A DISTRIBUTED DYNAMIC CHANNEL ALLOCATION IN CELLULAR COMMUNICATION

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ABSTRACT

Now a days, mobile users are growing rapidly and the available frequency spectrum is limited. Therefore the available spectrum must be efficiently utilized. In response a large number of channel assignment and allocation policies have been proposed. Mostly Dynamic Channel Allocation (DCA) has become an important subject of research and development for cellular networks. In this paper, we propose a distributed dynamic channel allocation (DDCA) algorithm for originating calls. This algorithm is executed at each base station and to allocate the channel to mobile station, base station communicates with each other. In DDCA, the total number of channels is divided into three groups. Any cell in the cluster can acquire the channel group as long as no one of its adjacent cells is holding the same group. Due to this the co-channel interference is avoided. The result show blocking rate of distributed dynamic channel allocation is reduced as compared to dynamic channel allocation algorithm with non-uniform traffic distribution

KEYWORDS

Cellular network, Blocking probability, Channel allocation, Originating calls

1. INTRODUCTION

As the frequency spectrum is limited and mobile users are increasing so the main task of resource management is to serve the maximum number of possible calls through a limited number of channels. The available wireless bandwidth is divided into channels, where each channel is capable of supporting a communication session. To support many users the frequency should be reused [2]. In frequency reuse, the same frequency can be reused again in another cell as long as the distance between these two cells is the minimum reuse distance so that the frequency does not interfere with each other. When mobile station want to communicate with another mobile user then it will send request for a channel to the base station. Depending on channel allocation algorithm either BS or MSC will allocates a channel to mobile station. Channel allocation is a process of allocating a channel to a call. While allocating a channel main focus is on selecting a channel frequency without violating the interference constraint so that the blocking of call is minimum.

D.C. Wyld, et al. (Eds): CCSEA 2011, CS & IT 02, pp. 114–126, 2011.

DOI: 10.5121/csit.2011.1213

In cellular communication, various channel allocation schemes have been proposed [4, 5 and 12]. They are

1. Fixed channel allocation (FCA),
2. Dynamic channel allocation (DCA),
3. Hybrid channel allocation (HCA).

Most cellular systems today use FCA (Fixed Channel Allocation). In fixed channel allocation [6], fixed number of channels is assigned to particular cell. In this scheme, when all the channels assigned to the cell are busy then the calls will be blocked, so to improve the blocking probability borrowing scheme can be used along with fixed channel allocation scheme. In borrowing scheme, if there is a channel request and all the channels in particular cell is busy then the cell borrows some additional channels from any of the neighbouring cells. The disadvantage of this scheme is channel allocation become more complex. In order to overcome the above problem, Dynamic channel allocation scheme is developed [6, 12]. The two types of dynamic channel allocation schemes are distributed dynamic channel allocation and centralized dynamic channel allocation method. In Centralized dynamic channel allocation, a single central pool of all available channels is maintained from which a central computer allocates channels to various cells on demand, and the cells return the channels to the central pool. In this, the spectral efficiency is higher but such schemes have a high centralization overhead, as well as a there is single central computer the failure of this computer may cause a serious problem This problem is avoided by the distributed dynamic channel allocation algorithm.. In distributed dynamic channel allocation scheme [1], a channel is selected and allocated to the cell based on co-channel interference and signal strength The hybrid channel allocation scheme is the combination of fixed and dynamic channel allocation schemes [5]. In this, each cell is given a fixed number of channels and if the cell has utilized all the fixed channels then the cell request for the channel from the dynamic channels which is available in the central pool.

In the distributed dynamic channel allocation algorithm the total number of channels are divided into three equal size groups. Any cell in the cluster can acquire the channel group as long as no one of its adjacent cells is holding the same group. Thus no adjacent base station uses the same group. The same group can be used by the two base stations as long as the distance between these two base stations is the minimum reuse distance. In this scheme each base station maintains the storage information table which contains information about which channels are currently in use by the cell as well as by neighbouring cells. The distributed dynamic channel allocation (DDCA) problem is to design a protocol for the cells to exchange information so as to acquire channels without violating the interference constraint. The goals are to avoid interference, minimize the call blocking and maximize bandwidth utilization. With this algorithm the blocking probability is reduced as compared to dynamic channel allocation algorithm.

This paper is organized as follows: Section 2 presents the interferences in cellular system. Section 3 describes System Model. In Section 4 presents a Modified Distributed Dynamic Channel Allocation (MDDCA) Algorithm. In Sub-Section 4.1 the allocation of groups to the base station is presented. Sub-Section 4.2 describes allocation of channels. In Section 5 performance parameter is discussed. Section 6 and 7, presents Simulation parameter and Experimental results. Finally, the last section describes the conclusion of the work.

2. INTERFERENCES IN CELLULAR SYSTEM

2.1. Co-Channel Interference

A finite number of channels is available in the cellular system. So the same channel can be used in different cell. But the channels can be used simultaneously by number of different cells only if the distance between each pair of cells using the same channel is greater than or equal to the minimum reuse distance [2]. Thus, each cell C is associated with an interference neighborhood IN_c which is the set of cells whose distance to C is smaller than D_{min}

$$IN_c = \{C' : dist\,(C, C') < D_{min}\} \tag{1}$$

From the above equation, if the a channel is available for use by cell C only if it is currently not being used by any cell in INc. That means if the cell C and C' uses the same channel and the distance between the two cell is less than D_{min} then the co-channel interference will occur. In MDDCA algorithm, to avoid co-channel interference total number of channels are divided into three groups and any cell can use the channel group provided that no one of its neighboring cell is holding the same group.

2.2. Adjacent Channel Interference

The adjacent channel interference will occur if one adjacent channel user is transmitting in close range to a receiver that is attempting to receive a weaker signal using neighboring channel [2]. The adjacent channel interference is a result of spreading of modulated RF signals into adjacent channels. In the cellular environment, signals from adjacent channels could be stronger than the desired channel to such a degree that the desired signal is dominated by signals carried on adjacent channels. This may result in cross-talk **as** well as dropped calls. This interfering signal from the adjacent cell can be minimized by filtering the interfering signal from the channel filter in the mobile and base station receivers. The adjacent channel is not a close neighboring channel but it is a nearest assigned channel in same cell which can be several channel apart. As channels are orthogonal in MDDCA algorithm, we deal with adjacent channel interference.

2.3. Co-Site Interference

The co-site interference will occur if the adjacent channels are used in the same cell [2]. This type of interference mainly due to imperfect receiver filter that allow nearby frequencies to leak into the pass band. The channel separation is provided to avoid the co-site interference.

3. SYSTEM MODEL

System model in this approach consist of cellular network with several clusters, where each cluster is a group of cells. The number of cells in each cluster is given by [2],

$$i^2 + ij + j^2$$

Where i represents number of cells to the transverse along i direction, starting from centre of the cell. And j represents the number of cells in a direction 60° to the direction of i. As for cellular system, specify C/I to be 18 dB or higher. Since 18 dB is measured by the acceptance of voice quality hence the reuse pattern is taken as 7.

Let the total number of channels in cellular system counts M channels [1]. These channels are partitioned into three groups G_a, G_b, G_c (Figure 1). The number of groups is taken as a three as it is a minimum number which avoids the co-channel interference. The groups are distributed among the base station based on mutual exclusion paradigm. λ is the call arrival rate of the originating calls. Among each of these groups CO of So_a channels are used by the originating calls from group a similarly S_{Ob} and S_{Oc} are the channels from groups b and c respectively.

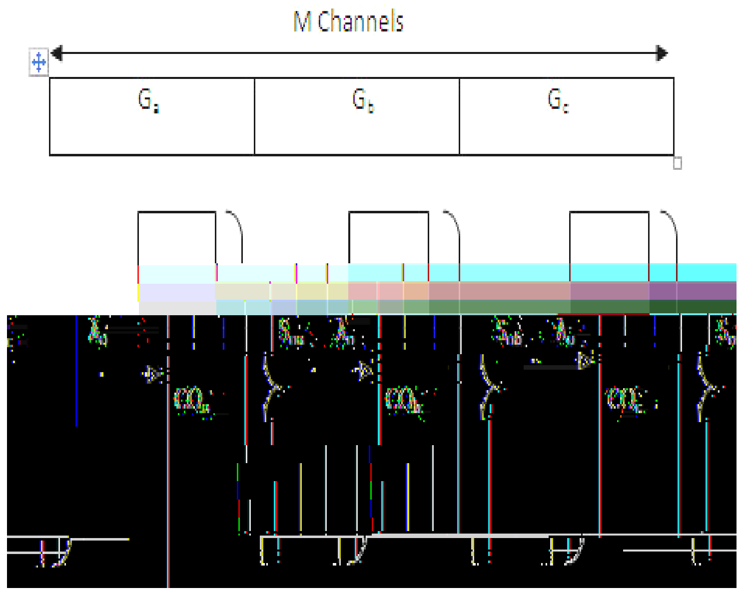

Figure 1: System Model

So_a = Channel used by originating calls from group a

S_{Ob} = Channel used by originating calls from group b

S_{Oc} = Channel used by originating calls from group c

If the probability of originating calls is λ_o, then P (i) is the probability of i channels to be busy, then P (i) can be determined from the state transition diagram as shown in figure 3.

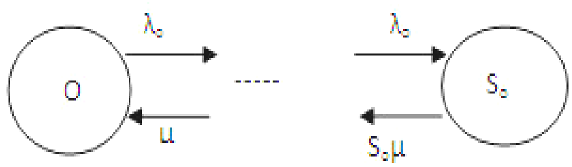

Figure 2: State Transition Diagram

The state balance equation can be obtained as,

$$i\mu P(i) = (\lambda o)P(i-1), \qquad 0 \le i \le So \tag{2}$$

The steady state probability P(i) can be obtained:

$$P(i) = \frac{(\lambda_o^i)}{i!\,\mu^i} P(O) \qquad 0 \le i \le So \tag{3}$$

Where the P(O) is given by,

$$P(O) = \left[\sum_{i=0}^{So} \frac{\lambda_o^i}{i!\,\mu^i} \right]^{-1} \tag{4}$$

If there are M channels in cellular network, then the number of channels available virtually in the cellular network is given by,

$$S = \frac{N \times M}{G} \tag{5}$$

Where S = Number of virtual channels in the network.

N = Number of cells in the cellular network.

G = Number of groups into which total channels M are divided.

Virtual channels are the channel we can use in the system due to frequency reuse.

The blocking probability for an originating call is given as,

$$B_o = \sum_{i=0}^{S} P(i) \tag{6}$$

4. DISTRIBUTED DYNAMIC CHANNEL ALLOCATION ALGORITHM

The base station communicates with each other by message passing. The communications between any two base stations are assumed to be First-In-First-Out (FIFO). The types of messages used in this algorithm are

1. REQUEST for the channel and the group,
2. AGREE
3. REJECT
4. Channel BLOCK,
5. Channel RELEASE
6. Channel FREE

4.1. Allocation of Groups

Whenever a channel is required in particular base station BS_i, then that base station checks its group usage table GUT_i, this table contains the information about group visited by that base station.

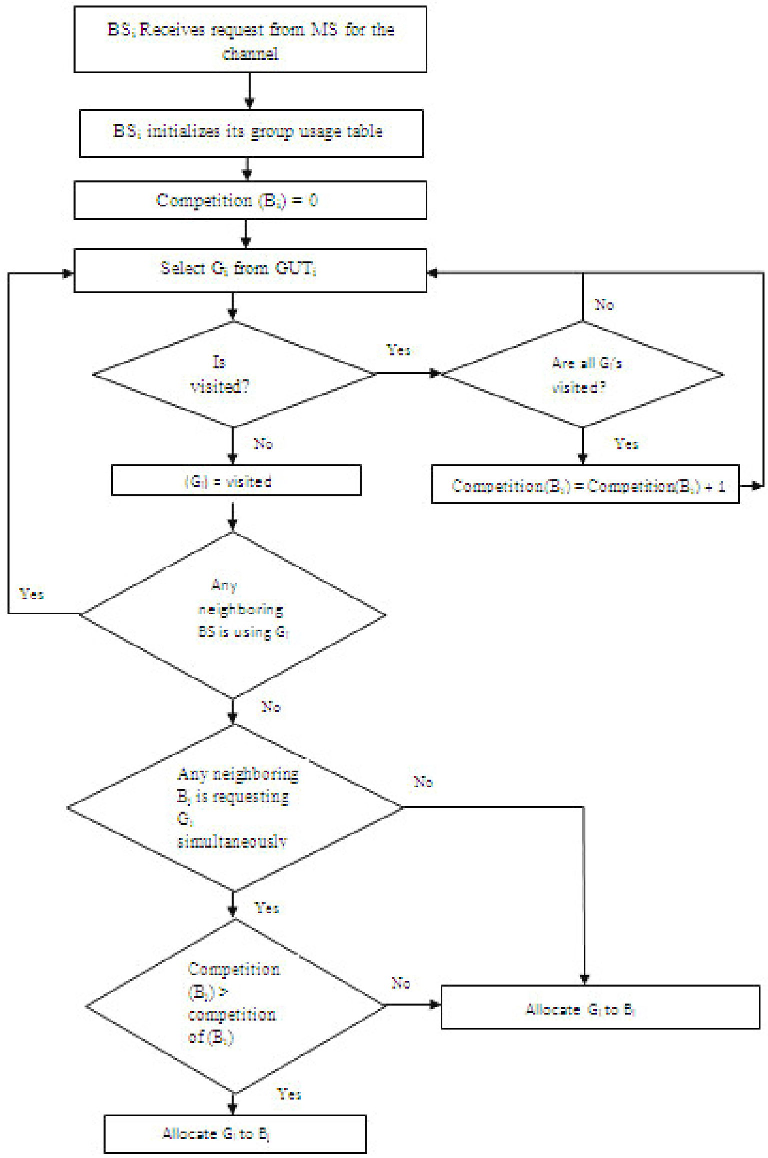

Figure 3: Allocation of Groups to base station

The base station can picks up the group which it did not visited yet and after that it will send a 'REQUEST' message to all of its neighbouring base station to verify whether any of the base stations are holding the same group. If neighbouring base station is not using that particular group then they will send 'AGREE' message to the requesting base station and if any of the neighbouring base station is using that particular group then that neighbouring base station will send 'REJECT' message to requesting base station. Now if requesting base station gets at least one 'REJECT' message from the base station then BS_i cannot pick that group and will try for the another group, otherwise if it receives 'AGREE' message from all the neighbouring base station then it will acquired that group. This is used to avoid co-channel interference. Figure 4 shows the base station and its allocated group after exchange of information.

Figure 4: Allocated Groups to the base station

When two base stations BS_i and BS_j request the same group simultaneously then base station with highest competition number will get that group. Each base station is assigned a competition number. It is a number that indicates that how many number of times each base station request the same group and how many times base station can gets that group. Suppose if competition number of BS_i is 2 and competition number of BS_j is 4 and BS_i and BSj request the same group simultaneously then the group will be allocated to BS_j as the competition number of it is greater.

4.2. Allocation of Channels

In this algorithm, co-channel interference is avoided by assigning the channel groups to base station provided that no neighbouring base stations acquire the same channel group. After acquiring the channel group, each base station acquires the channel. In order to acquire the channel each base station has to maintain the storage information table [1, 8, and 9]. Base station will access only the partition of the table. For example if base station 3 acquire group (G_a) then BS3 has to search the channel from group (G_a) , no need to search all the channels in the storage information table. Due to this time required for allocating a channel is less. The storage information table is a two dimensional table that contains the information about channel usage for itself and its neighbouring base station. The size of the table is determined by the number of channels in the cellular network and number of cells in the system. The size of the table is given by [1],

$$L = N \times M \tag{7}$$

Where, M = Number of channels in the cellular network.

N = Number of cells in the system.

In order to avoid co-site interference, each group consists of channels having spacing. For example if total number of channels are 24 then group a (G_a) consist of channel number 1, 5, 7, 11, 13, 17, 19, 22 and group b (G_b) consist of channel number 2, 4, 8, 10, 12, 15, 21, 24 similarly in group c (G_c) consist of channel number 3, 6, 9, 14, 16, 18, 20, 23. Now whenever base station 0 (BS0) wants a channel and if group b (G_b) is allocated then BS0 will directly search a channel from storage information table and pick a free channel and if a another call is coming in BS0 then it will take another free channel. Due to the channel spacing in one group the co-site interference is avoided. For example, BS0 acquires G_b and allocated channel number is 4 and if another call is coming then it will pick next channel number from group b (G_b) that is channel number 8.

Base Station Number	Channel number												Number of Assignable Channels
	Ga				Gb				Gc				
	1	5	…	22	2	4	…	24	3	6	…	23	
BS_3	1		…	1			…				…		3
BS_0			…		1	1	…				…		2
BS_1			…				…		1		…		1
BS_2			…				…				…		0
BS_4			…			1	…	1			…		3
BS_5			…				…				…		0
BS_6			…				…		1	1	…	1	6

Figure 5: Storage Information Table

Figure 6 shows the storage information table at base station 3, it contains the M number of channels and its neighbouring base station within co-channel reuse distance. When BS3 wants a channel then it will search the channel from each of the column from storage information table. If any of its neighbouring base station is using the channel then BS3 cannot use that channel. Each base station will not search all the channels but it will search the channel from the allocated group either G_a, G_b or G_c.

The content of the storage information table is updated by collecting channel occupancy information from all interfering cells through a simple procedure: After occupying a channel each base station will send ‘BLOCK’ message to all interfering cells, and when releasing a channel, sends ‘Channel RELEASE’ to all its interfering cells ki of them for cell i**.** A base station should update also if its own entry in the respective column has changed as a result of its neighbouring base releasing channels.

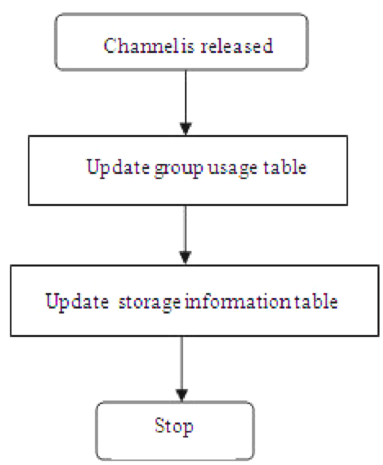

Figure 6: Steps to be taken when channel is released.

5. PERFORMANCE PARAMETER

In this algorithm, the important parameter is call blocking probability and is given by,

$$P_b = \frac{Number\ of\ blocked\ calls}{Total\ number\ of\ new\ calls\ initiated}$$

It is the ratio of number of calls which is blocked due unavailability of channels in the system to the total number of calls initiated in the system.

6. SIMULATION PARAMETER

In our simulation model, we have simulated a wireless network. We consider the call blocking probability to measure the performance of the distributed dynamic channel allocation algorithm. It is the probability that the originating call get blocked. We have simulated a cellular network with 24 channels using traffic with uniform and non-uniform distributions. Here arrival of calls is random process and hence calls are arrived according to Poisson's distribution process.

1. Uniform Traffic: With uniform call distribution, each cell has the same channel demand means call arrival rate λ is equal in each cell. And the service time μ per call is assumed to be exponentially distributed with a mean of 120 second. Thus loading is given by,

$$\frac{\lambda_i \times 120}{3600} = \frac{\lambda_i}{30}\ Erlang$$

2 Non-uniform: With non-uniform call distribution some of the cells are heavily loaded and some of the cells are lightly loaded mans call arrival rate λ is more in one cell and it is less in another cell. The call arrival rate of heavily loaded cell is 3 times greater than lightly loaded cell that is 3 λ. Thus the loading in heavily loaded cell is given by,

$$\frac{3\lambda_i \times 120}{3600} - \frac{\lambda_i}{10}\ Erlang$$

We have simulated a wireless network with 24 channels as shown in table 1and it is divided into three equal size group. Where in each group number of channels are 8. Therefore virtual channels (by using frequency reuse) in the system is given by,

$$S = \frac{N \times M}{G} = \frac{7 \times 24}{3} = 56$$

Table 1: Simulation Parameters

Parameter	**Value**
Number of cells	7
Number of channels	24
Number of groups	3
Number of channels in each group G_a, G_b, G_c (equal division)	8
Number of virtual channels in the system	56
Call arrival rate in heavily loaded cell	λ
Call arrival rate in lightly loaded cell	3 λ
Service time	120 seconds

7. EXPERIMENTAL RESULT

The performance of our algorithm is evaluated based on uniform and non-uniform traffic distribution. If the mobile users are equally distributed in each cell then it is referred as uniform distribution, and if the mobile users are unequally distributed in each cell then it is referred as non-uniform traffic distribution. The figure 7 shows the blocking probability with uniform and non-uniform call distribution. We can see from the graph the blocking probability with non-uniform distribution reduces as compared with uniform distribution. The second result shows (figure 8) comparison of blocking probability of dynamic channel allocation (DCA) and distributed dynamic channel allocation (DDCA) algorithm. The graph shows the blocking probability of DDCA algorithm which takes into consideration the interference constraint is reduced as compared with DCA algorithm.

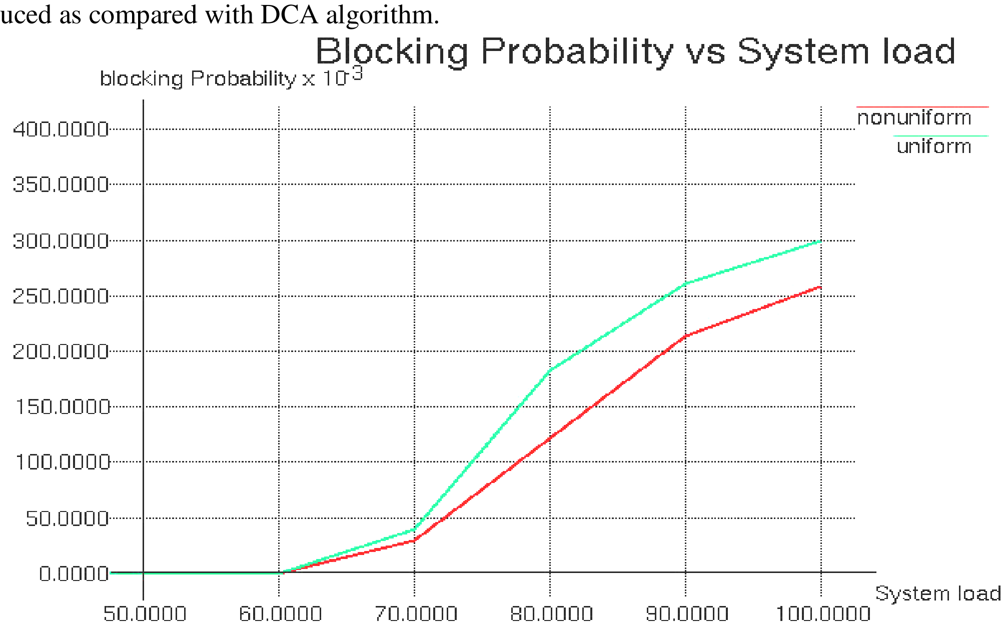

Figure 7: Call blocking probability with uniform and non-uniform call distribution.

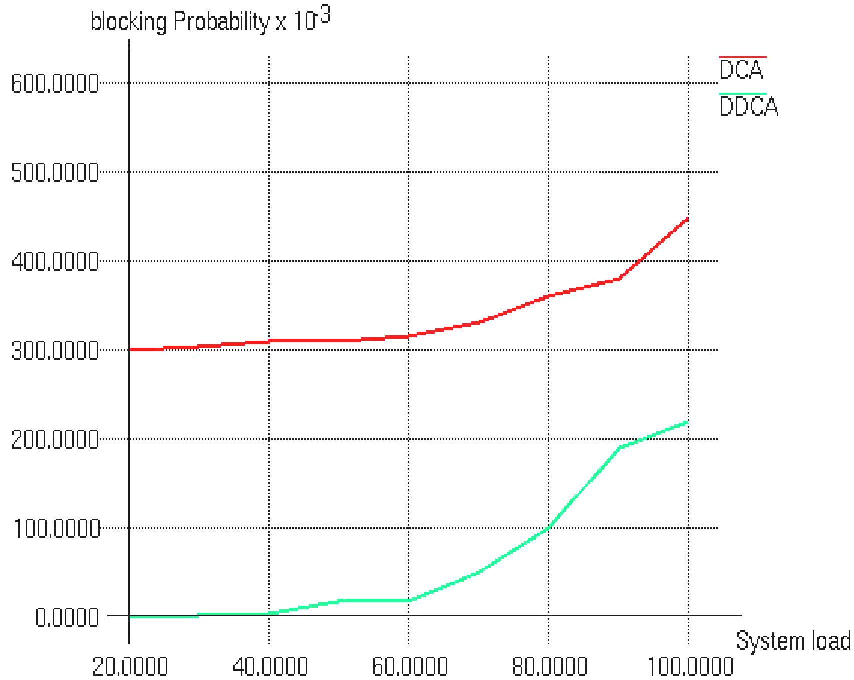

Figure 8: Comparison of blocking probability for DCA and DDCA

8. CONCLUSION

This paper proposed the distributed dynamic channel allocation algorithm which avoids co-channel interference by executing this algorithm at each base station. To avoid co-channel interference the channels in the system are divided into the three groups and a base station can use the channel group only when no one of its neighbouring base station is using that group. The result indicates clearly the channel allocation algorithm exhibits better performance than dynamic channel allocation algorithm. Again the blocking probability is depends on uniform and non-uniform traffic. In uniform traffic distribution each cell has same channel demand and in non-uniform traffic distribution each cell has different channel demand. So the blocking probability of non-uniform distribution is less as compared to uniform call distribution.

9. FUTURE WORK

This paper considered the performance of call blocking probability of distributed dynamic channel allocation algorithm. In future work, the performance of the algorithm is measured with dropping probability with adaptive channels reserved for handoff calls without reducing the blocking probability.

ACKNOWLEDGEMENTS

We take this opportunity to thanks the department of E & TC of PICT college, Pune for their great support and encouragement. We deeply acknowledge the support provided by Prof. G. V. Garje, HOD, PVG's COET, Pune.

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