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Dynamic Channel Allocation in 4G using Genetic Algorithm

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Abstract- The demand for mobile communication has been steadily increasing in recent years. With the limited frequency spectrum, the problem of channel assignment becomes increasingly important, i.e., how do we assign the calls to the available channels so that the interference is minimized while the demand is met? This problem is known to belong to a class of very difficult combinatorial optimization problems. In this Dissertation, we apply the genetic algorithms to channel assignment problems. Interference-free solutions cannot be found for some of these problems; however, the approach is able to minimize the interference significantly. With the limited frequency spectrum, the channel assignment problem (CAP) i.e., to assign the calls to the available channels so that the interference is minimized while the demand is met, has become increasingly important. The Channel Assignment Problem is an NP-complete problem to assign a minimum number of channels under certain constraints to requested calls in a cellular radio system. Examples of the many approaches to solve this problem include using neural-networks, simulated annealing, graph colouring, genetic algorithms, and heuristic searches. The dynamic channel assignment (DCA) in mobile communications systems using genetic algorithm (GA) is investigated in this research. Two new strategies using GA are proposed. In the first one, the channels previously assigned are kept locked during the call holding time (GAL). In the second one, the calls can be switched to different channels during the connection time (GAS). This paper review the available schemes for channel allocation.

Keywords: Dynamic Allocation, 4G Algorithms, Genetic Algorithm,

I. INTRODUCTION

As cellular phones become ubiquitous, there is a continuously growing demand for mobile communication. The rate of increase in the popularity of mobile usage has far outpaced the availability of the usable frequencies which are necessary for the communication between mobile users and the base stations of cellular radio networks. This restriction constitutes an important bottleneck for the capacity of mobile cellular systems. Careful design of a network is necessary to ensure efficient use of the limited frequency resources.

One of the most important issues on the design of a cellular radio network is to determine a spectrum-efficient and conflict-free allocation of channels among the cells while satisfying both the traffic demand and the electromagnetic compatibility (EMC) constraints. This is usually referred to as channel assignment or frequency assignment.

There are three types of constraints corresponding to 3 types of interference [1], namely:

1) Co-channel constraint (CCC)
- where the same channel cannot be assigned to certain pairs of radio cells

simultaneously

2) Adjacent channel constraint (ACC)
- where channels adjacent in the frequency spectrum cannot be assigned to

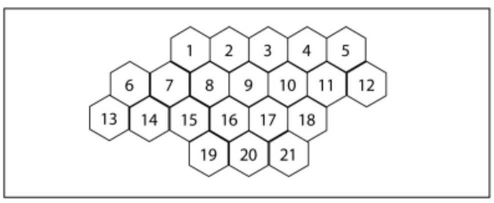
adjacent radio cells simultaneously.

3) Co-site constraint (CSC)
- where channels assigned in the same radio cell must have a minimal separation in frequency between each other.

One of the earlier aims of the channel assignment problem (CAP) is to assign the required number of channels to each region in such a way that interference is precluded and the frequency spectrum is used efficiently. This problem (called CAP1 in [2]) can be shown to be equivalent to a graph coloring problem and is thus NP-hard.

As demand for mobile communications grows further, interference-free channel assignments often do not exist for a given set of available frequencies. Minimizing interference while satisfying demand within a given frequency spectrum is another type of channel assignment problem (called CAP2 in [2]).

Figure 1 Cell division of wireless area



II. BACK GROUND AND LITERATURE SURVEY

There are three broad classifications for the channel assignment problem. The first is called Fixed Channel Assignment (FCA), the second is Dynamic Channel Assignment (DCA), and the third is Hybrid Channel Assignment (HCA) (Corne et al., 2000). In FCA, channels are assigned to each cell permanently based on a predefined channel demand. In DCA, channels are dynamically assigned to each cell based on the channel requests. HCA, as the name implies, is a combination between FCA and DCA (Kendall and Mohamad, 2004). Fixed resource allocation schemes use a predetermined assignment strategy aimed at improving average case performance. However, such schemes are not able to adapt to the varying nature of user traffic. FCA also provides the worst channel utilisation. However, FCA is the easiest scheme of the three. Dynamic channel assignment algorithms attempt to optimise system performance by adapting to the traffic variations. It completely removes the requirement of a static and structured frequency reuse pattern and makes available all radio channels available for every call. DCA, however, is much more complex than FCA.

By mapping the CAP problem to the generalised graph colouring problem, the CAP problem has been proven to be NP-complete. Taking advantage of this, Sivarajan et al. (1989) proposed non-iterative algorithms using ideas from graph colouring algorithms.

The eight algorithms they proposed are a combination of cell ordering and call ordering assignment methods. Yeung and Yum (2000) proposed four algorithms based on two node ordering principles: node-colour ordering (CR) and node-degree ordering (DR).

These algorithms are also based on two assignment strategies: Frequency Exhaustive Assignment (FEA) and Requirement Exhaustive Assignment (REA). The four resulting algorithms are FEA/CR, FEA/DR, REA/CR and REA/DR (We will describe FEA, REA and node-degree ordering in detail in the following sections.).

Another technique that has been applied to CAP in recent research work is Artificial Intelligence (AI) algorithms (Zhang and Yum, 1989). Besides AI algorithms, Chakraborty et al. (Chakraborty and Chakraborty, 1999) proposed a genetic algorithm that generates the initial population and creates near optimum solutions for large populations. They next apply a genetic mutation operation to improve the quality of the previously obtained initial solutions towards an optimum solution.

A similar genetic algorithm strategy can be found in Kim et al. (1996). Beckmann and Killat (1999) proposed a new genetic algorithm strategy. This algorithm first generates a list of all calls in the system. It then applies a genetic algorithm to determine an optimal call list. Next, for each generated call list, it assigns frequencies using the FEA strategy and evaluates the result by considering the number of blocked calls. It then executes the genetic algorithm and FEA repeatedly until the best solution is obtained.

Although Chakraborty et al. (Chakraborty and Chakraborty, 1999) and Beckmann and Killat (1999) presented strategies using genetic algorithms, their methods are substantially different. First, the approach in Beckmann and Killat (1999) is for fixed channel assignments and that of Chakraborty and Chakraborty (1999) is for dynamic assignments. In Beckmann and Killat (1999), the genetic algorithm is applied to a randomly generated population, and the FEA strategy is applied in every generation to select the best of the population. While in Chakraborty and Chakraborty (1999), the initial population (with a large population size) is restricted only to genotypes representing a valid solution. The genotype in Beckmann and Killat (1999) is an array representing the size of the number of cells and the value of the array of the assigned channel number. The genotype in Chakraborty and Chakraborty (1999) is an $M \times N$ matrix, where M is the number of channels and N the number of cells. The final results obtained by the two algorithms differ as well. An optimal call list is the end product of Beckmann and Killat's algorithm, whereas an optimum frequency assignment solution is the end product of the algorithm of Chakraborty et al.

Funabiki and Okutani (Funabiki et al., 2000) proposed a three-stage neural-network algorithm. The first stage of this algorithm assigns channels first to the cell that determines the lower bound at an interval of CSC. In the second stage, the cluster of cells whose centre cell has the largest node-degree (which is called the greedy region), is assigned channels by the REA strategy. Each time the overall assignment fails, the greedy region expands by additionally including the cells adjacent to the original region. In the third stage, the calls in the remaining cells are simultaneously assigned channels by a binary neural network.

Shinde [10] proposed a hybrid channel allocation model using an evolutionary strategy with an allocation distance to give efficient use of frequency spectrum. The problem of determining an optimal allocation of channels to mobile users that minimizes call blocking and call-dropping probabilities is emphasized. A new hybrid algorithm combining the genetic with the simulated annealing algorithm is introduced in [11] for Selecting the routes and the assignment of link flow in a computer communication networks which is an extremely complex combinatorial optimization problem.

Bhattacharjee [12] maximized the channel allocation of the active subscribers within the cognitive radio network(CRN). There are numbers of heuristics approaches being suggested to overcome the channel assignment problems based on fixed reuse distance concept such as neural networks (NNs) in [13], particle swarm optimization (PSO) in [14], and Tabu search (TS) in [15]. These type of algorithms can be used to solve complicated optimization task, such as optimal-local, multi-constrained and NP-complete problems. Lima [16] investigated in his research, the dynamic channel assignment (DCA) in mobile communications systems using genetic algorithm (GA). The performance of the proposed GA was evaluated in a 49 hexagonal cell arrangement operating under uniform and no uniform traffic distributions.

Feng Han, et.al, works on Energy-Efficient Base-Station Cooperative Operation with Guaranteed QoS [17], this work incorporate both the path-loss and fading effects in our system model, and derive closed-form expressions for two important quality of service metrics, the call-blocking probability and the channel outage probability. The proposed scheme guarantees the quality of service of the user equipments by identifying the user equipments situated at the worst-case locations. The energy-saving performance is evaluatedand compared with the conventional uni-pattern operation.

III. PROBLEMS IN CHANNEL ALLOCATION

The channel assignment problem arises in cellular telephone networks where discrete frequency ranges within the available radio frequency spectrum, called channels, need to be allocated to different geographical regions in order to minimize the total frequency span, subject to demand and interference-free constraints (CAP1), or to minimize the overall interference, subject to demand constraints (CAP2).

There are essentially two kinds of channel allocation schemes - Fixed Channel Allocation (FCA) and Dynamic Channel Allocation (DCA). In FCA the channels are permanently allocated to each cell, while in DCA the channels are allocated dynamically upon request. DCA is desirable, but under heavy traffic load conditions FCA outperforms most known DCA schemes. Since heavy traffic conditions are expected in future generations of cellular networks, efficient FCA schemes become more important. The fixed channel assignment problem, or in other words, assigning channels to regions in order to minimize the interference generated has been shown to be a graph coloring problem and is therefore NP-hard.

A cellular network is assumed to consist of N arbitrary cells and the number of channels available is given by M. The channel requirements (expected traffic) for cell j are given by D j . Assume that the radio frequency (RF) propagation and the spatial density of the expected traffic have already been calculated. The 3 types of constraints can be determined. The electromagnetic compatibility (EMC) constraints, specified by the minimum distance by which two channels must be separated in order that an acceptably strong S/I ratio can be guaranteed within the regions to which the channels have been assigned, can be represented by an N × N matrix called the compatibility matrix C.

In most situations, the number of assigned channels in a cell is adjusted to match its load through nonuniform channel allocation or static borrowing. Zhang and Yum [18] considered an FCA strategy using borrowing with directional channel locking (BDCL). In that model, a given cell employing all nominal channels can borrow free channels from its neighbour cells (donors) to accommodate new calls. A cell can borrow a channel if such a channel does not interfere in the calls already assigned. However, if many cells operate under heavy traffic, the lending of one channel may cause multiple lendings.

IV. GENETIC ALGORITHM APPLICATION IN CHANNEL ALLOCATION

(I) Initial Population-The algorithm starts by randomly generating an initial population of possible solutions. For our problem, the population is the randomly generated cells. We can select a cell, say cell one and if this cell requires a channel, we start from channel one to last and search for the best to allocate.

(ii) Evaluation phase-The quality measure to decide how fit one individual is among the whole generation is called the fitness. In our application, we can compare the frequency reuse distance and SNR of all the cells created in initial population. The fitness function is the value of both distance and SNR to maintain least interference between co channel cells.

(iii) Selection phase-The chromosome with better fitness will be selected, and the others will be eliminated. This will help improve the total fitness of the population. After this we sort the other cells that satisfy the condition of allocation of channel one, on the basis of highest SNR.

(iv) Crossover phase-After the selection step, the eliminated individuals are added by applying crossover to the selected individual. The selected cells can be used to create another cells having better fitness criterion. .

(v) Mutation phase-The mutation process is carried out by changing a random bit of the new genes. These new genes (cells) now become the next candidate to be assigned with channel one but only if they satisfy the fitness criterion. The cycle goes on until all the channels are scanned and the channel requirement of the cell is fulfilled.

IV. RESULT

The result for the dynamic channel allocation using Genetic Proposed algorithm is shown in figure drawn below:

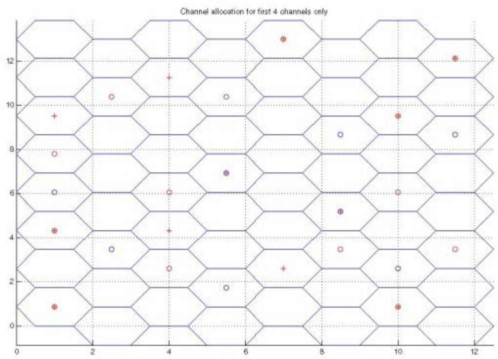


Fig 2 Dynamic Channel allocate 1

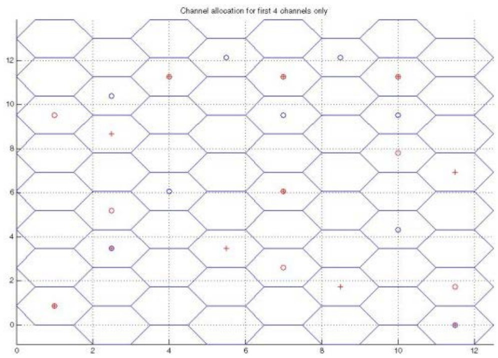


Fig 3 Dynamic Channel allocate 1

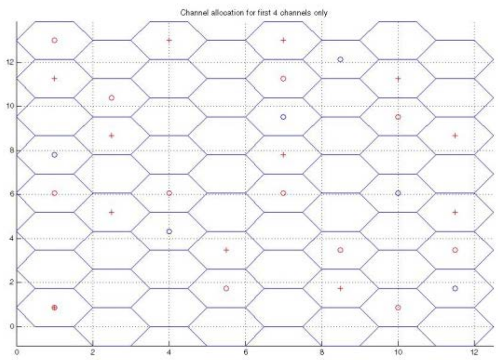


Fig 4 Dynamic Channel allocate 1

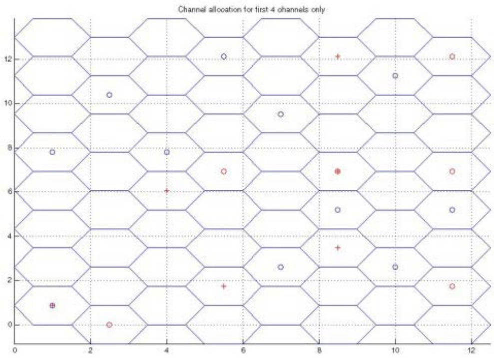


Fig 5 Dynamic Channel allocate for user 1

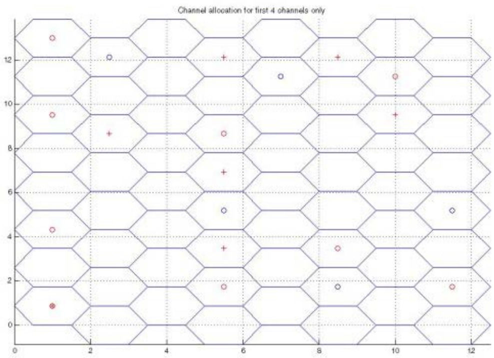


Fig 5 Dynamic Channel allocate for user 2

V. CONCLUSION

The channel allocation problem has been solved using dynamically via the use of genetic algorithm. the results proves that tha channel allocated using this schemes are the more frequency reusable with less handoff mechanism.

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