Call Blocking Performance of New Reservation based Channel Assignment Scheme in Cellular Networks

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ABSTRACT
Cellular operators are facing difficulties in supporting a huge increment in the subscribers due to spectrum and equipment restrictions. Substantial amount of investigation has been reported in the area of increasing call carrying capacity such as Reuse Partitioning and Directed Retry. However, such action increases the size of the network and results to higher installation, maintenance and optimization costs for the cellular operator. In this paper, a cost effective new channel reservation scheme based on subscribers' average call duration has been reported. A cell has been considered which has very few allocated channels and is also unable to execute load balancing methods such as channel borrowing, call transfer etc. A cell with such restrictions may have higher blocking probability during busy hours, but the results show that the proposed scheme can effectively reduce the overall call-blocking for such cell. The resulted scheme is particularly useful in a cell having heavy traffic with mostly business calls.

Keywords
Cellular network; Call carrying capacity; Channel Allocation; Estimation of Call Duration;

1. INTRODUCTION
The Demand for cellular mobile services is increasing at a very high rate each year and in a lot of metropolitan areas the demand has already far exceeded the capacity. Even under an ideal situation like popular areas such as stadium, traffic congestion and disaster etc, the mobile cellular system impose uneven traffic load in that cell. That is a cell with traffic load substantially larger than the design load called as hot-spot cell. Different techniques can be used to increase the capacity. Among such techniques cell splitting, cell sectoring and channel borrowing are in practical use. The cell splitting is an effective solution if most of the neighbor cells are highly congested or becomes hot-spot cells. However it is very expensive as it requires additional equipment such as power plant, radio transceiver, antennas and data terminals as cell splits simultaneously. The cell sectoring is used to increase the reuse distance and is applied to group of neighboring of hot- spot cells. Since new equipments are needed to upgrade Omni cell system to sectorized cell while implementing cell sectoring it is economically not favorable. Even though channel borrowing from adjacent cell is less costly, the penalty of channel borrowing is very large at the cost of interference.

For a given cellular system with a fixed spectrum assigned and a specific multiplexing technology used, the traffic carrying capacity of a system also depends on the efficiency of the channel assignment strategy used. Despite various proposals on dynamic channel assignment strategies, all existing cellular systems employ the fixed channel assignment because of its cost effectiveness and predictable performance. In fixed channel assignment, the total coverage area is divided into the number of cells and a number of channels are assigned to each cell according to some reuse pattern and considering interference depending on desired signal quality.

In this paper a new scheme is proposed to reduce the overall call drop or call blocking in a particular cell and thereby making room to accommodate more number of new originating calls. The average duration of calls generated by different subscribers within a cellular network is not same. Usually duration of an emergency or important call is short in comparison to the duration of personal and general calls. Many times an emergency call is blocked due to congestion i.e. all channels are allocated to other calls. A long-duration call reserves a channel for longer period of time whereas a short-duration calls for shorter period of time. Thus, in unit time period, a channel can support more number of short-duration calls than long-duration calls. We have addressed this property to propose the new channel reservation scheme to reduce call blocking probability. The average call durations of all subscribers are computed from the recent call history. Then all the subscribers are grouped into five different user groups. For each such user group, a set of few channels are reserved to be used by the subscribers belonging to that group. The proposed scheme is compared with the existing FCFS (First Come, First Served) scheme and also with the theoretical blocking obtained from the Erlang B table. Result analysis clearly shows that the proposed new scheme is the best algorithm in terms of reducing the call blocking. This scheme is particularly useful in a cell having heavy traffic with mostly business calls. Most of the earlier papers on enhancing cellular capacity have addressed the problem by efficient cell planning. But they require installing new base stations and thereby

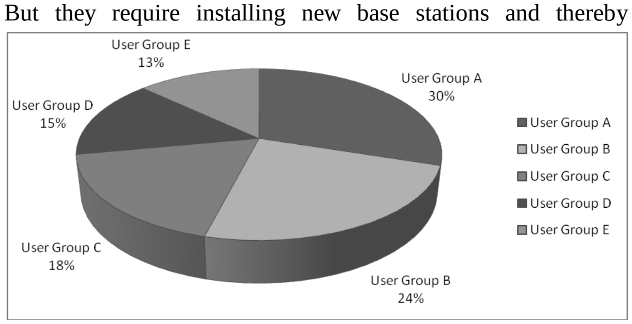

Figure 1 Distribution of Subscribers in the reference cell

increasing the operating cost for the network operators, which led to the motivation of our work in this area.

2. REVIEW WORK

Previous research on mobile cellular networks has led to many schemes to reduce the call blocking and thereby increase the system capacity and performance. A Hybrid Channel Allocation method [2] with two groups: group (A) – for fixed channel allocation (Assigned to Base Stations statically) and group (B) - for dynamic channel allocation (central pool at MSC) is presented. This method behaves similar to the FCA at high traffic and to the DCA at low traffic loads. Greedy-based Dynamic Channel Assignment (GDCA) strategy [3] dynamically allocates the channels based on greedy method and can be applied to any irregular cell shape. The multi-hop dynamic channel assignment (MDCA) scheme [4] assigns channels to calls based on interference information in surrounding cells, provided by the Interference Information Table (IIT) in the network. A channel allocation and handover algorithms for the HSCSD (High Speed Circuit Switched Data) service in SDMA (Space Division Multiple Access) systems [5] enable multi-slot operation with the number of HSCSD slots as parameter. Different traffic load balancing [6] schemes are also used to reduce call blocking. Most of the work related to traffic load balancing only focuses on different radio channel allocation schemes. A game-theoretic analysis for load balancing is presented in [7] which increase the capacity usage in the network even when the cells act in a non-cooperative way. Another relay-based load balancing scheme to transfer over-loaded traffic from hot cells to neighboring cooler cells is introduced [8], where an on-line algorithm which dynamically controls the associations of Relay Stations with Base Stations and associations of Mobile Stations with Relay Stations and Base Stations is proposed. A cell-cluster based traffic load balancing strategy [9] to solve the problem of cell congestion in cooperative cellular networks is proposed.

3. SYSTEM MODEL

A mobile cellular system with homogeneous cells and a fixed number of channels which are permanently allocated to each cell is considered. In such a system, attention is focused on a single cell; let this cell be called as the reference cell. Let us consider the total number of channels which are permanently allocated to the reference cell is 50.

Based on the average call durations, the users of the reference

cell are categorized into five user groups (User Group A –

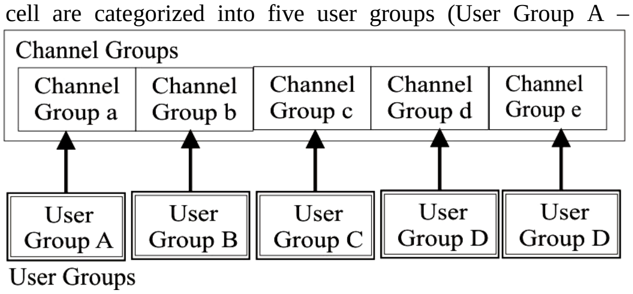

Figure 2 Assignments of User Groups to Channel Groups

Average call holding time: 120 seconds, User Group B – Average call holding time: 350 seconds, User Group C – Average call holding time: 800 seconds, User Group D – Average call holding time: 1400 seconds and User Group E – Average call holding time: 2000 seconds). The distributions of users from all the four User Groups in the reference cell are shown in Figure 1. The average call arrival rate for User Group A, User Group B, User Group C, User Group D and User Group E are based on poisson distribution and varying which constitutes different traffic load in the reference cell.

4. PROPOSED NEW SCHEME

In this Scheme for each reference cells the total available channels are divided into five reserved groups - Channel group a, b, c, d and e. Each User Group in their ascending order of average call duration is assigned to one of these Channel Groups. The User Groups A, B, C, D and E are in their ascending order of average call duration and are assigned to Channel groups a, b, c, d and e respectively (As shown in Figure 2). Each call originated by a user from a particular User Group can occupy channel from its reserved Channel Group but if all the channels from that reserved channel group are busy then a channel from next Channel Groups associated with the next user group in ascending order can also be allocated if available. If all the channels from the next channel group are busy, the same process of checking next user group in ascending order continues as shown in flow chart in Figure 3. For example, suppose a new call is originated by a user from User Group A and all the channels from Channel Group a reserved for User Group A are busy, then a channel may be allocated from Channel Group b which is reserved to User Group B. The reverse is restricted i.e. a new call originated by a user from User Group B is not allowed to be assigned a channel from Channel Group a reserved for User Group A whose average call duration is less than that for User Group B. This scheme is compared with the existing FCFS scheme and a theoretical blocking obtained from Erlang B table which are described below.

4.1 FCFS Scheme

In the system where all calls have same bandwidth, and all calls have the same priority, First Come First Serve (FCFS) is used. FCFS produces a good utilization of communication medium under the above-mentioned conditions. The entire channels are allocated on FCFS (First Come First Serve) basis.

4.2 Erlang B table

An Erlang B table presents the estimated traffic to be handled by a certain number of traffic channels according to a certain blocking probability. Erlang B table is based on the following assumptions:

a) There are an infinite number of sources;
b) Calls arrive at random;
c) Calls are served in order of arrival;
d) Blocked calls are lost; and
e) Holding times are exponentially distributed.

The Erlang B formula which is needed to create the table is used to predict the probability that a call will be blocked. The Erlang B formula is:

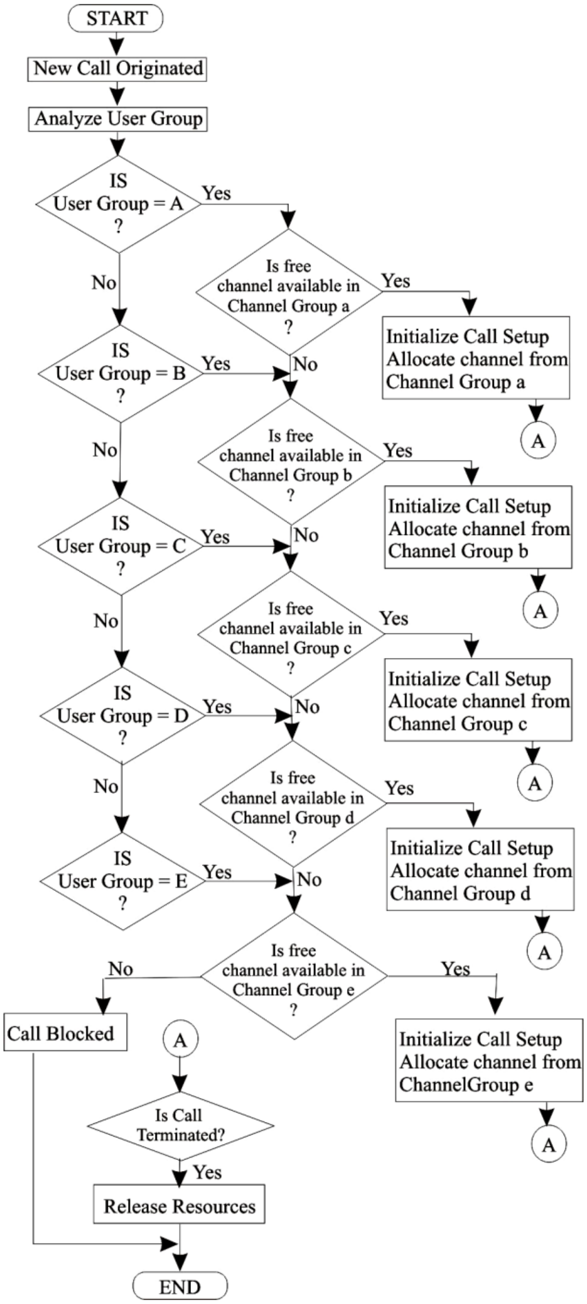

Figure 3 Flow chart of the proposed scheme

$$B = \frac{\frac{A^N}{N!}}{\sum_{i=0}^{N} \frac{A^i}{i!}}$$

where:

B=Erlang B loss probability
N=Number of available traffic channels
A=Traffic offered in Erlangs

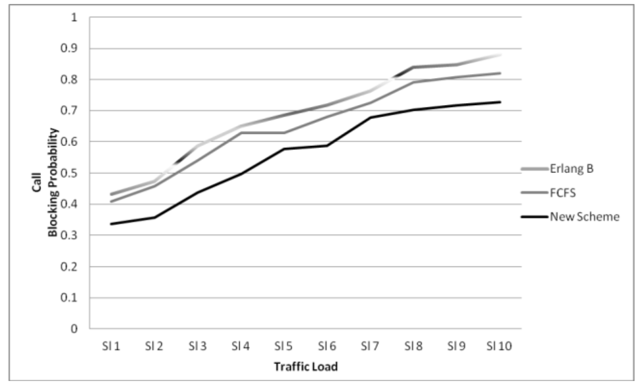

Figure 4 Comparison of Overall Call Blocking Probability

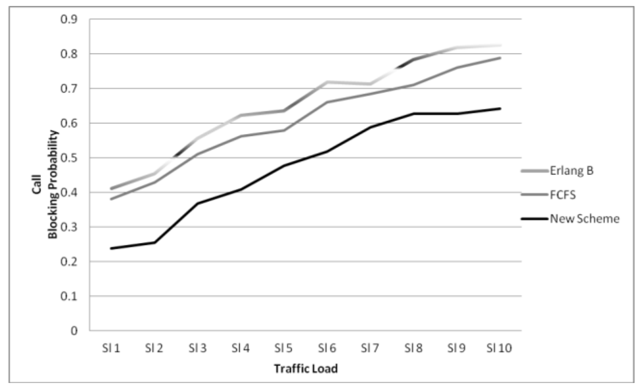

Figure 5 Comparison of Call Blocking Probability from User Group A

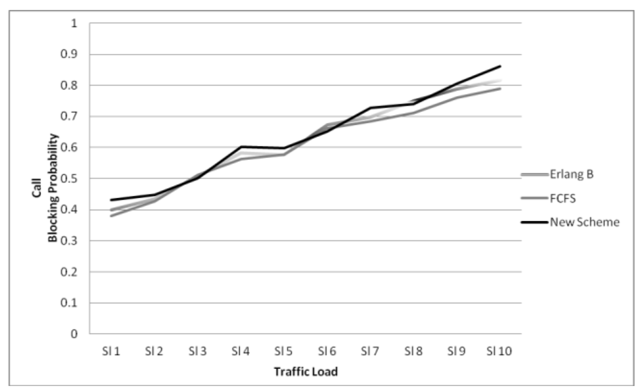

Figure 6 Comparison of Call Blocking Probability from User Group E

5. RESULT ANALYSIS AND PERFORMANCE COMPARISION

The performances of cellular networks are measured by Grade of Service (GoS) and by the Quality of Service (QoS). The Grade of Service (GoS) in cellular networks is measured by the call blocking probability. But most of the earlier research work has considered average call-duration as 2 minutes to compute overall call blocking and the total number of active calls in unit duration are also small. In this work the average call duration of the subscribers are taken much higher than this and also the total number of active calls in unit duration are more than 1000 calls. The total numbers of available channels are also kept very small. However, various load balancing schemes can also reduce the overall call blocking but in many situations the load balancing scheme are much complex or not feasible at all, specifically at busy hours. In this scheme no load balancing scheme is taken into consideration. Clearly the operating conditions of the reference cell are very restrictive. To reduce overall call blocking and to support more number of emergency or business calls is main objective of this work.

Initially, if large number of long-duration new calls are originated in unit duration, a large number of further short-duration calls are also get blocked due to unavailability of free channels. The solution of this problem is achieved by providing reserved channels for various user groups in this work. A burst of short-duration calls are supported by expense of blocking few long duration calls. Since, the available channels to be utilized by long duration callers are kept very small in this experiment, more number of long duration call may get blocked (as observed in Figure 6).

The Quality of Service (QoS) in cellular networks is defined as the capability of the cellular service providers to provide a satisfactory service which includes voice quality, signal strength, low call blocking and dropping probability etc. The results show that the proposed channel allocation scheme can effectively reduce the overall call-blocking. The proposed scheme is particularly useful in a cell having heavy traffic with mostly business calls and the call dropping probability of such short duration business calls are effectively reduced (as Shown in Figure 5). Since static channel allocation strategy is considered, it is assumed that there is no interference caused by co-channel interference and adjacent channel interference. Hence the voice quality and signal strengths are satisfactory.

6. CONCLUSION

This work focuses on our approach to solve the problem of reducing call blocking in cellular network. We have proposed a new channel reservation schemes to reduce call blocking in a cellular network. These schemes are compared with existing FCFS scheme which allocates a free channel on a first come first serve basis and with the theoretical call blocking obtained from Erlang B table. Result analysis clearly shows that the proposed scheme is efficient in reducing the overall call blocking. Further our scheme does not require installing a new cellular tower and can easily be implemented on existing cells.

7. REFERENCES

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