Hybrid Genetic Algorithm and Tabu Search For Solving the Frequency Assignment Problem in Cellular Network

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Abstract

As more individuals joined the mobile area, the demand for the mobile service is increased. However , the limited number of frequency allowed raises the problem of frequency allocation. Simply it defined as the allocation of different frequency to each cells and its neighbor. This problem is considered an NP –problem. This paper proposed a hybrid algorithm between genetic algorithm(GA) and tabu search techniques (TS) to solve this problem. The proposed algorithm embeds the features of the local search, elite list and intensification from TS into mutation operation of GA. The aim is to find an algorithm which behave more efficient than the primary algorithms in terms of speed, complexity and search space problem like cycling in TS and premature convergence in GA. Test results show that the proposed algorithm can get rid of the premature convergence problem in GA and can find the target solution faster than TS.

Keywords: Genetic Algorithm, tabu search, frequency allocation, hybrid techniques.

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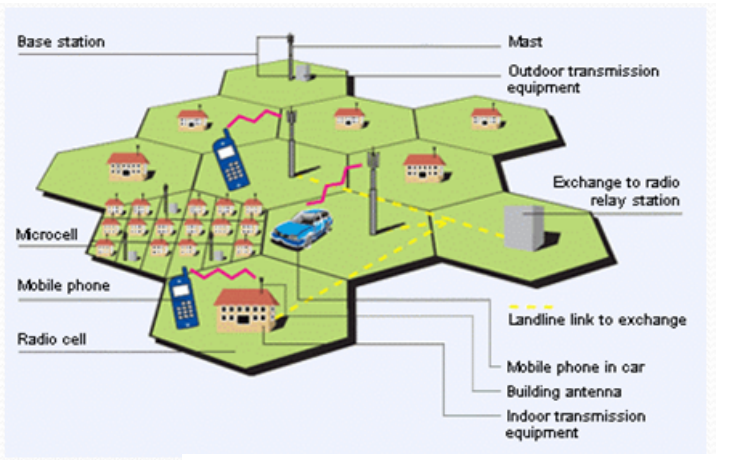
1. Introduction

The cellular telephone system is composed of small regions called cells. Each cell is provided with an antenna for propagating of the frequency, this antenna is controlled by AC powered system called base station [1]. A simple cellular area is shown in Figure (1).



Figure(1): Cellular Area

As the size of mobile area increased the demand for mobile service is increased exponentially. However, the frequency spectrum to support these services is limited [2]. Several methods have been suggested to address the limited power problem such as *cell splitting, frequency re-use, dynamic channel allocation or alternative routing and adaptive cell sizing algorithm*. All these method often imply either an increase in system complexity or a significant degradation in the quality of service [2]. In this paper the frequency re-use method is discussed and a proposed hybrid algorithm based on search techniques in artificial intelligence will be used to implement this method.

2. Research Problem

The frequency re-use is a fundamental principle in cellular network, is used to achieve coverage and capacity in cellular area using only a few set of frequencies [3]. Frequency allocation problem is one problem that must be solved when use this method since there is a limited

number of frequencies. The frequency allocation states that the given area is separated into cells and these cells are allocated frequencies in such a way that no neighbor cells could have the same frequency. Two cells are called adjacent only if they share the border segment [2]. Pattern repetition is an approach that implements the re-use principle. As shown in Figure (2) it is a configuration of N cells, N being the reuse factor. Each cell uses a unique set of frequencies. When the pattern is repeated the frequency can be reused. One limitation of this approach is that the same pattern is used all the time and any change in specific a cell the new pattern must be repeated to the other patterns. The frequency allocation problem consider an application of graph coloring problem and graph coloring problem is one of the hardest problem in class NP [4] .

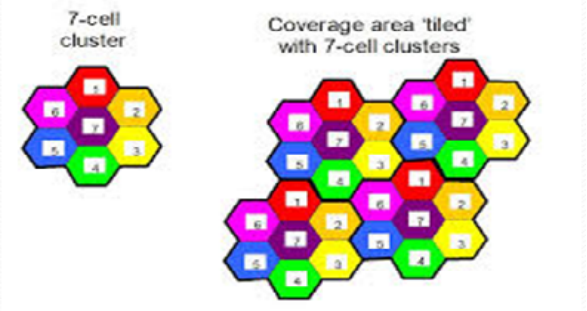


Figure (2): Frequency Re-use use Pattern Repetition

3. Search Techniques

Many search techniques have been used to solve the NP optimization problem like GA, TS,SA and others. Each method has advantage and limitation or disadvantage.

GA is an evolutionary approach based on the concept of natural genetics and natural selection [5]. It has the ability to explore the search space parallel and random which gives it the preference to be used to solve the optimization problem of class NP. On the hand GA is a memory less algorithm which limits its ability to backtrack in search space. Due to this limitation the GA cannot solve the problem of premature convergence which decrease the efficiency of the GA. Figure (3) shows a simple diagram for GA [6].

TS is an iterative procedure designed for the solution of optimization problems. TS starts with a random solution and evaluate the fitness

function for the given solution Then all possible neighbors of the given solution are generated and evaluated [7]. TS exploits data structures of the search history as condition of the next move. In contrast to GA, it has a memory in fact 4 four types of memory which gives it efficient exploration of the search space one disadvantage of this techniques is the complex structure which result in slow implementation and the search process may gets in cycling, Figure (4) shows the simple search and the frame work of TS..

The hybrid techniques tries to combine fully or partially two or more algorithm s to enhance the performance of the stand alone search method for optimization problem , to achieve such a goal , the hybridization should be able to embed the best features of the combined algorithms into a high level algorithm [8].

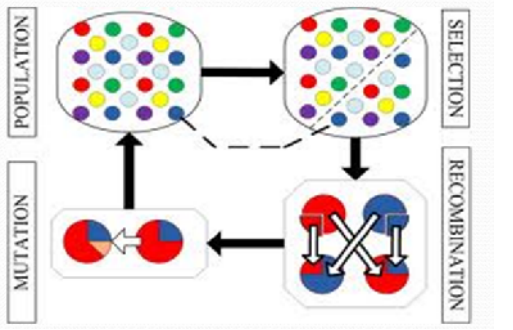


Figure (3): Simple GA

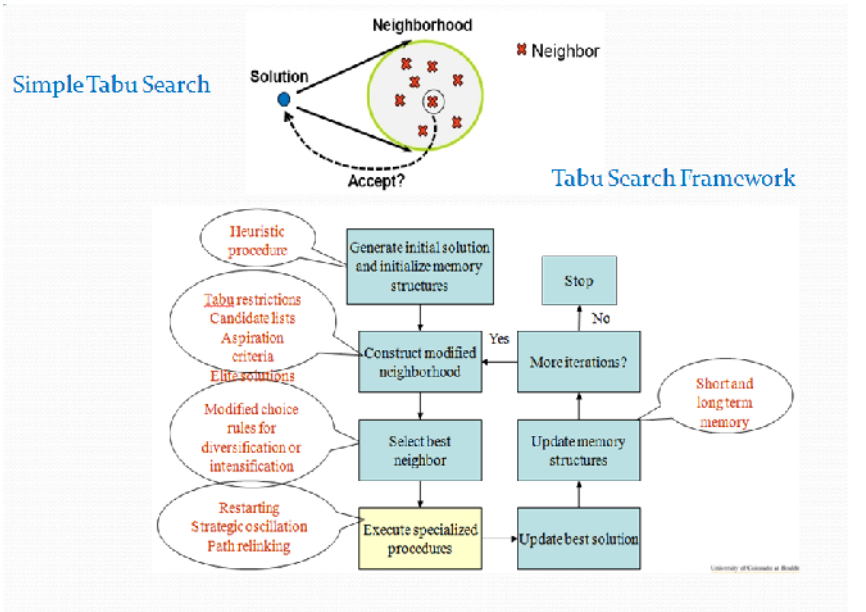


Figure (4): Simple TS Framework

4. The Proposed Hybrid Algorithm

The proposed hybrid algorithm combines the following best features from TS into the mutation operation of the GA ,

1-local search operation.
2- Elite list strategy.
3- intensification.

Where the local search operation is used to enhance the exploration process in GA, this will make the algorithm investigates more feasible solution in the search space . The elite list and intensification process will help the GA to implement the backtracking and get rid of the premature convergence problem.

The result hybrid algorithm will show a better performance compared to GA and TS in term of speed, complexly, best solution found. It will be faster, less complex, than TS since it uses some of the feature of the TS , also it will be free of cycling since it uses the parallel

random search from GA. And more efficient than GA with backtracking and exploration feature .

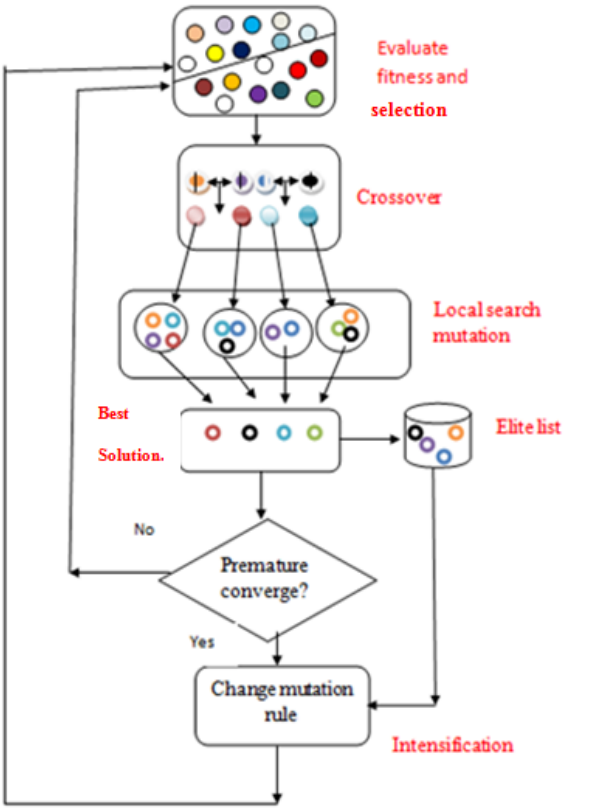


Figure (5): Framework of the Proposed Algorithm

Figure (5) shows a diagram for the proposed hybrid algorithm framework .The most important part of the diagram are the fitness evaluation function , mutation operation , and intensification process.

Where the fitness of each individual is computed as the sum of two variables (k and l), where k represents the number of cells which has no interference with its neighbors and l represents the number of cells which has interference with only one neighbor, in other words if l is the

interference factor then k is the sum of all cell which has I = 0 , I is the sun all cell which has I=1.

Mutation operation tries to solve the interference among cells by considering cell with I =1 and replace the frequency for that cells, such that f(v) ≠ f(w).

Intensification process makes use of the elite list to construct a new mutation population when the current mutation population become premature converge by applying a new rule for mutation.

5. Evaluation

A simple test example is considered here where a cellular area consisting of 24 cells are used (shown in figure (7)) the cells are marked with number 1,2…….24 and a four se of frequency ranged from 1 to 4 are to be allocated to these cells .

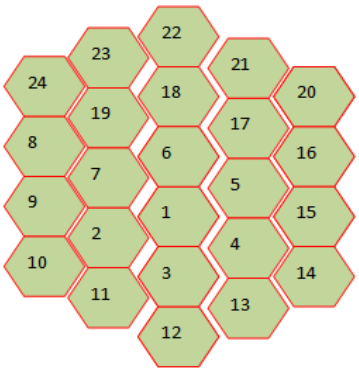


Figure (7): Sample Cellular Area

The hardware and software requirements for simulation process are summarized in Table (1). The accessory parameter and factors about the problem r are listed in Tables (2) and (3) respectively.

Table(1): H.W and S.W requirement

Hardware Requirements		Software Requirements	
processor	Core i3, CPU 1.8 GHz	**OS**	Windows 8
RAM	4 GB	**Programming Language**	VB.Net
System Type	64-bit		

Table(2): Problem Parameter

Parameter	Type
encoding	integer
Selection operation	Tournament
Crossover operation	Single point
Initial population	random

Table(3): Problem Factor

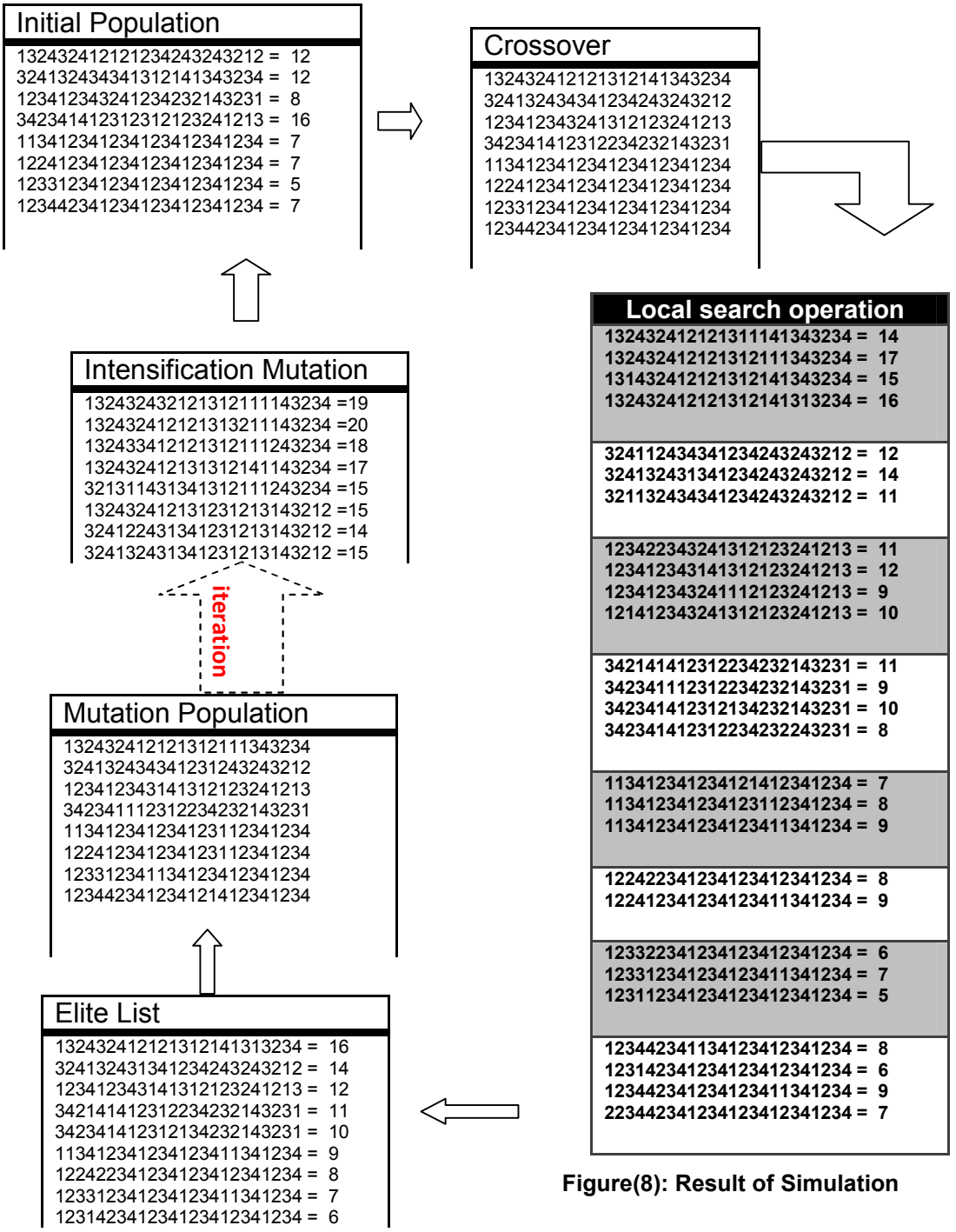
factor	value
Search space	$24^4 = 331,776$
Population size	8
Tournament factor	2
Crossover probability	0.5
Mutation probability	0.1
Stopping condition fitness	24

Table(4): summary for best solutions for 8 iterations

Iteration	1	2	3	4	5	6	7	8
GA	14	15	17	18	18	19	19	**19**
TS	15	16	17	18	16	18	19	**20**
Hybrid GA-TS	16	17	18	18	19	20	21	**21**

6. Results

The results of implementing the first iteration of the proposed algorithm are shown in Figure (8). As shown in the Figure the local search operation is feeding the elite list and the mutation population with best solution, but there is an important difference between them. The elite list stores the best solution gained from each local search operation for each chromosome in the crossover population without replication, this means that, if the best solution for the current chromosome is found earlier in the elite list, then the next best solution is considered . this check process is continue until a different solution is found. after 8 iteration the algorithm is get in premature convergence sate, and the intensification process is used to construct a new mutation population. The average time required to implement one iteration of the proposed algorithm is about (2 second) After 30 iteration the best solution found is : 134234234212134123134124 with fitness = 24 . Table (4) Lists the best solution found for GA, TS, and proposed hybrid GA-TS for (8) iterations. It is clear that the proposed algorithm finds the best solution with fitness value larger than the other algorithms, and this makes the algorithm find the best solution faster.



Figure(8): Result of Simulation

7.Conclusion

In this paper a hybrid algorithm between GA and TS was proposed . this algorithm had been used to solve the frequency allocation problem in cellular network . it was used to allocate a four set of frequencies among 24 cell in cellular area. The proposed algorithm was robust to face the problem of premature convergence in search space through the backtracking process offered in GA using the elite list and intensification process which help to redirect the search and change the mutation rule.

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حل مشكلة تخصيص الترددات في شبكات الخلوي باستخدام خوارزمية هجينة بين الخوارزمية الجينية والبحث المحرم

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المستخلص

بازدياد اعداد الاشخاص في منطقة الشبكات الخلوية يزداد الطلب على خدمات الشبكة. بالرغم من ذلك فان عدد الترددات الصالحة قليل السبب الذي يؤدي الى نشوء مشكلة توزيع الترددات بين الخلايا ومجاوراتها بدون تداخل. هذا البحث يقدم خوارزمية هجينة مقترحة بين الخوارزمية الجينية وطريقة البحث المحرم لحل هذه المشكلة . ان الخوارزمية المقترحة تدمج خصائص البحث المحلي ، قائمة ألنخبة وطريقة التكثيف من البحث المحرم في عملية الطفرة في الخوارزمية الجينية حيث ان الهدف من هذا الدمج هو الحصول على خوارزمية لها سلوك اكثر كفاءة من الخوارزميات الاساسية من ناحية ألسرعة، التعقيد ، والقدرة على التغلب على مشاكل البحث المتمثلة في الدوران في طريقة البحث المحرم والنضج المبكر في الخوارزمية الجينية. لقد اظهرت نتائج البحث بان الخوارزمية المقترحة لها القدرة على تخطي مشكلة النضج المبكر وإيجاد الهدف بصورة اسرع.

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