Efficient Call Acceptance Probability Principle for Mitigating Call Failures in a Wireless Network System

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Abstract— **With the rapid growth in the number of users of wireless communication networks, the network providers are therefore being demanded to provide better and reliable quality of services to their users. In this paper, we propose a new management scheme. This scheme gives priority to handoff calls and also adopt a relative probability factor (δ) which it uses to allocate some percentage of the reserved channels whenever the handoff rate is minimal within the last interval. This scheme is aimed at better utilization of communication channels at any time. With limited available channels, rather than block a new call whenever non-prioritise channels are filled, the proposed scheme however admits the new call provided the relative probability factor (δ) is less than 0.7. This helps in further reducing new call connection error rate in mobile systems. This scheme serves as a hybrid scheme only when the handoff rate is minimal.**

Keywords— **Call Acceptance Control (CAC), Handoff Call, Communication Network, Call Failure, Queuing Principle**

I. INTRODUCTION

In cellular networks, users making or receiving calls can move around within the network coverage area. When the mobile user crosses the current cell boundary to another cell while the call is still in progress, the network has to handover the call from the current cell to the adjacent cell the user has moved into. Idealy, the handover should occur without the user's awareness and also without signifcant degradation of QoS. As the demand for wireless communication systems by the users keep increasing, a good quality of service (QoS) is required to manage the incoming new calls and handoff calls more efficiently. In cellular networks, Radio resource management (RRM) is very essential for efficient utilization of the scarce radio resources and at the same time guarantee the QoS required by the mobile users. İn cellular networks, Call admission control (CAC) is an essential mechanism that is used for ensuring that the required QoS is attained. As a rule, new calls are admitted as long as the required QoS is not violated [13]. CAC is a key element in the provision of guaranteed QoS in wireless networks. Mobile cellular network's CAC algorithm designing is particularly challenging given that the network resources are scarce and highly dynamic , at the same time, users' mobility are prevalent in such networks. CAC takes a decision whether a call should be admitted into the system with respect to the standard QoS requirements and the current traffic load. CAC is such a provisioning strategy for controlling the number of call that are admitted into the networks so as to reduce the incidence of network congestion and call dropping. In wireless networks, users' mobility adds another dimension which is call dropping. In order to satisfy the preferred QoS requirements, good CAC mechanism must optimally handle call blocking and call dropping [2].Generally, traffic descriptor specifies network traffic characteristics along with the requiremed QoS. As such, CAC uses traffic descriptor for making its admission control decision. A new call request is accepted if there is free channel in the network resource, and also if the call meets the QoS requirements of new calls without disrupting the QoS for the already supported calls. Too many calls lead to a situation where the mutual interference between the connections degrades the QoS for the new call as well as for the ongoing connections. Therefore, CAC is very essential in ensuring that the users' QoS requirements are satisfied while at the same time ensuring efficient network capacity utilization and preventing incidence of outage due to overloading [5]. An accepted call that is still in progress can be handed off from the current cell to another BTS. During the process, the ongoing call can be dropped if there is no free channel in the new BTS to be assigned to the ongoing call that is to be handed over to it. Relatively, new calls and handoff calls can be treated differently in terms of resource allocation. Unmistakably, users feel more irritated when ongoing call is dropped than when new call is blocked. As such, in terms of access to wireless network resources, handoff calls are usually assigned higher priority than new calls. The higher priority offered to the handoff calls increases the new blocking probability thereby reduces bandwidth utilisation[14].

In cellular systems, continuation of active calls is of utmost importance. This process of continuation of active calls is known as handoff. During handoff, the channel (the channel can be frequency, spreading code, time slot or combination of them) assigned to the current connection while the call still in progress. Usually, this is initiated either by crossing a cell boundary or signal quality degradation in the current channel. Therefore mobile station (MS) can move from one BTS to another, without dropping the call or experiencing difficulties. There are basically two types of handoff principles – the soft handoff and the handoff If a new BTS has some unoccupied channels, it will assign one of the free channels to the call that is handed off. Nevertheless, if at the time of the hand off, all the channels are in use, two things could happen; the call could be dropped or it is delayed for a while [7]. Different approaches are proposed and applied in order to achieve better handoff service. The principal parameters used to evaluate handoff techniques are usually forced termination probability and call blocking probability. Queuing handoff calls as well as guard

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channels reduces forced termination probability but at the same time they increase the call blocking probability [4].

II. REVIEW OF RELATED WORKS

Considering the tremendous rate of growth of mobile users, it can be understood that the population growth rate of the users often exceeds the rate at which the telecommunication operators of the networks can deploy additional communication facilities to meet the demand [1]. This sometimes leads to situation where calls are being dropped as a result of call congestion and degradation of service. This effect is known as handoff failure [4]. To minimise the problem of call dropping, RRM is needed to efficiently utilise the limited radio spectrum and radio network resources. However, studies show that mobile users always feel bad and dissatisfied whenever their calls cannot be connected to the network or their calls being dropped. Meanwhile, some of the factors affecting handoff performance in wireless systems are; call arrival rates, cell radius, signal strength, number of cell channels, mobility factor, call duration, path-loss variation versus distance, interference, etc. [8], [3]. Channel utilisation is usually denoted as U_{ch}. According to [9], the utilisation of a resource is measured as the fraction of time the resource is busy servicing requests. It can thus be seen as the ratio of busy time and total elapsed time over a given period. At times the resource might not be in used. This time is known as idle time. Generally, system designers and managers including cellular systems managers are often interested in balancing the load so that no one resource is utilised more than others. In this discussion, the resource refers to the available channels. The effective allocation of the channels determines in a long way the efficiency of the network systems. [10] gave a formula for the calculation of the utilisation of a cellular as the relation of the overall traffic to the number of channels.

$$U = \frac{\rho}{C} \qquad (1)$$

Where ρ is the intensity of the traffic and C is the number of channels. It shows therefore that the channel utilisation depends on the total traffic and the number of channels.

These performance parameters will be examined as a function of the total GSM offered traffic load. Values for a maximum blocking probability of 2% will be marked in the curves with a dash-dot line; this means that the cell has been engineered at 2% blocking probability for the mean traffic load in rush hours, which gives the values for the worst case situation. As a result, the actual capacity reduction experienced by GSM services would be less than that obtained in all studied cases because real offered traffic will be usually smaller than that in rush hours. Aanalysis of those performance parameters, will make it easier to realize a network that uses a specific handover scheme and at the same time meet the required level of performance. Handoff probability is the probability that a call connection needs at least one more handoff during its remaining lifetime is known. These probabilities are often referred to as handoff probability for a new call or the handoff probability for a handoff call, depending on whether a call connection is a new call or a handoff call. According to [6], a new call needs at least one handoff if and only if the call holding time Tc is greater than the residual cell residence time Rc. Four main handoff initiation techniques exist [12], [11]. These are relative signal strength, relative signal strength with threshold, relative signal strength with hysteresis, and relative signal strength with hysteresis and threshold.

III. METHODOLOGY

A. Description Of System Model

The Figure 1 shows two different BTSs with their coverage areas and boundaries with a comprehensive detail of how new and handoff calls are being initiated. It should be noted that the BTS must be a talking BTS before it can support both new and handoff calls. Figure 1 presents a scenario explaining that even though MT1 initiated its call to BTS1, it is free to be handed over to BTS2 during transition as far as all other conditions for handing over are met.

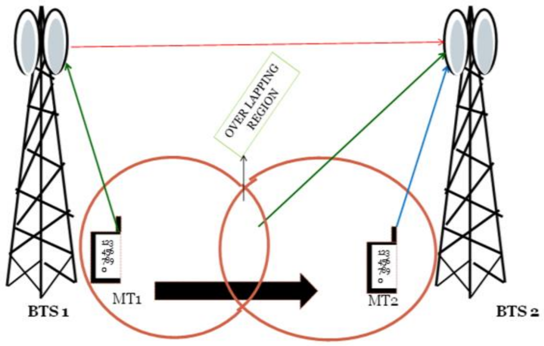

Figure 1: New/handoff call concept

The proposed model of Figure 2 is obtained from the knowledge of the existing schemes. This proposed system model is aimed at providing better management scheme. Also, this proposed scheme will adopt queuing theory which in turn provides queuing mechanism for this scheme as shown in Figure 3.

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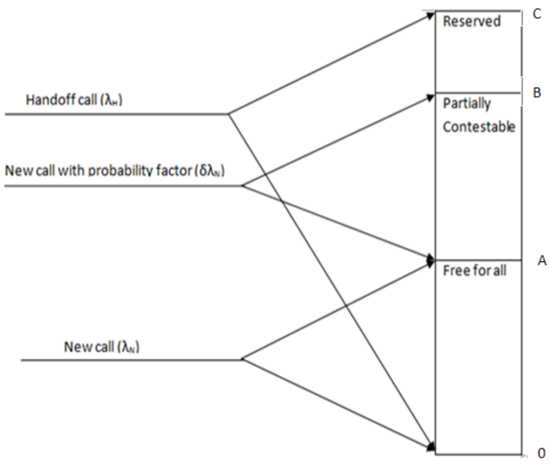

Figure 2: System Model for the Proposed Scheme

The model shown in Figure 2 is divided into three parts; free for all, partially contestable, and reserved. The “free for all” part does not prioritise any call, be it new call or handoff call. The “partially contestable” part accepts both new calls and handoff calls but gives priority to handoff calls, but uses a probability factor (δ) to determine the percentage of the free channels within this part before priority is given to handoff calls. The “reserved” part is purely for handoff calls only. Meanwhile, the queuing model for the new proposed model is as shown in Figure 3. In the queuing model, the new calls can queue between level “0” and level “B” with a probability factor (δ), while handoff calls can queue between level “0” and level “C”.

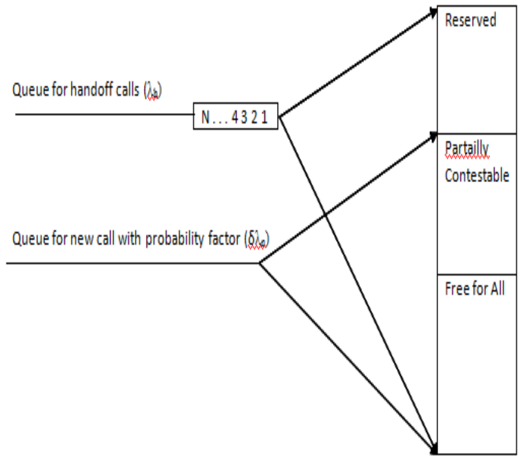

Figure 3: Queuing model for the proposed scheme

Meanwhile, Figure 3 presents a model that showed how queuing can be handled in the newly proposed model shown in Figure 2. The state transition diagram of the proposed model is as shown in figure 4.

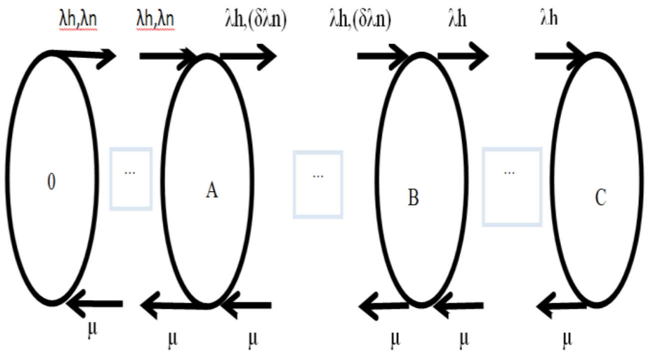

Figure 4: State Transition Diagram of the Proposed Model

B. Mathematical Analyses Of The Proposed Model

The state of the cell as the number of calls in progress for the base station containing that call can be denoted as i. Where

i = 0, 1,2,3, ….. A, (A+1)….B, (B+1) … C 1

The probability that the BTS is in state *i* is given as P(*i*), and can be solved using the birth-death process. The state balance equations as derived from the states transition diagram are as follows:

The probability that the call is in any state within the cell is given thus;

$$i\mu P\,(i) = \frac{\lambda^i}{\mu^i i!}\,P_0 \quad 0 \le i \le C \tag{2}$$

Meanwhile, the different equations for the three parts of the model are;

$$i\mu P\,(i) = \frac{(\lambda_N + \lambda_H)^i}{\mu^i\, i!}\,P_0 \quad 0 \le i \le A \tag{3}$$

This Eq. 3, is derived from states “0” to “A”

$$i\mu P\,(i) = \frac{(\lambda_N+\lambda_H)^i}{\mu^i\, i!} \times \frac{(\delta\lambda_N+\lambda_H)^{i-A}}{\mu^{(i-A)}\,(i-A)!}\,P_0 \quad A \le i \le B$$

(4)

This Eq. 4 is derived from states “0” to “B”

$i\mu P\,(i) i\mu P\,(i) =$

$$\frac{(\lambda_N+\lambda_H)^i}{\mu^i\, i!} \times \frac{(\delta\lambda_N+\lambda_H)^{i-A}}{\mu^{(i-A)}\,(i-A)!} \times \frac{(\lambda_H)^{i-B}}{\mu^{(i-B)}\,(i-B)!}\,P_0 \quad B \le i \le C (5)$$

This Eq. 5 is derived from states “0” to “C”

Therefore, the normalisation condition is given as

$$\sum_{i=0}^{C} P(i) = 1 \tag{6}$$

Using Eq. 2, Eq. 3, and Eq. 4 recursively along with the normalisation condition of Eq. 5, the steady-state probability P(i) is easily found as follows:

$$P_i = \begin{cases} \frac{(\lambda_n+\lambda_h)^i}{\mu^i i!}\,P_0 & 0 \le i \le A \\ \frac{(\lambda_n+\lambda_h)^i}{\mu^i i!} \times \frac{(\delta\lambda_n+\lambda_h)^{i-A}}{\mu^{(i-A)}(i-A)!}\,P_0 & A \le i \le B \\ \frac{(\lambda_n+\lambda_h)^i}{\mu^i i!} \times \frac{(\delta\lambda_n+\lambda_h)^{i-A}}{\mu^{(i-A)}(i-A)!} \times \frac{(\lambda_h)^{i-B}}{\mu^{(i-B)}(i-B)!}\,P_0 & B \le i \le C \end{cases}$$

(7)

Where the probability at state zero or initial probability (P_0) is given as follows:

$P_0 = [P_{0a} + P_{0a}]^{-1}$ (8c)

Where,

$$P_{0a} = \sum_{i=0}^{A} \frac{(\lambda_n+\lambda_h)^i}{\mu^i i!} + \sum_{i=(A+1)}^{B} \frac{(\lambda_n+\lambda_h)^i}{\mu^i i!} \times \frac{(\delta\lambda_n+\lambda_h)^{i-A}}{\mu^{(i-A)}(i-A)!}$$

(8a)

$$P_{0b} = \sum_{i=(B+1)}^{C} \frac{(\lambda_n+\lambda_h)^i}{\mu^i i!} \times \frac{(\delta\lambda_n+\lambda_h)^{i-A}}{\mu^{(i-A)}(i-A)!} \times \frac{(\lambda_h)^{i-B}}{\mu^{(i-B)}(i-B)!}$$

(8b)

Eq. 8 which is the probability at state zero or initial probability (P0), is the inverse of the sum of the three equations derived from the three different partitions. Figure 5 represents the flowchart of the proposed call management scheme. It contains the sequential activities of the proposed scheme. The proposed scheme can summarily be described as shown in Figure 5. This flowchart contains some symbols such as;

(i) Gamma (γ), which represents the probability factor that uses handoff call rate and handoff duration at certain interval to determine the number of free channels to be allocated to the new calls within the partially-shared channels.

(ii) Sigma (δ), represent the signal strength of both the new and handoff calls.

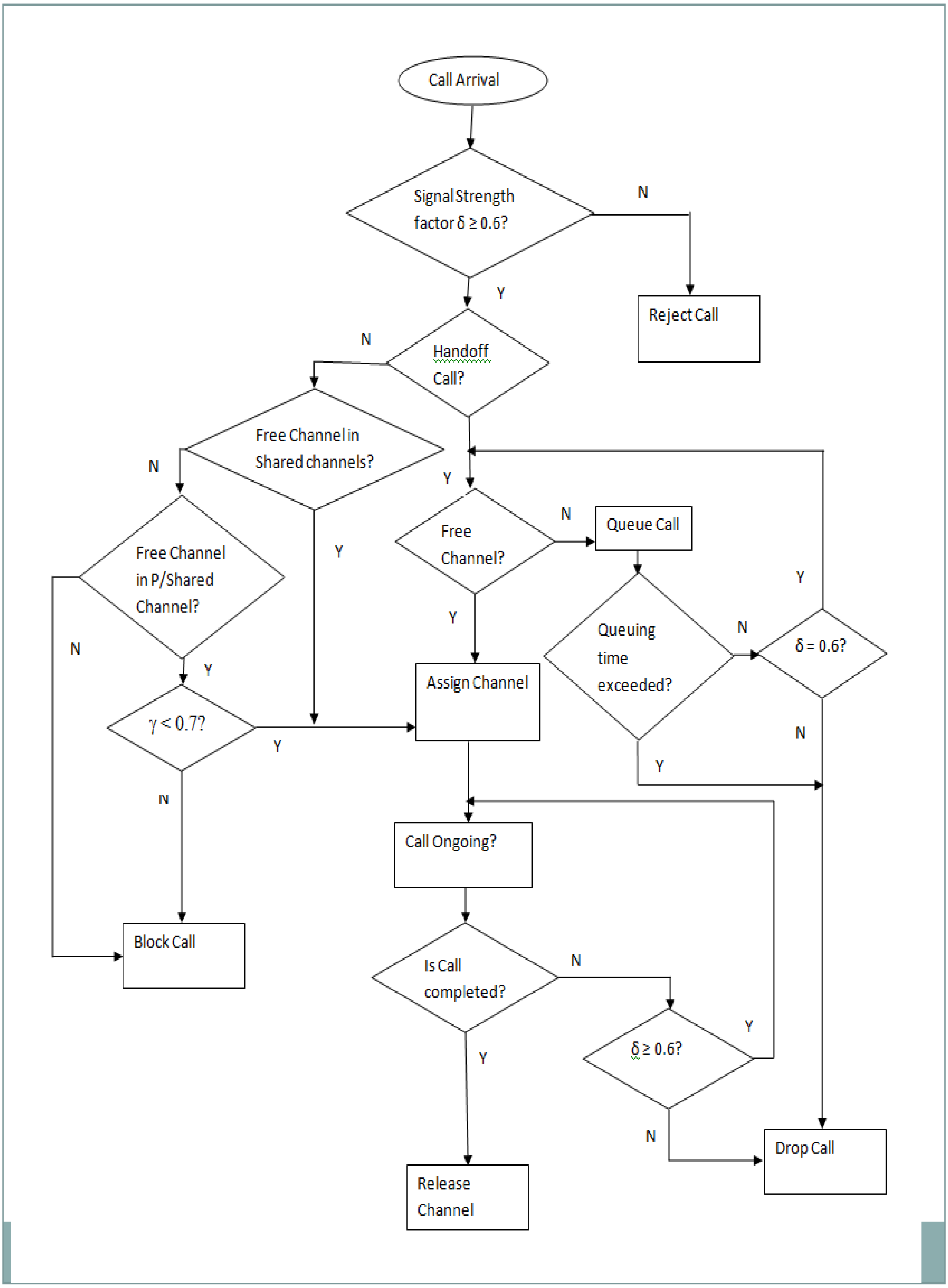

Figure 5: The flowchart for the proposed Dialoke's scheme

IV. RESULT AND DISCUSSION

The different parameters and their values or range of values are as presented in tables 1.

Table 1: Proposed system parameters and their value(s) for simulation

PARAMETERS	VALUES
No. of channels (C)	5 – 34
New call arrival rate (λn)	1.5(/s)
Handoff arrival rate (λh)	2(/s)
Signal strength factor (δ)	0.6 – 0.9
Reserved (Guard) channels (R)	Varied from 2 – 8
Mobility factor (α)	0.9
New call duration (mean 1/µn)	1 – 3(s)
Handoff call duration (mean 1/µh)	2 – 5(s)
New/Handoff traffic ratio	Varied from 2 – 5

The values assigned to the parameters were chosen after several experiments were carried out to determine the best values or range of values that will help this scheme to produce the best results. The simulation was done using MATLAB. The numerical results of the effect of new/handoff traffic ratio on new/handoff acceptance probabilities are as shown in the figure 6 and 7 below;

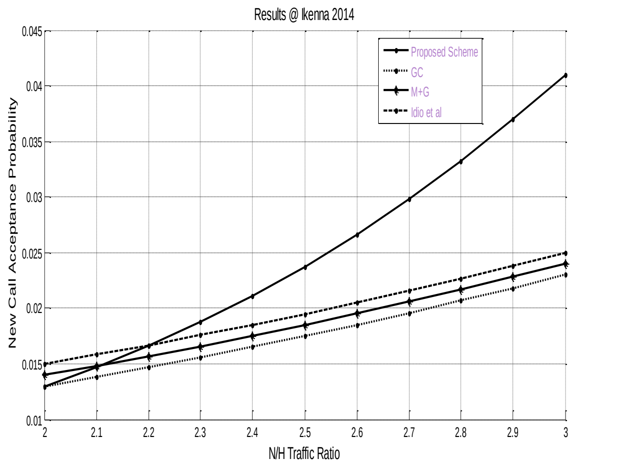

Figure 6: Effect of new/handoff ratio on new and handoff call acceptance probabilities

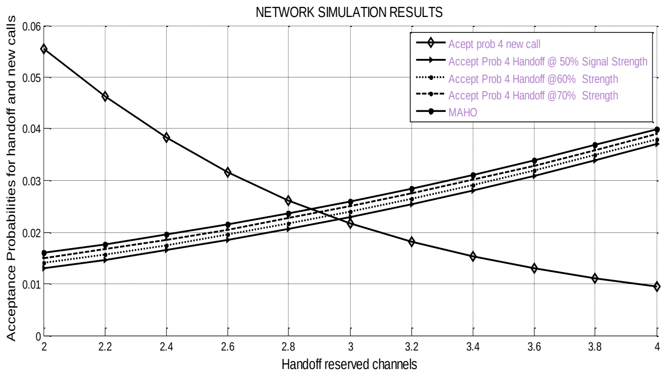

Figure 7: Effect of handoff reserve channels on new and handoff call acceptance probabilities

V. CONCLUSION

Having studied different schemes for managing new calls and handoff calls especially those of non-prioritised and prioritised schemes, therefore, the researcher is of the opinion that the available channels need better management scheme. Hence a new scheme has been proposed in the research paper. The proposed scheme is a prioritised one which ensures better channel utilisation at all time. The performance of this new scheme in terms of call blocking and dropping probabilities was carried out using MATLAB software. The different results obtained through simulation of both the existing and proposed new/handoff management schemes were considered and compared. Hence, this scheme provides better call management that will ensure better service for GSM users.

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