

Survey of Call Blocking Probability Reducing Techniques in Cellular Network

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Abstract- In cellular networks, blocking occurs when a base station has no free channel to allocate to a mobile user, blocking can be new call blocking or handoff call blocking. One of the research challenges for cellular systems is the design of improved call admission control scheme which will reduce call blocking probability and improve the quality of service. The Previously proposed schemes are reviewed here through which we can build such a scheme in future for cellular network which can easily improve the quality of service.

Index Terms- Cellular system, handoff management, blocking probability, hot-spot cells, auxiliary stations

I. INTRODUCTION

In a cellular system, as the distributed mobile transceivers move from cell to cell during an ongoing continuous communication, switching from one cell frequency to a different cell frequency is done electronically without interruption and without a base station operator or manual switching. This is called the handover or handoff. Typically, a new channel is automatically selected for the mobile unit on the new base station which will serve it. The mobile unit then automatically switches from the current channel to the new channel and communication continues.

In cellular networks, blocking occurs when a base station has no free channel to allocate to a mobile user. One distinguishes between two kinds of blocking, the first is called new call blocking which refers to blocking of new calls, and the second is called handoff blocking which refers to blocking of ongoing calls due to the mobility of the users.

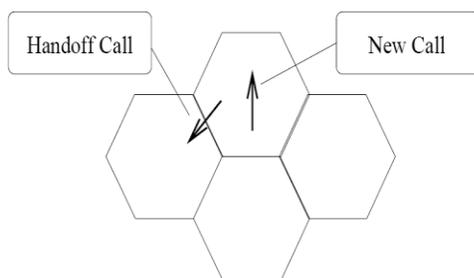


Fig.1. New call and handoff call

By using reservation based channel assignment technique we can assign channel groups to user groups according to call duration so that short duration calls will not be blocked due to long duration calls.

In hierarchical based scheme dual-band cellular mobile communication network is considered where each cell i.e. the macro and microcells are served by different base stations that are center excited. If the speed of the user is determined to be fast then the call is sent to the macro cell, else if the user were slow then the call would be sent to microcell to be served. When a call is sent to the microcell but the required bandwidth of the call is large than the available bandwidth, then the call would be forwarded to the macro cell.

In hybrid channel allocation (HCA) which is the combination of fixed channel allocation (FCA) and dynamic channel allocation (DCA). When a mobile host needs a channel for its call, and all the channels in its fixed set are busy, only then a request from the dynamic set is made.

Also call blocking can be reduced using auxiliary stations. Failure probability may be minimized if the handoff request is served by an Auxiliary Station (AS) closest to the mobile station (MS), if the channels of base station (BS) are not free. The mobile station, being in the auxiliary station, will send requests to the base station within fixed time intervals and when it will find free channels are available in base station it will automatically connect with it, rejecting the connection of the auxiliary station (AS). This process effectively reduces the handoff failure probability.

II. CALL BLOCKING PROBABILITY REDUCING TECHNIQUES

A. CALL BLOCKING PERFORMANCE OF NRBCA SCHEME IN CELLULAR NETWORKS[1]

Here a 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.

Here proposed 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. This scheme is particularly useful in a cell having heavy traffic with mostly business calls.

1. SYSTEM MODEL USED FOR NRBCA

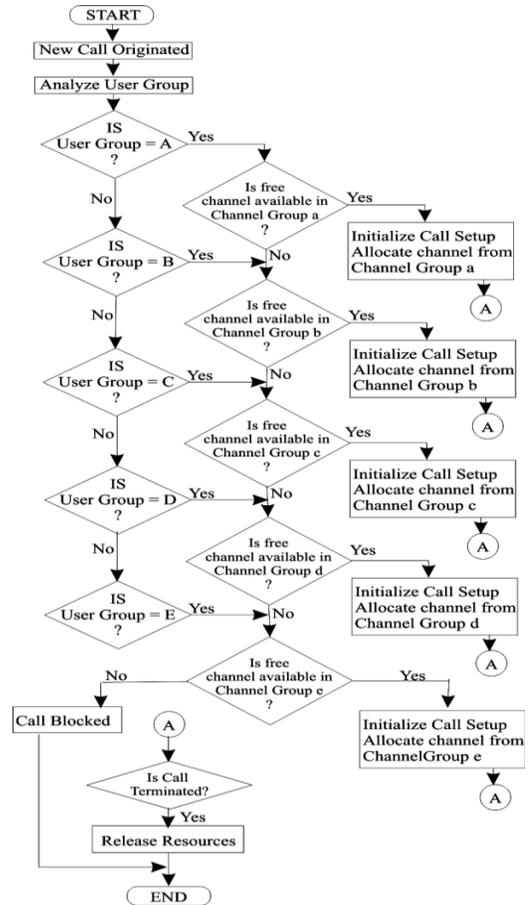
A mobile cellular system with homogeneous cells and a fixed number of channels which are permanently allocated to each cell is considered. In such a system, attention is focused on a single cell; let this cell be called as the reference cell. Let us consider the total number of channels which are permanently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

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.

2. NRBCA PROPOSES FOLLOWING 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.

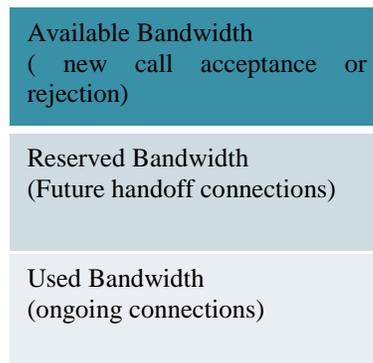
Each call originated by a user from a particular User Group can occupy channel from its reserved Channel Group but if all the channels from that reserved channel group are busy then a channel from next Channel Groups associated with the next user group in ascending order can also be allocated if available. 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. 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.



B. NCBP IN IMPROVED ADQOS FOR WIRELESS MULTIMEDIA COMMUNICATIONS USING HCA[2]

This method utilizes a hierarchical cellular approach with a bandwidth reallocation algorithm to determine the acceptance or rejection of a new call. The main criteria to implement the structure are to have 2 different sets of operating frequency bands to avoid interference. Thus, a dual-band cellular mobile communication network is considered where each cell i.e the macro and microcells, are served by different base stations that are center excited.

1. BANDWIDTH ALLOCATION



2. HIERARCHICAL CELLULAR STRUCTURE

The main criteria to implement the structure are to have 2 different sets of operating frequency bands to avoid interference. Thus, a dual-band cellular mobile communication network is considered where each cell i.e the macro and microcells, are served by different base stations that are center excited.

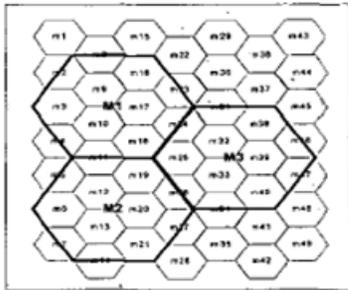


Fig.2. A Sample 2-tier Hierarchical Cell Topology

One macro cell covers a number of m micro cells and calls are assumed to originate in any cell and not interfere with each other. The main advantage of implementing this structure is due to the much better spatial reuse of microcell frequencies, which yield a substantial capacity increase, efficient bandwidth utilization and inherent load balancing. One of the aim in designing and planning of cellular communication network is to reduce NCBP.

The QoS Admission Control receives the application profile of a new call. The system checks the speed of the user for the preliminary process to determine at which level the call should be served, whether in the macro cell or the microcell.

3. QoS ADMISSION CONTROL ALGORITHM

The basic algorithm for the admission control in a hierarchical structure is shown below, where the call would be separated according to its serving macro or microcells. The QoS Admission Control receives the application profile of a new call complete with the speed of user, the required bandwidth and the minimum acceptable bandwidth requirements. The system checks the speed of the user for the preliminary process to determine at which level the call should be served, whether in the macrocell or the microcell.

- (1) Receive a
- (2) Get Speed of User, a_s
- (3) if(a_s ==fast)
- (4) Send Call to Macrocell
- (5) Serve
- (6) Else(a_s ==slow)
- (7) Send Call to Microcell
- (8) Get Bandwidth Available (B)
- (9) if($a_{req} \leq B$) then
- (10) Serve
- (10) Else
- (11) Send Call lo Macrocell
- (13) Serve

If the speed of the user is determined to be fast then the call is sent to the macrocell, else if the user were slow then the

call would be sent to microcell to be served. When a call is sent to the microcell but the required bandwidth of the call is large than the available bandwidth, then the call would be forwarded to the macro cell to be served as stated in the algorithm, else it would be served in the microcell itself.

C. A CHANNEL ALLOCATION ALGORITHM FOR HOT-SPOT CELLS IN WIRELESS NETWORKS[3]

In wireless mobile communication systems, the radio spectrum is limited resource. However, efficient use of such limited spectrum becomes more important when the two, three or more cells in the network become hot-spot. The use of available channels has been shown to improve the system capacity. The role of channel assignment scheme is to allocate channels to cells in such way as to minimize call-blocking probability or call dropping probability and also maximize the quality of service. In this scheme attempts are made to reduce call-blocking probability by designing hybrid channel allocation (HCA) which is the combination of fixed channel allocation (FCA) and dynamic channel allocation (DCA). A cell becomes hot-spot when the bandwidth available in that cell is not enough to sustain the users demand and call will be blocked or dropped. In HCA, channels are divided into two disjoint sets: one set of channels is assigned to each cell on FCA basis (*fixed set*), while the others are kept in a central pool for dynamic assignment (*dynamic set*). The fixed set contains a number of channels that are assigned to cells as in the FCA schemes and such channels are preferred for use in their respective cells. When a mobile host needs a channel for its call, and all the channels in its fixed set are busy, only then a request from the dynamic set is made. It also shows that it behaves similar to the FCA at high traffic and to the DCA at low traffic loads as it is designed to meet the advantages of both.

1. SYSTEM MODEL AND DEFINITION FOR CHANNEL ALLOCATION

We consider a wireless cellular network where the covered geographic area served by the system is divided into several hexagonal-shaped cells. Each cell is served by a base station (also called the MSS (Mobile Service Station)), usually present at the center of the cell. The base stations are connected with one another through a fixed wired (or wireless) network, in general. A mobile host can communicate only with the base station in its cell directly. When a mobile host wants to set up a call, it sends a request to its base station in its cell on the control channel. The call can be set up only if a channel is assigned to support the communication between the mobile host and the base station. No two cells in the system can use the same channel at the same time if they are within minimum channel reuse distance; otherwise, channel interference will occur. It is assumed that a base station can keep the count of number of calls originated (successful or unsuccessful) in its related cell over a given period of time. This count will help the base station to determine its present level of "hot-spot" and to send a multi-level "hot-spot" notification/signal to its Mobile Switching Center (MSC). The system uses a hybrid channel allocation scheme where the total number of C channels is divided into two disjoint sets, F and D . The set F contains the channels for fixed (or static) assignment, while the set D contains the channels for dynamic assignment, i.e., $C = F \cup D$. Moreover, each base station maintains a *temporary pool*

(called T) to retain a channel that was originally transferred from the dynamic assignment pool at MSC. The system uses a frequency reuse factor N . The fixed channels are assigned to a cell statically as in FCA; while dynamic channels are kept in a centralized pool at MSC. Let r be the ratio of the number of dynamic channels to the total number of channels available in the system, i.e.,

$$r = |D| / |C|$$

The ratio r will remain fixed in the system (i.e., it will not change dynamically over the period of time). The value of r is a design parameter, and it depends on the designer's view about the heterogeneity (or difference) in traffic volumes in different cells in the network. For example, if most of the cells in the network has the chance of becoming "hot-spots", then it is a good idea to keep the ratio $r > 0.5$. The "hot-spot" notification level is an integer-valued number L , such that $L \in \{0, 1, 2, \dots, M\}$ where M represents a pre-defined maximum level supported by the system. The value for L represents the fact that up to L borrowed channels can be retained by the base station after a call on the borrowed channel from that cell terminates. The hybrid channel allocation algorithm (described next) will use the appropriate value of L in several of its steps.

2. HCA ALGORITHM

It consists of two phases

- Channel acquisition phase
- Channel release phase

2.1. Channel Acquisition Phase

Set level ($L = 0$) at the beginning to indicate that the channel request can be accommodated from the first group (A) and there is no hot-spot cell in the network.

1. When a mobile host wants to initiate a call, it has to send a channel request on the control channel to its related base station.
2. If the base station has an available channel from first group (A), it will assign a channel to mobile host.
3. If no channel from the first group (A) is available, then base station updates the value of (L) as shown in Fig 3.

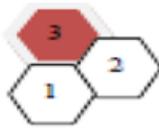


Fig.3.Cell no. 3 is hot-spot cell $L=1$

$$L = L + 1$$

$$L = 0 + 1 = 1$$

$$L = \max(L, M)$$

4. The base station then sends a request to borrow a channel from the central pool located at MSC. It also includes the current value and maximum value of (L).

2.2. Channel Release Phase

1. The MSC, on receiving channel request from the base stations assign up to the (L) channels if available from dynamic pool.

2. When the base station successfully acquires channel from the dynamic pool at MSC, it also adds a channel to its temporary pool (T).

3. When a call terminates on a channel at a mobile host, the base station needs to find out which type of channel the call belonged to.

4. If channel is belonged to dynamic pool at MSC the base station estimates current level of hot-spot (h) in the cell as shown in Fig.4.

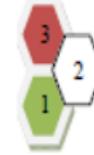


Fig.4.Estimation of correct hot-spot level

5. If ($h \leq L$) meaning that the congestion in the cell is same or easing, the base station checks its temporary pool (T) and retains up to (h) channels in random order and all the remaining channels in (T) are returned back to MSC.

6. If ($h > L$) meaning that the congestion in the cell is getting worse, the channel is retained in the cell. The channel is not returned back to MSC.

7. If MSC is unable to assign even one channel, the call will be blocked.

3.3 Theoretical result of HCA:

The blocking probability (P_b) in HCA is given by as Eq.1

$$P_b = \frac{\frac{A^N}{N!}}{\sum_{k=0}^N \frac{A^k}{k!}}$$

Where A is given by $A = \lambda / \mu$, which is successive call time arrivals. In which, λ is the call arrival rate per second, μ is average call departure rate of users per second, and N is number of channels in the system.

In this new hybrid channel allocation algorithm that sends a multi-level "hot-spot" notification to the central pool on each channel request that cannot be satisfied locally at the base station. This notification will request more than one channel be assigned to the requesting cell, proportional to the current hot-spot level of the cell. This also reduce control message overhead needed to acquire each channel individually. When a call using such a "borrowed" channel terminates, the cell may retain the channel depending upon its current hot-spot level.

D. MINIMIZATION OF CALL BLOCKING PROBABILITY USING AUXILIARY STATIONS[4]

Call blocking probability can be reduced by adding auxiliary stations. Here, a method is proposed which attempts to reduce handoff failures in mobile networks without significant increase in blocking probability of originating calls within a cell. A Mobile Station (MS) on entering a new cell requests a channel from the Base Station (BS) for continuing the existing call.

However, if no such free channels are available, then a handoff failure is said to occur, i.e. an existing call is dropped. This failure probability may be reduced if the handoff request is served by an Auxiliary Station (AS) as shown in Fig.5. closest to the MS when no free channel from BS is available. However, the main purpose of the auxiliary station is to provide channels for the originating calls in its area. Thus assigning channels of these AS for handoff would lead to increase in blocking probability of originating calls. So, to prevent this unwanted increase in Blocking Probability, the MS which is occupying a channel of the AS will try to changeover to a channel under the BS at the earliest possible opportunity. This method also ensures that there is no need for repeated handoffs as the MS moves inside the cell from one AS to another. Thus the probability of failure in handoff is reduced.

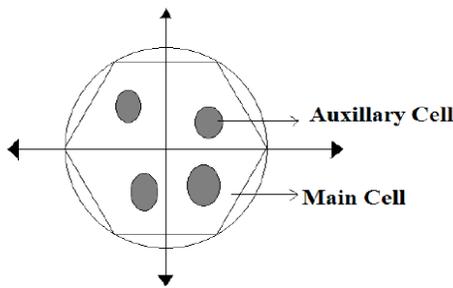


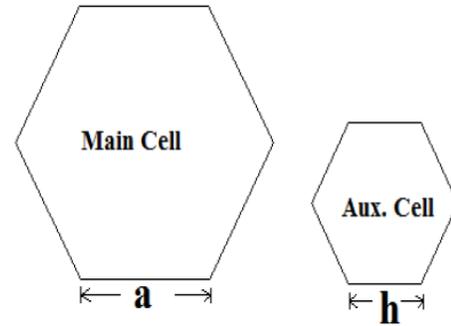
Fig.5. Auxillary cells and Main cell

We know,

Blocking probability of new calls = number of originating call rejected / number of originating call Also,

The handoff failure probability = number of existing call dropped / number of MSs coming into the cell.

Now, by applying the AS we can effectively reduce the number of rejected originating calls as well as the number of dropped existing calls. So the Blocking probability of new calls and the handoff failure probability both are reduced simultaneously. This approach may result in handoff failure when all the channels of the nearest AS will be busy. To find the nearest AS one can follow pre-scanning method but that may increase the expenditure. Such limitations can be effectively eliminated using mobility measurements of the MS involved in handoff as future research.



Area of the main cell = $3\sqrt{3} a^2/2$

Area of the auxiliary cell = $3\sqrt{3} h^2/2$

Let N number of auxiliary station is required to cover the whole area of the main cell.

Thus, area to be covered by each auxiliary station = $3\sqrt{3} a^2/2 N$

So, $h=a/\sqrt{N}$

1. HANDOFF USING AUXILIARY STATION:

- i. We will calculate the minimum distance L. $L = \sqrt{(7/4N)} a$
- ii. We will calculate the minimum time T, that a MS has to stay in an AS to perform handoff. $T = \{\sqrt{(7/4N)} a\}/v$
- iii. We will find the time interval t, that a MS stays in an AS (Auxiliary station).
- iv. *If* $t < T$, Trivial case i.e. handoff is not required.
- v. *Else*
 1. Handoff is performed by the nearest Auxiliary Station (AS).
 2. Check the number of free channels(C) in the BS after fixed time intervals.
 3. *If* $C = 0$
 - 3.1. Handoff job will be continued by the nearest AS.
 4. *Else*
 - 4.1. Handoff job will be taken over by the BS from the AS.
 - 4.2. End
 5. End
 - vi. End

III. COMPARITIVE STUDY

Paper	Call Blocking Performance of NRBCA Scheme in Cellular Networks	NCBP in Improved AdQoS for Wireless Multimedia Communications using Hierarchical Cellular Approach	A Channel Allocation Algorithm for Hot-Spot Cells in Wireless Networks	Minimization of Call Blocking Probability using Auxiliary Stations
Description	-Channel allocation in groups according to call duration.	-Dual band cellular mobile communication.	-Hybrid channel allocation is the combination of fixed channel allocation and dynamic channel allocation.	-Here proposed a method to minimize the handoff failure probability by effectively placing auxiliary cells in the main cell.
Advantages	-This scheme is particularly useful in a cell having heavy traffic with mostly business calls. -Scheme does not require installing a new cellular tower and can easily be implemented on existing cells.	-Much better spatial reuse of micro cell frequencies, which yield a substantial capacity increase, efficient bandwidth utilization and inherent load balancing.	-It behaves similar to the PCA at high traffic and to the DCA at low traffic loads as it is designed to meet the advantages of both. - reduce control message overhead needed to acquire each channel individually.	- By applying the AS we can effectively reduce the number of rejected originating calls as well as the number of dropped existing calls. -There is no need for repeated handoffs as the MS moves inside the cell from one AS to another -Traffic distribution can be improved between AS and BS.
Disadvantages	-No load balancing scheme is taken into consideration. -More number of long duration calls may get blocked.	-Problems like call setup and signalling protocol, and power consumption control for mobile terminal will become complex in hierarchical cellular structure.	-Need to keep watch on hot-spot level.	-This approach may result in handoff failure when all the channels of the nearest AS will be busy. -To find the nearest AS one can follow pre-scanning method but that may increase the expenditure. -Such limitations can be effectively eliminated using mobility measurements of the MS involved in handoff.

IV. CONCLUSION

We have just seen some call blocking probability minimization techniques for cellular network. These aims to minimize the call blocking probability and easily get the channel for new connection as well as seamless handoff should be there. The researchers continue to find the best solutions supporting real-time applications. In this paper, we have just presented some existed methods, comparative study of the four papers and collected the information for next studies.

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