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Dynamic Channel Allocation in Cellular Networks

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ABSTRACT: The wireless technology and its application growing faster and faster in last decades. Mobile network is one of the fastest growing technologies in wireless network. This headed to some challenges that face mobile network such as how to serve the big number of users, efficiently of frequencies is scarce and interferes with each other. One of the solutions to deal with such challenges is Cellular Networks which is used to divide a geographical area in to cells so that we can reuse the scarce frequencies in order to support more users and also to decrease interference. This paper introduces the importance of dynamic channel allocation in cellular networks and how much gain could be utilized by this technique. The Methodology depend on an intensive reading of what other research has been done in the field, then the model factors and the goal was built according to the main importance issues in this field. In order to realize the complications and limitations of the topic and to have comprehensive understanding many work in the literature have been revised. The mechanism was tested in two different scenarios, with uniform and non-uniform load distribution. For the findings: A new mechanism was introduced to overcome the previous limitations and to gain more efficient results. Also it utilizes artificial intelligence approach to make the allocation process optimal. Moreover, the new mechanism depends on four factors cell size, coordination, frequency reuse, and hand over to make the allocation process efficient and reliable.

KEYWORDS: Channel Allocation, Cellular, Cooperation, Frequency Reuse, Dynamic.

1 INTRODUCTION

The development in wireless and mobile applications in the last decade was huge and it's expected to grow more in the future. The domain of applications for wireless networks includes communications, military, media, medical, and much more. This led to challenging problems to deal with, like how to serve this big number of users efficiently given that frequencies are scarce and interfere with each other. One of the solutions to deal with such challenges is Cellular Networks which is used to divide a geographical area in to cells so that we can reuse the scarce frequencies in order to support more users and also to decrease interference (Fig 1). When cellular approach is applied frequencies could be allocated in several ways, one is called fixed channel allocation, in this approach channels are allocated for each cell and do not change then, the number of channels depends on the number of users in each cell and the allocated channels for neighboring cells, since cells that are close in distance will suffer from interference. [1] [2] [3]

Another approach is dynamic channel allocation in which the allocation of channel for each cell is dynamic which means the for each cell the number of channels depends on the varying numbers of users inside that cell, if the number of user increases the allocated channel will increase too without causing interference or system failure, in this approach if a cell needs more channels then the system will borrow idle channels from cells that have unused channels. The last type is hybrid channel allocation where each cell has a fixed number of allocated channels and there is a pool of dynamic channels that could be allocated dynamically for any cells that needs more channels. For the previous types of channel allocation approaches there are four important factors that affect their application, coordination between cells in cellular networks, frequency reuse, cell size, and handover. [4] [5] [6] [7]

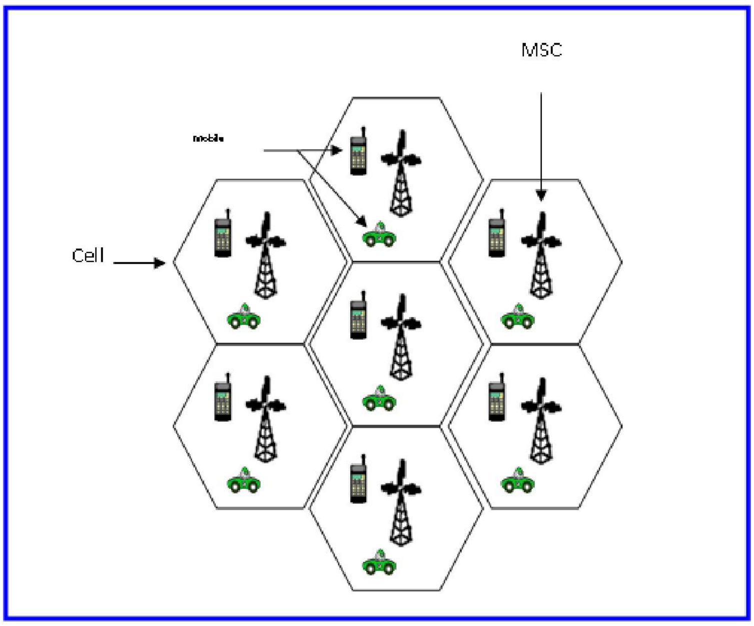

Fig. 1. Cells over a Geographical Area

2 RESEARCH METHODOLOGY

The research methodology is one of the most main sections in any research. In research method we identify the explanation and the conclusion of the problem, in this paper we develop a model that is derived from articles which used to allocate channels dynamically in cellular networks. As shown on the following model there are four main factors that used to increase the efficiency of channel allocation in cellular networks in a dynamic way (Fig 2). These factors were listed after a deep review in the literature; many researchers have talked about this topic due its importance in now a day's technology. [8, 9] [10] Most researches emphasized on these four factors as will be shown in the next discussion. The following figure shows the main four factors along with the goal of this research methodology.

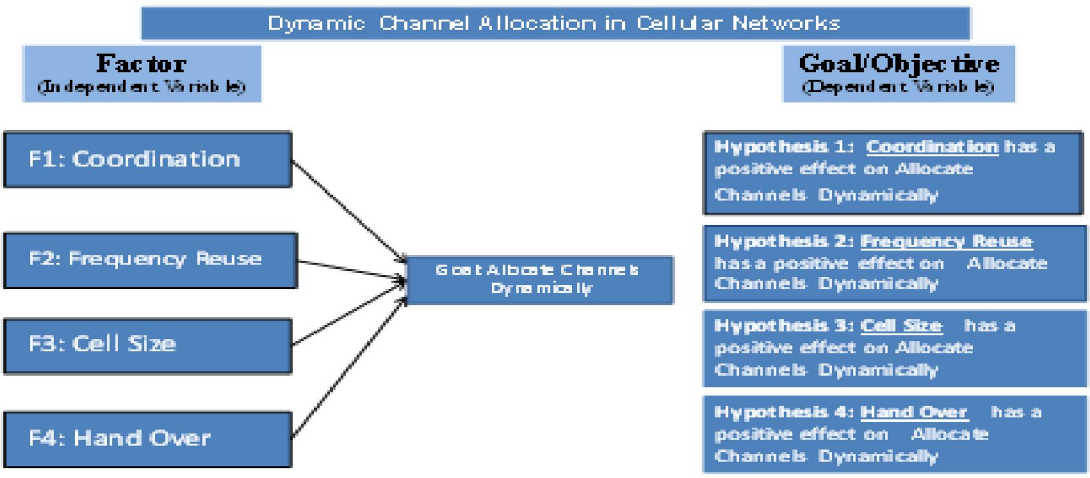

Fig. 2. Proposed Model

2.1 FACTOR 1

Coordination “There are several possible degrees of cooperation, offering a trade-off between performance gains and the amount of overhead placed on the backhaul and over-the-air feedback channels. Multi-cell MIMO cooperative networks [11] p. 3". The author here mentions the importance of cooperation between base stations and what complications we may suffer for achieving the intended degree of cooperation.

2.2 FACTOR 2

Hand over “If the user moves to another cell, then the problem of hand-off must be considered [12] p. 10”. The author here specifies when the hand over process should occur and exactly between two base stations.

2.3 FACTOR 3

Frequency Reuse “the FRS are used for improving the QoS of the cell edge MS and the BS usually focus on the central MS. [13] p. 1”. Here, the frequency reuse is used for improving the quality of service between multiple base stations.

2.4 FACTOR 4

Cell Size “Cell size is also important in facilitating intelligent CAH strategies involving CDMA beacons. [14] p. 4”. The authors focused on relation of cell size and intelligent techniques in cellular networks.

2.5 GOAL

“The available bandwidth for cellular communication is limited and the number of subscribers is increasing day by day, therefore it became necessary to find an optimal frequency assignment scheme that uses frequencies as efficiently as possible [15] p. 9”. The authors focused on the importance of how to allocate the rare available channels in an optimal way so that we can support the largest number of users as we can, and we should take care of the harsh competition on those scarce channels.

3 EXPLANATION/DISCUSSION OF MODEL

As mentioned before there are many factors that affect channel allocation in cellular networks, here we will focus on four of the most importance. Understanding these factors and how they relate to channel allocation; will help to analyze the problem and try to weight each part in any possible solution. In addition each part of these factors has a major role in the proposed dynamic solution and will determine to what extent we can deploy the dynamicity. [16] [17]

3.1 F1: COORDINATION

Base station coordination means that each base station should contact the neighboring cells base stations to know about used frequencies so that each base station is aware of interference that may be caused by close frequencies in the spectrum. Also each base station which has a network load that could not be served by the currently allocated channels may borrow other frequencies from neighboring cells that have unused allocated channels. In [18] emphasized on the importance of coordination between base stations in cellular networks to decrease the interference and as a result to increase the capacity of the network. They found that interference could be reduced by coordinated base stations when it compared with non-coordinated system. [19] [7] [20]

In [21] investigated the importance of coordination between cellular networks base station and found that it has a positive effect in the boundary users and also decreases interference, also they applied their technique using coordination between sectors in different base station. In [22] presented a resource allocation technique that utilize coordination between base station, they used a local dynamic strategy for a cell that varies depending on traffic load, and resulted interference.

3.2 F2: HAND OVER

The hand over term in cellular networks is related to situations where users whom belong to one cell moves to another cell during an active call, in this case the call will be blocked for a period of time until the new cell reserve a time slot on a new channel for this call that differs from the original channel. This call blocking is a measure of how efficient the channel allocation technique is. In dynamic channel allocation we present a new technique to deal with hand over problem, the proposed solution depends on reserving a number of special channels for each cell that used only for users located on the boundaries of each cell such that these channels will be overlapped between the cell and its neighbors, and it's used only for the boundary users who have active calls, when such users moves from one cell to another during an active call we guarantee no interrupt in the call since the same channel is shared between different cells and its usage is exclusive for boundary users, and also when a cell reserve a time slot in one of the shared channels it will inform the neighboring cells so that no conflict occurs.

Types of Hand Over:

There are two common types of hand over the soft and hard hand over.

- Soft hand over: in this technique when the mobile user moves from one cell to another, it can keep the old channel in the first cell until it reserve a new channel in the new cell so that it guarantee no cut in service.
- Hard Hand Over: Here the mobile user should release the old channel in the old cell before a new channel is allocated for it in the new cell.

In [23] they introduced the importance of hand over process in cellular networks and also into femto cells, they proposed a new mechanism to handle the handover between regular base station and femto cells, their solution was fast but the cost was more computation resources will be consumed.

In [24] they investigated the effect of mobile IP on the hand over process in cellular network and they found that the link layer could be deployed in parallel between two cell to achieve more efficient and robust handover process that will increase the throughput of the dynamic channel allocation. In [3] they used the handover process inside and at the edge of the cells and they found that the performance of the multi-hop cellular network is much better than single hop, also the use of the relay stations has a positive effect on the handover process.

3.3 F3: Frequency Reuse

In cellular networks, a geographical area is divided into a number of cells where the whole frequency bands are divided equally between these cells and no cell is allowed to share any frequency between other cells in the same pattern. This technique is used to prevent any interference that may occur by giving each cell in the pattern unique subset of frequencies. To cover other areas the same pattern is repeated and by this way we guarantee no interference will happen since the distance between the same reused channels is far enough to cause any interference. In our proposed solution where the distribution of channels is dynamic and no fixed channels are reserved during the network life time, we propose to make the initial distribution to pattern wise and then during the run of the network we could reuse channels in the same pattern on condition that it's not used in the same time inside the pattern and also there is enough distance between the cell and any other cells outside the pattern that is currently using the same frequency.

By applying frequency reuse we guarantee more users will be able to be served by the network operator which means more users with same number of frequencies and this leads to decrease cost. In [25] they proposed a novel technique for dynamic frequency reuse that will lead to more efficient utilization of the shared spectrum, they said that dynamic reuse of channels will enable a base station to reuse all of the allocated spectrum. In [26] focused on the usage of end-to-end devices as a cellular network to achieve tremendous multimedia load by improving cell capacity by efficiently and intelligently allocation available channels. In [27] a novel way for self-organizing and adaptive frequency reuse was introduced, they found that three factors play a major role for enhancing frequency reuse and one of them is the frequency reuse factor with number of sectors in a cluster.

3.4 F4: Cell Size

When we divide a geographical area to cells; each cell has one base station that is responsible for providing the required channels for service. Usually the base station is located in the middle of the cell and should be located in a high location to support all of the coverage area of the cell (Fig3). The size of the cell has a direct impact on the capacity of the base station such that when the cell size is small the capacity of the base station is high and when the cell size is big the capacity of the base station is low. For the relation between the cell size and dynamic channel allocation, it was found that when the size of the cells is small then it's better since more cells can cooperate to find the optimal channel allocation among the available frequencies. On the other hand smaller cells means more communication and computation overhead in the network which will make the allocation process complicated even the allocation is optimal, so the degree of the smallness of the cells is a relative value that is correlated with a threshold value, and this threshold value depends on the number of intended customers to support and the area to be covered. As a result a smaller cell is better but it's limited to a threshold value.

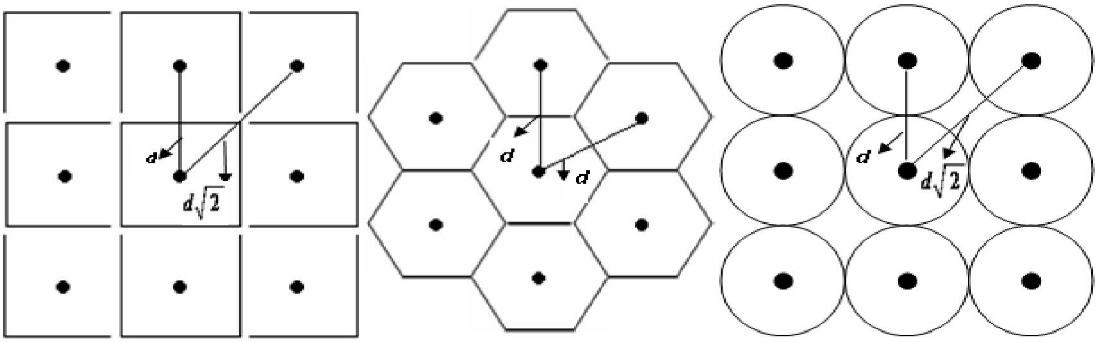

Fig. 3. Cell Shapes

In [28] they found that the cell size should be calculated using a heuristic function depending on the cell capacity and the coverage area to reach a balanced throughput. While [29] argued that the cell size should adapt to the distribution of the users and their requests for channels to reach the optimal cell size. In [30] they discussed the effect of dynamic cell sizing on the overall performance of the cell capacity, they found that by dynamic cell sizing they can increase the cell transmit power and reduce the radii and this is consistent with dynamic channel allocation.

4 WORKING ENVIRONMENT METHODOLOGY

In cellular networks, the traffic load of each cell varies from one cell to another and from one pattern to another; the variance comes from the number of users in each cell Which is differs from one location to another and from time to time. As a result, to make sure that the dynamic channel allocation technique is efficient then it should be tested under different traffic loads. The traffic load could be divided into two types:

- Uniform Traffic Load Distribution: Here the number of users in each cell is equal to the number of users in other cells in the pattern, also it is supposed that in case there is an increase in this number in once cell then the same ratio should increases on their cells in the pattern during the simulation time and vice versa if it is decreases.
- Non Uniform Traffic Load Distribution: In this model we assume that the number of users inside one cell is different from any other cells even with big variance; also this difference may change during the simulation time. In addition, there are cells that suffer from hot spot effect where the number of users during most time of the simulation is steady but in some times it grows rapidly and the cell needs urgent channel to serve the new coming users, this may occur in hotels, stadiums, downtowns. From the previous, any dynamic channel allocation technique should works efficiently in such different simulation scenarios.

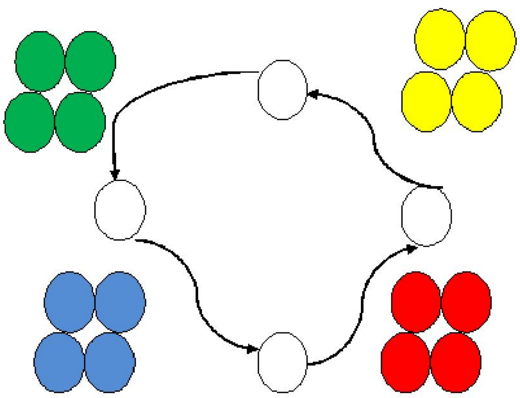

Fig. 4. ResMes Between Cells

Here we classify the system into groups of base stations, the grouping her depend on the distance between the base stations, for each group of base stations that are close enough to be affected by their interference we introduce a special type of message called 'ResMes', this message will circulate between the base stations in each group (Fig 4), when a base station receive the ResMes message it can know what the neighboring cells currently allocate, also the base station which hold the ResMes has the exclusive right to allocate new channels, when it's done the base station will bypass the ResMes to the next base station in the group. With each base station in each group aware of what other base stations have then it can allocate new channels without any conflict.

In this new model, the four important factors that were mentioned before are used; the cell size here has a major role on the number of needed channels and number of other cells in the group. Frequency reuse is the core of this new technique since each base station can allocate any channel when it needs it on condition that it does not violate the interference restrictions, so one channel could be reused several times in different base stations and different groups. For the hand over problem, in our technique it will be solved perfectly since the allocation of channels is done intelligently and each cell has an accurate view of what neighbors has so it can predict the channels needed to be kept free for boundary users. Finally, for coordination, we can obviously see how the ResMes message shows the coordination between the base stations and also between the groups; actually coordination is the heart of our technique.

5 IMPORTANCE OF MODEL

Since the available frequencies for channel allocation in cellular communication networks are scarce, whatever way to improve the utilization of these resources is important to support better service. In this work our model helps to optimally allocate the scarce channels and thus provide better service. The strength of our proposed work comes from the dynamic and intelligent way of allocation channels.

6 CONCLUSION

In this work we found how much important the dynamic allocation process in cellular networks. There are four factors that affect the efficiency of this technique, cell size, coordination, hand over, and frequency reuse. A new dynamic channel allocation method based on artificial intelligent was proposed, the base stations here should be intelligent to communicate with other base stations in order to allocate channel intelligently to reach the optimal balance between the available frequencies and the number of users.

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