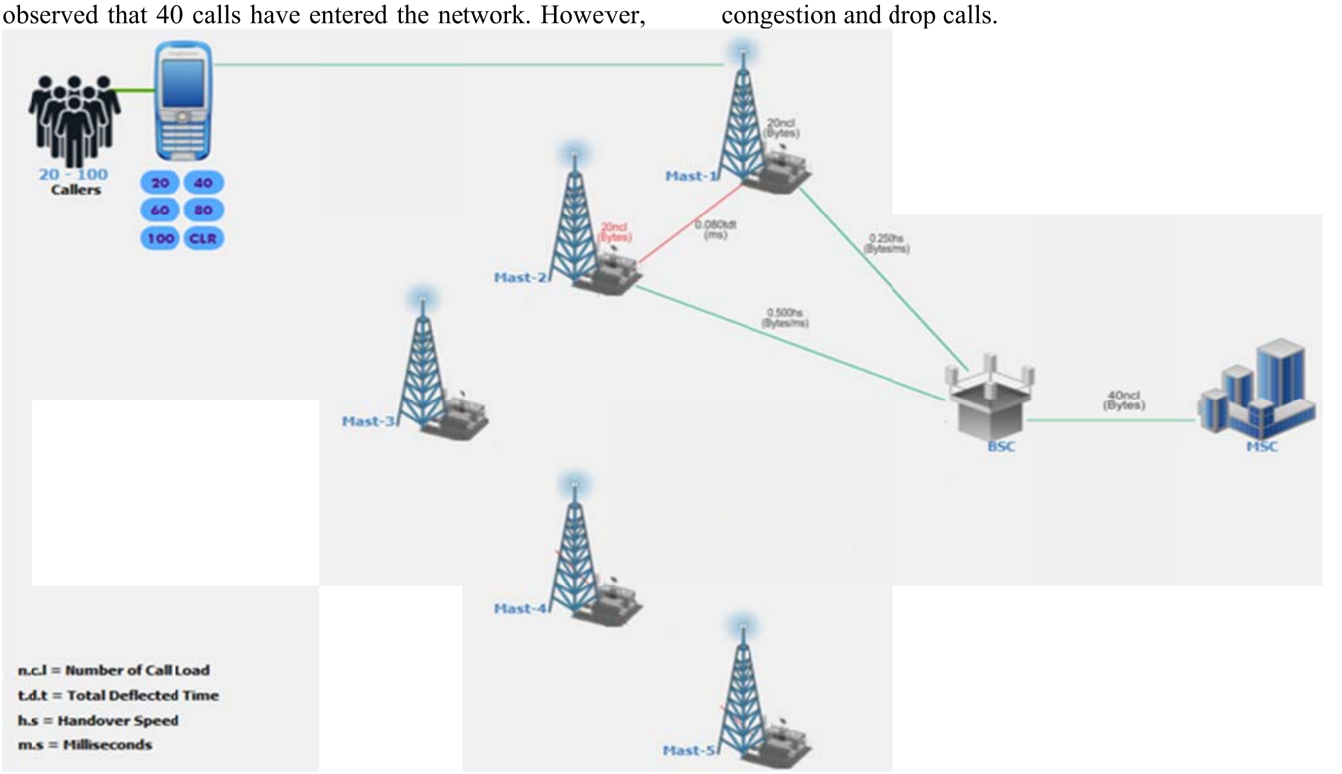

Figure 3: The PYTHON simulation model for the case where the total number of calls in the network is greater than 20 but less than 40

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3.5 THE RESULTS OF THE HANDOVER DEFLECTION MECHANISM FOR CASE WHERE THE TOTAL NUMBER OF CALLS IN THE NETWORK IS GREATER THAN 20 BUT LESS THAN 60

The PYTHON simulation model for the case where the total number of calls in the network is greater than 20 but less than 60 is shown in Figure 4. In Figure 4, it is observed that 60 calls have entered the network. However, the maximum number of calls a base station can handle is 20 calls at a time but as seen in Figure 4, the calls entering the network has exceeded the maximum calls stipulated by the network. At this point, the handover deflection module will simply deflect the other 40 calls to the other nearest Base Transceiver Stations (BTS) in that vicinity with 20 calls for each, that means three (3) Base Transceiver Station (BTS) or more are now in operation because of the other (40) calls and with the same handover time of 0.800ms. The Base Station Controller (BSC) has the capacity to process all the 60 calls injected across the network as well as the Mobile Switching Center (MSC) because of their huge processing capacity. This help to reduce congestion and drop calls.

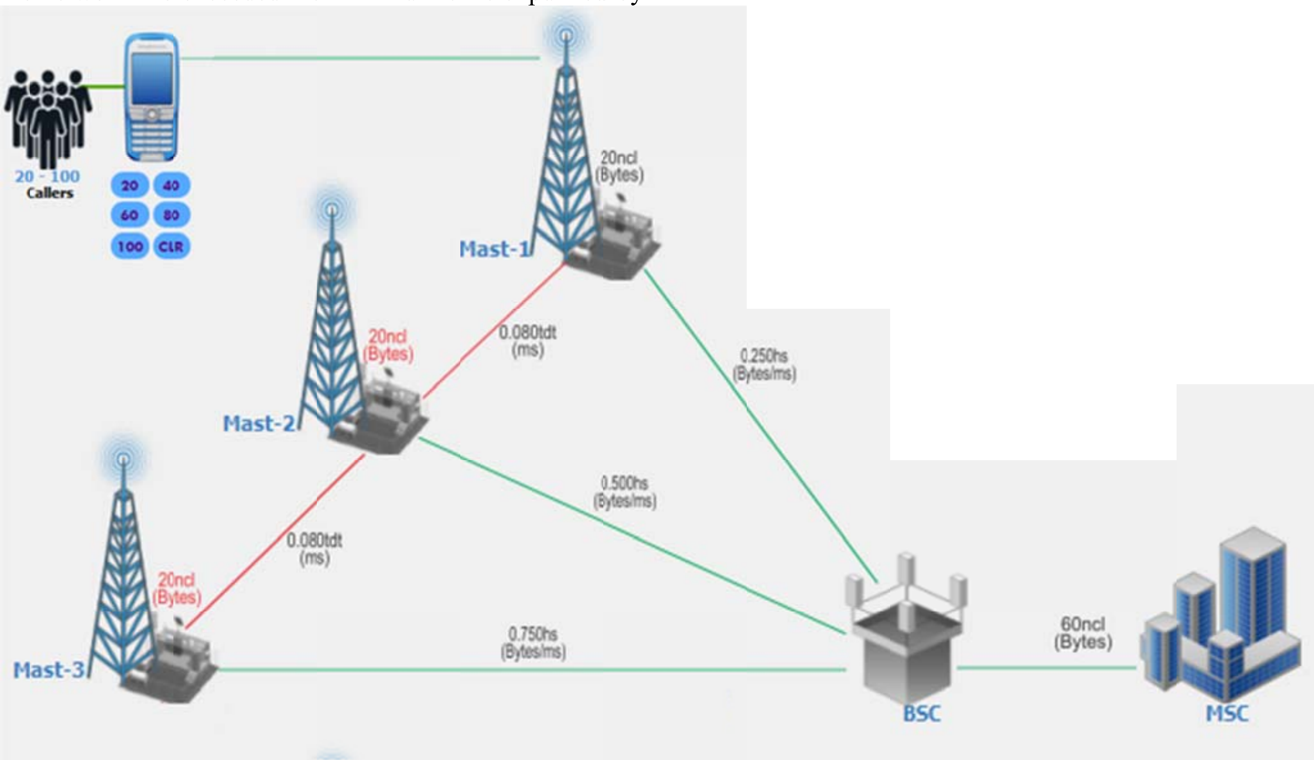

Figure 4: The PYTHON simulation model for the case where the total number of calls in the network is greater than 20 but less than 60

3.6 THE RESULTS OF THE HANDOVER DEFLECTION MECHANISM FOR CASE WHERE THE TOTAL NUMBER OF CALLS IN THE NETWORK IS GREATER THAN 20 BUT LESS THAN 80

The PYTHON simulation model for the case where the total number of calls in the network is greater than 20 but less than 80 is shown in Figure 5. In Figure 5, it is observed that 60 calls have entered the network. However, the maximum number of calls a base station can handle is 20 calls at a time but as seen in Figure 5, the calls entering the network has exceeded the maximum calls stipulated by the network. At this point, the handover deflection module will simply deflect the other 60 calls to the other nearest Base Transceiver Stations (BTS) in that vicinity with 20 calls for each, that means four (4) Base Transceiver Station (BTS) or more are now in operation because of the other (60) calls and with the same handover time of 0.800ms. The Base Station Controller (BSC) has the capacity to process all the 80 calls injected across the network as well as the Mobile Switching Center (MSC) because of their huge processing capacity. This help to reduce congestion and drop calls.

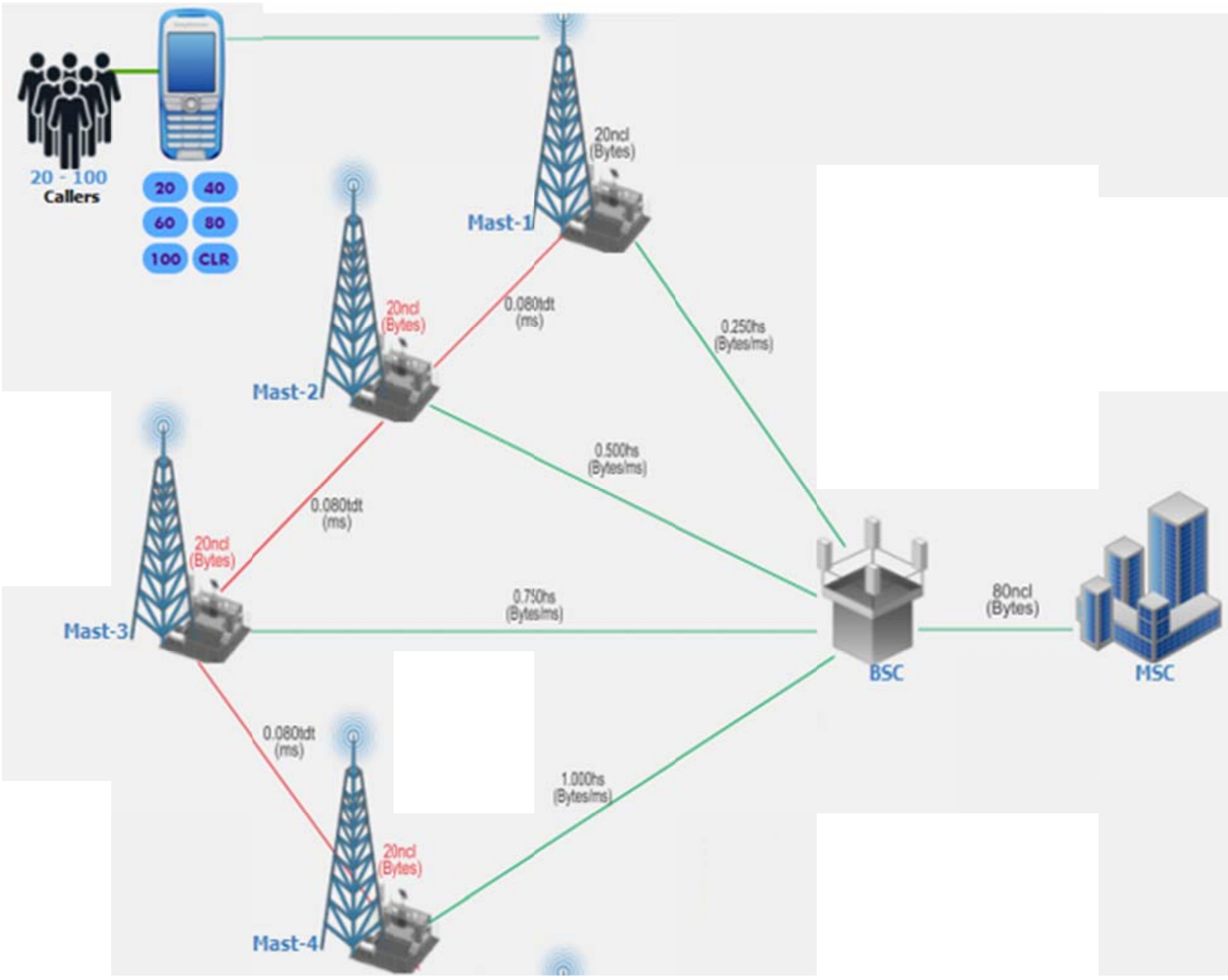

Figure 5: The PYTHON simulation model for the case where the total number of calls in the network is greater than 20 but less than 80

4. CONCLUSION

A mechanism for addressing the problem of handover failure in mobile telecommunication networks in Nigeria is presented. The mechanism is based on a dynamic deflection of calls from one base station to the nearby base stations when the base station is being flooded with incoming calls. The call deflection mechanism has knowledge of the call carrying capacity of the base stations and has mechanism to determine when calls need to be deflected to nearby base stations and the deflection time. The dynamic call deflection mechanism was implemented using programs written in JAVA and in PYTHON. Sample simulations runs were used to validate the operation of the mechanism and to establish its ability to mitigate congestion and also improve on call handover probability performance of the network.

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