

A Novel Load Balancing Scheme for Hot-spot Cells

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Abstract- The radio spectrum that is available to us is very limited. The cellular network works fine when the traffic conditions are normal or below normal. But when the cellular traffic increases the network cannot perform efficiently under this increasing traffic load as the radio spectrum to serve this increasing traffic is very limited. To avoid degradation and to increase performance of wireless cellular network frequency reuse and channel allocation techniques are used. The sole purpose of the channel allocation techniques is to allocate the available channel in such a way that the call blocking probability is reduced. In this paper we propose a HCA technique which will reduce the call blocking probability when the Cell becomes a hot spot i.e. the cellular traffic is beyond normal. These papers propose a novel load balancing scheme that will allocate channel to the overburden cell using hot spot notification. The HCA scheme is a combination of FCA and DCA scheme which effectively utilize the central pool for allocation of channels to the cells under heavy traffic. This HCA Scheme work like FCA in initial stages i.e. under low traffic levels and more like DCA at later stages i.e. high traffic levels and also reduces the Call blocking probability to great extent.

Keywords:- hot spot, hybrid channel allocation (HCA), blocking probability, fixed channel allocation (FCA) and Dynamic channel allocation (DCA).

I. INTRODUCTION

Today millions of people use cell phones around the world they can connect with one another from anywhere at any time. This is possible due to recent advances in wireless communication in the last couple of decades. Now as the millions of people use cell phones that means millions of call and millions of conversation. This requires a lot of bandwidth but unfortunately we do not have large amount of bandwidth available with us to support this calls but thanks to the technology we can use this limited available bandwidth to support these calls.

Now bandwidth is generally divided into channels and these channels are then allotted to each cell. Also the allocation must be done by taking into consideration the minimum reusable distance constrains. Now how each cell utilizes these channels to handle the call determines the quality of service. QoS is good if channels are utilized effectively and vice versa. So for better utilization of channels and Good QoS many channel allocation techniques are used.

Several channel allocation schemes have proposed till date, and they can be classified into three categories: Fixed Channel Allocation (FCA), Dynamic Channel Allocation (DCA), and Hybrid Channel Allocation (HCA). In FCA schemes, number of channels allocated to each cell are fixed these are done according to predetermined traffic demand and co-channel interference constraints. FCA schemes are very simple; but they cannot adapt or change according to the changing traffic [4, 14-15]. The disadvantages of FCA schemes can be overcome by, DCA schemes [6,9,13 and 16-19]. In DCA schemes, channels are placed in a pool at Mobile Switching Center (MSC) or distributed among various base stations and are assigned to new calls as needed. Any cell can use a channel as long as the interference constraints are satisfied and after the termination of the call the channel is returned back to Central pool. DCA Scheme provides flexibility and traffic adaptability however they are costly and require a complex control message. During some experiment it was found that DCA scheme are not effective for heavy cellular traffic condition. To

improve performance, some DCA schemes use channel reassignment, where on-going calls may be switched, when possible, to reduce the distance between co-channel cells. Another type of DCA strategy involves channel borrowing mechanism from neighboring cells. In such a scheme, channels are assigned to each cell as is normally done in the case of FCA[6,9,13 and 16-19]. However, when a call request finds all such channel busy, a channel may be borrowed from a neighboring cell if the borrowing will not violate the co-channel interference constraints.

HCA scheme techniques are designed in such way that it uses the advantages of both FCA and DCA [21-23]. In HCA, channels are divided into two sets of channel: 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*). Fix set of channels are allocated to each of the cell and are always preferred to be use first in a cell i.e. when eve a call is initiated or a mobile user need a channel the cell fist goes to the fixed set of channel and only if they are not available then and then only it allocates a channel from the dynamic set. The ratio of the number of fixed and dynamic channels plays an important role. It noted that if the ratio of fixed to dynamic channels is 50% or more, FCA performs better than HCA. The HCA techniques proposed in the literature are complex to implement. Hence there is a need of new hybrid channel allocation schemes which can be suitable in very heavy short time traffic load conditions.

II. SYSTEM ARCHITECTURE

This section presents basics of cellular network and system architecture.

A. Architecture

A cellular network is distributed over a large area. These large areas are covered by a structure called as cells. The cells are hexagonal in shape and each cell is served by a base station (BS). Base stations are generally located at the center of the

cell. Several base stations are connected to base station controller (BSC) which then with other several BSC connects to the Mobile switching center (MSC). However a mobile host is allowed to communicate with Base station only. MSC act as a gateway for cellular network and backbone network.

B. Frequency Reuse

Each cellular base station is allocated a group of radio channels to be used within a small geographic area called a cell. Base stations in adjacent cells are assigned channel groups which contain completely different channels than neighboring cells. Base station antennas are designed to achieve the desired coverage within a particular cell. By limiting the coverage area within the boundaries of a cell, the same group of channels may be used to cover different cells that are separated from one another by geographic distances large enough to keep interference levels within tolerable limits. The design process of selecting and allocating channel groups for all cellular base stations within a system is called frequency reuse or frequency planning. Considering a cellular system that has a total of S duplex radio channels. If each cell is allocated a group of k channels ($k < S$) and if the S channels are divided among N cells into unique and disjoint channel groups of same number of channels, then,

$$S = kN$$

The N cells that collectively use the complete set of available frequencies is called a cluster. If a cluster is replicated M times within the system, the total number of duplex channels or capacity,

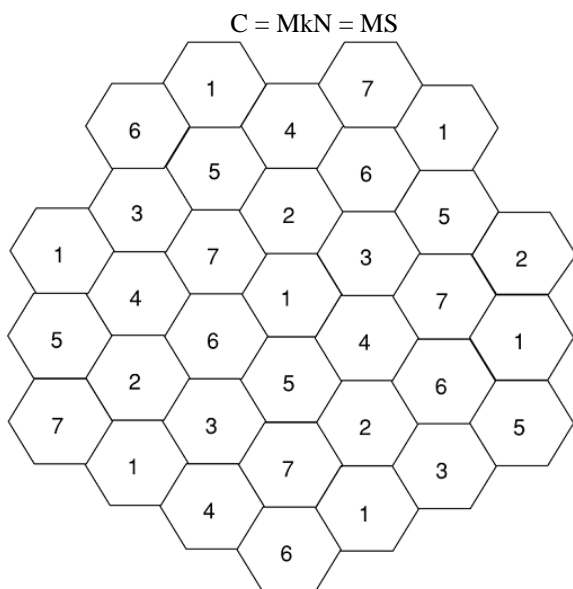


Fig 1: Example of frequency reuse

In figure depicted above frequency from 1 to 7 are assigned to each cell, and based on their distance from each other frequencies are reused. Cells using the same frequency called as co-channels. The elements that determine frequency reuse are the reuse distance and the reuse factor.

C. Channel Allocation

Channel allocation is a technique used by cell for improving the QoS. Channel allocation scheme also make use of the frequency reuse concept where each set of frequency can be reused if we could provide a minimum reuse distance avoiding interference between two cells using the same set of frequency. This allows several transmitters to send information simultaneously over distance using same set of channel as long as there is no interference between them.

III. HYBRID CHANNEL ALLOCATION

In HCA scheme there are two set of channels available with the cell one is a fix set and another is dynamic set. The dynamic set is available at the MSC. Initially the cell will allocate a channel for a mobile call from the fix set and if it fail to find a fix set it will allocate a channel from the dynamic set and after the termination of the call it will return back the channel to MSC

Let there be C channels which are to be distributed as fix set F of channels and dynamic set D of channels. Therefore $C = F + D$ will have all the available channels. Let r be the ratio of number of dynamic channels to total number of channels available in the network i.e.

$$r = D/C$$

The ratio r will remain fixed with the system and cannot be changed dynamically over the period of time [1].the value of r is calculated in such a way that network performs in a best way. If we keep large number of channels in dynamic pool then on every call arrival BS have to request MSC for channel as Fix set of channel are getting exhausted very frequently which will ultimately lead to increase in call blocking probability. However if we keep ratio too low, less number of calls will get executed. Hence optimal value of ratio will balance between call initiation period as well as call blocking probability.

IV. PROPOSED METHOD

In HCA scheme a Base has to send request to MSC whenever it requires a Channel from the Dynamic set. On receiving a request the MSC allocates one channel to the BS from the set of available channels. While allocating a channel it has to take care of the Frequency reuse pattern and cell pattern. This process take time hence increases the call initiation waiting period this is not suitable for "hot-spot cells"

A. Hot Spot Cells

A cell becomes a "hot-spot" when traffic generated in that cell exceeds far beyond its normal traffic load for that particular hour. An example of a "hot-spot" cell(s) was during the the 7/11 train blast in Mumbai when after the blast several people simultaneously tried to all their loved ones but due to lack of availability of channels their calls were dropped and also suddenly the traffic of that cell increased largely. The documented HCA techniques in the literature do not offer effective strategies in case a cell in the system becomes a "hot-spot". Therefore it becomes necessary to define new HCA schemes to handle hot-spot cells effectively.

In "hot-spot" HCA schemes, it is necessary to first identify "hot spot" cells and then allocate appropriate number channels for increasing the performance.

Let us assume that base station is able to keep track of total number of calls initiated within that cell, which include served as well as failed calls. This count represents the sum of served + unserved calls. This count helps to determine the present "hot spot" level of the cell and is sent to MSC.

Let's assume "hot spot" notification level L is an integer such that

$$L = \{0, 1, 2, \dots, M\}$$

M is a predefined level supported by the network. The number L represents the fact that up to L number of channels can be retained by the base station after it finishes the call.

B. Algorithm:

- I. On every new call request, base station assigns a channel from fixed pool to mobile host.
- II. If channel from fixed pool is not available, base station updates the values of L as follows

$$L = L + 1,$$

$$L = \max\{L, M\}$$
- III. Base station then sends a request to MSC to acquire a channel from dynamic pool. This request contains the current value of "hot spot" level L .
- IV. MSC receives requests from all base station and depending on their current value of L , MSC can determine the "hot spot" condition of the cell. Let's assume N channels are at "hot spot" load conditions i.e. currently there are N "hot spot" cells.
- V. MSC has total D number of channels available in dynamic centralized channel pool. MSC reserved Y number of channels which cannot be allocated to "hot spot" cells. Hence total dynamic channels available for "hot spot" cells can be defined as $K = D - Y$.
- VI. MSC distributes all these K channels relatively in N sets according to hot spot levels. Hence now MSC has N sets of channels as $S_1, S_2 \dots S_N$. Set of channels are allotted to each requesting cell even if one channel is required. This is an effective measure to reduce the number of channel requests to MSC.
- VII. Base station maintains a temporary pool. Where it stores the set of dynamic channels that it received from the MSC and serves each call request from this temporary pool.
- VIII. If MSC cannot assign up to L number of channels, then it will try to assign maximum number of channels. If no channel is available then MSC rejects channel allocation request.
- IX. After call termination, base station examines which type of channel was used temporary or from fixed set. If channel from temporary pool was used then BS will add it back to temporary pool. Hot spot level of the cell is again calculated as h .
- X. If $h > L$ means congestion is getting worse, however if $L > h$, congestion is residing. After the congestion is fully eliminated channels from temporary pool are returned to MSC.

It is observed the use of this algorithm at channel acquisition and release phases, reduces the call blocking probability to a great extent.

V. PERFORMANCE EVALUATION

Congestion, traffic/load, channel utilization blocking probability etc are various parameter used to evaluate the cellular network. Among the several parameters we used probability of call blocking to evaluate our network. Call blocking probability is defined as probability that all servers in a system are busy and no further call can be served.

A. Simulation Parameters

Wireless cellular network is simulated using Matlab. Network which was simulated was simple and numbers of calls were few and their duration was limited. Blocking Probability is calculated for calls with varying load. The optimal value of r is calculated by varying the value. The threshold value of M is also calculated and also effect on call rejection ratio due to variation of M was studied.

B. Simulation Results

The algorithm was simulated and studied for few numbers of calls with limited duration. Call blocking probability for various load condition was analyzed and was compared with various allocation techniques and it was found that the call blocking probability of the proposed method was much less than that of the various other Schemes also it can be concluded that as the traffic load increase all the schemes provide us with almost same blocking probability but then too HCA has the least blocking probability.

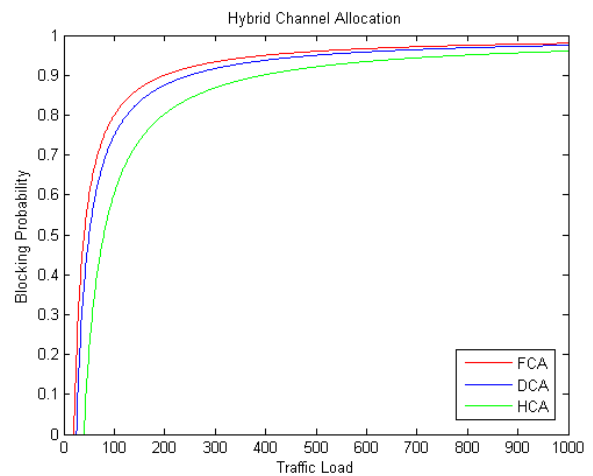


Fig 2: Channel Allocation Algorithms

In next set of experiments the value of r was changed to analyze the performance of the network and a 3D plot is plotted.

C. Conclusion

It can be concluded that the HCA has a less call blocking probability than the FCA and HCA for any traffic load condition and any value of r . HCA work like FCA in initial stages i.e. under low traffic levels and more like DCA at later stages i.e. high traffic levels. Also from the 3D plot it is seen that at high value of r performance is better but in real scenario optimal value of r should be used. As high value of r will lead to degradation of system performance due to large overhead.

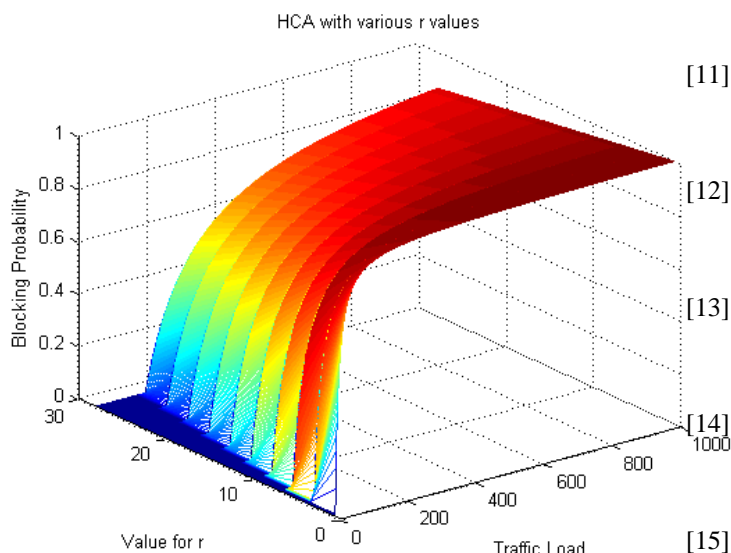


Fig 3: performance of network for various values of r

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