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Planning and Design of Mobile Communication Network Site

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Abstract

With the rapid development of mobile communication technology and the continuous expansion of operation scale, the communication network becomes more and more complex. How to reasonably plan the location of base stations according to the existing weak coverage points has always been a difficult problem. By establishing a mathematical model and using the method of computer simulation, this paper optimizes the selection of station site and regional division. Considering that the establishment of the base station should meet that 90% of the traffic of the weak coverage points should be covered by the planned base station, and considering the loss and construction cost caused by repeated coverage, this paper takes the minimum total construction cost and the minimum repeated coverage as the optimization goal, and establishes a multi-objective programming model under the condition of meeting the priority coverage of the weak coverage points with high traffic, The corresponding solutions for station location selection and area division are given by using the method of computer simulation.

Keywords

Site Selection; Multiobjective Programming; Mobile Communication.

1. Introduction

With the development of 5G, the bandwidth of communication becomes larger and larger, but the coverage of base stations becomes smaller and smaller, which makes the number of base stations needed to cover the same area become more and more. In addition, the types of base stations and antennas are more complex. This makes the problem of base station location selection more and more complex. In the actual network planning, considering the construction cost of the base station and some other factors, it is necessary to give priority to the weak coverage area with high traffic. Moreover, with the development of 5G technology, the current network base station is difficult to meet people's needs for mobile networks. Many areas are not covered or located around the coverage, resulting in unstable signal strength received by the terminal and poor air interface quality, which is difficult to maintain the normal needs of surrounding residents or enterprises. This requires corresponding strategies for the site planning of new stations.

2. Station Site Planning Scheme

2.1 Site Selection Principle

Whether the selection of base station location is appropriate or not has a great impact on the network performance and network operation. Unreasonable site location may not only lead to the phenomenon that some areas are still weak coverage areas, but also lead to the cost of re establishing base stations to solve this phenomenon in the later stage. Therefore, the following basic principles should be observed when selecting a base station location [1].

(1) The site division of the base station shall fully meet the requirements of network traffic volume and service distribution. The base station distribution is consistent with the traffic density distribution.

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The base station shall be limited to meet the areas with high traffic volume, and the established base station shall meet the requirements that the total traffic of weak coverage points shall be covered by the planned base station as much as possible. Take more than 90% as an example.

(2) The distance between the established base station and the existing network base station should be greater than the threshold value, where the threshold value is D, and the distance between the newly established base stations should also be greater than this threshold value.

(3) When establishing a base station, the coverage of the base station should be selected at the same time. Assuming that the coverage of the base station is D and the coordinates of the points planned by the base station are $p(x_0, y_0)$, for the points with coordinates of $p(x, y)$, if$|p - p_0| \leq d$, the point is considered to be covered by the base station, and the responsible person considers that it is not covered.

(4) The cost of base station construction should be reduced while meeting the demand, and on this basis, the repeated coverage area should be reduced as much as possible. The repeated coverage of signals between base stations will not only affect the quality of signals, but also lead to the increase of cost caused by the repetition of coverage area.

2.2 Establishment of a Single Base Station

In order to improve this problem, a certain number of points are selected for the weak coverage area of the existing network according to the coverage of the existing network antenna, so that the coverage problem of the weak coverage area of the existing network can be solved after a new base station is built on these points. There are two types of base stations established in the weak coverage area: macro base station and micro base station; The traffic volume of different demand points is different, which will lead to different requirements for the selection of new base stations. For the point with large traffic, it may be difficult for one base station to meet the service level of the region, which requires the establishment of multiple base stations near the point to meet the normal service requirements around. That is, a demand point may come from the supply of multiple base stations, and a base station will also supply multiple demand points.[2].

Two 0-1 variables X are introduced herex_j, S_j (respectively indicating whether to choose to establish macro base station and micro base station); Then for the demand point$i$, it should meet the following requirements:

$$\sum_{j \in B} y_{ij} + \sum_{j' \in B'} y_{ij'} = 1 \; (i \in N) \tag{1}$$

Where y_{ij} is the demand of the jth macro base station to meet the demand point I and the demand D of this point_ Ratio of I, $y'_{ij}$is the demand of the jth micro base station to meet the demand point i and the demand D of this point_ I, then the sum of the supply ratios of all micro base stations and macro base stations should be equal to the demand, that is, 1. It should be noted here that set n is the set of all demand I, that is, it contains all demand points; Set B is the set of coordinate points of all newly established macro base stations; Set $B'$is the set of coordinate points of all newly established micro base stations.

Moreover, the premise that the demand point I can be served is that the service point can be covered by the established new base station. Then, for the macro base station, the distance between the coordinates of the point and the established base station should be less than the coverage range T, and for the micro base station, the distance should be less than the coverage range P, that is:

$$0 \leq \sqrt{\left(\alpha_j - \alpha_i\right)^2 + \left(\beta_j - \beta_i\right)^2} \leq \mathrm{T}(j \epsilon B) \tag{2}$$

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$$0 \le \sqrt{\left(\alpha_{j'} - \alpha_i\right)^2 + \left(\beta_{j'} - \beta_i\right)^2} \le \mathrm{P}(j \epsilon B') \tag{3}$$

Where(α_i, β_i) Is the coordinate of demand point I. for a demand point that is not necessarily supplied by one base station but may come from multiple base stations, demand point i should be within the coverage of all supply base stations J in order to meet the coverage conditions.

When establishing a new base station, it is necessary not only to consider the demand at this point, but also to ensure that the distance between the new base station established at this point and the existing network base station is greater than the threshold value, that is:

$$\sqrt{\left(\alpha_{j_{all}} - \alpha_p\right)^2 + \left(\beta_{j_{all}} - \beta_p\right)^2} > 10(\forall j_{all} \epsilon B_{all}, \forall p \epsilon P) \tag{4}$$

Where(α_i, β_i)The current set of base stations represents the set of base stations, and P represents the set of base stations. It should be noted here that both macro base stations and micro base stations should meet the threshold problem in the establishment process, that is, the distance from the current network base station is greater than D. for convenience, a new set B_{all} is introduced here:

$$B_{all} = B \cup B' \tag{5}$$

Where B_{all} is the set of coordinates of all macro base stations and micro base stations.

2.3 Establishment of Multiple Base Stations

When a base station is built and the next new base station is built, the previously built base station can be considered as a part of the existing network base station for the next new base station. For this base station, it should not only meet the threshold problem with the original existing network base station, but also meet a threshold problem with the previously established base station, that is:

$$\sqrt{\left(\alpha_{j_{all}} - \alpha_{j_{all}+\Delta j_{all}}\right)^2 + \left(\beta_{j_{all}} - \beta_{j_{all}+\Delta j_{all}}\right)^2} > \mathrm{d}, (\forall j_{all} \epsilon B_{all}, \forall (j_{all} + \Delta j_{all}) \epsilon B_{all}) \tag{6}$$

A variable Δj_{all} is introduced here, $(\alpha_{j_{all}}$,$\beta_{j_{all}})$ refers to the coordinates of the base station to be established, so the coordinates of the other new base station points out of the point are$(\alpha_{jall+\Delta jall}$, $\beta_{jall \ \ \Delta jall})$, which realizes the threshold problem between new base stations.

Since the stations to be supplied by each base station are not unique, it is necessary to consider the problem of a gate valve, that is, the maximum supply for macro base stations and micro base stations. Regardless of the demand, the amount that macro base stations and micro base stations can supply is certain, so the total amount supplied by base station J should be less than the gate threshold, that is:

$$\sum_{i \in A} y_{ij} d_i \le C_j x_j (j \epsilon B) \tag{7}$$

$$\sum_{i \in A'} y_{ij'} d_i \le C_{j'} S_{j'} (j' \epsilon B') \tag{8}$$

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Where, $y_{ij}d_i$ represents the supply of a single demand point I, and set a represents the set of all demand points supplied by macro base station J, then for $\sum_{i\in A} y_{ij}d_i$ the total supply of macro base station J is obtained, C_j is the proportion coefficient of the supply-demand relationship threshold of Acer station, then C_jx_j is the gate threshold of Acer station. The same is true for micro base stations. $C_j$and $C_{j'}$ here we give a current range: $Q \le C_j \le 3Q$, where Q is the traffic volume of the weak coverage point with the largest traffic volume in the covered area.

For the newly built total base station, the original intention of the establishment is that 90% of the total traffic of the weak coverage point can be covered, that is, the sum of the percentage of the total traffic provided by the macro base station and the percentage of the traffic provided by the micro base station should be greater than 90%, that is to meet the following requirements:

$$\sum_{i\in N}\sum_{j\in B} y_{ij}x_j + \sum_{i\in N}\sum_{j\in B'} y_{ij'}S_{j'} \ge 90\% \tag{9}$$

3. Results

The essence of base station location lies in how to take the minimum cost m as the optimization objective, so here the minimum cost of the built base station is taken as the objective function:

$$\min \quad M = \sum_{j} 10\, x_j + \sum_{j'} S_{j'}\ (j\epsilon B, j\epsilon B') \tag{10}$$

In order to reduce the loss caused by repeated coverage of the base station, the optimization goal is to minimize the total repeated coverage r for each demand point:

$$\min \quad R = \sum_{i\in N}\sum_{j\in D(i)} x_j + \sum_{i\in N}\sum_{j\in D'(i)} S_{j'} \tag{11}$$

Where, set $D(i)$ represents the set of macro base stations covering weak coverage point I, and $D'(i)$ represents the set of micro base stations covering weak coverage point I.

Here, it is considered that the demand is in direct proportion to the number of base stations, that is, when the demand is large, the number of base stations supplied will also increase. Therefore, to sum up, the following station site planning scheme can be obtained:

$$\min \quad M = \sum_{j} 10\, x_j + \sum_{j'} S_{j'}\ (j\epsilon B, j\epsilon B')$$
$$\min \quad R = \sum_{i\in N}\sum_{j\in D(i)} x_j + \sum_{i\in N}\sum_{j\in D'(i)} S_{j'}$$

$$s.t.\begin{cases}\sum_{j\in B} y_{ij} + \sum_{j'\in B'} y_{ij'} = 1\ (i\in N)\\ 0 \le \sqrt{(\alpha_j-\alpha_i)^2+(\beta_j-\beta_i)^2} \le \mathrm{T}(j\epsilon B)\\ 0 \le \sqrt{(\alpha_{j'}-\alpha_i)^2+(\beta_{j'}-\beta_i)^2} \le \mathrm{P}(j'\epsilon B')\\ \sqrt{(\alpha_{j_{all}}-\alpha_{j_{all}+\Delta j_{all}})^2+(\beta_{j_{all}}-\beta_{j_{all}+\Delta j_{all}})^2} > \mathrm{d}(\forall j_{all}\epsilon B_{all}, \forall (j_{all}+\Delta j_{all})\epsilon B_{all})\\ \sqrt{(\alpha_{j_{all}}-\alpha_p)^2+(\beta_{j_{all}}-\beta_p)^2} > \mathrm{d}(\forall j_{all}\epsilon B_{all}, \forall p\epsilon P)\\ \sum_{i\in A} y_{ij} d_i \le C_j x_j (j\epsilon B)\\ \sum_{i\in A'} y_{ij'} d_i \le C_{j'} S_{j'} (j'\epsilon B')\\ \sum_{i\in N}\sum_{j\in B} y_{ij}x_j + \sum_{i\in N}\sum_{j\in B'} y_{ij'}S_{j'} \ge 90\%\\ x_j, S_{j'} = \{0,1\}\end{cases} \quad (12)$$

The final station location planning model is shown in formula (12). In practical application, when the coverage, cost, threshold value, traffic volume in weak coverage area and the coordinates of established base stations are known, they can be brought into the above formula to obtain the final results.

4. Conclusion

Base station location optimization is an important part of 5G network construction and network optimization. That is, when the signal quality, construction cost, coverage limit, and the number and location of base stations are known, other network parameters are optimized. The goal is to achieve the rate of high coverage network with low base station construction cost. At present, it is an important period of 5G network construction. Reasonable planning of base station location is very important to reduce costs and improve user satisfaction. The model selects and constructs the base station in a specific area for the weak coverage area. Referring to the reality, it can be considered that the current network base station is the 4G base station that has been widely built, and the new base station to be built in the weak coverage area is the base station to be built in the 5G network. Using this model, we can put forward constructive suggestions on the construction of 5G base station. However, the model needs to be combined with the actual terrain and more advanced coverage area design to be applied to today's base station construction, and for the setting of parameters in some models, appropriate indicators can be obtained by simulating the existing data.

References

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