OPTIMIZATION OF CHANNEL ALLOCATION ALGORITHM FOR HOT SPOT CELLS IN WIRELESS NETWORKS

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ABSTRACT

Dense deployment of cellular networks is leading to scarcity of communication bandwidth or what we call as channel. If compared to its wired counterparts, wireless cellular network have limited number of channels available, which gives rise to problem of efficient channel allocation. Here, in this piece of work, the main objective is to put an effort to improve existing channel allocation scheme. In earlier existing hybrid allocation scheme, the base station notifies about the hot-spots to the Mobile Switching Centre (MSC) and if MSC has available channels in its central pool then it satisfies the request. Now, the novelty of this work starts where central pool gets exhausted and request of channels from base station (BS) still arrives and is served by returning the unused channels by different cells back to MSC on its request.

The simulation of this approach is expounded and evaluated over OMNeT++ in a scenario with fixed channel allocation and hybrid approach by varying the proportion of dynamic channels to total number of channels available and the effectiveness is evaluated in terms of Call blocked and Call dropped versus System load.

General Terms

Wireless Cellular networks, Channel Allocation Schemes.

Keywords

Channel allocation schemes, Hot-spots, Cellular networks, Fixed Channel Allocation, Dynamic Channel Allocation, Hybrid Channel Allocation.

1. INTRODUCTION

Cellular traffic has found increased application in the recent years, which leads to challenge of efficient channel allocation strategy because it is a limited resource in such networks. In cellular network, efficient allocation of channels to each cell is of great importance, since there is a limitation in bandwidth [1], [8]. Since the channels are limited, they should be reused as much as possible. The channel allocation problem becomes more severe when the cells in the system becomes congested or hot-spot. It means that the traffic in a particular cell is more than that it can accommodate. Therefore, we need to efficiently reuse the channels. An efficient channel allocation strategy is required to exploit the principle of frequency reuse to increase the availability of channels to support the maximum number of calls at any given time.[5]

A cell can be classified either as a hot or a cold cell according to the traffic load. A hot spot is defined as a stack of hexagonal rings of cells and is termed complete if all the cells within it are hot i.e. they are heavily loaded and are not able to sustain the need of current users.The ratio of number of available channels in this cell and the number of channels which have been allocated beforehand is known as the degree of coldness of a cell [1]. The hot-spot problem can be solved by dynamically balancing the load of the hot cells in cellular network i.e. by serving the excess traffic of the congested cell by some cold cells in the system i.e. the cells that are less used in the system.

2. CHANNEL ASSIGNMENT

In cellular networks, communication bandwidth is a limited resource. Efficient utilization of the same has always been an issue. A number of channel allocation scheme have been proposed to utilize the channel bandwidth and allocate the communication channels to base stations, access points and terminal points efficiently and competently. The main objective is to acquire maximum efficiency by means of frequency reuse. There are broadly two types of strategies that are followed for the same and are as follows [8] [9]:

2.1 Fixed Channel Allocation (FCA)

In this scheme, the set of channels are permanently allocated to each cell based on a pre-estimated traffic pattern. FCA requires manual planning for bandwidth allocation which is a tedious task in case of TDMA (Time Division Multiple Access) and FDMA (Frequency Division Multiple Access) systems. As such systems are highly sensitive to co-channel interference from nearby cells. One more drawback of FCA scheme is that the number of channels in the cell remains static, irrespective of continuous growth of users in that cell. This results in congestion and call drops.[8]

2.2 Dynamic Channel allocation (DCA)

In this scheme, system can overcome the drawback of former scheme by borrowing channels from neighboring cells under the supervision of MSC. In other word,s there is no permanent allocation of channels to the cells. But the entire set of available channels is accessible to all the cells, and the channels are assigned by a call-by-call basis. However, DCA strategies are less efficient than its fixed counterpart under high load conditions. This gives rise to a midway approach which is known as Hybrid Channel Allocation which possesses properties of both strategies [2].

In HCA, channels are divided into two disjoint sets. One set of channels is assigned to each cell on FCA basis i.e. fixed set and the others are stored in a pool for dynamic assignment i.e. dynamic set. The fixed set has a number of channels that are assigned to cells as in the FCA strategy. These channels have preference for their use in their respective cells over the other. Whenever a call needs a channel and if all the channels in its fixed set are busy serving the other calls, then a request from dynamic set is made.[7] [9]

3. SYSTEM MODEL

In cellular networks, the geographical area served by the system is divided into smaller regions, known as cells. Each cell consists of a Base Station (BS) usually located at center of the cell and a number of Mobile Hosts (MH). Each base station serves the requests generated by the Mobile hosts present in the cell.

The base stations are connected with one another through a wired or sometimes wireless network, while, the communication between base stations and Mobile Hosts is wireless compulsorily. A communication between two mobile hosts within the same cell is through the Base station in its cell.

When a mobile host initiates a communication with another mobile host, the base station should assign a channel to support the communication for which two kinds of channels are available in the system [3].

a) Communication channel.
b) Control channel.

Communication channels are used to support communication between Mobile host and a Base station. While, control channels are set aside to be used exclusively to send control messages generated by the channel allocation algorithm. For an efficient channel selection algorithm, the status of the channels should be known beforehand. The process of assigning status to channels beforehand is known as Resource Planning. In Resource Planning Model, a set of primary channels are pre-allocated to each cell. When a channel is needed to support a call in a cell, if there are available primary channels, then one such channel is used to support the call without consulting its neighbors. Otherwise, the base station in this cell sends the request messages to its interfering neighbors to borrow a secondary channel. The base station can borrow a channel from its neighbors as long as it does not result in co-channel interference. To ensure this, the base station consults its neighbors before it uses the borrowed channel. When the call terminates, the borrowed channel is returned to the cell from which it was borrowed. In these algorithms, if one base station wants to borrow a channel, it has to wait until it receives replies from all its interfering neighbors.

In our approach, at initialization phase, the base station monitors its cell and keeps record of the successful and unsuccessful calls to get knowledge about hot-spots to forward it to MSC. Each base station also maintains a temporary pool of channels which are allotted dynamically by MSC. Whenever a mobile wants to originate a call; it asks for a free channel to the base station. If the base station has a free available channel in its fixed set, then the channel is allocated statically as in FCA. If the base station does not have any free channel then it asks the MSC's dynamic pool for a channel.

To satisfy maximum possible call request, each base station requests for two channels, one for the subsequent use and one for expected future use, so that each base station has a set of fixed channel in its fixed set and a set of dynamic channels in its temporary pool. In the case, when a call is to be generated and the MSC has no available free channel then it asks its neighboring base station's temporary pool for a free channel and the call gets completed. If there is no free available channel then the call drops. When a channel remains unused for a longer duration in the temporary pool, it is returned back to the MSC to avoid call drop at MSC.

When a Mobile host needs a channel to support a call, since its local pool gets exhausted, it sends a request message to the base station in its cell through a control channel. On receiving such message, it tries to assign a channel using a channel allocation algorithm. A channel allocation algorithm is usually divided into two phases i.e. channel acquisition and release phase.

The purpose here is to use the total number of **K** channels into two disjoints sets, **F** and **D**. **F** stands for the channels for the fixed assignments and **D** stands for the channels for dynamic assignments and **K** is the total available communication bandwidth of the network i.e.

$$\mathbf{K = F \cup D}.$$

Reuse of available bandwidth is permissible but with a constraint of the geographic distance between them which should be less than a threshold distance, minimum channel reuse distance (D_{min}) because it will cause co-channel interference. A cell say C_i , is said to be an interference neighbor of another cell say C_j, if the distance between them is less than D_{min}. So, if a channel k is used by a cell C_i, then none of the interfering neighbors of C_i can use k concurrently.

Let r be the ratio of the number of dynamic channels to the total number of channels available in the system

$$r = D/K= D/(F+D)$$

The ratio r will remain static for the system. The value of r is a design parameter and depends on the level of the traffic volume generated in different cells in the network by the designer.

The 'hot spot' notification level is an integer valued number H, such that

$$\mathbf{H \in \{0, 1, 2, \ldots, X\}}$$

Where, **X** signifies an assumed predefined maximum level supported by the system. The value for **H** represents the fact that up to **H** 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 will use the appropriate value of **H** in several steps.

4. PROPOSED WORK

The work which is presented here is for efficient management of unused channels. The unused channels are returned back to MSC on cell request, if there is non- availability of channels. The request is implemented by rending the whole process in three phases.

a) Channel Procurement Phase.
b) Channel Emancipation Phase.
c) Channel retrieval phase (Optional)

In former phase i.e. when a mobile host wants to procure a channel to initiate a call, it should send a request to its base station. Algorithmically,

1. MH, requests a channel from BS to initiate a call.
2. If available, in local pool that is in set F(fixed channel), the same will be allocated and channel procurement phase terminates. Else
3. Hot-spot notification value is updated(since its local pool gets exhausted) as-

   H=H+1
   H= max(H, X)
   and BS sends the request accordingly to the dynamic pool located at MSC.

4. If MSC cannot allocate even one channel, then the call will be dropped.

This can be posed as a limitation to the approach which can be overcome if the MSC on certain interval of time sends notification to BS for requirement of unused and extra channels provided by the MSC during Channel Procurement phase in step 3. The only reason for allocating H+1 channels to BS instead of H, is a proactive measure, because request is generated by hot-spot cell which is dealing with heavy load and it is assumed that in near future it will require more communication bandwidth, so as to reduce overhead up to some extent, this particular fashion is adopted.

But, as seen in step 4 of Channel Procurement phase, the situation of call dropping can be avoided if unused channels with any cell can be retrieved.

So, here to manage channel allocation scheme in a better way, step 4 can be modified as-

4. If MSC cannot allocate even one channel, then Channel retrieval phase will be initiated.

Now suppose in Channel retrieval phase, dynamic pool gets exhausted then

1. MSC notifies all BS which borrowed a channel from dynamic pool to return unused channel, if any.
2. On receiving such request (notification), those BS, having the same will return the unused bandwidth to MSC.
3. On retrieving bandwidth Channel retrieval phase terminates, and request of any hot-spot BS is served.

Lastly, the issue of channel emancipation, if a call gets terminated at any MH. So, algorithmically,

1. On termination of any call at MH, a channel, let us suppose k_i gets free and is to be returned back either to local pool at BS site or dynamic pool at MSC's site.
2. On analyzing that the released channel belongs to dynamic pool, before returning, the BS estimates the current value of hot-spot level (let us say, h), in the cell.
3. If $h \leq H$, then after checking its temporary pool, channel is returned back to MSC. Else
4. Channel k_i is retained in its temporary pool as condition got worse, and cell is in urgent need of communication bandwidth.

5. SIMULATION ENVIRONMENT& RESULTS

To evaluate the effectiveness of our approach, a cellular network is simulated over OMNeT++ simulation environment which is an Integrated Development Environment and is based on the Eclipse platform, and extends it with new editors, views, wizards, and additional functionality. OMNeT++ adds functionality for creating and configuring models (NED and ini files)[10], performing batch executions, and analyzing simulation results, while Eclipse provides C++ editing, SVN/GIT integration, and other optional features (UML modeling, bug tracker integration, database access, etc.) via various open-source and commercial plug-ins[10] and results are expounded in various scenarios viz. Fixed channel allocation scheme, and hybrid channel allocation scheme by varying the number of dynamic channels used, and the behavior is studied in terms of Call drop rate and Blocked call rate versus System load.

The parameters and scenarios used in this simulation are illustrated in this section in which we have simulated the approach on over environment with total available channels i.e. K=300 over a BS grid of 6×6 over a area of 50,000×50,000 meteres^2 with one Mobile switching Center. Now, the approach has been evaluated for four different scenarios. Firstly, with fixed channel allocation Scheme for all available channels, and secondly, by varying the number of dynamic channels used by 30, 150 and 240 channels which in turn will vary the ratio of the number of dynamic channels to the total number of channels available in the system and the results are tabulated below.

Table-1: Call blocked v/s System load

System Load	Percentage of Call blocked			
	FCA	D=30 channels	D =150 channels	D =240 channels
0.25	0	0	0	0
0.5	1.48	1.11	1	0.45
0.75	5.96	4.99	5.64	2.84
1.0	13.53	10.28	8.65	7.58

Table-2: Call dropped v/s System load

System Load	Percentage of Call dropped			
	FCA	D=30 channels	D =150 channels	D =240 channels
0.25	0	0	0	0
0.5	4.81	5.11	5.11	6.44
0.75	13.29	13.75	11.43	12.17
1.0	19.70	22.03	19.02	20.61

The obtained results, illustrates the expound effectiveness of work in terms of call dropped and call blocked compared against system load in both cases in different scenarios mentioned above and compared with and without employing Hybrid Channel allocation scheme. In the case of HCA, three different cases of different ratio of the number of dynamic channels to the total number of channels available in the system i.e. D has been considered as 30, 150 and 240 channels. In implementation, number of MSC is 1 in all cases for the sake of simplification. The results are illustrated graphically to show the behavior of network with above defined approach

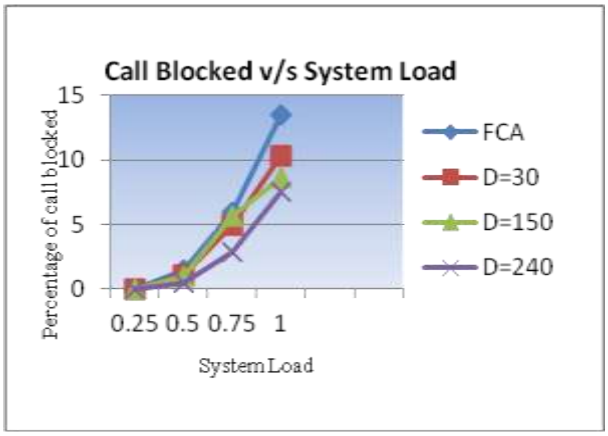

Figure1: Graphical Evaluation for Table 1

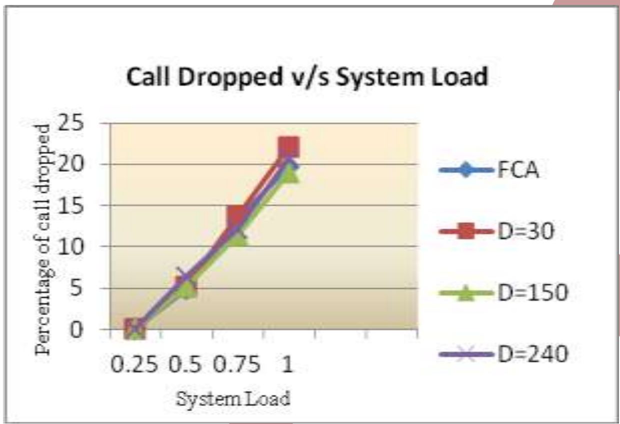

Figure2: Graphical Evaluation for Table 2

Figure 1 and 2 are expounding the results of call dropped versus system load for FCA, different scenarios with different number of dynamic channels i.e. 30, 150 and 240 channels and the same for call blocked versus system load.

Above mentioned results have been plotted, which illustrates pattern of call dropped and call blocked when total available pool of channels is divided in subsets of fixed and dynamic allocation schemes and the ratio is varied. It is observed from above illustrated results that call blocked in a cellular network if FCA is deployed is more than if available channels are distributed among subsets for static and dynamic assignments and this proportion is varied. It is observed in case of 240 channels assigned to dynamic pool, i.e. when number of channels for dynamic assignment increases, the percentage of call blocked reduces drastically. It is also obvious that on increasing system load the call blocked will increase respectively.

Similarly, if pattern of Call dropped is observed a slight improvement is seen when hybrid approach is used as compared to its fixed counterpart. An unexpected increase in call drop rate is observed when the number of channels in dynamic pools was 30, which might be the result of abrupt network traffic pattern and other parameters which affects the performance such as poor connectivity, interference, and many more. Here best outcome is observed when number of dynamic channels is varied to 150, where call drop rate is least for increasing load.

6. CONCLUSION

The present work is carried in the general context of channel allocation issue involved in cellular networks at heavy load situations. The work presented here illustrates the efficiency and flexibility of hybrid channel allocation algorithm along with a slight modification in conventional algorithm by introducing the channel retrieval phase which retrieves back the channels with BS, borrowed from MSC and are unused and allocates the same to some BS requiring it and thus resolving the limitation of MSC of being exhausted of communication bandwidth to serve further calls in heavy load. The effectiveness of the work has been illustrated in simulation where the approach performs better in almost all cases as compared to its fixed counterparts.

7. REFERENCES

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