GSM Automatic Frequency Planning with the Aid of Genetic Algorithms

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2 authors:

Iyad Amro
Birzeit University

Wasel Ghanem
Birzeit University

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Iyad Amro
Faculty of Information Technology
Birzeit University
Birzeit, Palestine
e-mail: iyad.amro@jawwal.ps

Wasel Ghanem
Faculty of Information Technology
Birzeit University
Birzeit, Palestine
e-mail: ghanem@birzeit.edu

Abstract—**Due to the high demand of mobile services, and the full loading of the mobile allocated spectrum, a very tight frequency reuse schemes appeared, and high levels of interference occurred and due to the overlap of cells, which in turn made it very difficult to allocate frequencies for the different cells in the cellular system. Here in this seminar genetic algorithm was implemented as a method to get the optimum frequency allocation for such cases. Alphabetical encoding was used since the problem size and the number of cells in the scope is relatively large, an existing GSM network was used as a model to test the work. Different scenarios were applied on the genetic algorithm to tune and the system parameters and get best performing form of it for such problems**

Keywords- Evloutionary Algorithm; Genetic Algorithm (GA); crossover; mutation; GSM; SDCCH; TCH.

I. INTRODUCTION

Evolutionary Algorithms and Natural algorithms are gradually taking more importance in computing and optimization especially for those problems that have no exact solution, but optimum or near optimum. Through out of this work I focused my study on genetic algorithms as mean to solve the problem of frequency allocation challenge in GSM network.

GSM is a mobile system that works with 900 MHz of 124 channels, 1800 MHz of 512 channels mainly or 1900 MHz. Each cell in the service area has its own frequencies to handle signaling and traffic voice channels and has to comply with the GSM standards of EMC interference to be able to serve the users in its service area (i.e C/I of 9 db for co-channel and 3db for adjacent channel interference). Using the same sub frequency band or channel multiple times in different spots in the same service area is called the frequency reuse. Allocating channels to cells is a major problem of interest, where it takes a big consideration when the allocated spectrum to the operator is very tight, i.e. little number of channels, like 18 or 24 channels.

Genetic Algorithms (GAs) are adaptive heuristic search and optimization algorithm based on the evolutionary ideas of natural selection and genetic. They were introduced by Holland and his group in 70's. The basic concept of GAs is designed to simulate processes in natural system necessary for evolution, specifically those that follow the principles of survival of the fittest. As such they represent an intelligent exploitation of a random search within a defined search space to solve a problem to its optimum or near optimum solution and may not the exact one.

GA's were first pioneered by John Holland on 70's at Michigan University. They were widely studied, experimented and applied in many fields of engineering. Not only does GAs provide alternative methods to solving problem, it consistently outperforms other traditional methods in most of the problems link. Many of the real world problems involved finding optimal parameters, which might prove difficult for traditional methods but ideal for GAs.

II. RELATED WORK

Many researches dealt with resources allocation optimization and among that few of them dealt with the channel allocation problem, the channel frequency allocation either in static or dynamic manner. Chiu Y. Ngo and Victor O. K. Li (1) applied modified GA to solve the static channel allocation problem, by fixing the number of one's or zero's over all of the binary chromosomes they are dealing with and using a minimum-separation encoding to eliminate redundant zeros in the solution representation. They gained good results out of their work by reducing the search space. They claimed minimum 80% convergence to the solution within reasonable time.

Based on the same problem formulation of (1) and the minimum-separation encoding scheme to reduce the search space Lipo Wang et al. (2) applied Genetic Algorithm to find the optimal channel assignment for mobile communication. and they found the effect of mutation probability on the convergence of the fitness value, where they found the too small mutation leads to fast convergence, while increasing it beyond some limit increases the

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randomness of the fitness. The effect of the population size where they found the 20 is a good population size for some cases. Where here in this work effects of mutation and the crossover were tested and effect of mutation of mutation was obtained.

Xiannong and Bourgeois, Anu G. (3) applied multiple stages algorithm for dynamic channel allocation by using regular interval assignment stage, greedy assignment stage and genetic algorithm stage. Where here, in this work few tests made on the regular interval assignment they were not promising because of the very limited bandwidth with the high interference level in work scope.

Shirazi, Sayed and Menhaj, Mohammad (4) used a modified Genetic Algorithm where they proposed using the elitist chromosome in the population for cross-over and production of new offsprings. Here in this work, by changing the crossover probability led to a similar algorithm structure but without exclusion per bad chromosome. i.e. all of the new generated offsprings were ranked and passed to the next stage.

III. Case Description

A. Formulation:

Here the same problem formulation as in (1) is applicable. A cluster of 130 JAWWAL (a GSM Operator) cell sites of about 425 cells in one of west bank cities need to have each BCCH frequency allocated well in order not co-channel interfered with others and minimally adjacently interfered. The basic input data are the ICDM table and the traffic volume per cell for that city. The spacing of the sites reaches 100 m in some cases, so the overlapping of the coverage between the cells is so high and hence the interference. Another factor that leads to the high inference is the hilly terrain of the city.

The fitness algorithm is the sum of the interference percentage out of the ICDM for each cell for all of it co-channel interference at each solution instance.

$$F_{cc} = \sum_{i=1}^{I} \sum_{j=1}^{J} N_{ij} * T_i \quad \ldots\ldots(1)$$

Where F_{cc}: cumulative fitness value for the co-channel interference.

I: No of cells in the problem.

J: No of incidents that the cell is co-channel interfered i.e BCCH(i) = BCCH(ij).

Ti: Traffic volume on that ith cell.

$$F_{adj} = \sum_{i=1}^{I} \sum_{j=1}^{J} M_{ij} * T_i \ldots\ldots(2)$$

Where F_{adj}: cumulative fitness value for the adjacent channel interference.

I: No of cells in the problem.

J: No of incidents that the cell is co-channel interfered i.e BCCH(i) = BCCH(ij)+1 or BCCH(i) = BCCH(ij) - 1.

Ti: Traffic volume on that ith cell.

The spectrum allocated to network is 24 consecutive GSM channels, 10 channels out them are allocated for traffic channels (TCHs) in all of the cells and are dynamically allocated according to frequency hopping algorithms. The remainders are 14 channels that are used to carry the BCCH, the SDCCH and other 6 TCH channels, so we may call them BCCH frequencies.

B. Algorithm Applied

The Elitist Selection GA with was used through of the program where 10 % of the population was selected as the elitist. Alphabetic encoding was used since it is robust for large problem like this. So the frequency channels as encoded as characters representing the no. of channels A – N for 14 channels and then aligned in string representing the sequence of the cells in the network, any arbitrary sequence, which is fixed throughout the program run. The length of the chromosome is the no. of the cells subject of the problem.

IV. Results

Running the algorithm for 425 cells with 14 frequencies shows convergence tendency after 60 generations. With 15 frequency channels the problem was easier, and the tendency to the optimum was before generation 60. The size of the problem i.e the number of cells and the no of the frequency is a big measure of how fast the results converge.

By testing the algorithm, using 20 to 30 individuals per population generation was enough and fast lead to the optimum solution, the tests were done over 100 generations to check the algorithm behavior. Regarding the mutation, changing the value shows that mutation value ranging from 0.003 to 0.011 are the best to choose for the mutation as shown in figure 1.

This conclusion was realized by running the program for 100 generations 3 times for each mutation step and with cross over probability of 0.6.

Running the program for different crossover probabilities showed a sensitivity of changing it at the values close to zero. While above 0.015 the algorithm become slower in finding the target solution. First tests included running the program over 0.01 step from 0 to 1. Then after finding the most changing behavior interval of the algorithm the process was repeated for the range 0-0.2 in steps of 0.02 with 3 runs over each value. The results obtained at each step were in the same range which made it easy to average them. Figure 2 shows the relation between the crossover probability and fitness of the solution toward the target solution over 100 generations.

Since the problem is a multi-objective problem (i.e. reducing the co-channel and the adjacent channel interference to the minimum). Multiple sorting of the fitness values was introduced. That was done by sorting the sum of the two fitness values, then selecting best part of that, 0.1-0.5. My trials showed that 0.14 of that is fair, then sorting that value to the Co-Channel interference fitness. Figure 3 illustrates the situation without multiple sorting while Figure 4 shows the output after applying the second sorting of 0.14 of firstly sum sorted.

V. Conclusion

Genetic Algorithm still valid for channel allocation problem even the spectrum is tighter, even in a very congested hilly terrain area, but to do that Algorithm parameters should be set carefully. That will lead to a good speedup of the algorithm, where it needs many generations to reach the ultimate solution. Using 0.01 crossover, means that dealing with best one or best two individuals at each generation speeds up the process very well. Setting penalties of the cost inputs may improve the output dramatically and speedup the search process.

Then the algorithm become as follows:

Initialize the set of solutions (the population).

Calculate the fitness of two objectives per each individual.

Sort ascending the sum of the two objectives.

Select part of the sorted.

Sort ascending this selected part.

Reserve the elite size and generate new individuals out to fill the rest of the population.

Repeat step 2, until the objective value is reached.

VI. FURTHER WORK:

To improve the Algorithm, applying adaptive mutation and even adaptive crossover is suggested. Where after the output diverges different steps of mutation or crossover may be applied, where it will stimulate different solutions out of the local search space. When dealing with a number of channels of 14 with level of interference in scope, it is a must to implement parallel genetic algorithm in order to get result in reasonable period, if we know that about 10000 generations are required to get reasonable free of co-channel or with 2 incidents of co-channel interference results.

REFERENCES

[1. *Fixed Channel Assignment in Cellular Radio Networks Using a Modified Genetic Algorithm.* **Chiu Y. Ngo, Member, IEEE and Victor O. K. Li, Fellow, IEEE.** 1, s.l. : IEEE, 1998, IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, Vol. 47.

2. **Lipo Wang*, Sa Li, Sokwei Cindy Lay, Wen Hsin Yu, and Chunru Wan.** *Genetic Algorithms for Optimal Channel Assignments in Mobile Communications.* Singapore : School of Electrical and Electronic Engineering, Nanyang Technological University.

3. *Using a genetic algorithm approach to solve the dynamic channel-assignment problem.* **Fu, Xiannong and Bourgeois, Anu G.** 2006, International Journal Mobile Communications.

4. *A New Genetic Based Algorithm for Channel Assignment Problems.* **Shirazi, Sayed and Menhaj, Mohammad.** s.l. : Springer, 2006. Computational Intelligence, Theory and Applications . pp. 85-91. DOI: 10.1007/3-540-34783-6_10.

5. **Haupt, Randy L. and Haupt, Sue Ellen.** *Practical Genetic Algorithms.* s.l. : John Wiley and Sons, 2004.

6. **Halonen, Timo - Nokia and Melero, Juan Javier Romero - TarTec, [ed.].** *GSM, GPRS and EDGE Performance, Evolution Towards 3G/UMTS.* 2nd. s.l. : John Wiley and Sons, 2003.

7. **S.N.Sivanandam and S.N.Deepa.** *Introduction to Genetic Agorithms.* s.l. : Springer, 2008.

8. **Redl, Siegmund M., Weber, Matthias K. and Oliphant, Malcolm W.** *GSM and Personal Communications Handbook.* s.l. : Artech House, 1998.

9. **Mishra, Ajay R.** *Fundamentals of Cellular Network Planning and Optimisation.* s.l. : Wiley, 2004.

10. **Coello, Carlos A. Coello, Lamont, Gary B. and Veldhuizen, David A. Van.** *Evolutionary Algorithms for Solving Multi-Objective Problems.* 2nd Edition. s.l. : Springer, 2008.

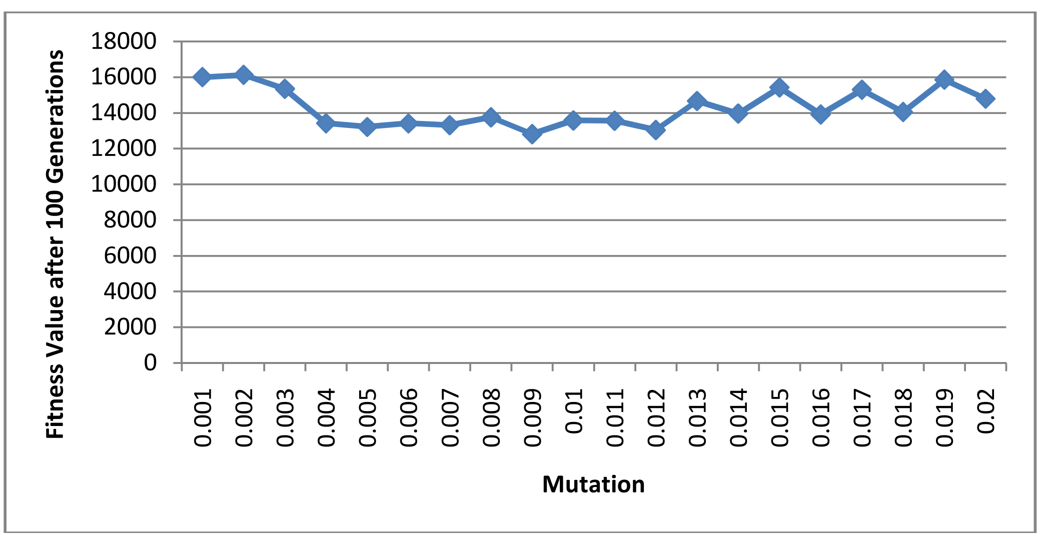


Figure 1. Fitness against mutation values.

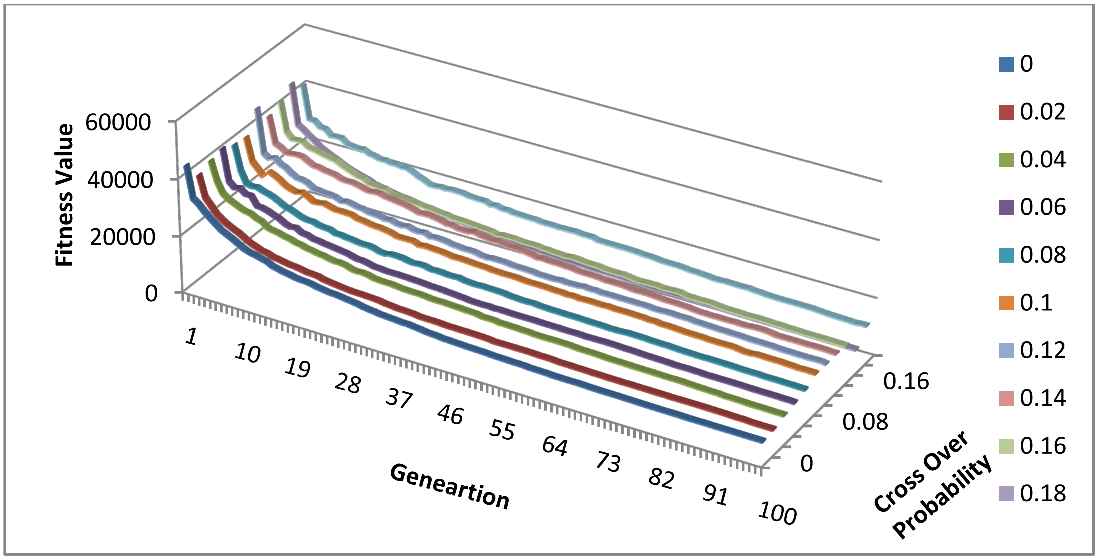


Figure 2. Crossover Effect on the Algorithm Behavior.

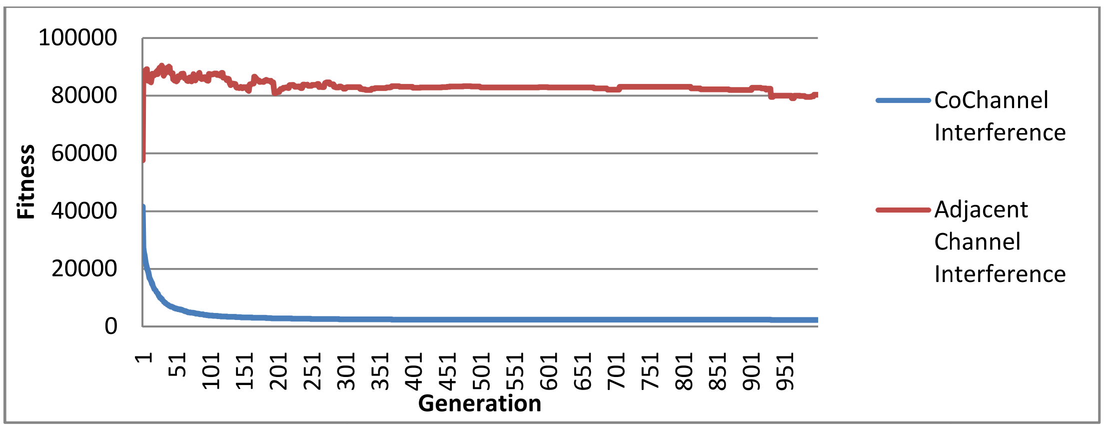
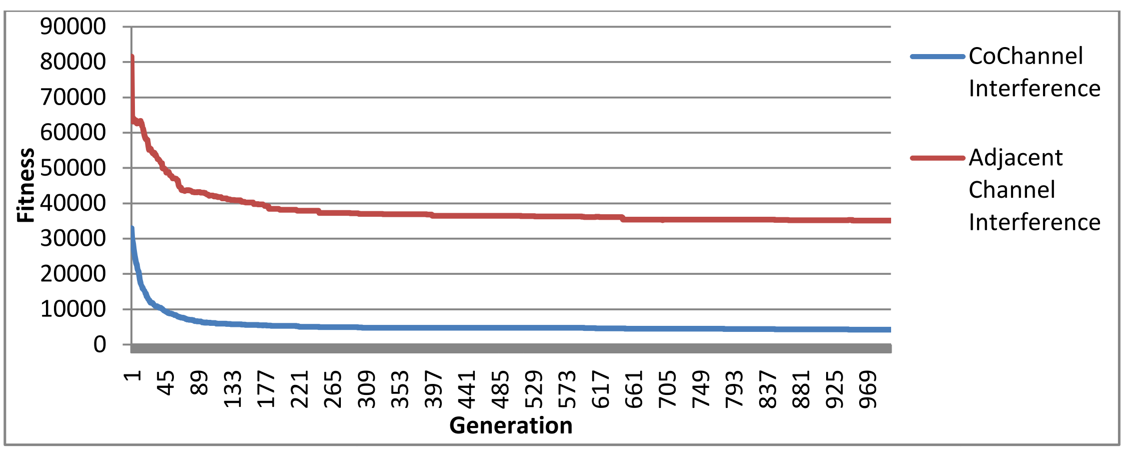


Figure 3. Fitness to Generation relation with sorting for Co Channel Interference.



Fitness vs. Generation with multiple sorting.