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A Modified Greedy Algorithm for Solving the Planification of eNodB Position in 5G network

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Abstract: *5th generation mobile networks known as 5G can provide high-speed internet connection with a very large number of connected objects, but due to high propagation loss and characteristics sensitive to blocking millimeter waves (mm waves), the deployment of such a network requires to install ultra-dense base stations (eNodB) to achieve satisfactory coverage of communication services. However, finding optimal locations for these enodBs allow reducing the construction and operating costs of this type of network ensuring a best quality of coverage. Essentially, 5G eNodB location optimization to cover the largest users can be considered as a type of maximum coverage localization problem which is considered as a NP-complete problem which cannot be solved in determinate polynomial time, we propose an algorithm based on artificial intelligence approaches which give an approximate solution for this problem. The chosen so-called greedy algorithm initially favors the most important request areas, i.e. those with the greatest number of customers; the application of this technique allows optimizing the locations of eNodB which ensures maximum customer coverage. We were able to improve the result obtained by GA by proposing a new region selection technique, which is our contribution, in order to avoid a solution that remains stuck in a local minimum. The application of modified GA on the case of the city of Tlemcen gave a better solution than that found with the GA version.*

Keywords: *5G network; radio planning; eNodB; IA; greedy algorithm.*

1. Introduction

The fifth generation of cellular mobile network (5G) offers numerous advantages compared to the ancient generations of mobile networks|1]. 5G network ensures a connectivity level which is very much higher than that offers with the LTE network. Deploying 5G networks while maintaining 3G and 4G networks operational will certainly be a new challenge for operators, especially if the expected volume on IoT is expected with the establishment of new services such as local clouds, which forces operators to plan their networks well, especially since this generation of networks operates in high frequency bands, which reduces the range of the signal and is therefore a massive use of eNodB is required to have good coverage. To cover the same area as traditional cellular networks (2G, 3G, and 4G), the number of 5G base stations (BSs) could be tripled[2]. Another challenge for the rollout of 5G is posed by concerns about power consumption. In the pre-5G era, information and communication technology already consumes 10% of energy worldwide[3,4].

There are numerous and important complex problems in 5G that needs to be solved efficiently like the problem of resource management [1, 5], the problem of planning and dimensioning [6], the problem of antenna positioning and selection [7], the problem of optimal routing [8,9,11], the problem of Inspection of the Cellular Networks Relays[10], and so on.

These problems are also characterized by the great number of possible solutions. In theory, they are called NP-hard combinatorial optimization problem and can be solved by using meta-heuristics approaches, like the genetic algorithms that were used for example in [9] to solve the problem of radio frequency planning problem. IA can also intervene in the test of the quality of service provided by the mobile network by the use of intelligent drive tests as described in [12].

We are interested by the eNodB pacification Problem. The latter consists in finding the locations for the base stations which ensures coverage of maximum customers, it's an optimization problem. In this work, we present an metaheuristic to solve the presented planification Problem. First we adapt the greedy algorithm prensented in [13] with our problem and we propose in the second an improved version of this algorithm.

The remainder of this paper is organized as follows: in the next section, we present a formulation of the presented problem. Then, in section 3, we present the optimization algorithms used to solve the problem. In section 4, we present the experimental study carried out on three instances, one of them is realistic. In the conclusion we present some perspectives.

2. Formulation of the 5G BS Optimization Problem

Our aim is to maximize coverage (population covered) for a given region i within a desired service distance S by locating a fixed number of facilities Pi allowing to cover the region i. Will designate this problem as the maximal covering location problem.

The maximal covering zone problem seeks the maximum population which can be served within a stated service distance or time given a limited number of facilities. A mathematical formulation of this problem can be stated as follows :

$$\text{Maximiz :} \quad C = \sum_{i=1}^{N} Ci * Yi \qquad (1)$$

With

C: is total consumer covered;

Ci : population size in area i;

Yi= 1 if the region is covered

0 else;

N : Designate the number of area.

where Ci is the expected number of users in zone i . Yi is a ballan value equal to 1 if zone i is covered by the 5G network. p is a constant determined by the Deciders, and it represents the maximum number of eNodB to be installed in the study area. Pi is the number of eNodB needed to cover area i , Usually the value of Pi for each area is determined by prior knowledge according to the area of the study area and the distribution of buildings to achieve satisfactory coverage.

3. Algorithm of Optimization and Resolution Method

To solve the optimization problem described in the previous section, we propose to use in the first phase the called the Greedy Adding (GA) Algorithm. In order to achieve a maximal cover population by P facilities, the algorithm starts with an empty solution set and then adds to this set one at a time the best facility sites. The GA algorithm picks for the first area that site which covers the most of the total population. For the second region, GA picks the site that covers the most of the population not covered by the first selection. Then, for the third region, GA picks the site that covers the most of the population not covered after exclusion of sites already covered. This process is continued until either P facilities have been selected or all the population is covered. Details of the algorithm are given in [14], and that we have implemented it as is shown by Fig 1.

```
Function GA(C: set of region; Pzone: set of number installation;
P: number of eNodB designed by decider): set of regions
Begin
P:_used=0
S : solution initialized at empty
C: set of region
Repeat
  region= choose_the_region_with_max_population(c)
  p_used=p_used+ Pzone (region)
  if p_used(region)<=p then
            Add_to_solution(s,region)
            delete_region(c,region)
  endif
  until(p_used>=p)
return S
end.
```

Fig.1. Ga Algorithme.

the GA function has as a parameter the array C , in each case of this array is stored the estimated number of users in the zone i , the second parameter is another array named Pzone which stores the number of eNodB necessary to cover by a reliable connection each area of the study region. P is the available number of eNodBs to be scheduled. the GA function returns an array containing the areas to cover.

4. Case Study

4.1. Study Area and Data

We present a case study that attempts to cover part of the city of Tlemcen ,located in the northwest of Algeria, 520 km west of the capital Algiers. The region chosen for the test is completely covered by the LTE network, we propose a method to cover by the 5G network the ultra dense areas which have more users, table 1 shows the characteristics of each area which are :

- the estimated number of users in a given area and which is calculated from statistical data provided by telephone operators in the case of the LTE network.

- the number of eNodB reserved to reserve the region concerned, which is already calculated according to the number of users planned to use this network and the geographical characteristics of this zone.

Figure 2 shows the areas that are chosen for 5G network coverage which are surrounded by circles, each area has a number. we note that the densest areas located in the city center are numerous and small in size due to the geographical characteristics of this region which constitutes a large number of buildings and users.

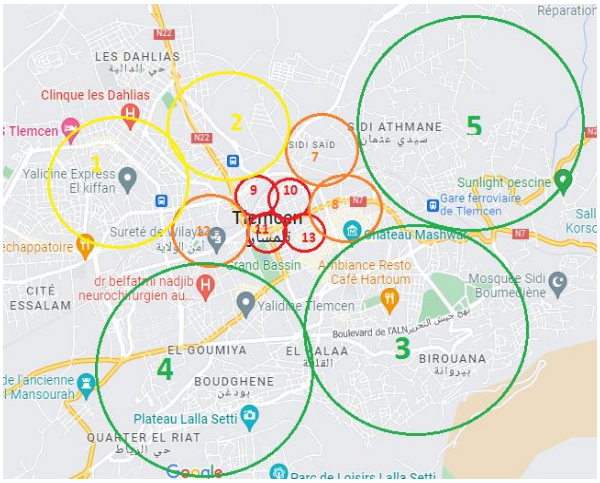
In our case study, we have 13 areas already covered by the LTE network , we want to find the combination of areas to be covered by the 5G network using P eNodB which are available, to cover the maximum number of users.

The number of eNodB reserved for each zone is calculated according to tree criteria which are

-The geographical nature and the density of buildings in the area, therefore the ATOOLS software is used for calculate the 5g signal.

- The estimated number of users in each area.

- The technical characteristics of the eNodB used in terms of the maximum number of users that can be served. For example if the nature of buildings in a region requires the use two eNodB to have accepted coverage, and each eNodB has a capacity to serve 100 users together, therefore the use of two 2nodBs that are not enough to serve 280 users in this case the addition of a third eNodB is necessary.




```
Function ModifiedGA(C: set of region; PZone: set of number installation;
 P: number of eNodB designed by decider): set of region
Begin
S =GA(C,PZone,P);
P_used=0
Repeat
   Region= shearch_the_region_with_max_population(s)
   //searche of area with max of population to replace
   delete_region(s,region);
   p_used=p_used-PZone(region)
   repeat
        choose_the_region_with_max_population(c)
        p_used=p_used+PZone(region)

        if(p_used<=P) then
                        Add_to_solution(s,region)
                        delete_region(c,region)
        endIf
   until(p_used>P)
end.
```

Fig.2. Study area

Fig 3. The Modified GA

The estimated number of users, and the number of eNodB that provide reliable coverage for each area is shown in Table 1. In our case study, we have 13 areas already covered by the LTE network , we want to find the combination of areas to be covered by the 5G network using P eNodB which are available, to cover the maximum number of users. The number of eNodB reserved for each zone is calculated according to tree criteria which are:

-The geographical nature and the density of buildings in the area, therefore the ATOOLS software is used for calculate the 5g signal.

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TABLE I: Information areas

Area	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
C	260	220	360	600	480	380	200	180	80	80	80	192	88
PZone	2	2	4	7	6	5	1	1	1	1	1	2	1

We have a several possible solutions for example: when P= 28 eNodB we can choose the regions : 1,2,4,5,7,8,9,10,11,12,13 . This solution requires exactly 28 eNodB and it provides coverage 11 regions of 13 regions with a total of customers equal to 2460 customers of 3200 possible customers, this solution seems good but it is not the best. The application the greedy algorithm give a best solution, the regions : 1,2,3,4,5,6,7,8 are choosed, and 2700 customers are covered. The choice of zones was made by selecting the regions which had the greatest number of customers.

4.2. The Modified GA

Sadly, this algorithm does not always give an optimal solution, and in some cases it returns a local optimum.We propose an improvement of the greedy algorithm. We note that the selection of the area i with the maximum population excluded the choice of several other regions.

our contribution is therefore the proposal of a modification of GA in order to improve its result. The idea is therefore to see if the replacement of this area by a subset e formed of the regions which are not chosen improves the result then the area i will be replaced by the subset e else we keep the region e and we use the same process to replace the next region which has a maximum population by another subset and we stop the search when we do not find a better solution after several replacement attempts.

We see that the solution 1,2,3,4,6,7,8,9,10,11,12,13 is better that the solution obtained by de GA algorithme, it cover 2780 users

Modified GA algorithm has replaced region 5 which has 120 customers by the subset of regions formed by the regions: 9,10,11,12,13 and we note that the sum of the population of this subset is equal to 130 customers, we also notice that region 4 which has 150 customers has not been replaced because there is no subset which replaces this region and which can improve the solution.

The modified GA algorithm starts from the solution found by GA and tries to improve this solution by replacing the zones which require a large number of eNodB with a set of zones which are not in the solution and which require less facilites provided that such replacement increases thenumber of customers covered.

To see the efficiency of each algorithm, we ran them for several values of P, we set the initial value of P equal to 4 and then, P was gradually increased to 36 in steps of 8. Table 2 shows the obtained results for each value of P, we notice that the modified version of the GA algorithm gave better user coverage.

We also see that from a given value of p for which GA and modified GA will be equivalent, we can explain this situation that apart from a value of P , the eNodB available are largely sufficient to cover all users, we notice as it is illustrated in figure 3 that for P=36, we can obtain 100% user coverage, this is logical because 36 eNodB is greater than the number of eNodB necessary to cover all customers.

TABLE II: Obtained results of GA and Modified GA

P	*Areas selected with GA*	*Areas selected with Modified GA*	*User coverage with GA*	*User coverage with Modified GA*
4	3	1-7-9-	11%	20%
12	4-6-	1-2-7-8-9-10-11-12-12	30,62%	44,12%
20	1-4-5-6	1-2-3-6-7-8-9-10-12-13	53,75%	63,75%
28	1-2-3-4-5-6-7-8	1-2-3-4-6-7-8-9-10-11-12-13	83,75%	87%
36	all areas are selected	all areas are selected	100%	100%

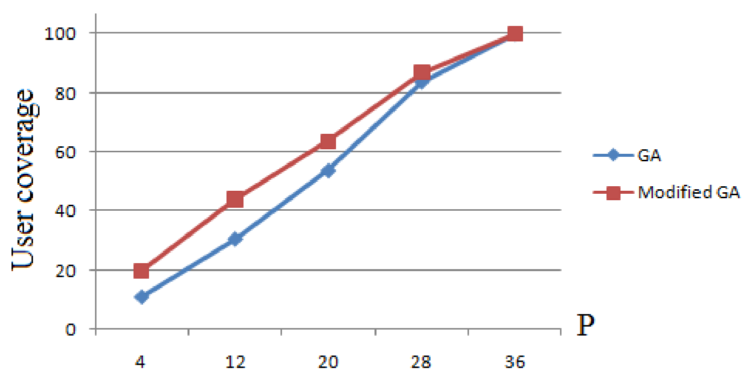

Fig 4.The results of GA and Modified GA

5. Conclusion

This research paper shows how the use of artificial intelligence can help find a better solution to plan eNodB locations to cover a maximum population. we therefore proposed to use the greedy algorithm which gave a good solution and to avoid having a local minimum which is an incovenion of GA we proposed the modified GA which improved the result of GA. As a perspective of this work, we want to use a genetic algorithm that ensures to really approach the optimal solution, this type of algorithm requires starting from a good initialization so that we can initialize this algorithm by the result obtained by modified GA..

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