Optimization of Handover in Mobile System by Using Dynamic Guard Channel Method

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Abstract

Handover process is a very essential process in the Global System for Mobile Communication system (GSM). Its study is one of the major key performance indicators in every GSM network, and its linked to the quality of service of an each service provider strives to attain. The failure of the handover process is regarded as the drop of quality of service which in turn dissatisfies the customers. This study, contributes more on improving call drop rate in general, reduce handover failure rate and thus save on upgrade costs, this will be beneficial to GSM service providers to easily optimize their network faults relating to the resource management. In this paper, dynamic guard channel algorithm is presented that was developed using JAVA Software. This algorithm prioritizes the handover calls over the new originated calls. All handover calls are ongoing calls and if they are dropped it causes frustrations. Matlab was used to compare simulated results to the other schemes by use of graphs and charts. From this paper we were able to establish and come up with a definitive solution to the handover crisis befalling telecommunication companies.

Keywords: GSM, handover failure rate, call drop rate, dynamic Guard channel, JAVA, Quality of Service (QoS).

1. INTRODUCTION

Conventionally, after network infrastructure deployment, a few unforeseen problems are met. We start to notice the process where a person is able to migrate from a cell area to another and still maintain the network availability. This process is called "handover process". As [1] described, handover is a process that transfers or shifts an active call from one cell area to another cell area as the subscriber goes through the coverage location of a cellular wireless network. Noerpel [2] suggested that, for a handover to be successfully processed, the new base station (BS) selected, must have an idle available channel that is open to handle the new handover call. Otherwise, the handover call will be dropped. Rather than dropping the call to the current mobile station (MS), the mobile switching centre (MSC) that is serving currently may decide to handover or shift this call to another available and better serving base station system or in some times to another mobile switching centre [3]. By doing this, GSM ensures a greater retention of calls thus improving the quality of service (QoS). Handover process is therefore very critical where improper handover process can result to call drops. If the rate of dropped calls increases, the subscriber becomes annoyed and dissatisfied and sooner or later he/she moves to another network. In addition to that, as [4], [5] acknowledged, new calls usually have low sensitivity to delay than a handover calls because handover calls need continuity for voice and message transfer.

2. RELATED WORK

2.1 Types of Handover Mobile System

The word handover is largely used in Europe, where handoff is inclined to be used in North America [6]. Handoff and handover refer to the same mechanism. There are four scenarios for handovers calls; within the second generation system there are four categories of handover calls that can be done for GSM networks [7]:

2.1.1 Intra-BTS handover (between channels)

In this kind of handover, handover occurs when a fresh channel in the same base transceiver station (BTS) is allocated to the mobile station. Intra- BTS handover, occurs when a new frequency is needed because of interference, or other reasons [8]. The procedure is performed independently by the base station controller (BSC), but the MSC may also be in charge. It is important to emphasize that an Intra-BTS handover is consistently synchronized, since all transceivers (TRXs) of a BTS have to use the same clock [9]. Figure 1 illustrates Intra-BTS handover.

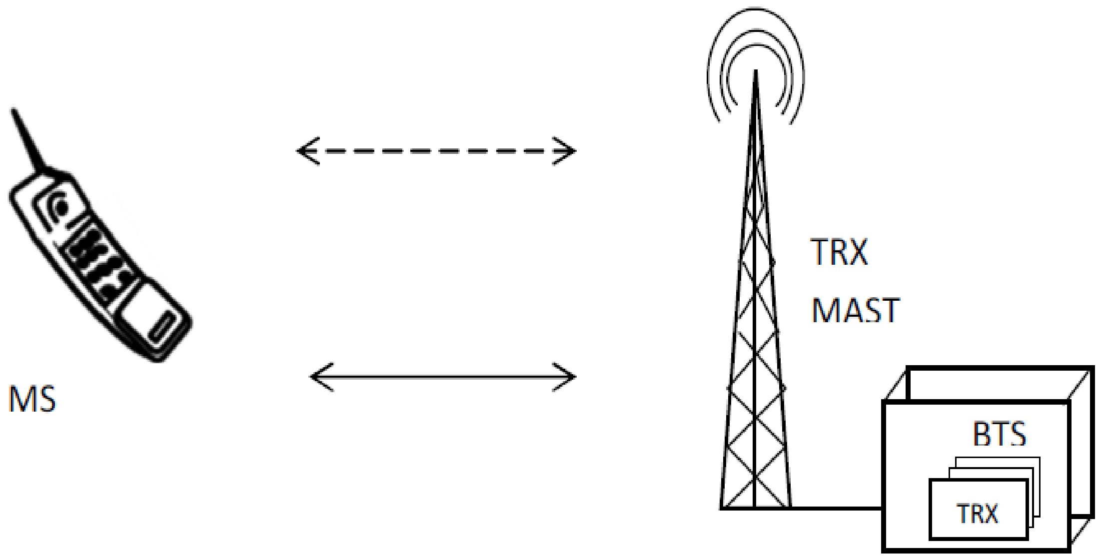

Figure 1: Intra-BTS handover [9]

2.1.2 Intra-BSC handover (between cells)

This kind of handover occurs when the call is relocated from one BTS into another BTS coverage area under the control of the same BSC, as illustrated in Figure 2. In this case base station controller can do a handover and it allocates a fresh channel before dismissing the discarded BTS from communicating with the handset [8]. This handover may be done independently by the base station controller without the intervention of the mobile switching centre [9]. Moreover, the MSC is alerted when the handover has occurred.

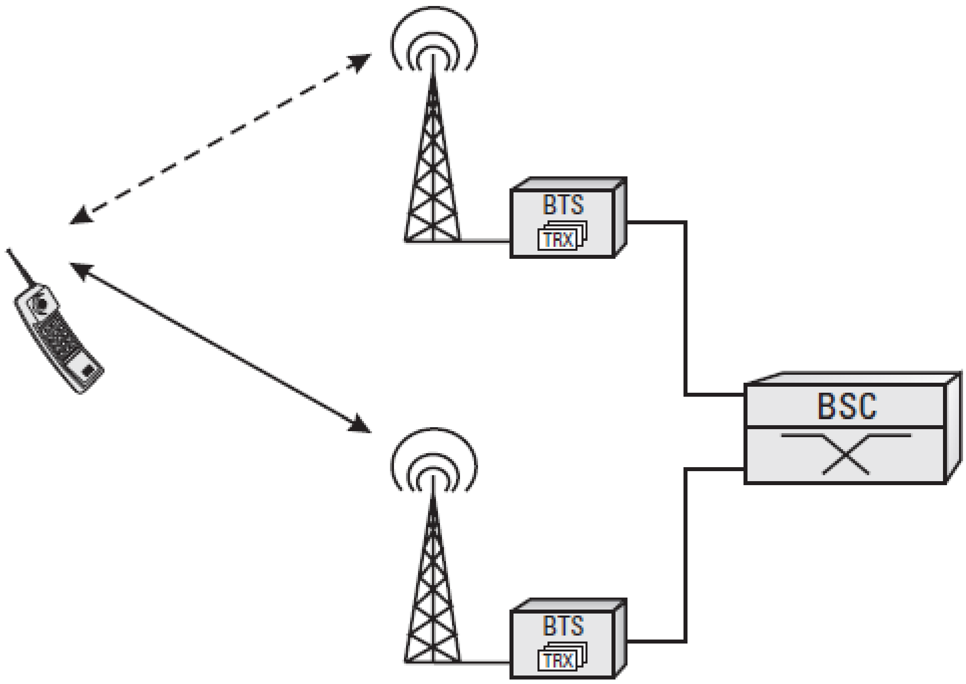

Figure 2: Intra-BSC handover [9]

2.1.3 Intra-MSC Handover (between BSCs)

Whenever the cell or mobile moves outside the range of the cells under the control of one base station controller, a more complicated procedure of handover may be executed, handing over the call not only from one base transceiver station to another but also from one BSC to another [9], or, in other words, In this handover, the mobile station changes the base station controller and the base transceiver station, as well, as illustrated in Figure 3. Unlike to the Intra-BTS handover and the Intra-BSC handover, this handover is controlled by the MSC. The role of the MSC is not processing the capacities of the BTS or MSC but just to achieve the handover. When the resources are allocated the MSC initiated to access the fresh channel and the call is relocated to the new BSC [7].

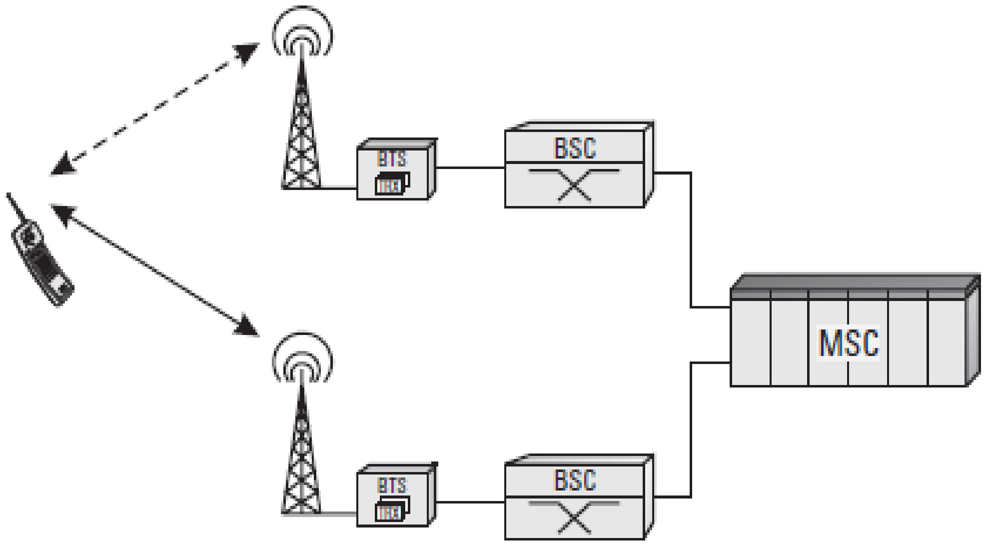

Figure 3: Intra-MSC Handover [9]

2.1.4 Inter-MSC Handover (between MSCs)

It occurs when there are two cells which belong to different MSC in the same system [9]. This is illustrated in figure 4. For an inter-MSC handover the old (current serving) MSC is mostly referred to as the anchor the MSC and the new (target) MSC is referred to as the relay MSC [10].

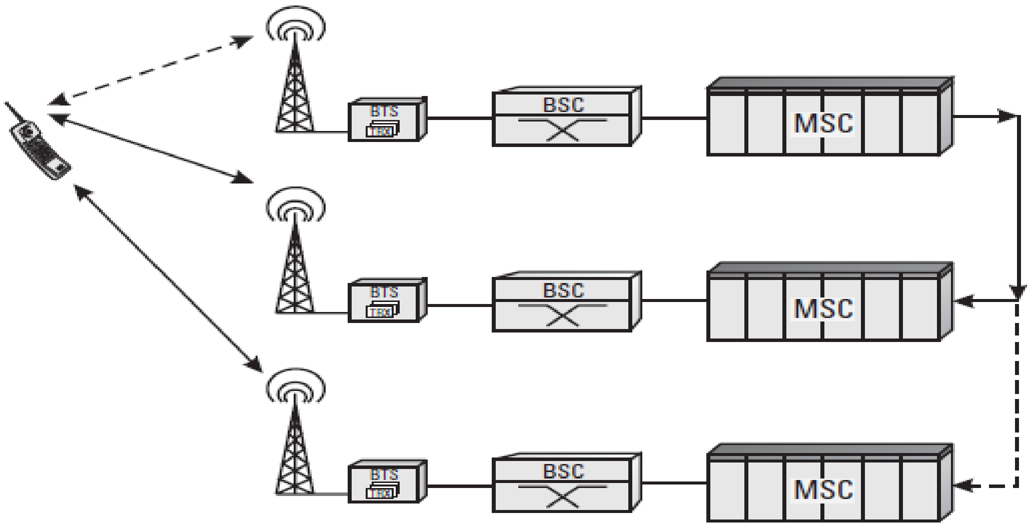

Figure 4: Inter-MSC Handover [9]

2.2 Handover Protocols

Usually the Handover request is originated either by the MS or by the BS. Handover decision protocols are categorized into four basic types as briefly described below.

2.2.1 Network Controlled Handover (NCHO)

In this technique, the MSC is accountable for the whole handover decision [11]. In network-Controlled Handover protocol [12], the MSC creates a handover decision depending on calculations of the RSS (Signal Received Strength) from the mobile station at a number of base transceiver stations. At occasion when the system creates a linkage between the current and target BTS and this reduces the time period of handover. Generally, the handover process takes 100–200 milliseconds and creates obvious impact in the conversation [13]. Statistics about the quality of the signal for all subscribers is found at MSC. The information enables resource assignment. Therefore [14], the total delay may be about 5–10s. This kind of handover is not fitting for a dynamic condition and congested customers as the result of the associated delay. This protocol is used in 1st generation analogue systems like AMPS &NMT [13].

2.2.2 Mobile Assisted Handover (MAHO)

As [12] indicated a mobile assisted handover (MAHO) procedure allocates the handover decision process. Here the Mobile Station is in charge of discovering the BS where the strength of the signal is closest to it. The Mobile Station calculates the signal strength and bit error rate values occasionally in the neighbouring base station.

Based on the obtained parameters, the MSC and BSs decides when to perform handover [15]. According to [14], there is a possibility of a delay of 1 sec. MAHO is currently being used in GSM.

2.2.3 Soft Handover (SHO)

Soft handover is creating a connection to another station before breaking it, which is, the link to the current base station (BTS) is not destroyed till the link to the target BTS is made. Soft handover utilizes the method of macroscopic diversity [16]. The same concept can be used at the MS too. When a MS is in the overlapping area of two neighbouring cells then a soft or softer handover can occur. The user will therefore have a dual concurrent connection to the UTRAN portion of the network, utilizing various air interface channels simultaneously [17]. This protocol is for CDMA.

2.2.4 Mobile Controlled Handover (MCHO)

In this protocol [12] the mobile station is totally in control of the handover process. This kind of handover has a quick response (about 0.1 s) and is appropriate for micro-cellular systems [14]. The Mobile Station measures interference levels on all channels and the strength quality of the signal from the neighbouring BSs. A handover is originated when the strength of the signal which is serving the base station becomes lesser than the signal of another BS by a definite threshold. The targeted BS is therefore requested by the MS for a channel which has the least interference.

This protocol is the highest level of handover devolution. There are several advantages of handover decentralization, where some of the handover decisions may be done fast, and the mobile switching centre doesn't need to do handover decisions for all mobile or cells, which are very complicated duty for the mobile switching centre of high volume micro-cellular schemes [18]. This protocol is used in the DECT. The handover decisions are made by the mobile station. Both inter cell and intra cell handovers are possible. The handover time is around 100 Ms [12].

2.3 Handover Schemes

In GSM system supporting handover, there is a main element in present to guarantee that there is a continuity of connections and the Quality of Service observed by subscribers. The handover process is then accomplished by the purported handover methods; the main importance is focused on them. The handover methods can be generally categorised into Prioritization and Non-Prioritized Schemes as in figure 5 [11].

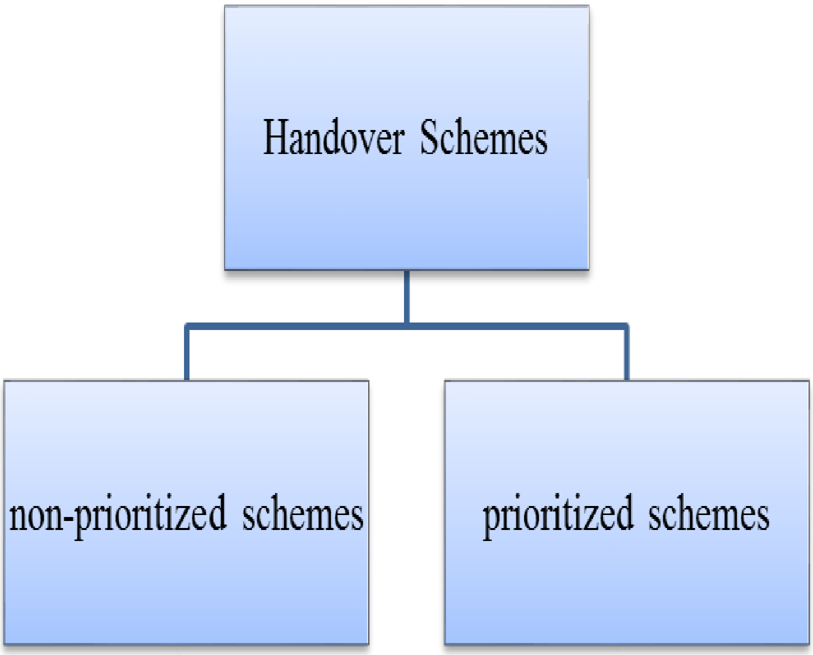

Figure 5: Classification of the handover schemes

2.3.1 Non-Priority Handover Scheme

For non-prioritization scheme originated calls and handover calls are to be handled using a similar approach. The moment the BS has a free channel, it is allocated according in a first arrive first serve technique irrespective of if the present call is a fresh call or handover call. If there aren't any idle channels, then the request will be rejected instantly. One of the disadvantages of this method is that, because there isn't any precedence that accorded to the handover request calls over new calls, the handover dropping rate is quite higher than it is basically estimated [12].

From the subscriber's view point, the unintended end of a call which is on-going is more irritating than the blocking of originated call that hasn't even started [13]. Subsequently, the handover dropping and the involuntary dropping probabilities need to be reduced. To attain these requirements, various handover prioritizing methods have been suggested.

2.3.2 Handover Prioritization Schemes

The mobile device usage, rapid increase necessitates the needs to meet QoS requirements of the subscribers. These requests nevertheless, allocation usually cause network congestion and call drops. The Different concepts and methods are presented to lessen the handover dropping rate. One of the used techniques is to minimize the percentage of handover failure rate which gives handover higher priority than fresh calls [7]. This prioritization method has a major effect on the handover call drop rate and originated call rejected probability. Therefore such a system works by allowing a high consumption of capacity while ensuring the QoS of handover calls is maintained [8].

Handover prioritization schemes offer a better performance at the cost of a falling in the sum of accepted load traffic and upsurge in the rejected call probability of originated calls [14]. Nonetheless, the enhancement in efficiency is normally associated with the way that each technique provides precedence to handover requests.

2.4 Channel Allocation Schemes

According to [15] Channel allocation technique can be categorized into a various types along the foundation of contrasting plans, they devised for allocation of channels. There are three fundamental channel assignment methods in cellular networks.

2.4.1 Fixed Channel Allocation Scheme

In this method, a group of channels is permanently allotted to each base station in such a way that the frequency reuses control can hardly be disrupted. Each cell only can use its channels. The FCA strategy, originated call or a handover call can only be accepted if there are free channels available in the cell; or else, the call must be dropped or rejected [11]. In this algorithm, the capacity will get wasted if all the assigned channels neither in use nor freely available at that moment bandwidth won’t be allotted [16]. The main advantage of FCA scheme is its lack of complexity, but it is not flexible to varying traffic environments. The major disadvantage of FCA scheme is high blocked calls, because of lag of flexibility in the scheme [15].

This algorithm is useful and well functioned when the demand is not dynamic. However, in the real world the traffic is irregular and changes dynamically with time. This method lacks flexibility to satisfy the dynamic requirement of channels [17].To get a solution of this drawback Dynamic Channel Assignment (DCA) method has been proposed.

2.4.2 Dynamic Channel Allocation Scheme

This method doesn’t assign any channel to each cell [17]. In DCA method, channels are dynamically assigned to cells [15], this is in contrasts to fixed channel allocation. In DCA, The mobile switching centre manages all channels in a region of many cells. When a call comes to these cells, the BS of the cell will request for a channel to MSC. If the centre has any open channels, then it will accept this call. If not, then this call will be blocked [17]. Also, a base station does not own any specific channels and it is returned to the central chosen cell when a call is finished.

In DCA method [18], when the traffic is congested in a cell, additional bandwidth are provided to that cell, and when the traffic become slight, assigned channels are minimized. Dismissed channels are made available to other cells which need extra channels. This reflects reducing the call setup failure rate in these high traffic load cells. This channel readjustment process needs the cells to have loads of communication and data exchange. Consequently, a DCA approach must be applied in a way that necessitates the lowest info being exchanged among BSs to reduce the signalling overhead and complexity.

2.4.3 Hybrid Channel Allocation Scheme

HCA combines both of features of DCA and FCA methods. HCA algorithm allocates other channels dynamically and some channels statically. This algorithm [16], total bandwidth are divided into two clusters. One is static and the other one is dynamic. In [18], the frequencies included in the static channels are allocated to each cell via the FCA methods. But, the dynamic settle of channels is shared by the BSs. When a mobile station needs a channel to handle a call, and the frequencies in the static set are all occupied, then a request from the dynamic set is sent [18]. This technique therefore gives fewer loads to centre than DCA and provides more flexibility than FCA [17]

2.4.4 Comparison between FCA and DCA

Table 1: Comparison between DCA and FCA

Evaluation Parameter	FCA	DCA
Average handover blocking rate	High	Low
Average call dropping probability	More	Less
Minimize the interference	Not good	Good
The load in the network traffic	Un balance	Balance
Resources utilization	Less	More
Channel Al location	Do not modify during processing of calls	Changing Dynamically
Complexity	Less	More
Flexibility	Less	More
Implement at ion Cost	Low	High

2.5 Types of Handover Management Schemes.

Basic methods of handover prioritization methods are handover queuing schemes, call admission control (CAC), and guard channels (GChs). At times some of these schemes are joined together to find better results [19]. The main goal of any handover technique is on how call dropping or the unexpected dropping probability can be minimized.

2.5.1 Handover Queuing Prioritization Schemes

Handover queuing scheme (HQS) allow either the handover to be queued or both the new calls and handover requests to be queued [11]. In HQPS, this method lines the handover calls when there is no available channels in the BSC. If one of the calls are finished and the channel is dismissed in the BSC, then it is allocated to one of the handover call in the line. This method minimizes the unexpected termination probability at the cost of the augmented call setup failure rate. As [19] stated, Queuing is performing well when handover requests come in bunches and the traffic load is light. When handover requests occur uniformly, no need for queuing. The FIFO technique is one of the most common queuing methods.

In HQS method when the RSS of the BSC in the under usage cell extends to certain predefined threshold then the call is queued from service a neighbouring cell. Originated call request is allocated to the channel frequency if the queue is unoccupied and if there is any of idle channel in the BSC [8].

2.5.2 Call Admission Control

CAC is a method that is used to maintain the Quality of service by estimating the originated call blocking rate and handover unexpected termination probability where average channel holding time is very important term to calculate this quality of service (QoS). These measurements may be specified in cellular systems that the handover call terminated rate is lower than 5%, for voice calls [20]. The CAC method [21], is responsible to decide and view whether originating call requests are going to be accepted into the system or not. This algorithm, the arrival of originated call is assessed constantly and when they are of a higher threshold than the advanced declared threshold point then the calls are cleared and rejected regardless if a frequency is free or full to minimize the rate of handover dropped calls. There is a transaction between the Quality of Service level supposed by the subscriber and the utilization of unusual network resources.

There exists various techniques and expressions to estimate these QoS parameters where following presumptions are generally utilized: and call arrival is a Poisson process [22], the channel holding time, and the call holding time those are supposed exponentially distributed, the cell residence time. In call admission control method both the handover calls and new calls have a permission to use all the available channels. And when the originated call cannot get a free channel then the call is rejected instantly [21].

2.5.3 Guard Channel Scheme (GChS)

The quality of service is not satisfactory if the handover dropping rate is same as originated call blocking rate. In the GChS policy, static numbers of frequencies in each cell are allocated mainly to support handover calls. The GChS improve the probability of a successful handover because they take the highest priority by assigning a static or dynamically adjustable number of channels only for handovers among the total number of channels in the network, while the remaining channels can be shared equally by handover and originated calls [23].The arriving calls can be categorized into two classes, the originated new calls, and the handover calls; which are handovered from the adjacent cells, as shown in figure 6.

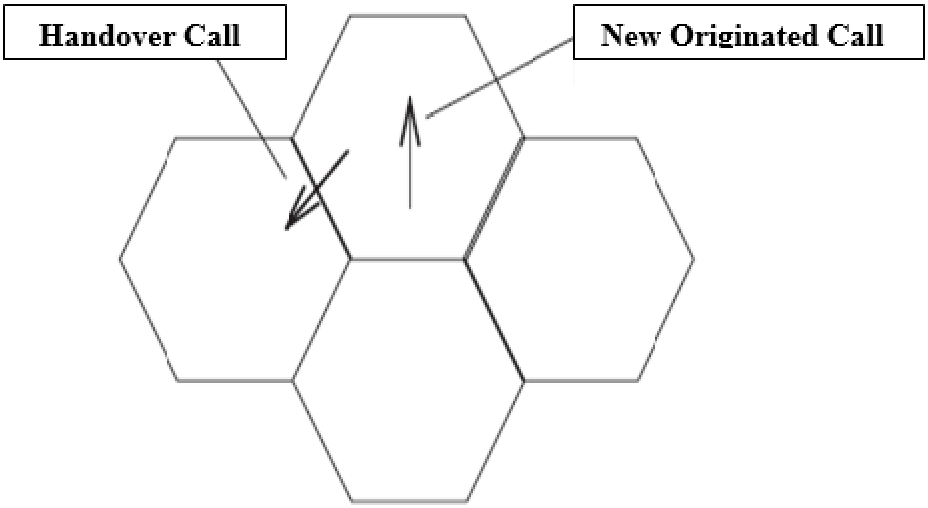

Figure 6: New call and handover call

It is worth to notice that to drop the handover call is more destructive than to block the new call, because the handover call is an existing and working call. To drop a handover, call means to disconnect a communicating call [17].

In fixed GChS, the higher priority calls such as voice and video calls have been given more priority than data. So by ignoring some resources of the lower priority classes the rejected call probability of the higher priority classes can be reduced. In this case the channel utilization falls. Because in this scheme if the number of higher priority traffic arrival rates are low; then some channels remain empty and these channels cannot be used by the lower priority traffic classes. It causes the reduced utilization of channels [24].The fixed GChS normally offers acceptable performance under nominal stationary traffic loads, but actual traffic loads are rarely fixed or have the same level as the nominal. Based on that, in this paper, dynamic guard channel algorithm was developed using JAVA Software.

3. SIMULATION MODEL AND RESULTS

3.1 Dynamic guard channel model description

This method uses threshold to explain the present state of traffic. If channels occupied are less than the stated threshold, the load traffic is light; otherwise, the load traffic is heavy. The channels used in the cell can also be divided into two parts: the guard channels “for handover calls only” the shared channels” for both” as shown in the figure 7.

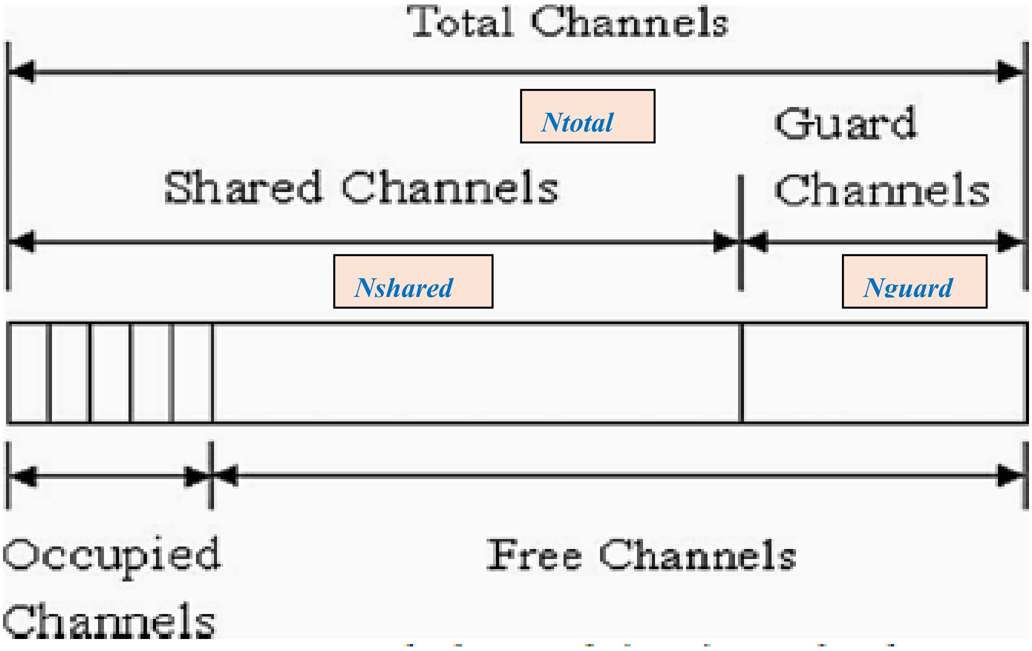

Figure 7: Channel Assignment structure with Priority for Handover Calls

For instance, when new incoming calls can admit the idle channels limited by the selected number of shared channels, the incoming handover calls can then access all the total channels as illustrated in the above figure.

The model mathematically described as:

$$N_{total} = N_{shared} + N_{guard} \quad (1)$$

$$N_{shared} = N_{total} - N_{guard} \quad (2)$$

$$N_{guard} = N_{total} - N_{shared} \quad (3)$$

Where

Ntotal : the total amount of available channels.

Nshared: the number of shared channels.

Nguard: the number of GChs.

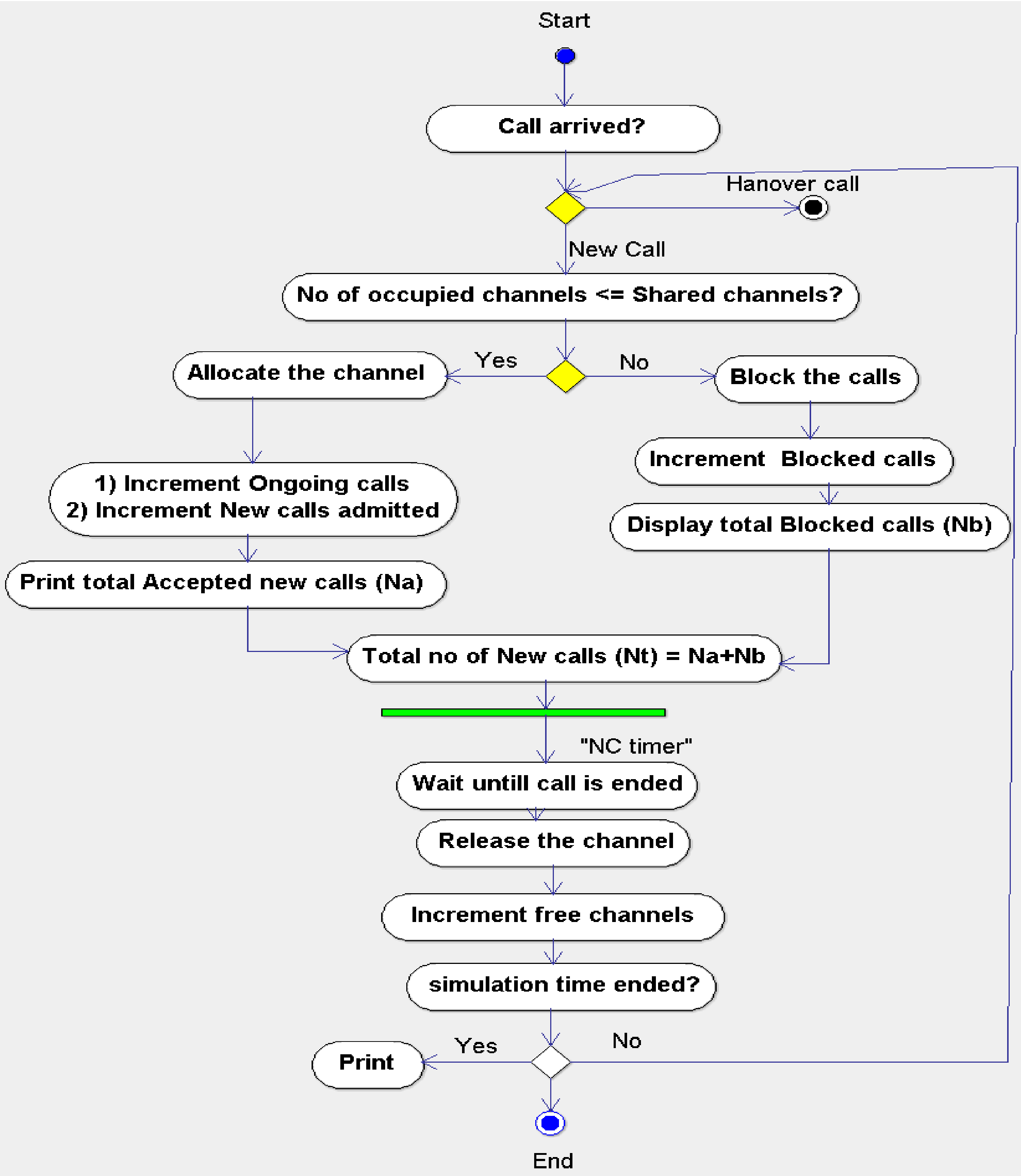

Figure 8: Flowchart for New Calls

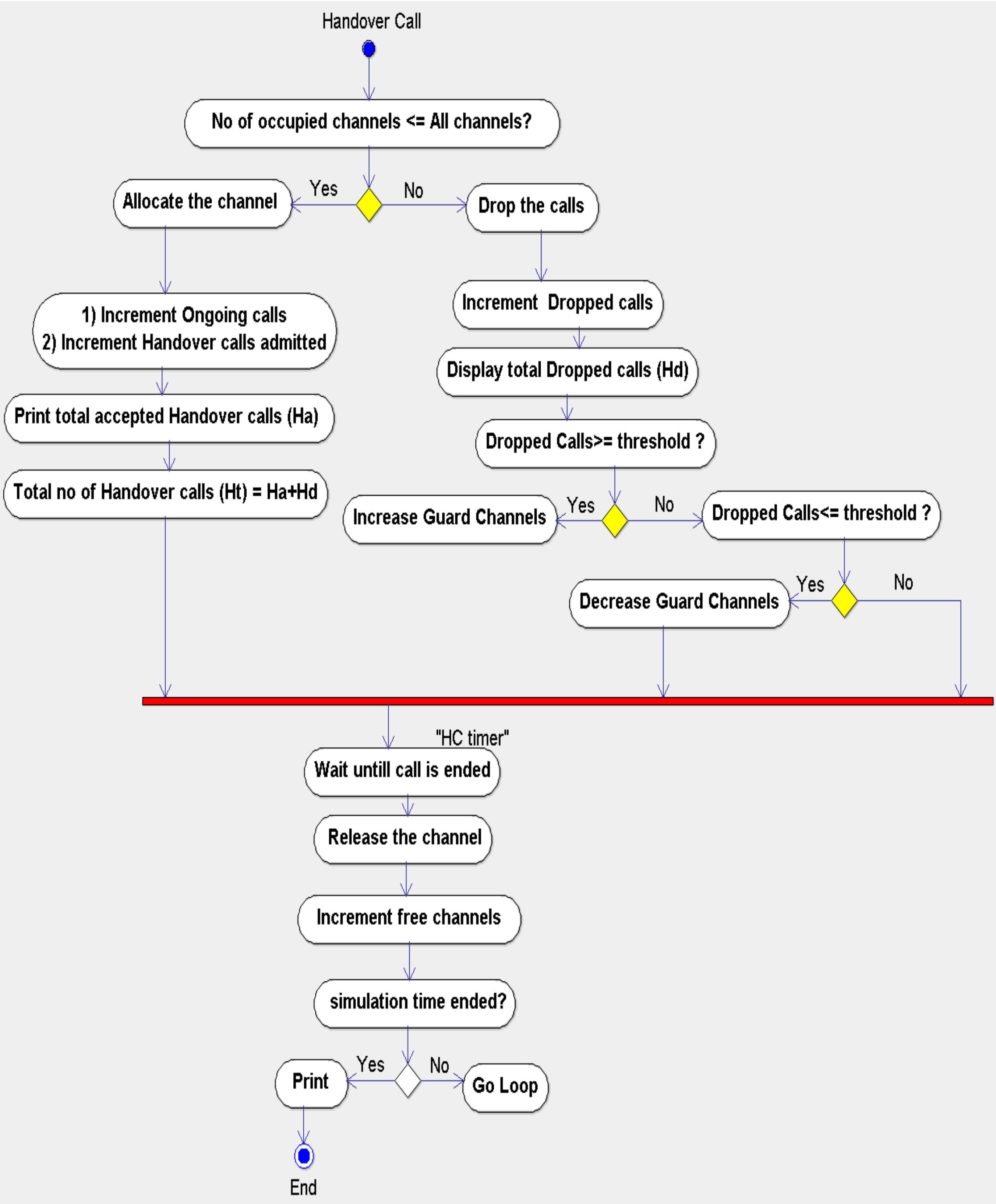

Figure 9: Flowchart for Handover Calls

3.2 Simulation results

To show the efficiency of the dynamic guard channel algorithm, performance indicators such as handover success rate, handover call dropping probability, originated call blocking probability and channel utilization are calculated. New originated and handover calls need to be analysed independently, because handover call dropping probability has a much greater influence on the quality of service than the probability of originated call blocking. Also new originated calls have low sensitivity to delay than a handover calls because handover calls need continuity for voice and message transfer [5]. Moreover, for the purpose of analysing the performance of our algorithm, with a holding time of 3 seconds and 3.2 seconds per call for new originated calls and handover calls respectively, an additional 2 guard channels are factored in.

Table 2: Average Simulated results

No of Channels	Simulation Time (Min)	No of Calls	New Calls	Handover Calls	Call Setup Success Rate (%)	Handover Success Rate (%)	New Call Blocking Probability	Handover Call Dropping Probability	Channel Utilization
120	1	50	34	16	100	100	0	0	100
120	2	112	72	40	100	100	0	0	100
120	3	172	128	44	94.77	100	0.0523	0	94.767
120	4	233	176	57	81.55	100	0.1845	0	81.545
120	5	294	227	67	75.85	99.66	0.2415	0.0034	75.510
120	6	355	275	80	69.86	99.44	0.3014	0.0056	69.296
120	7	415	284	131	65.31	98.55	0.3469	0.0145	63.855
120	8	475	367	108	62.53	99.37	0.3747	0.0063	61.895
120	9	535	381	154	62.62	98.88	0.3738	0.0112	61.495
120	10	596	437	159	60.24	99.66	0.3976	0.0034	59.899
150	11	652	461	191	62.88	98.62	0.3712	0.0138	61.503
150	12	712	493	219	60.95	98.03	0.3905	0.0197	58.988
150	13	772	523	249	59.59	97.67	0.4041	0.0233	57.253
150	14	832	592	240	58.29	98.80	0.4171	0.0120	57.091
150	15	893	469	244	58.23	98.81	0.4177	0.0119	57.11

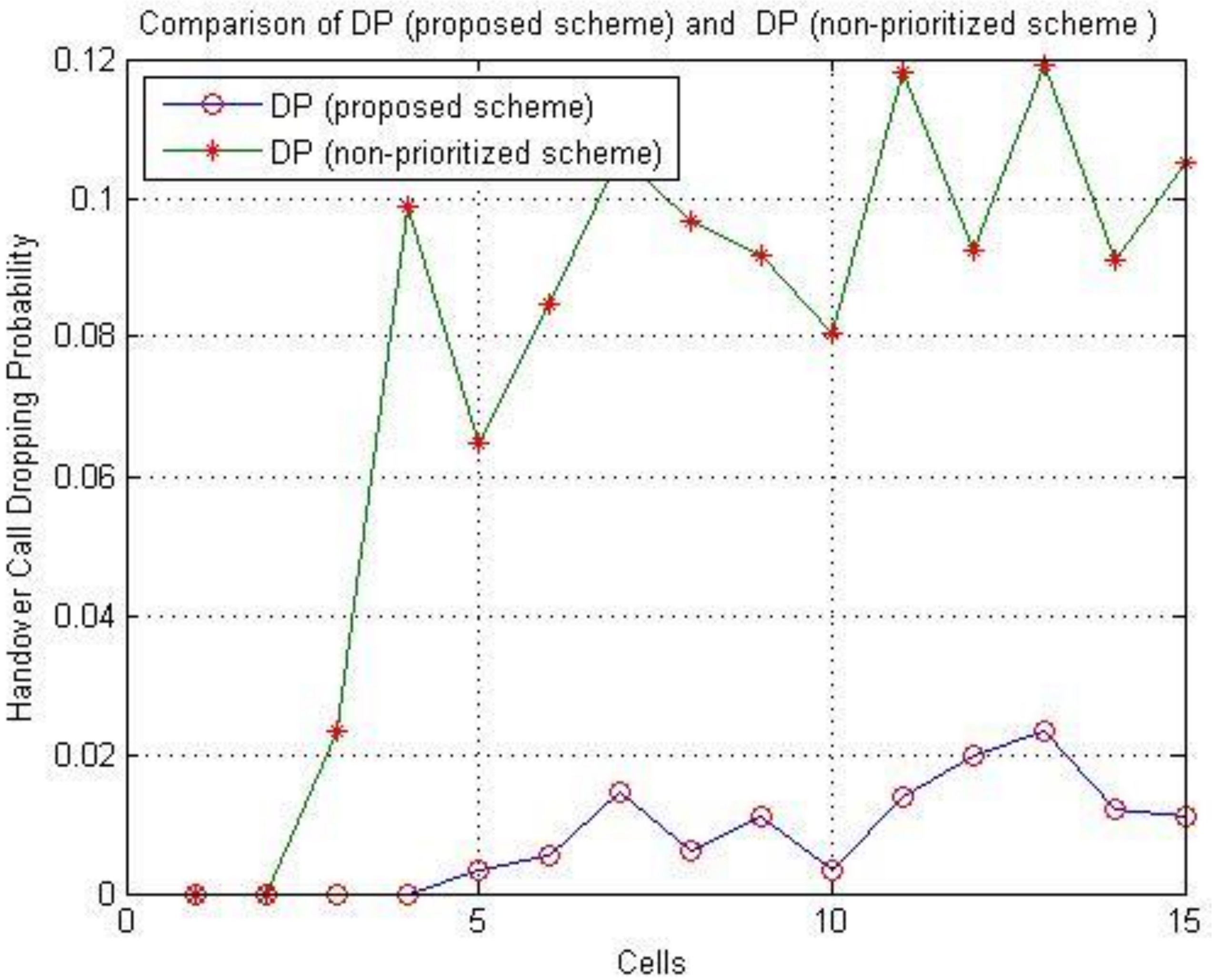

Figure 10: Handover call dropping probability (proposed scheme) vs handover call dropping probability (non-prioritized scheme)

Handover call dropping probability shows the probability that a new initiated handover call will be dropped. This value should be as small as possible an average of 0.02. The smaller the number is, the better the networks' quality of service would be, for both handover call dropping and new call blocking probability. Figure 10 shows the comparison between handover call dropping probability (non-prioritized scheme) and proposed handover call dropping probability. It's clear from the figure that the proposed algorithm outperforms and reduces the dropping probability of handover calls in comparison to other schemes, since the channels are reserved for handover calls based on the current estimate of terminating probability of handover purposes.

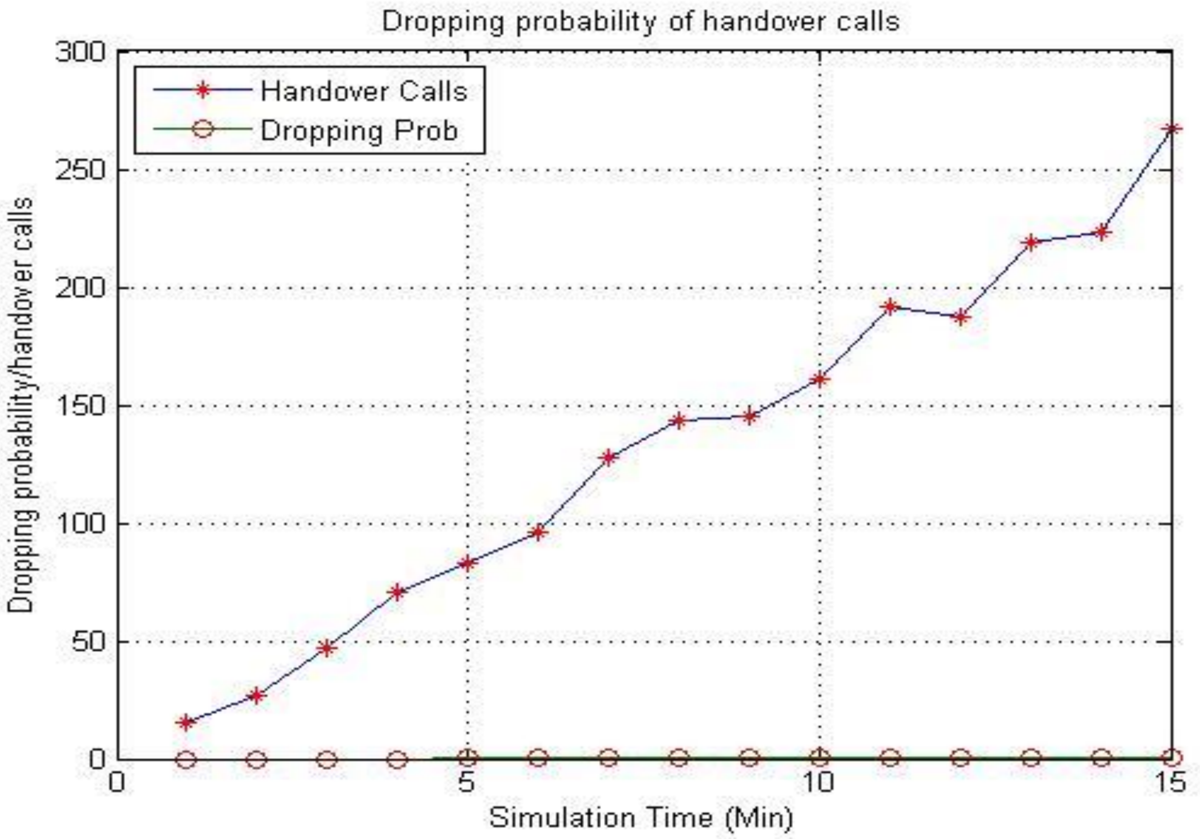

Figure 11: Handover call dropping probability

It's clear from the figure 11 that the number of handover calls gradually increased with time, but handover call dropping probability is maintained between 0 and 0.02**.** It was found that even though handover calls are increased almost three hundred, still handover call dropping probability is at the acceptance level. It is demonstrated in figure 11, that the number of handover calls dropped is much less in number even during in a heavy traffic.

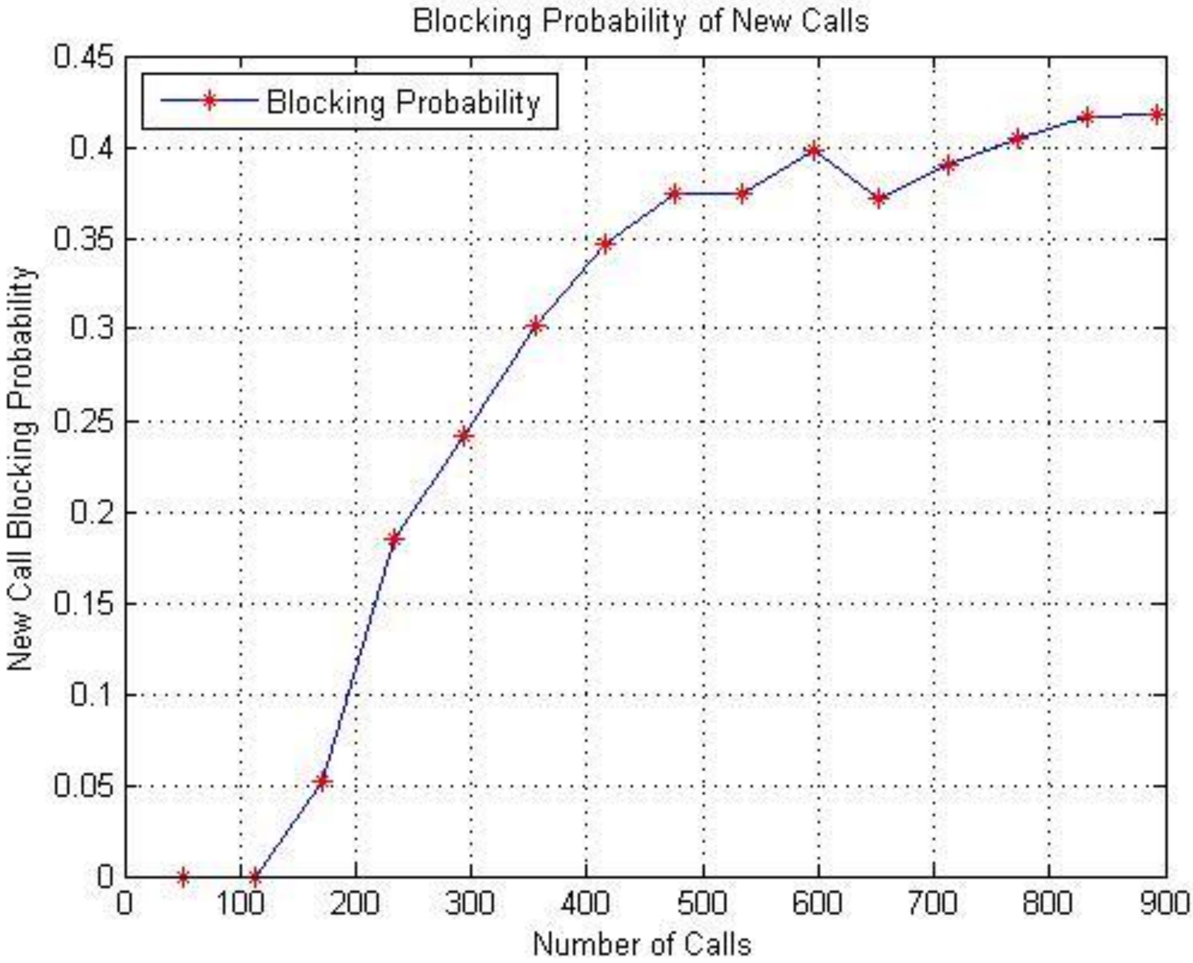

Figure 12: New call blocking probability

The dynamic guard channel method reduces significantly the blocking probability in comparison to the static guard channel algorithm. The call blocking probability shows the possibilities in which a new originated phone call may be dropped before it is admitted to the system. Each base station is different from the next and this probability should be kept as low as possible. It's observed from Figure 12, when the number of calls increases then the chance of getting a channel by the originated calls decreases and this fact results in more new call blocking probability taking place. In order to maintain a blocking probability smaller than this simulated result, the arrival rate of originated calls would have to be less.

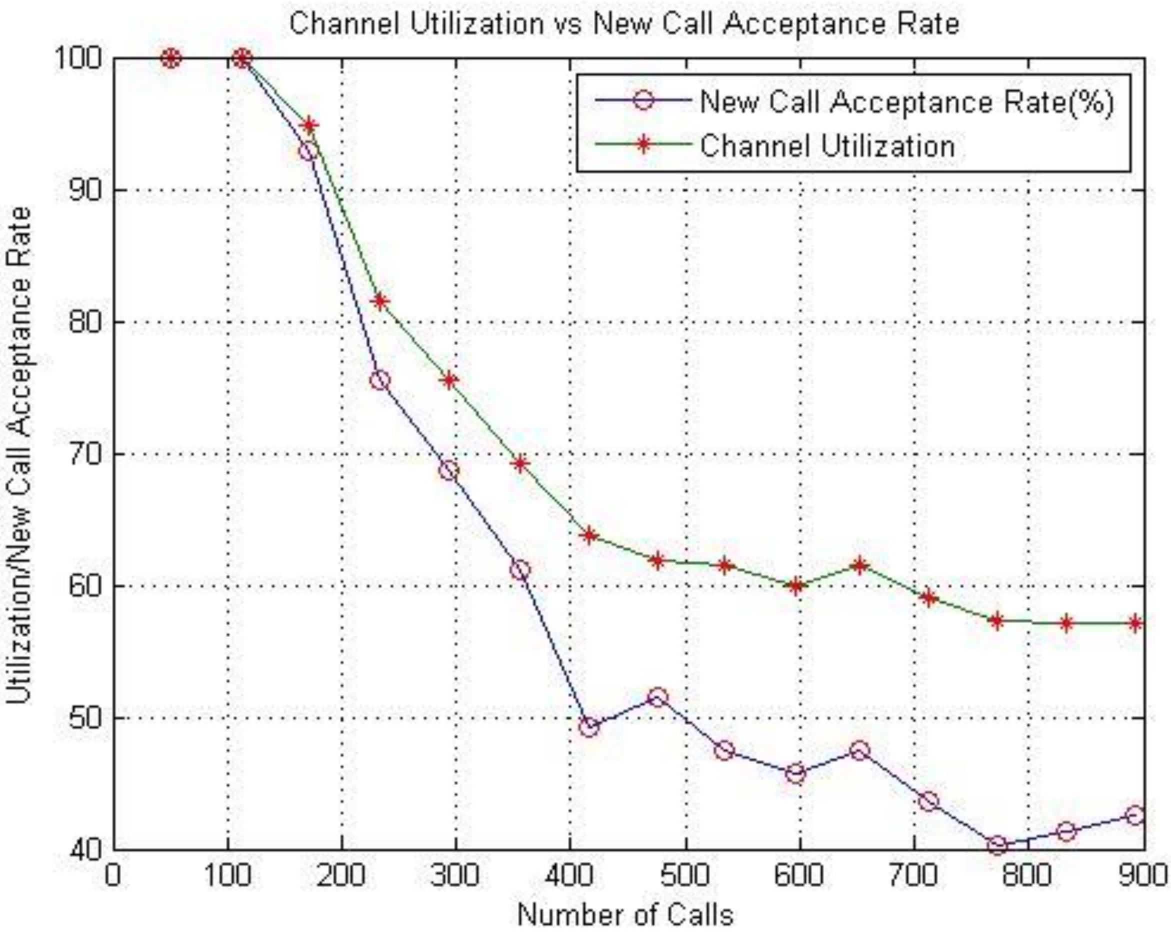

Figure 13: Channel utilization with new call acceptance rate

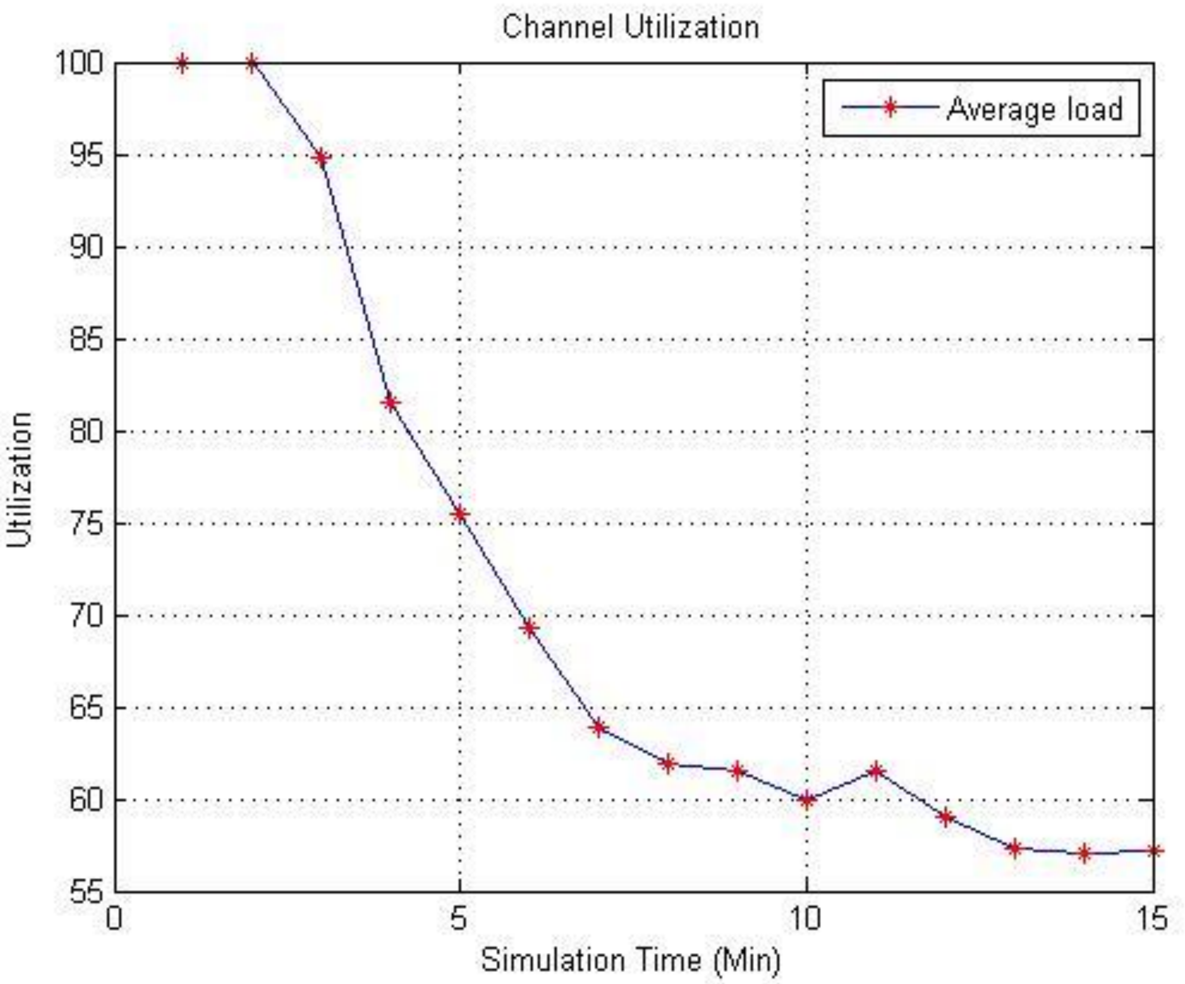

Figure 14: Channel utilization

Channel Utilization is able to monitor the general and overall performance of a network and how the resources are being utilized and if there is too much traffic it affects the overall experience that a user gets. In figure 13, it’s observable that with the increment of new originated call admittance rate the utilization of the channels is increased. Generally it’s also noticed that acceptance rate below fifty percent has a propensity to lessen channel utilization because of a slight drift to increase the blocked probability. New originated call admittance rate of any value more than 60% has satisfied channel utilization. Our algorithm shows a nearly constant value of channel utilization regardless of the variant of mobility and the time as presented in figure 14, and the use of dynamic GChS can attain a better channel utilization since the number of guard channels is dynamically allocated.

4. Conclusion and Further Work

In this paper, a dynamic guard channel scheme has been proposed. In comparison with the other algorithm, like non-prioritization (no guard channels) scheme we have seen our algorithm was able to deliver better performance and utilization. Our algorithm maintained the handover call dropping probability at (<=0.02) while constraining the new call blocking probability within acceptable level and optimizing the channel

utilization. Even in the heavy traffic, the handover call dropping probability are at the acceptance level. Moreover, with this algorithm, one hundred percent channel bandwidth are utilized and wastage of bandwidth are avoided, which will allow the service providers to generate more revenue.
Till now, this research deployed just one cell, further research may deploy several cells and run simultaneously. So that when a new or handover call enters or evacuates a cell, the directly related cell notifies its neighbour cells, and if the is admitted (either a handover call or a new call) in a chosen cell, say x, each of cell x's neighbouring BSs, say y, reserves a channel for incoming call in either direction.

While establishing the algorithm, we found out that balance is an important factor in order to improve or to reduce performance of the system. Following repetitive testing and also stress testing of different variations, there are some given limits whereby the system runs effectively and efficiently where other times it isn't. A major factor in these equations was the traffic load, which shows how the system is responding to certain pressure points. In the future research and study, the impact of the channel holding time on the quality of service can be studied and analysed.

Studying, analysing and figuring out advantages of other forms of algorithms where we may be able to improve or merge the Guard channel algorithm with another to make a better algorithm.

5. Acknowledgement

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