

Base Station Location Modeling and Signal Coverage Optimal Design Based on Genetic Algorithm

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Abstract. With the development of mobile communication technology, the rapid information transmission of 5G communication technology at this stage is full of It meets people's increasing communication needs, but its large bandwidth and small base station coverage make the planning problem of communication network more and more complicated. Therefore, it is particularly important to optimize the deployment of base station location selection. The problem is a regional clustering problem based on distance and density, and the object of clustering is the given weak coverage points that exist in the area. The severity of the signal loss of each weak coverage point is visualized through the heat map, and each weak coverage point is defined as a label based on two levels of "signal loss degree" and "distance between sites", and then aggregated by DBSCAN. The class model performs hierarchical label search, and groups the points with the same two-layer label into one class, so as to realize the density-based regional clustering of weak coverage points. The model combines hierarchical clustering and density clustering to achieve the effect of multi-layer synchronous density clustering, making it faster in processing, and in terms of clustering results, the degree of signal loss and point distance Carry out more comprehensive clustering, so that the finally obtained clustering area points have stronger interrelationships and achieve better clustering effect.

Keywords: Genetic Algorithm, DBSCAN Region Clustering, Mobile Communication, Delaunay Triangle.

1. Restatement of the problem

In the information age, mobile communication network, as the carrier of information transmission, plays a pivotal role in urban construction and development, while the efficient deployment of broadband network is a prerequisite for quickly obtaining the latest information resources. However, with the rapid development of mobile communication technology and the increasing people's demand for communication, the development of the new generation of communication technology 5G, its large bandwidth and small base station coverage make the planning of communication network become more and more complex, and the design of site selection is more and more difficult. In order to minimize the area with weak signal coverage and meet the communication needs of urban construction, it is very important to strengthen the planning and construction of mobile communication base station. But on the site selection of new base station, need to meet the needs of larger communication coverage and cost problem, but also need to consider the bearing capacity of the city, avoid intensive base station layout of electromagnetic radiation on people's life, and in the construction layout and harmonious unity of urban landscape. Therefore, how to plan the deployment and construction of new base stations to better serve the urban development is of great significance in the process of modern society.

We need to build mathematical models to solve the following problems:

(1) to make 90% of the total business volume of the weak coverage points in the given area covered by the planned base station, please plan the site reasonably, Give the coordinates of the planned new site and the type of base station selected for each site;

(2) according to the actual situation, Since each station is not fully round covered, Instead, each station has 3 sectors, Each sector has the maximum coverage in the main direction, That is, the Acer station is 30, microbase station is 10, And within about 60 degrees in the main direction, Its coverage shrinks linearly, The coverage at 60 degrees is half of the coverage in the main direction, A range

beyond 60 degrees Celsius cannot be overridden; And the angle between the main direction of any two sectors of each station should not be less than 45 degrees. Based on the above conditions, whether the optimal site and sector angle can be planned, so that the new station can cover 90% of the total business volume of the weak coverage point. If possible, give the results of the optimal site and sector angle; not, give the results of the optimal site and sector angle and the proportion of the total business volume of the weak coverage points that can be covered;

(3) regional clustering of the weak coverage points to achieve separate management of different weak coverage areas. If the distance of the two weak coverage points is not more than 20, the two weak coverage points gather into one class; and the clustering 2 page 50 pages, that is, if A, B and B and C are one class, A, B and C are one class. Please cluster all the weak coverage points, and make the total time complexity of the clustering method as low as possible.

2. Model assumptions

Suppose the signal strength of the base station is the signal strength of the three sectors; In the distance calculation, the calculated distance is the horizontal linear distance; If the weak coverage point is covered by the signal of the new base station. The signal strength of the point covered by multiple base station signals is the sum of each base station signal, and there is no interference between the signals.

3. Problem analysis

This problem belongs to a discrete optimization problem in space, which is essentially a multi-objective under certain conditions. The problem to be solved is to make the site selection and layout of new base stations in the range of weak signal coverage of existing base stations in a given area, taking into account the distance threshold between each site, the shape of the coverage area formed by a single site, and the cost of building a site. constraints to achieve the design optimization problem of maximizing coverage for weak coverage areas. Problem 1 Taking the circular base station coverage as the condition, according to the multi-objective genetic algorithm combined with the establishment of the new site location and the selection of the base station type with the traffic volume as the dominant factor, the optimal plan for the layout design is made to realize the Minimize the cost of building the station to maximize the signal coverage; the second problem is that on the basis of the first question, the limited conditions are given for the coverage of the base station, and the original large circular area is reduced to three coverages A sector where the domain decreases linearly with the radius by a value of $1/2$. Therefore, it is necessary to add constraints on the relationship between the point distance and the azimuth angle of the base station to the constraints of the model built in the first question to evaluate the coverage effect of the newly built station. The third problem is the regional clustering of weak coverage points based on their distances. According to the key condition of "distance not greater than 20" set in the question, an appropriate clustering model is selected, and the model is optimized to achieve a simple and faster regional clustering.

4. Model establishment and solution

Problem 3 is the regional clustering problem based on distance and density, which are the weak coverage points existing in the given region. In the thermal map of the signal coverage of the weak coverage areas, the severity of the weak coverage points can be evaluated, the signal coverage of the weak coverage points, and the signal loss degree is divided into three categories: "severe signal loss", "moderate signal loss", "mild signal loss", and grades 1,2 and 3 indicate the severity of different signal loss are set. The first layer of labels for each weak cover point is then clustered by the distance-based clustering condition set in the topic, that is, to determine whether the distance between two weak cover points with the same first layer label is greater than 20, and set the distance of two points to the second layer label. If not greater than 20, the two points have the same second layer label, otherwise,

different labels are affixed. Finally, by the DBSCAN clustering model, the points with the same two-layer labels are clustered into one class, realizing the density-based regional clustering of the weakly covered points. The overall idea is shown in Figure 1.

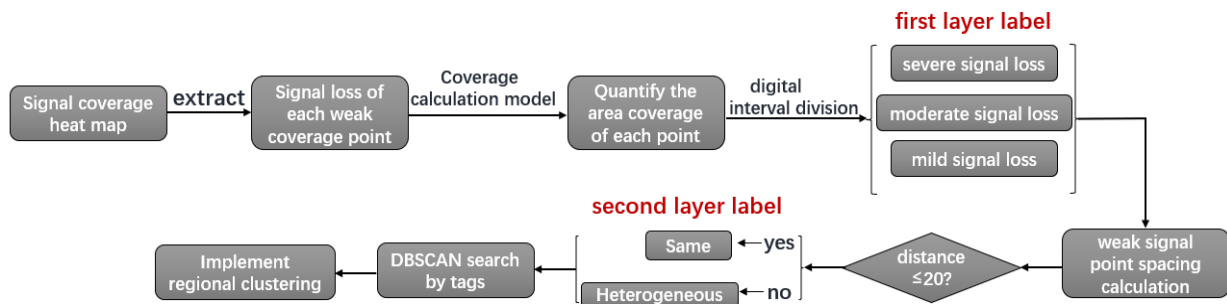


Figure 1. Flowchart of the full text idea

5. Model improvements

5.1. A simplified analysis of the number of existing sites based on the Delaunay adaptive triangle profile model

In order to more efficiently quantify and evaluate the coverage of the existing base station signals more efficiently, and to evaluate the coverage of the new base station layout of the new site added one by one, the number of existing sites should be reasonably reduced. Therefore, we divided the given region into multiple triangles with existing site points as vertices through a Delaunay triangle section model adapted to the base station location. Since the area closer to the base station will have a higher signal value coverage, the given area can be divided into signal intensity area and non-intensity area, and a threshold needs to be set for division. According to the intensity of the adaptive triangle in the high intensity area sparse point, low intensity area, and Delaunay section of the area into larger triangle, to realize the signal intensity of any point in the whole area by the base station signal index at the triangle vertex to simplify the calculation, Figure 2 is the reduced base station signal coverage triangle network.

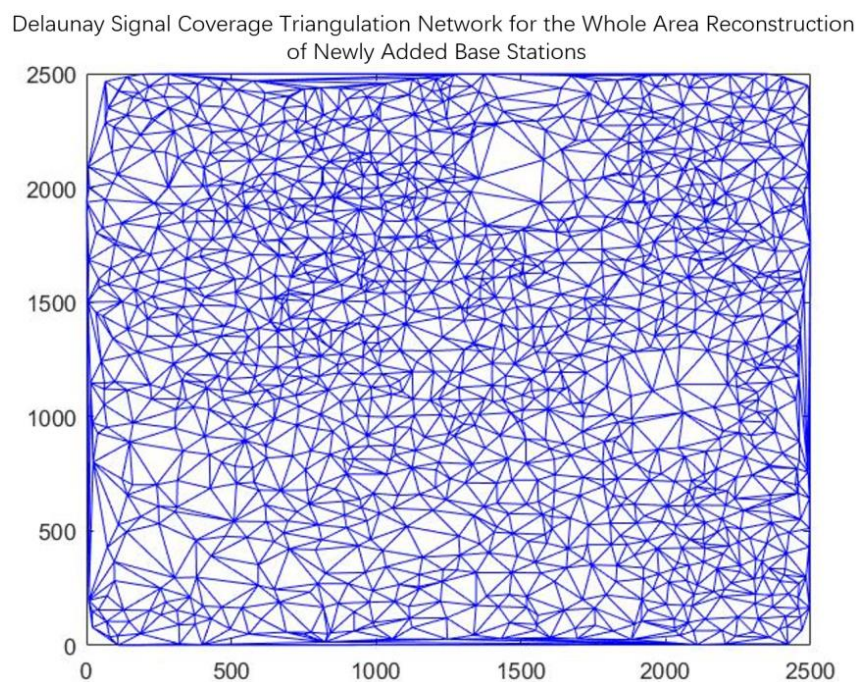


Figure 2. Overall area of the new base station reconstructed Delaunay signal coverage triangle network

5.2. New site optimization model and problem modeling based on GA Model

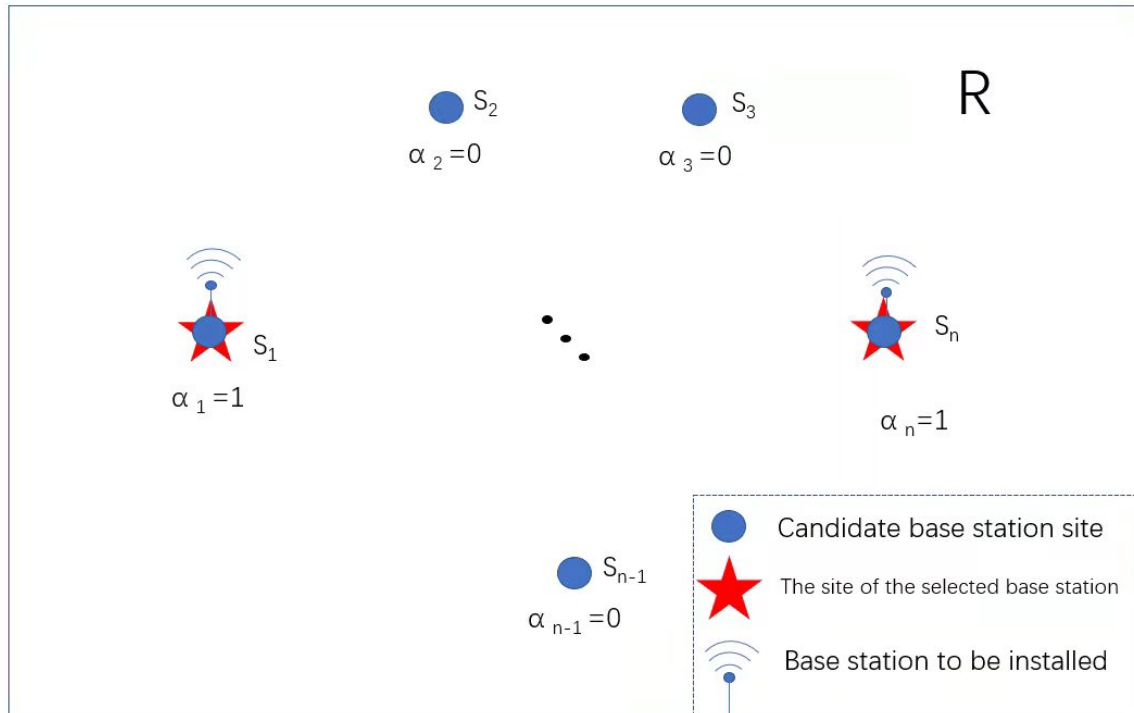


Figure 3. Schematic diagram of weak coverage points and site selection points in the given area

To meet the signal repeat coverage as small as possible, it is assumed that any geographical location can be covered by only one base station. Therefore, the coverage area C_i , $1 \leq i \leq n$ of all base station sites is mutually exclusive, so that for any two weak coverage points, S_p and S_q . In order to meet the target condition of the coverage Cover function that maximizes the total effect of the site selected from S , so the optimization model expression for this problem is as follows:

$$\max_{\alpha} \text{Cover}(\alpha) = R \cap \left(\sum_{i=1}^n c_i(\alpha) \right)$$

5.3. Computational model of the sector coverage domain based on the gradient descent algorithm

Gradient descent algorithm is used to calculate the coverage of each sector of the base station to improve the calculation of continuous values in the coverage optimization problem. When calculating the regional coverage of the sector, the linear search in the gradient direction is conducted by gradually reducing the local gradient information of the sector in the main direction as the leading search direction, and the search result normalization process so that the result is still available in the (0,1) value range of the problem one model. Only the probability of the original model is measured with a continuous value between 0 and 1, and the continuous value makes the target function can be derived to realize the gradient calculation.

Comparing the two quantified values, the effective total Angle of the three sectors covered by the base station is added as the selection standard of macro and micro base stations. For the simplification of the selection, When considering the coverage domain of the two base stations, Record only the maximum sector angle in the three sectors per base station, The optimization value uses 3 times the maximum angle optimization value to replace the total optimization value covering the three sectors of the base station as its selection condition, That is: the average optimization value of the maximum sector angle coverage optimization value * 3/30 * 30 block and the average optimization value of the maximum sector angle coverage optimization value of the current point micro base station * 3/10 * 10 block of the average optimization value of the coverage area; Compare the two value sizes, The base station type is the base station type of the current point.

After the base station type of each new base station is determined, the signal coverage of the given area is calculated from the quantified coverage according to the coverage calculation model in the first question. After code operation, the coverage of the new station accounts for 95.7787513109654% of the total business volume of the weak coverage point, reaching the requirement of 90% of the total business volume of the weak coverage point. Specific code appendix: "Problem 1: Overlay calculation model code", see the supporting material: "Problem 1: Overlay calculation model code operation result diagram". The specific site selection results are shown in the calculation result document "Second Question Results of the optimal site and sector Angle".

5.4. Label classification based on the degree of missing signal

Since any weak coverage point is affected by varying degrees of the signal coverage of the surrounding number of built base stations, the length of the actual geographical distance and the signal but also the actual intensity should be considered in determining the optimized cluster. However, the coverage calculation model constructed by the first two questions in the evaluation of the signal coverage of the weak coverage area gives the quantified signal coverage of each weak coverage point, and the signal coverage of each point is given by the visual heat map. Therefore, the missing degree of the signal of each weak coverage point can be graded based on its coverage rate: the interval threshold of each level is established based on the number domain intensity of the signal coverage of all weak coverage points, that is, the gradient division of all coverage values, normalize the sum of the values of the divided primary area, and results the threshold coefficient c of the final number interval. For the establishment of c , we used the code to simulate and determine the multiple thresholds. The specific regional threshold division model code is shown in the appendix: "Question 3: level division threshold code".

5.5. Classification of distance labels based on the automatic point-finding growth triangle net

According to the clustering conditions set in the topic, by calculating the separation distance between the weak coverage points, if it is within the interval of 20, the two points are clustered into one class, and the next target point is automatically searched for the triangle structure network. The resulting triangle network is clustered as a whole into a class to realize the nature of cluster transitivity.

In order to facilitate the screening and classification of the points by the subsequent DBSCAN model, More about the search and clustering work, To achieve faster classification results, Adding the first layer label identification module when defining the second layer label for each weak coverage point, Taking the signal absence degree label of the first layer as one of the judgment conditions to define whether the second layer is a similar label, If the two points have the same first label that meets the distance requirements of the second layer, The second layer of label defined as "similar" can be used as the final screening tag of the DBSCAN model; If the first and second floor labels do not meet the conditions simultaneously, Then it is classified by DBSCAN. More comprehensive and effective regional clustering is realized by defining two layers of labels for each weak coverage point as their clustering basis to better solve the weak coverage problem.

5.6. Regional clustering of the density-based DBSCAN clustering models

The two hierarchical labels of each weak coverage point were initially classified by the DBSCAN model, The special properties of the second layer label model incorporating the level of missing label signal set by 5.3.2, therefore, The DBSCAN model directly converges on the weak coverage points defined by the second layer label that can serve directly as the final point screening label; For the first and second layer labels, That is, the degree of signal loss of the selected point does not belong to the same ladder as the two characteristics of the distance, When a simple division is impossible, DBSCAN models for level by level label lookup, Two labels are weighted by the weight coefficients set within the model, To determine the final coverage missing metric value for this weak coverage point.

Therefore, these three factors can define the "separation length" of the DBSCAN model, Then, the weak coverage points of the given region are clustered by the search target with the signal coverage of

the respective points, Select a certain weak coverage point in a subtriangular block domain, A constant search of its surrounding points, Associate the missing metric value within the same threshold, For the cluster convergence, To gradually increase the density around the selected point, Until the weak coverage point density in a formed cluster subcell reaches its threshold set based on the density parameters of the given global region, To form the final clustering results. For specific operation code, see Appendix: "Question 3: Regional clustering algorithm based on DBSCAN model". The final clustering result diagram is shown in Figure 4.

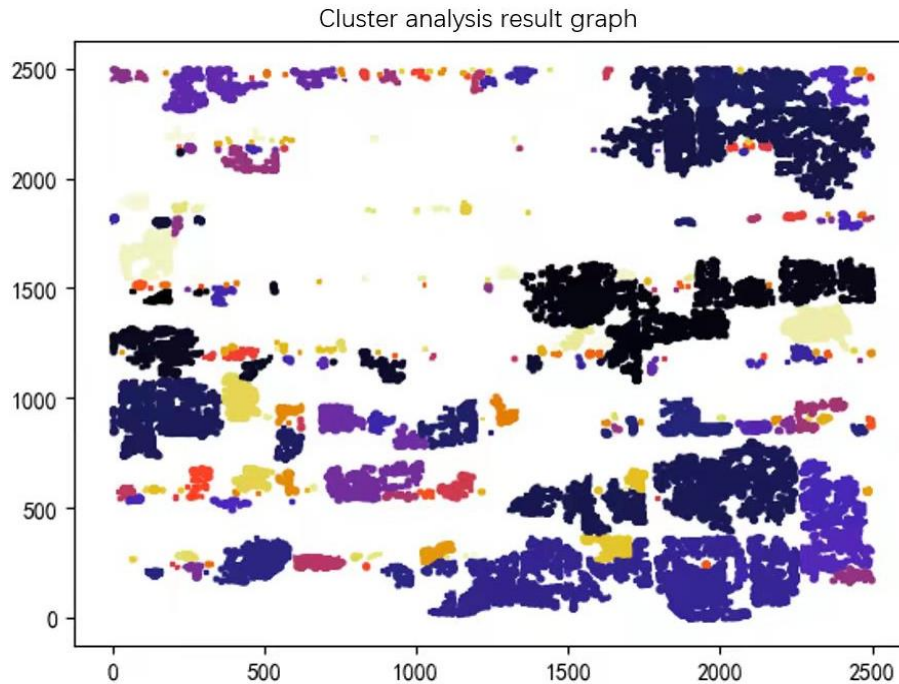


Figure 4. Cluster analysis result graph

By DBSCAN clustering model in two levels of synchronous work and cluster convergence, increase in time to its running speed, and on the clustering results, from the degree of signal missing and point clustering, so as to realize the cluster area formed the point correlation is stronger, make the regional separate management more targeted, the management and solve the problem of weak coverage effect is better.

6. Promotion and application of the model

6.1. The innovation point of the model

(1) The data results obtained by the model are expressed in heat map, scatter map, etc., and the signal coverage of the region is given by the visual coverage map to make the coverage effect displayed more intuitively.

(2) The clustering model in the third question, by the point with two labels to define the similarity between the points, combining hierarchical clustering and density clustering, make density-based DBSCAN clustering model through the label level in the front of the two levels of synchronization and cluster convergence, thus increasing its speed in time, on clustering results, with the degree of missing signal and point clustering two more comprehensive clustering.

6.2. Shortcomings of the model

(1) The DBSCAN clustering model uses parameters based on the global representation density, therefore, for large areas, although the hierarchical label module is added in front of the model to reduce the discrimination time of point similarity, the number of points in larger areas is large, which increases the amount of data it processes and reduces the operation efficiency.

(2) For the clustered regions, if the distribution density of points within the region is not uniform and the distance between clusters is large, the representativeness of the internal density based on the global average decreases, so that the final clustering effect is poor.

7. Improvement of the model

For DBSCAN in regional clustering is based on the density parameters of the region, and the uneven distribution of areas with poor clustering effect, can add the empty convolutional layer module in the DBSCAN model, by extracting eigenvalues, both reduce the amount of data, and retain the signal coverage of the subregion. According to the types and number of empty convolutional cores in the given region, select the regions of each convolutional kernel, divide the region and set the density parameter of the DBSCAN model for the divided region is larger than the clustering effect.

8. Extension and application of the model

The base station site selection model based on signal coverage intensity synthesizes more comprehensive and diversified influencing factors, and finally realizes the coverage of over 95% of the total business volume of the weak coverage point in the given area, so the point optimization degree of the selected site and the design accuracy of the sector Angle are high. The model has important implications for areas such as optimal location of other service facilities in the society. Arrange poverty alleviation policies and the order of the assistance according to the poverty level, show the regional poverty reduction level by the heat map to directly reflect the effectiveness of poverty alleviation policy, and deploy new poverty alleviation policies to realize the blueprint of common prosperity in modern society.

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