

## CONGESTION CONTROL SCHEME FOR WIRELESS MOBILE NETWORK

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### ABSTRACT

This work is based on the fact that everyday users of mobile phones increase with the increasing demand of applications making congestion in our network to grow rapidly with the limited resources at our disposal. Congestion in our network leads to delay, low throughput and most importantly users or subscribers don't enjoy better quality of service.

Users find it frustrating and annoying when their calls are not completed. Welfare will increase if handoff calls are treated properly even though it increases the blocking probability of new calls since users will prefer to complete an on-going call than establish a new one. The key issues here which were addressed are call admission control and resource allocation. C++ was the programming language used to implement this work. This work aimed at combining both call admission control and buffer to reduce the blocking probability of handoff calls and to also reduce the frustration experienced by the end users.

From the result compiled, it is evident that the blocking probability of handoff call reduces when a queuing system is used and a better quality of service is provided to users. Network resources will be utilized especially among handoff calls.

### 1.0 INTRODUCTION

Congestion in mobile networks is when a link or node is carrying so much data that its quality starts to deteriorates. It also occurs when signal strength is subjected to slow fading and interference from other signals. It can also be defined as the situation when circuit groups are inundated with calls and are unable to serve all subscribers (Ramesh, 2009). When network in mobile communications is in a state of congestion, the demand for resources is too close or exceeds the capability of the network (Raniwala, 2009). Due to the increasing rate of mobile users and the increasing demand of applications, more resource requirements is needed and this have been proven to be right over the past years with wireless growth increasing tremendously. Wireless network must be kept from reaching a point of congestion since this will lead to a loss rate rise, increased delay, traffic and this will be totally unfair to calls which have to pass through a number of radio counts to establish a communication. Mobile Wireless users have the ability to move from one point to another, this has to be monitored so ensure adequate network resources are distributed to enhance throughput in the network.

Call Admission Control and resource allocation are the key issues to be addressed in this project. CAC also known as call admission control is the process of controlling traffic volume in voice communication especially in wireless mobile network. It is used to maintain audio quality in voice communications and its algorithm works by regulating the bandwidth, number of calls passing through a point at a particular point in time (Behdis et al., 2009) while network resource allocation determines how to accept new request connection in the network. Quality of service performance parameter will be considered such as new call blocking probability, handoff call blocking probability. Probability is the measure of likelihood of an event while handoff call occurs when a user moves from one cell in a base station to another due to reasons like a change in environment, the user moving from one position to another. When a user moves to another cell to establish a

communication it first obtain a channel, if a channel is available it is granted to the user if otherwise the call is blocked.

In addition to the call admission scheme proposed, a buffer will be introduced to handle and control handoff calls, its effect on the mobile wireless network. A buffer is a data area shared by program processes which operate on its own without having to wait on any other process depending on its speed and priorities (Georgios et al., 2010). When customers go to the bank either to make a withdrawal or an enquiry, the customers wait in a queue to be attended to by the bank officials but it is possible for the bank to provide high priority to some customers than the other depending on the state or status of such customer. This could also be done in mobile network when user move from one cell to another, handoff calls will be buffered rather than rejecting them it will be allocated a channel if a user completes a call or if the user moves to another cell before the call is completed where it is believed to be assigned a channel if there is no channel available. Some questions are to be properly addressed and answered in terms of mobile network like the call admission control parameters, the goal of the call admission control, buffer in the network and how quality of service can be maintained. In this work the way call admission control can be utilized in the network and how buffer can be properly combined will be explored. This work seeks to combine call admission control and buffer to provide quality of service in the network and see how network resources can be utilized among new calls and especially handoff calls.

## **2.0 PROBLEM DEFINITION**

Wireless technology has made a great impact on the global economy ever since the introduction of GSM which has led to congestion in wireless network, not only with mobile phones also the advent of applications that run on this phones increases day by day leading to a further congestion in the network thereby resulting into slow performance of the network, signal loss etc. Statistics has it that there are over 4 billion users accessing their phones at the same time. It is very frustrating to lose a call whose connection has been established than preventing a new call. Handoff call is affected due to a change of environment or the user needs to change base station. Welfare will be increased if handoff calls is treated properly even though it increases the blocking probabilities of new calls.

## **3.0 REVIEW OF RELATED WORKS**

### **3.1 Analytic Modelling of Handoff in Wireless Cellular Network**

This journal presents recent findings about the solutions to the blocking and dropping probability in mobile wireless network especially with handoff. A performance model of cells is developed where the different effect of handoff and guard channels were varied. Formulas for the call blocking probability and the handoff blocking probability were developed together with an algorithm to determine the number of channels in the network. In this journal in order to determine the arrival rate of handoff an iteration scheme is proposed. The channels were deliberately made to fail and a performance analysis was provided for the mobile system. A hierarchical model was presented combining both the performance of the system, availability of channels and also its solution. (Helen et al., 2002).

### **3.2 Call Blocking Performance Study for PSC Network under more realistic Mobility Assumption**

In PCS network there is high mobility of users or subscribers on the network which leads to frequent occurrence of handoff. In this paper the blocking probability of calls is investigated using an analytic and simulation approach. A simulation model is constructed in which the effect of handoff traffic was studied. An approximation model was also developed from which analytical results for the various blocking probability performance metrics can be obtained. From the simulation model, how various factors affect call blocking performance is investigated. The analytical results gotten from the study shows that various factors like the time spent by a call in a cell, mobility factor etc. has a great impact on call blocking probability, handoff blocking probability and other call performance metrics. (Fang and Zeng, 2002)

### **3.3 Hybrid Channel Allocation in Wireless Cellular Network**

This paper proposes that with the rapid growth of mobile traffic and the limited number of channels to satisfy call in a base station, there is a need to efficiently reuse channels. The three categories of channel allocation schemes which are the fixed channel allocation (FCA), dynamic channel allocation (DCA), and the hybrid

channel allocation which consists of the fixed and dynamic channel allocation is discussed with emphasizes on the hybrid channel allocation scheme. The paper presents a hybrid channel allocation notification to the central pool on each channel request made that cannot be satisfied locally at the base station. The function of this notification is to request for more than one channel to be assigned to a cell. The effect of the various channel allocation schemes is studied and the simulation results in terms of HCA shows that the blocking probability of calls with hybrid channel allocation will be low for less traffic and will be high for high traffic. (Shukla, 2012).

### **3.4 Survey of Channel Allocation Algorithm Research for Cellular Systems**

The various wireless channel allocation schemes is discussed in this paper to ensure continuous service that provides quality of services to users on the network. Since quality of service offered by the network is always of concern by users of this network, it was observed that there is always a trade-off with the quality of service parameters. Discussion was made on the different channel allocation scheme like the static channel allocation, dynamic channel allocation and the hybrid channel allocation schemes together with the quality of service parameters like the call blocking probability and handoff blocking probability. The advantages and disadvantages of the various channel allocation schemes was summarized in terms of their performance and complexity. Complex situations like in multimedia services, mobile base station etc. various handoff schemes was also discussed in this paper. (Kumar et al., 2010).

### **4.0 RESEARCH METHODOLOGY**

In this work an analytical model was built to find the blocking probabilities of users in the network both for new and handoff calls. C++ was also used to get the performance of the model and to provide an interface to receive the quality of service parameter to determine the various blocking probability. The description to the modification made to the channel modeling technique used to control congestion in this work was also established.

A study of a call admission control was carried out to have a clear view of how they work. There was proper consultation of books and articles and relevant journals on the research work were reviewed. SCILAB was also used to generate the graphs for various probability.

### **5.0 EXISTING SYSTEM**

The system used for handling calls a type of system that has limited regard for handoff calls. All calls that enters the system are treated the same, and if there is no available channel to handle any call the call is dropped irrespective of the type of call. Since handoff calls are preferable to be completed before a new call, there is a need for a buffer to store handoff call if there is no channel to handle such call.

#### **5.1 Drawback of the Existing System**

- i. Handoff calls are dropped when there is no channel to handle such calls.
- ii. Frustration from users who could not complete their calls.

### **6.0 DESIGN OF THE PROPOSED SYSTEM MODEL ALGORITHM**

The system is designed to handle both calls as they enter the network i.e. new calls and handoff calls giving priority and focus to handoff calls since users prefer to complete their call or have a successful call than not establishing the call at all, because dropping of handoff calls is irritating to users. Handoff calls are calls that move from one base station to another due to reasons like a weak link in the initial base station. In order to avoid a drop in the call, a movement from one base station to another is needed. The system is designed in such a way that decisions are made depending on the type of call and their arrival. When a call enters the network either a new call or handoff the system checks if the call is a new or handoff call. If new calls enter the network a check is done to know if the number of calls is lesser than the number of channels in the network, if not the call is dropped and if yes the system checks if there is any available or free channel in the network. If there is a free channel in the network the call is accepted and a channel is assigned to it, but if there is no available channel the call is blocked.

In the case of handoff calls a check is also performed like in the case of new call to know if the number of handoff calls is lesser or greater than the number of channels in the network. If the number of handoff call is not less than the number of channel the call is dropped, but if the number of handoff call is lesser than the number of channels the system checks to see if there is any available channel in the network and if there is the call is accepted and assigned a channel. But if there is no available channel the call is buffered in as much as the buffer is not full. If otherwise the call is dropped. Figure 1.0 shows the flow diagram of the system model.

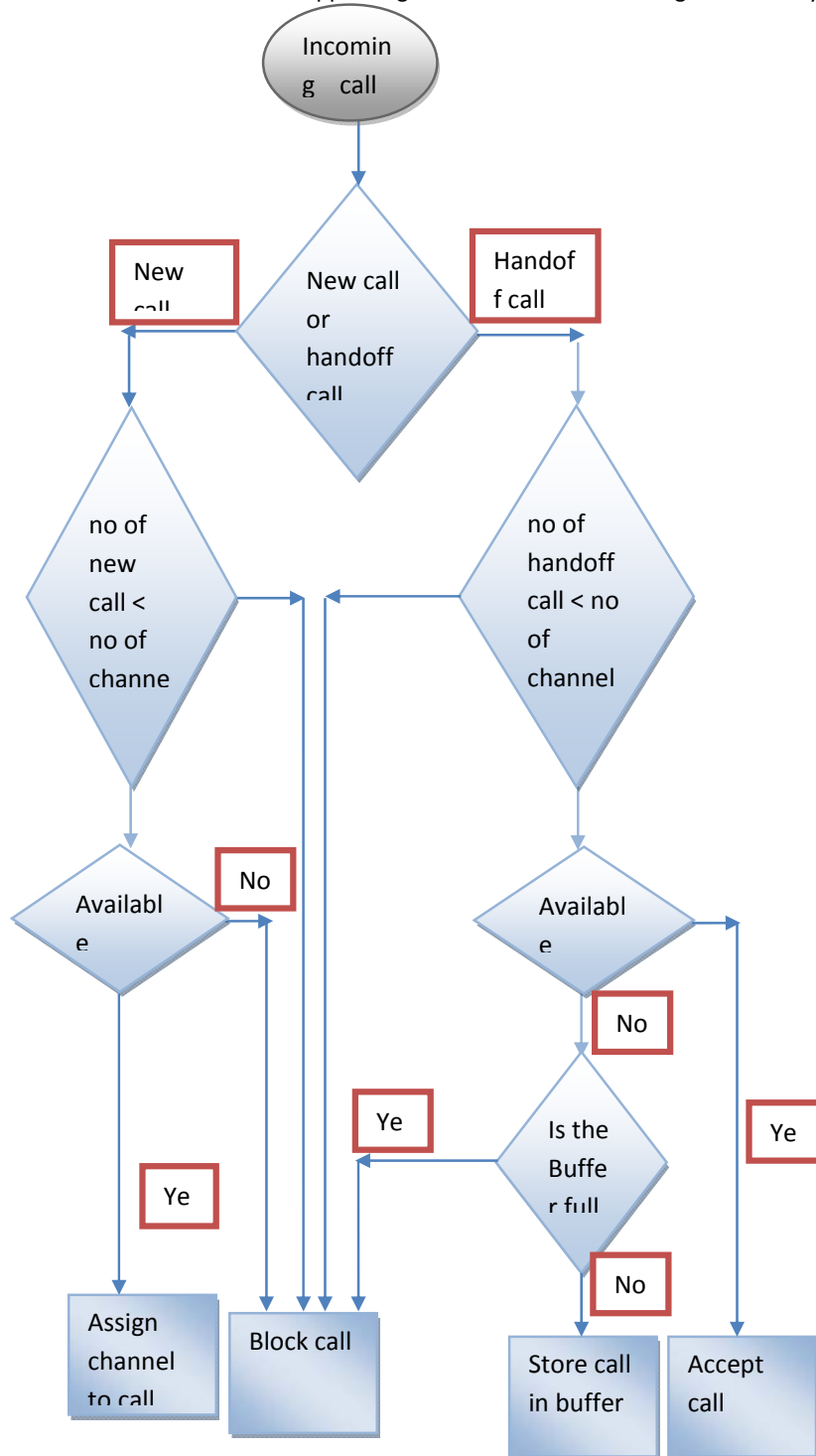


Figure 1.0: Flow Diagram of the System Model

## 7.0 THE SYSTEM MODEL

The system model consists of both handoff calls and new calls entering into the network. The handoff call that does not have any free channel in the cell to continue the establishment of call moves to the buffer. It employs the dynamic channel allocation scheme with a central pool of channels that assigns channels to both handoff call and new call as they enter the network. New and handoff calls are assigned a channel as they enter into the cells ( $C_1, C_2, C_3, C_4, C_5, C_6, C_N$ ). The model is structured over a number of users that move in and out of the cell. Due to the fact that a resource in mobile wireless network is limited, each cell is assigned the same number of channels. When a call is established in the network, the call declares its priority whether a new call or a handoff call and this is done by the call processing entities of the system like the base station, mobile switching center, and the base station controller. The resources available in the network or system is the number of channels in each cell and the buffer that is used to store handoff call if there is no channel in a particular cell to handle the call. The handoff calls queued in the buffer which have a high priority is therefore assign a channel in the cell whenever there is a free or available channel in the cell. The size of buffer in the network to handle handoff calls can be adjusted to handle the influx of input traffic as they enter the network. The First In First Out (FIFO) queuing method was employed in assigning channels to the calls in the buffer and the call will stay in queue as long as the mobile user is still active or alive. The first user or subscriber in the queue takes the first channel released by a user in a cell since we will be using the FIFO queuing method. An analytical mathematical model will be used to support the system model and various call performance metric like the call blocking probability, handoff blocking probability will be derived from this model using quality of service parameters like the call holding time, arrival rate of calls, buffer size etc. Figure 2.0 and figure 3.0 shows the system model and the architectural design of the proposed system.

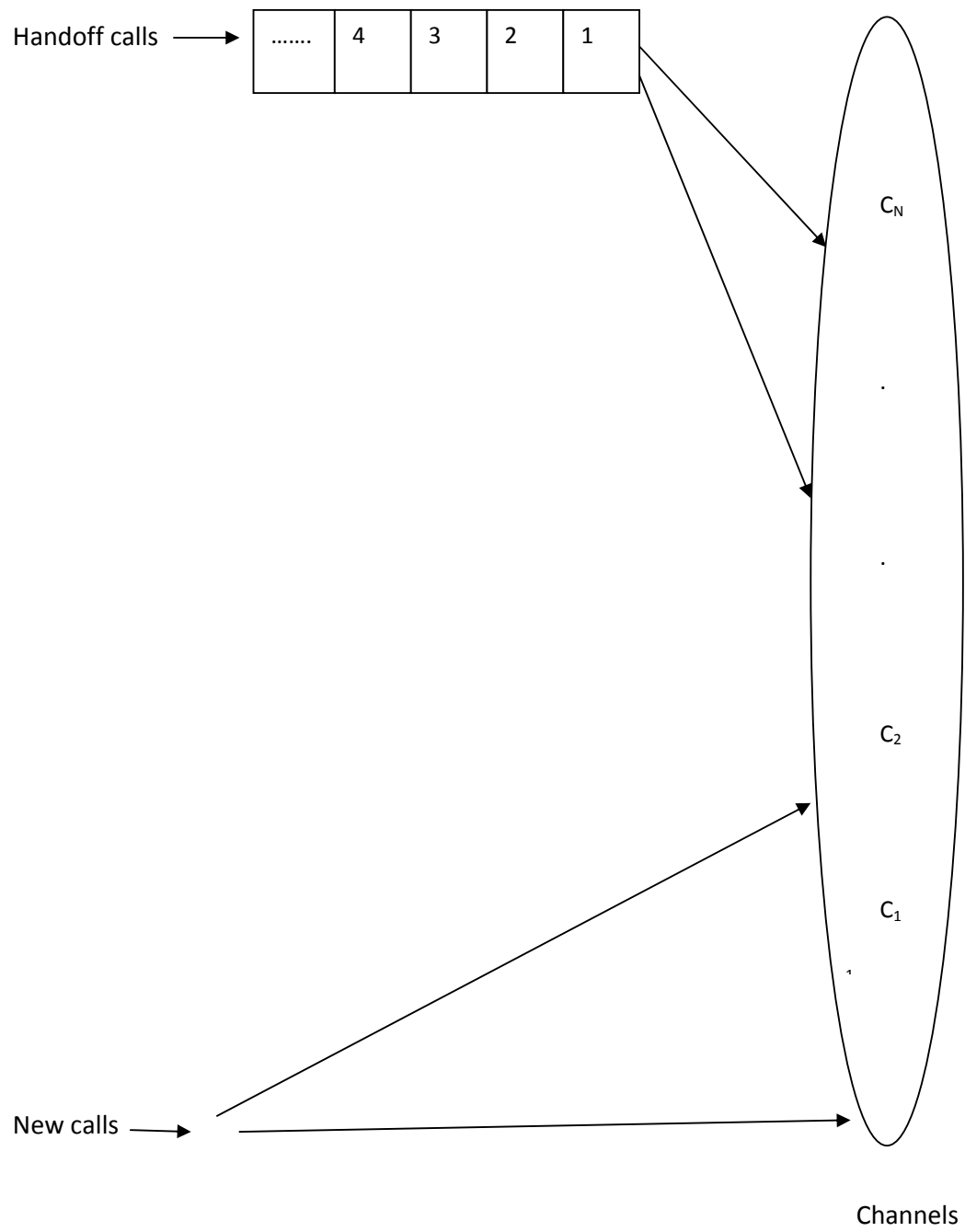


Figure 2.0: The System Model

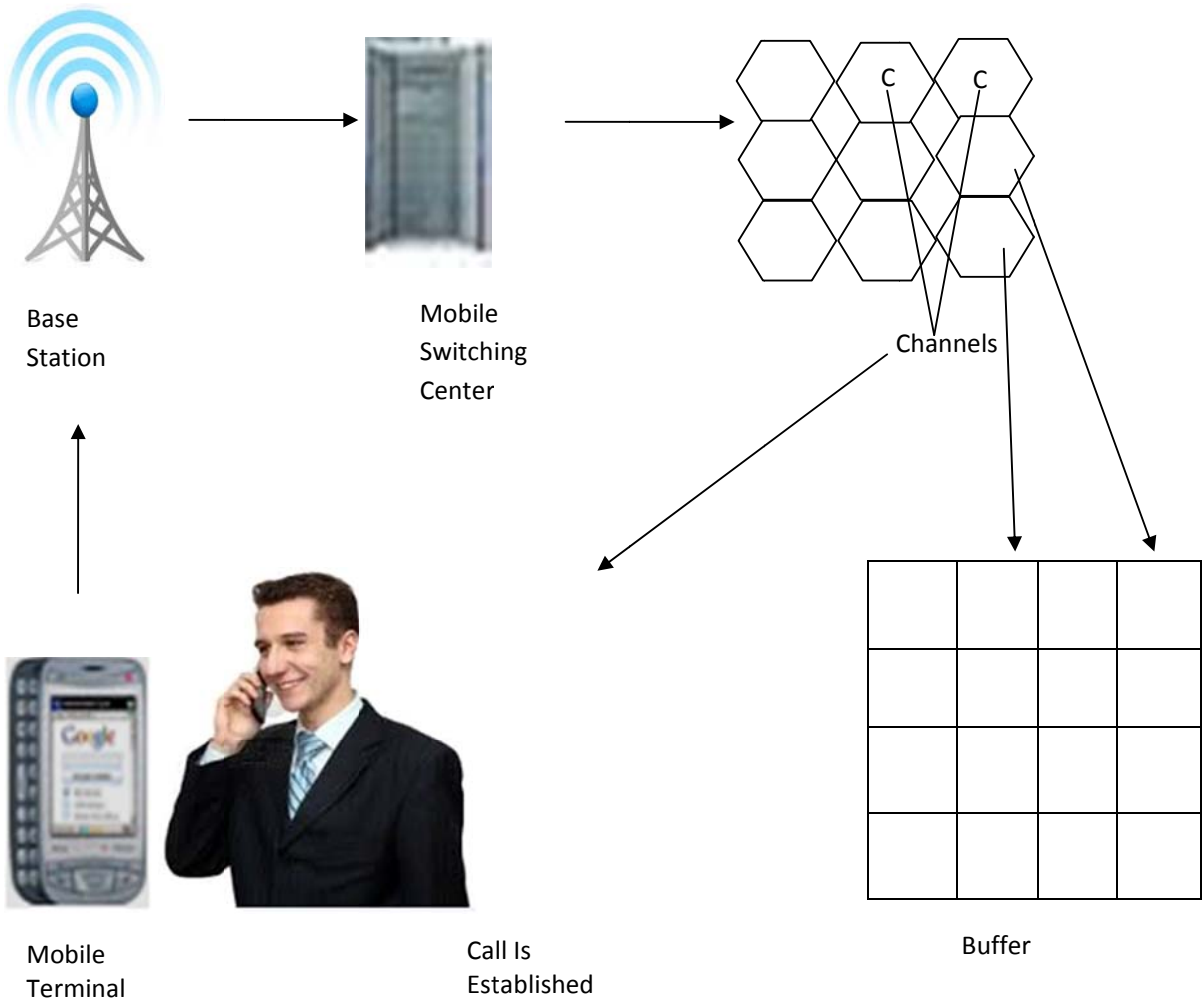


Figure3.0: Architectural Design of the Proposed System

## 8.0 RESULTS AND DISCUSSION

### 8.1 Overview of Results Analysis

This section shows the result of a calling system using the analytical mathematical formulas for calculating the blocking probabilities of new call and handoff calls. Two types of system will be considered, the existing system and the proposed system which will contain a buffer for storing handoff calls if and only if there is no channel in a base station for such a call. Several calculations will be made to compare the performance of the two systems with the use of a C++ programming language, because it is object oriented which makes program easy to understand, correct and modify. Such calculations include new call and handoff call blocking probabilities under each type of systems (a system without a buffer and a system with a buffer).

The performance of the system will be compared under four conditions which include the behavior of the system without a buffer and its behavior when a buffer is used using their blocking probabilities (new and handoff call). Graphical diagrams will also be generated to enhance the understanding of the systems after which observations and conclusions will be made based on the results gotten from the analytical formulas. The graphical representation will be carried out using a SCILAB which is a modern programming environment that includes an editor for coding.

### 8.2 Analytical Model and Parameters

For the purpose of this work the cell denoted as  $N$  which was investigated is set to 10. For simplicity we assume that all the cells are of the same type i.e. micro cell or macro cell and that the arrival rate of new calls in each cell are the same. Each cell in the system was assigned 10 channels. A mean call holding time of 3 minutes was assumed ( $\mu = 0.3$ ). The mean dwelling time  $\mu_d$  for any type of cell either micro or macro is 1.5 minutes. Since users in a cell can spend longer time in a queue especially low speed users, all calls in a cell were assigned the same queue time. Mean queue time of 0.2 was used because the cross distance over the overlapping zone between two hexagonal cells is approximately 0.13 of the diameter of the cell. Therefore the mean time it takes an handoff call in a cell to stay in this zone or area is 0.13 of the time a call stays in a cell before it is been handed-off to a new cell which can also be referred to as the mean dwelling time. In order to study the impact of the various network parameter, the arrival rate of new calls and handoff calls and the state of the system at a particular time varies while other parameters like the queue time, queue size, mean call holding time, mean dwelling time, arrival rate of new calls are fixed. The arrival rate of handoff calls is varied from 15 calls to 42 calls.

It should be noted that the calls in the buffer will be blocked or dropped when they cannot find an idle channel in the cell when there queue time expires. The impact of the buffer size will be evaluated as technology trend indicates that it is challenging to have large size of buffer in mobile network. Due to this reason its performance will be evaluated.

### 8.3 Blocking Probability of new and Handoff call without a Queue

From the table below i.e. table 1.0 and table 2.0 and figure 4.0 below showing the blocking probability of new call and handoff call is deduced. This is a non-priority scheme where all the channels  $S$  are shared by new and handoff calls as they enter into the network. When there is no idle channel, both types of calls are blocked. From the tables above it can be noticed that the blocking probability of new call is equal to the blocking probability of handoff calls, this is because both types of calls are granted the same right to access a channel in the cell and moreover no priority is issued on a particular type of call. The cell with the highest blocking probability is cell 10 and since we assumed the arrival rate of new call in any type of cell to be the same for simplicity i.e. cell 10 of the blocking probability is plotted against the arrival rate of handoff calls. From the graph and table above it is noticed that the blocking probability of new and handoff calls increases with increasing arrival rate of handoff calls ( $\lambda_h/c\mu$ ). No priority scheme is employed and so making the blocking probability of new call and handoff call to be equal which amounts to the total blocking probability of the network. This type of system will be very unpleasant and frustrating since users prefer handoff calls to new calls, and in other for users to get the satisfaction and preference they require priority should be given to handoff calls in other to reduce its blocking probability. A way of reducing the blocking probability of handoff

calls is by introducing a buffer to store handoff calls when there is no idle channel for such a call in the network.

**Table1.0: Blocking Probability of New Call Without a Queue**

| Cell    | S  | $\Lambda$ | $\lambda_h$ | i | $\mu$ | Blocking Probability of new call |
|---------|----|-----------|-------------|---|-------|----------------------------------|
| Cell 1  | 10 | 10        | 15          | 5 | 0.3   | 0.88                             |
| Cell 2  | 10 | 10        | 18          | 5 | 0.3   | 0.89                             |
| Cell 3  | 10 | 10        | 21          | 5 | 0.3   | 0.90                             |
| Cell 4  | 10 | 10        | 24          | 5 | 0.3   | 0.91                             |
| Cell 5  | 10 | 10        | 27          | 5 | 0.3   | 0.92                             |
| Cell 6  | 10 | 10        | 30          | 5 | 0.3   | 0.925                            |
| Cell 7  | 10 | 10        | 33          | 5 | 0.3   | 0.93                             |
| Cell 8  | 10 | 10        | 36          | 5 | 0.3   | 0.935                            |
| Cell 9  | 10 | 10        | 39          | 5 | 0.3   | 0.939                            |
| Cell 10 | 10 | 10        | 42          | 5 | 0.3   | 0.94                             |

**Table 2.0: Blocking Probability of Handoff Call Without a Queue**

| Cell    | S  | $\Lambda$ | $\lambda_h$ | I | $\mu$ | Blocking Probability of new call |
|---------|----|-----------|-------------|---|-------|----------------------------------|
| Cell 1  | 10 | 10        | 15          | 5 | 0.3   | 0.88                             |
| Cell 2  | 10 | 10        | 18          | 5 | 0.3   | 0.89                             |
| Cell 3  | 10 | 10        | 21          | 5 | 0.3   | 0.90                             |
| Cell 4  | 10 | 10        | 24          | 5 | 0.3   | 0.91                             |
| Cell 5  | 10 | 10        | 27          | 5 | 0.3   | 0.92                             |
| Cell 6  | 10 | 10        | 30          | 5 | 0.3   | 0.925                            |
| Cell 7  | 10 | 10        | 33          | 5 | 0.3   | 0.93                             |
| Cell 8  | 10 | 10        | 36          | 5 | 0.3   | 0.935                            |
| Cell 9  | 10 | 10        | 39          | 5 | 0.3   | 0.939                            |
| Cell 10 | 10 | 10        | 42          | 5 | 0.3   | 0.94                             |

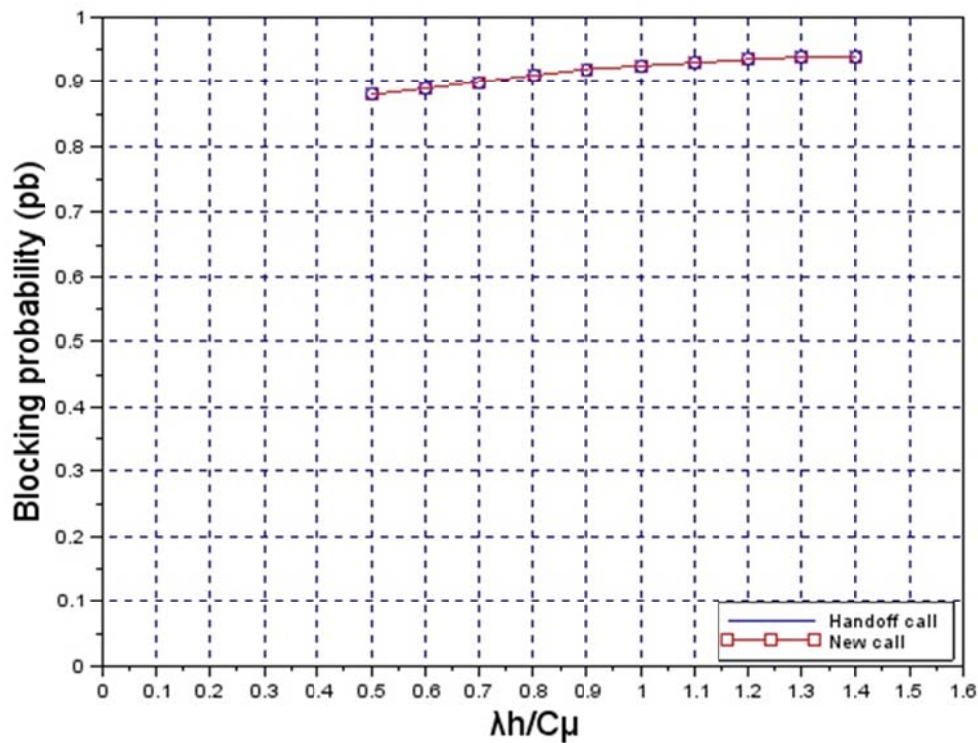


Figure 4.0: Blocking Probability of New and Handoff call in a non-priority Scheme

#### 8.4. Impact of Queue on Handoff call Blocking Probability

The tables and plots below shows the blocking probability of new calls and handoff calls when a queue is used in a network compared to the above where no queue or form of priority is set. From the graph and table of the network that uses a queue, it is noticed that the blocking probability of new calls and the blocking probability of handoff calls are different and that the handoff blocking probability decreases drastically compared to the handoff blocking probability of the network without a queue. The analytical model is said to be correct since the handoff blocking probability reduces which is the aim of this work. It can be observed from the plot below that when the load on the network (with a queue) is low there is a great advantage in the blocking probability of handoff calls while as the load in the network increases, the blocking probability of handoff calls increases.

Also from the plot and graph below, it is noticed that the blocking probability of handoff calls reduces at the expense of the blocking probability of new call. The mean queue time cannot be increased too much because doing that will increase the overlapping zone between cells which also reduces the frequency distance and this simply implies that fewer channels can only be assigned to each cell and this will definitely increase the blocking probability of calls in the cell. The use of a queue has a significant impact on the blocking probability of handoff calls.

**Table 3.0: Blocking Probability of new call with a Queue**

| Cell    | C  | $\Lambda$ | $\lambda_h$ | I | U   | $u_d$ | $u_q$ | q | Blocking probability of new call |
|---------|----|-----------|-------------|---|-----|-------|-------|---|----------------------------------|
| Cell 1  | 10 | 10        | 15          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.35                             |
| Cell 2  | 10 | 10        | 18          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.47                             |
| Cell 3  | 10 | 10        | 21          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.59                             |
| Cell 4  | 10 | 10        | 24          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.67                             |
| Cell 5  | 10 | 10        | 27          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.75                             |
| Cell 6  | 10 | 10        | 30          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.81                             |
| Cell 7  | 10 | 10        | 33          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.85                             |
| Cell 8  | 10 | 10        | 36          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.88                             |
| Cell 9  | 10 | 10        | 39          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.90                             |
| Cell 10 | 10 | 10        | 42          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.92                             |

**Table 4.0: Blocking Probability of handoff call with a Queue**

| Cell    | C  | $\Lambda$ | $\lambda_h$ | I | U   | $u_d$ | $u_q$ | q | Blocking probability of handoff call |
|---------|----|-----------|-------------|---|-----|-------|-------|---|--------------------------------------|
| Cell 1  | 10 | 10        | 15          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.25                                 |
| Cell 2  | 10 | 10        | 18          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.35                                 |
| Cell 3  | 10 | 10        | 21          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.43                                 |
| Cell 4  | 10 | 10        | 24          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.50                                 |
| Cell 5  | 10 | 10        | 27          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.55                                 |
| Cell 6  | 10 | 10        | 30          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.59                                 |
| Cell 7  | 10 | 10        | 33          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.62                                 |
| Cell 8  | 10 | 10        | 36          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.65                                 |
| Cell 9  | 10 | 10        | 39          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.66                                 |
| Cell 10 | 10 | 10        | 42          | 5 | 0.3 | 1.5   | 0.2   | 3 | 0.68                                 |

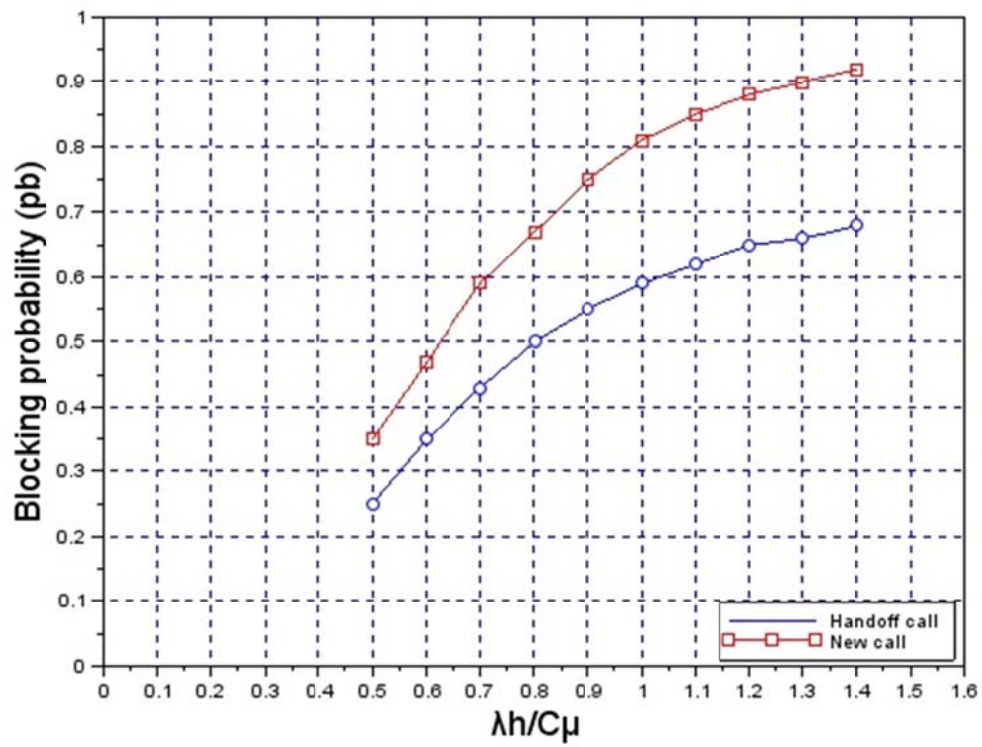


Figure 5.0: Blocking Probability of New and Handoff call in a Handoff call Queuing Scheme

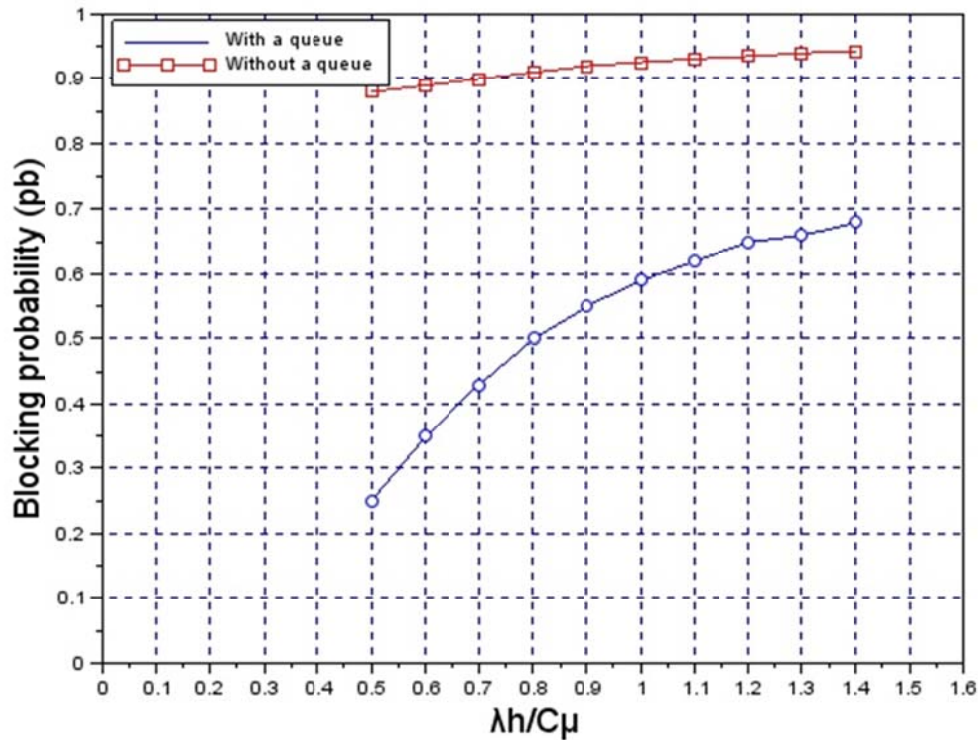


Figure 6.0: Blocking Probability of Handoff call in a System using a Queue and that without a Queue

## 9.0 CONTRIBUTION TO KNOWLEDGE

This work has unveiled a better congestion control scheme which proves better in terms of blocking probability of handoff calls. Our work has also contributed to knowledge in the following perspective:

1. A congestion control scheme that provides better quality of service for users in mobile wireless network.
2. Generation of parameters for measuring the performance of call admission control system such as new call blocking probability, handoff call blocking probability, buffer size.
3. Integration of buffer with a call admission control to control congestion in mobile network, reducing the blocking probability of handoff calls.

## 10.0 CONCLUSION

This work presents a congestion control scheme for mobile network, although many research work have been done on congestion control but most of them did not consider buffering handoff calls for the purpose of reducing the blocking probabilities of handoff calls. Instead of deteriorating the quality of handoff calls which is a user's preference, a buffer is used to store handoff calls when there is no available channel which in turn increases the throughput of the network. This scheme provides quality of service to calls especially handoff calls which are the goal and aim of this work.

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