Development of Improved Scheme for Minimising Handoff Failure Due To Poor Signal Quality

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Abstract

Presently, cellular mobile networks are witnessing rapid advances in the number of subscribers and the classes of services (voice, data and multimedia). There has been growing demands on the mobile wireless operators to provide seamless and satisfactory quality of service to their teeming subscribers. In order to provide service with high capacity and quality the signal quality must be at acceptable level. In addition, handoff and the mobility management schemes must be acceptably and optimally implemented. This paper aims to improve and enhance the quality of services by developing an improved scheme for minimizing handoff failure due to poor signal quality. The proposed scheme considers not just the channel availability and signal strength but also the direction of movement of the mobile terminal. In this paper, an analytical approach is adopted to model and analyze the performance of the proposed handoff scheme and through the use of MatLab, the results for the scheme are computed.

Keywords: Call Drop; Direction of Mobility; Handoff Failure; Mobile Networks; Quality of Service;

1. Introduction

There is growing demands on the mobile wireless operators to provide continuous, satisfactory, and reliable quality of service to their teeming subscribers.

Over the years, call drop due to handoff failure has been one of the major challenges prevalent in the mobile systems worldwide. Handoff which is the process of changing the channel (frequency, time slot, spreading code, or combination of them) associated with the current connection while a call is in progress is usually a major task in the wireless system [2]. In practice, handoff is initiated either when the mobile terminal (MT) crosses a cell boundary or whenever the call signal quality degrades in the channel currently held by the call. This ensures the mobile terminal (MT) to move from one Base Station (BS) to another, without experiencing difficulties or getting the call dropped. There are basically two types of handoff principles: the soft handoff and the hard handoff [4]. In the practical case, the BS makes handoff decisions with assistance from the MT. This is known as mobile assisted handoff (MAHO). In operation, if a new BS has some unoccupied channels, then it assigns one of them to the handed off call. In contrast, if all the channels are in use at the time of the hand off, the call either gets dropped or it is delayed for a moment [5].

Researchers have observed that, the wireless communication environment which is characterized by dynamic channels, high influence of interference, band with shortage and strong demand for Quality of Service (QoS) support often posses major challenge for achieving optimum spectral efficiency and high data rate in wireless cellular communication networks [1]. Therefore, for the implementation of the various integrated services with certain QoS requirements in these wireless networks, Radio Resource Management (RRM), Radio Resource Provisioning (RRP), and mobility management are important issues [2].

In the cellular system, two principal QoS measures have been defined. These are the new call blocking probability and the call dropping probability. The call dropping is attributed largely to handoff failure and usually leads to an undesirable phenomenon known as forced call termination [3].

Since the introduction of wireless mobile communication network in Nigeria in 2001, subscribers have constantly been accusing the Nigerian network operators of providing poor services. Notably, subscribers experience difficulties in initiating calls or have their calls prematurely and forcefully terminated when they have not completed their discussion. This effect (forced call termination) is due to handoff failure and it is quite frustrating [2]. The poor QoS can be attributed largely to poor handoff mechanisms. This defect has caused many mobile users to subscribe to more than one service provider in order to maintain seamless service connection. Issues like call admission, connection quality, handoff success and mobility management determine the users' satisfaction [5][6]. This paper seeks to improve and enhance the quality of services by developing an improved scheme for minimizing handoff failure due to poor signal quality using signal strength, number of channels, call duration, call arrival rates and the direction of MS (mobility factor) as parameters.

2. Related Works

As the result of high level of resentment and prolonged dissatisfaction users express towards handoff failure issues in wireless cellular networks, researchers have continued to develop, implement and enhance various handoff schemes for minimizing handoff failures.

Fuzzy logic Call Admission Control (CAC) scheme for wideband CDMA cellular system was presented in [10]. The fuzzy logic is used in this paper to meet the disputes in CAC due to user mobility, limited radio spectrum, heterogeneous and dynamic nature of multimedia traffic and QoS constraints. It was realized that the Fuzzy approaches overcome measurement errors; mobility and traffic model uncertainty, and avoid the necessities of complex mathematical relations among various design parameters.

[9] carried out an analytical model for novel multimedia wireless and mobile networks using smart antennas. In this work, proposed networks several beams with the same physical channel were formed in a call in the. Two types of multimedia services; real time services and non-real time services were considered. The four dimensional Markov chain was employed to analyze the system. Blocking probabilities of originating calls and blocking probability of handoff calls were obtained from their formulae. It was observed that by employing smart antenna, the system capacity and performance were highly improved.

Nasif et al in their work [4], presented an overview about issues related to handoff initiation and decision. In their paper, different approaches were proposed and applied in order to achieve better handoff service. Call blocking probability and Forced termination probability are engaged as principal parameters in evaluating the various handoff techniques. It has been observed that some mechanisms such as guard channels and queuing handoff calls have the tendency to decrease the forced termination probability while increasing the call blocking probability [4]. traffic scenarios were also considered and the simulation result revealed that MC-AC algorithms have many advantages over single cell admission control in terms of call dropping probability, overall stability of the system and total system throughput.

An analytical approach for performance evaluation of wireless cellular networks was presented in [2]. This approach demonstrated how simple mathematical techniques can be employed to obtain outstanding analytical results for many performance metrics such as the call blocking and dropping probabilities. The analysis presented more realistic distribution models for the involved various wireless random variables.

The performance of 3G UMTS mobile network covering an urban area and surrounding suburban was investigated and studied in [8]. The COST-231 extended Hata model was used in modeling the propagation, which represents more realistic propagation models for the environments. Furthermore, detailed simulation was used to study the performance of the network under different traffic and interference conditions. The study showed that some design and environmental parameters; the height of the base station, and the average height of the mobile, affect the performance of the network.

A new handoff technique that combines the Mobile Assisted HandOff (MAHO) and Guard Channels (GC) techniques was proposed in [11]. In this technique the mobile terminal (MT) reports back not only the Received Signal Strength Indicator (RSSI) and the Bit Error Rate (BER) but the number of free channels that are available for the handoff traffic as well. This is done to ensure that the handed off call meets both the acceptable signal quality standard and the free available channel demands. In addition, analytical model was used to obtain the desired performances measures in terms of call blocking and dropping probabilities in the analysis. The analysis proved that ignoring the effects of poor signal quality handoff calls can results in deterioration in performance. Therefore, in other to handle the poor signal quality handoff, their work describes two new handoff techniques; the M+G (MAHO & GC) approach and the rehandoff [11]. The latter observes that, it is better to rehandoff poor quality handoff calls to some other Base Station System (BSS) instead of dropping such calls.

In [12], an analytical model for a communication network providing integrated services to a population of mobile users was developed. The performance results were presented to validate the analytical approach and areas of the quality of services offered to the end users of the system. It was shown in the paper that the analytical model is based on continuous time multidimensional birth-death process and is focused on just one of the cells in the network. In the analysis, the authors assumed that the system provides three classes of services; the basic voice service, a data service with bit rate higher than the voice service, and a multimedia service with one voice and one data component. Some channels are reserved for handovers, while multimedia calls that cannot complete a handover are decoupled. This is done by transferring to the target cell only the voice component and suspending the data connection until a sufficient number of channels becomes free. This improves the overall performance of the network.

3. Research Methodology

In this research, the M+G scheme [11][13] is combined with the concept of mobility to develop a new handoff scheme to minimize the drop call probability due to poor signal strength. The analytical modeling approach is adopted to develop this model and evaluate the model for the proposed handoff scheme. Various mathematical expressions for various metrics for the model are developed. With MatLab software, the performance of the model is evaluated. The metrics for the performance analysis include the Handoff failure probability and the new call blocking probability. Furthermore, the effects of the direction and the speed of mobile station are also investigated.

4. The Handoff Scheme System Model

The M/M/C/C queuing approach [13][14] is used in this model. The system is considered to be made of many identical cells. Since the cells are identical, they are assumed to be of the same capacity, performance and characteristics. Consequently, only one cell will be studied. The results of this marked cell are applicable to other cells. Two traffic request types will be considered in this analysis, namely; the new calls and handoff call requests. The following two assumptions are adopted in the system model:

(i) The new call and Handoff rates in the cell are assumed to form a Poisson process with mean values of λ_N and λ_H respectively.

(ii) The new call and handoff completion time are exponentially distributed with mean rates of μ_N and μ_H respectively.

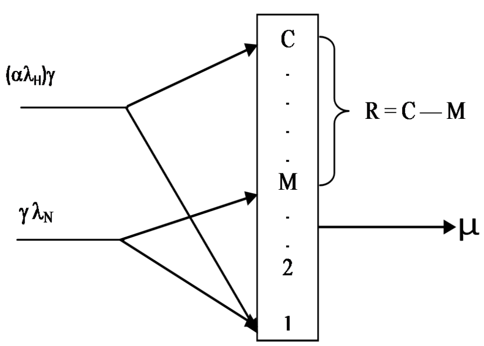

Fig. 1 The Proposed Handoff Scheme System Model

As shown in fig. 1, the system cell is made of a total of C channels. Here we give priority to the Handoff calls. This is because mobile subscribers are more sensitive to call drop than new call blocking. The given priority is be implemented by the use of the Guard Channel method. Out of the C channels of the call, we reserve R channels exclusively for Handoff calls while the remaining M = C - R channels are for both handoff calls and new calls.

Let us define the handoff traffic as

$$\lambda_h = (\alpha\lambda_H)\,\gamma_H \qquad (1)$$

and

the new call traffic define as

$$\lambda_n = \gamma_N\,\lambda_N \qquad (2)$$

γ_H and γ_N are the probabilities that the system is processing good signals for handoff and new calls respectively. We assume in this model that γ_N and γ_H are the same and denoted asγ. Accordingly;

$$\lambda_h = (\alpha\lambda_H)\gamma \qquad (3)$$

And

$$\lambda_n = \gamma\,\lambda_N \qquad (4)$$

for states zero to M, the effective service time can be given as

$$\mu = \mu_N + \mu_H \qquad (5)$$

From M+1 to C, the effective service time is given as μ_H.

To maximize the priority given to handoff calls, the mobility concept that considers the direction and speed of the MT is used in this scheme alongside the M+G. this is a concept where a poor signal handoff request is accepted with probability of α if the MT is approaching the BS. The notion behind this is that the signal is assumed to improve as the MT gets closer to the BS. We denote this factor as α and it lies between zero (0) and one (1). The state transition diagram for the model is as depicted in Fig. 2.

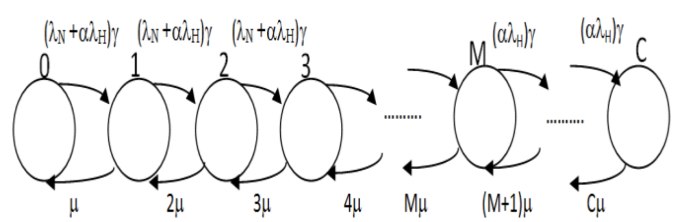

Fig. 2 State Transition Diagram

From the state diagram, the effective incoming rate for state O to M is λ, where

$$\lambda = (\lambda_N + \alpha\,\lambda_H)\gamma \qquad (6)$$

From state M, the effective incoming rate is $\lambda_{h,}$ where;

$$\lambda_h = (\alpha\, \lambda_H)\gamma \quad (7)$$

From state M up to C, only handoff calls are accepted while new calls are blocked. Assuming, the state of the call as the number of calls in progress for the base station containing that call to be S, where;

S = 0, 1,2,3, ….. M, (M+1)…. (C-1), C., the probability that the BS is in state S is given as P(s). Solution of P(s) can be obtained usual using the birth-death process. The state balanced equations from the states transition diagram of fig 2 are

$$S\mu\, P(s) = \lambda P(S-1) \qquad O \leq S \leq M \quad (8)$$

$$S\mu\, P(s) = \lambda_h P(S-1) \qquad (M+1) \leq S \leq C \quad (9)$$

The normalisation condition for (8) and (9) is

$$\sum_{S=0}^{C} P(s) = 1 \quad (10)$$

$$\frac{1}{S!}\left(\frac{\lambda}{\mu}\right)^{S} P(0) \qquad 0 \leq S \leq M \quad (11)$$

$$\frac{1}{M!}\left(\frac{\lambda}{\mu}\right)^{M} \frac{1}{(S-M)!}\left(\frac{\lambda_h}{\mu_H}\right)^{(S-M)} P(0) \qquad (M+1) \leq S \leq C \quad (12)$$

where P(0) is given as;

$$P(0) = \left\{\sum_{S=0}^{M} \frac{1}{S!}\left[\frac{\lambda}{\mu}\right]^{S} + \sum_{S=(M+1)}^{C} \frac{1}{M!}\left[\frac{\lambda}{\mu}\right]^{M} \frac{1}{(S-M)!}\left(\frac{\lambda_h}{\mu_H}\right)^{(S-M)}\right\}^{-1} \quad (13)$$

If the new call finds all shared channels (M) busy at it

arrival, it will be blocked with probability P_{BN} , where;

$$P_{BN} = \sum_{S=M}^{C} P(s) \quad (14)$$

Also, if an handoff request on its arrival finds all channels (both shared (M), and reserved (R) busy, the call will be dropped with probability P_{BH}, where;

$$PBH = \frac{1}{M!}\left[\frac{\lambda}{\mu}\right]^{M} \frac{1}{(S-M)!}\left[\frac{\lambda_h}{\mu_H}\right]^{(S-M)} P(0) \quad (15)$$

$$PBH = \frac{\frac{1}{R!M!}\left[\frac{(\lambda_N + \alpha\lambda_H)\gamma}{\mu_N+\mu_H}\right]^{M}\left[\frac{\alpha[\lambda_H\gamma]}{\mu_H}\right]^{(R)}}{\sum_{S=0}^{M}\frac{1}{S!}\left[\frac{(\lambda_N + \alpha\lambda_H)\gamma}{\mu_N+\mu_H}\right]^{S} + \sum_{S=(M+1)}^{C}\frac{1}{M!}\left[\frac{(\lambda_N + \alpha\lambda_H)\gamma}{\mu_N+\mu_H}\right]^{M}\frac{1}{(S-M)!}\left[\frac{\alpha[\lambda_H\gamma]}{\mu_H}\right]^{(S-M)}} \quad (16)$$

(16)

5. Implementation of the Scheme

We can recall that this scheme considers signal strength, channel availability and the direction of the mobile for handoff decision. When the request arrives, the system carries out a signal strength check on the it using the signal strength factor γ. This value ranges from zero to 1 ($0 < \gamma \leq$). As the value of γ increases, it implies that the signal strength is stronger. If the request signal strength is greater than or equals to 0.7 (threshold), the request is granted for further tests. The next test is to determine if the request is new call or handoff. If it is handoff, the system checks for free channel and assigns the free channel to the handoff request and allow the call to be ongoing. If there is no free channel, the handoff request is rejected (that is, the call is dropped) or the call is rehandoff to another BS. In the other hand, if the request is a new call, the system checks for free channels in the shared M channels. If there exists free channel, the call is assigned a channel and the call is allowed to go on. If no channel exists, the new call request is rejected out rightly (that is, the call is Blocked). Accordingly, if the signal quality is below 0.7, the system will have to determine what request type it is. If new call, it is rejected instantly (call blocked). If it is handoff, the direction of the movement of the MS to BS is determined by using the value of α. If the MS is approaching the BS, the call is admitted with probability α. The system then checks for free channel and assign it to the handoff request or else the call is dropped or rehandoff. Also, the system does interval checks on the signal quality of the ongoing signal. If the signal is still within the threshold (0.7 or above), the call is allowed to be ongoing. But if is discovered that the signal is below 0.7, the system will check the direction of the MS to BS. If it is still in the direction of the BS, then the call is allowed to be ongoing, else, it is dropped or rehandoff. This is illustrated in the flow chart below in Fig. 3.

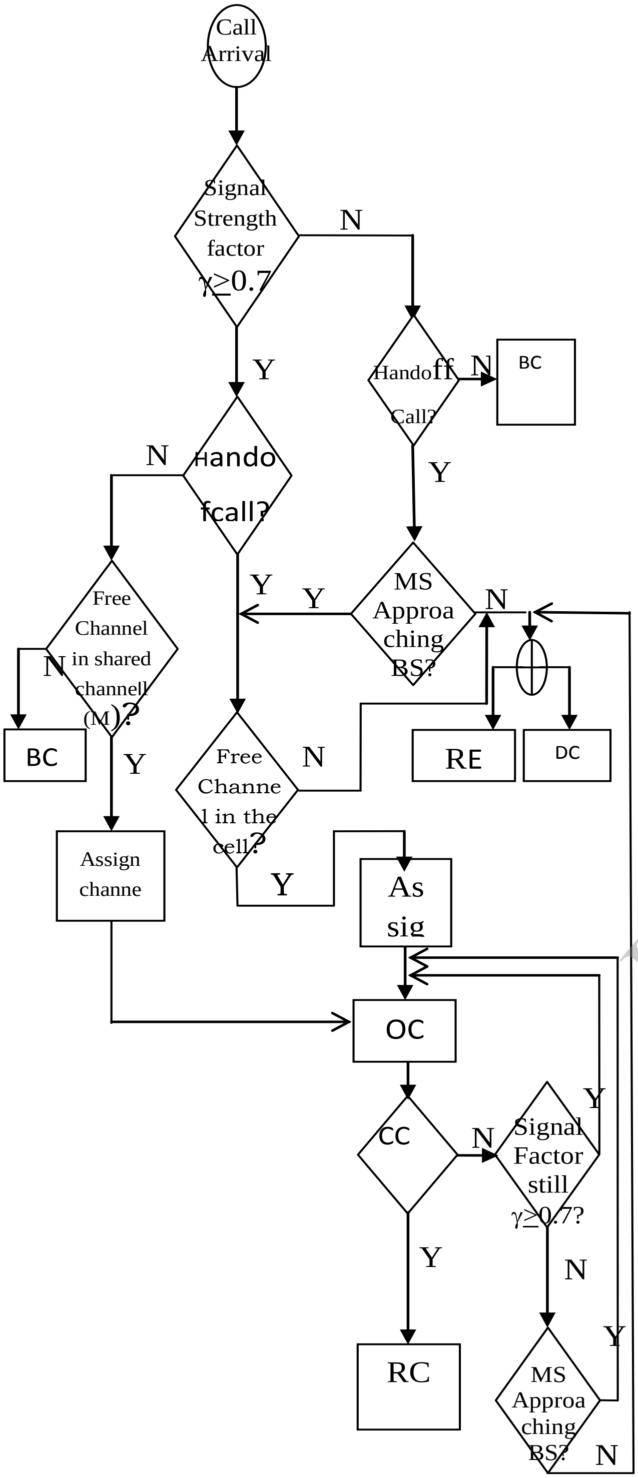

Fig. 3 Flow Chart for the proposed Scheme.

BC – Block Call; RE – Rehandoff call; RC- Release Channel;

OC – Ongoing Call; CC – Call Completed

6. Presentation and Discussion of Results

MatLab software is used to determine the numerical values of the various parameters.

6.1. The Numerical Analysis Discription

Numerical analysis and results for the proposed model are presented and discussed in this section. The effects and impacts of the various parameters on the various system performance metrics will be assessed. We achieve this by taking the numerical examples and developing computations for the system performance in terms of call blocking probability and handoff failure probability. The numerical analysis is conducted using MatLab software.

6.2. System Parameters

This section presents the parameters and their values for the computation of the results.

The number of channels was varied from 1-16, New call arrival (λ_N) was fixed at 1.5/s and the Handoff arrival (λ_H) was fixed at 1.2/s. the signal strength factor (γ) was varied from 0.7 to 1. We set the reserved channel size from 6 – 12 to assess its impact on the system performance. The Mobility Factor (α) also was adjusted between 0.1 to 1. The higher the value of the mobility factor, the more likely that the MT is approaching the BS. The new call duration (mean $1/\mu_N$) and handoff call duration (mean $1/\mu_H$) was fixed at100s and 80s respectively.

6.3. Discussion Of The Results

Fig.4 shows the effect of reserved channel size on handoff failure probability for the new handoff scheme with the channel size of 16, γ at 1 and α at 1. This implies that the signal strength is maximum and the MT is approaching the BS.

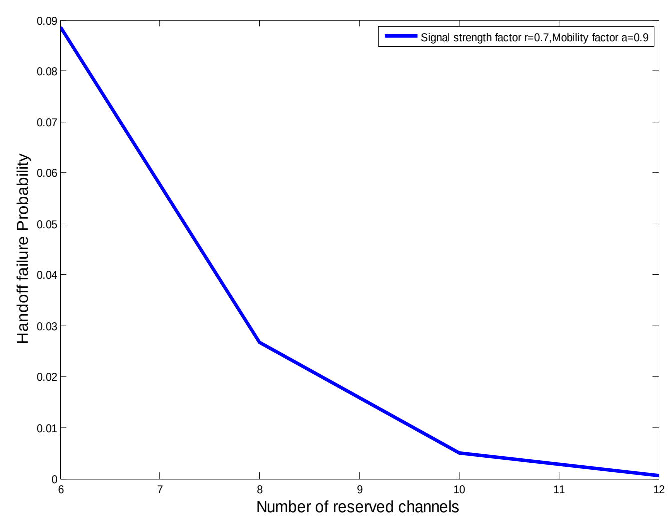

Fig.4 Effect of Reserved Channels on Handoff Failure Probability for the New Handoff Scheme

It is shown from Fig.4 that the handoff failure probability decreases as the reserved channel increase. This is because as the reserved channel is increased, more handoff calls can be handled.

Fig.5 shows the relationship between the reserved channels and call blocking probability also with the channel size of 16, γ at 1 and α at 1.

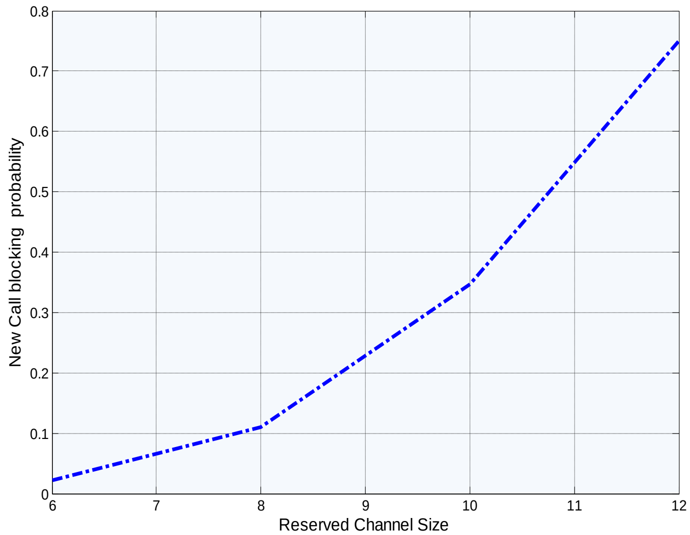

Fig.5 Effect of Reserved Channel size on new call blocking probability for the new handoff scheme

Contrary to the handoff failure probability, the call blocking probability increases as the reserved channels increases. This is as the result of the fact that priority is given to the handoff calls. More channels are reserved for Handoff while few are shared by both the new calls and Handoff calls.

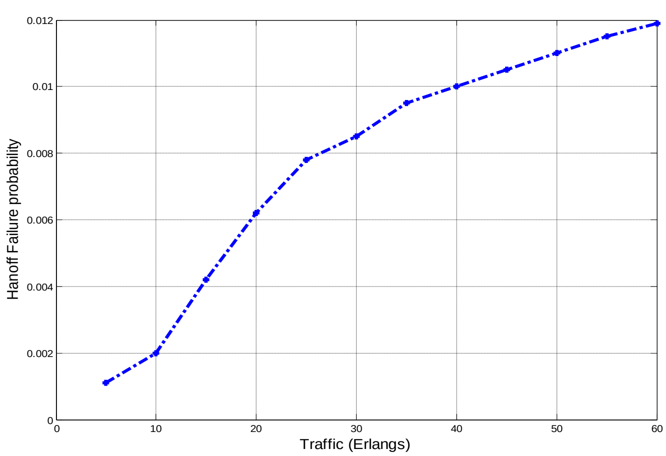

Fig.6 Effect of Traffic on Handoff failure probability

It can be seen from Fig.6 that the handoff failure probability increases as the traffic load increases, with the channel size of 16, reserved channel R = 8, γ = 1 and α = 1. This can be explained from the fact that the more the traffic the more likely the channels will be occupied and less chance for admission of new handoff requests.

Fig.7 shows the effect of Channel size on Handoff Failure probability with the reserved channel size of 8, γ = 1 and α = 1. It can be seen that the handoff failure probability decreases as more channels are available.

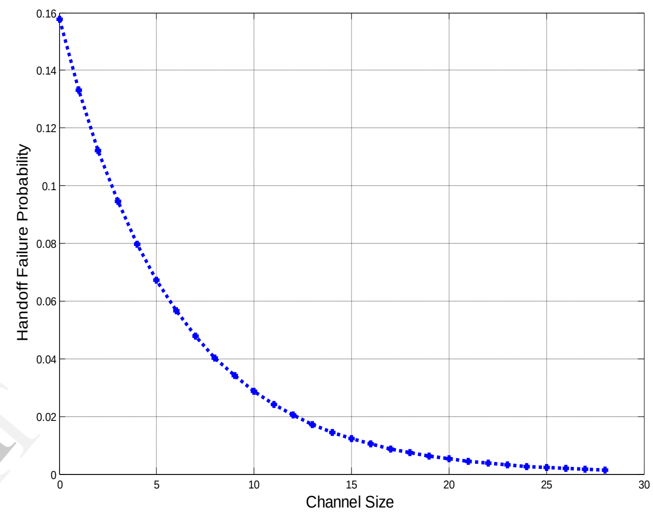

Fig.7 Effect of Channel size on Handoff Failure probability

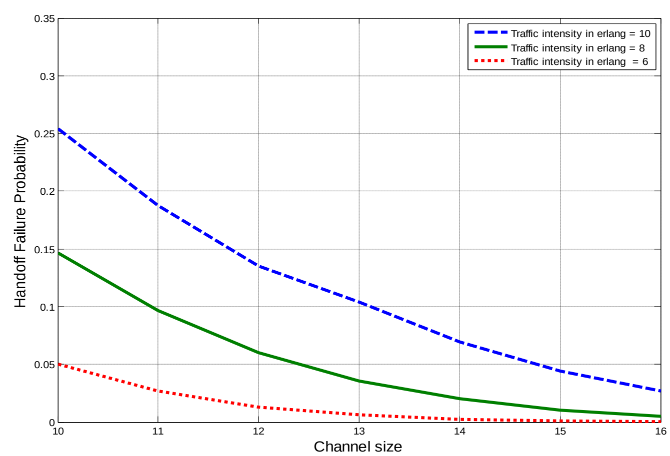

Fig. 8 Effect of Channel size on Handoff Failure probability at different Traffic conditions

Fig.8 shows the effect of Channel size on Handoff Failure probability at different traffic condition of 6, 8, 10 erlangs respectively with the reserved channel size kept 8, γ at 1 and α at 1. It can be seen that the handoff failure probability decreases as more channels are available. When the traffic is small, the failure probability drops significantly. By increasing the value of traffic load, the handoff failure probability increases. Therefore the system traffic prediction is usually thoughtful in implementation of the scheme.

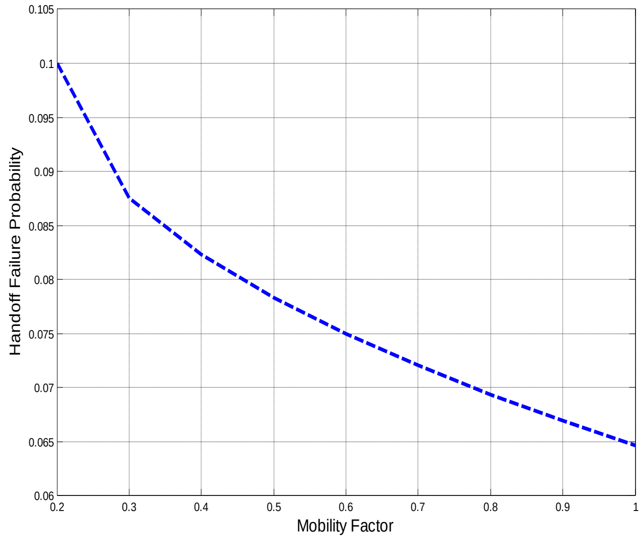

Fig 9 Effect of Mobility factor on Handoff failure probability

Keeping the channel size at 16, the reserved channel at 8, and α at 1, we investigate the effect of mobility factor on the handoff failure probability. Fig.9 proves that the handoff failure probability decreases as the value of mobility factor increases. This is because, the proposed scheme through mobile assistance and updates ensures that α is always one (1) before the handoff request can be accepted. The value of one (1) for the factor depicts that the MS is approaching the BS thereby causing improvement in the signal quality. It can be observed that the handoff probability will be minimum handled if the mobility factor is kept at one (1). This ensures that the MT is approaching the BS before the poor signal Handoff request is accepted with the assertion that the signal quality of the call will improve as the MT gets closer to the BS.

7. Conclusion

In this paper, an improved handoff scheme for minimizing handoff failure in mobile networks was developed and analyzed. Using analytical computation method, we demonstrated the impacts of various network parameters on the handoff failure and new call blocking probabilities. We also demonstrated that the use of the direction of the mobile station in the handoff scheme helps in further reducing handoff failure in mobile systems. The basic concept behind this new scheme is the idea that if the mobile terminal is approaching the base station, the poor signal handoff request can be accepted with probability α that increases as the mobile terminal approaches the base station. The assumption is that the signal quality will improve as it nears the base station. In essence, this scheme ensures that α is always one (1). This ensures that the handoff request is handed-off to the BS with the best ability to handle the request.

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