A Research on the Priority of Power Distribution Based on Graph Computing

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Abstract. With the construction and gradual development of microgrids, multiple interest themes have emerged in traditional distribution networks, such as distributed power sources, flexible loads, etc. Microgrids can be integrated into large power grids or operated as independent power grids. Effectively improve the power grid's ability to resist disasters and ensure the safety of power supply within the grid. It can also effectively achieve high-quality matching of power supply and consumption and optimize the distribution of power resources within the network. The ability to fully and effectively solve the problems of grid connection of distributed energy sources such as wind and solar is of great significance to the reasonable planning of the power system and the safe operation of the power system. This paper proposes a planning evaluation system that takes into account the microgrid connection, constructs a graph calculation-based distribution priority division and a node model under the microgrid central control system, and uses the Mean-shift clustering algorithm to obtain node attributes. Use the optimal sequence graph method to calculate the index weight of the distribution network planning scheme, and finally calculate the distribution plan between nodes through the graph path finding algorithm.

1. Introduction

The construction of the graph node model under the microgrid central control system is mainly composed of three parts. The first part is our coordinated controller node. The second part is the grid-connected interface node, and the third part is the equipment node. Each equipment node is not only a power supplier, but also a power user. When a certain regional power grid fails, it can purchase electricity from adjacent regions. In order to achieve a user experience without perception of electricity consumption, a new power distribution inspection mode with non-stop operation as the core is established.

2. Data Model of Microgrid Central Control System

The data model of this project is a graph-based power data model. By simulating the power consumption and power generation information data of various devices under different scenarios and different geographical information, sample information of different nodes under uniform distribution conditions is obtained and stored in the training set. After calculating the weights of the nodes using the optimal sequence graph method, the centrality algorithm of the nodes in the graph is used to obtain the priority sequence. Among them, the attribute information of graph nodes under uniform conditions is used to determine the priority of the nodes.
distribution includes power consumption, power supply, geographic information, equipment information, demand, cost, and loss.

The model is based on the urban smart energy system and is divided into four areas: commercial area A, industrial area B, residential area C, and other areas D. A total of 420 node information is collected uniformly for electricity consumption and power generation data in four regions for a fixed period of time. After obtaining the local climate, temperature, wind and other information, the average value will be constant by default. At this time, temperature, climate, human factors and other related factors will no longer be considered.

2.1. Demand Degree
Obtain the power consumption characteristic information of all nodes. These nodes are evenly distributed in four areas. Through the Mean-shift clustering algorithm, the nodes are divided into different categories and different demand degrees are obtained. At this time, the nodes are clustered. There are three categories, divided into three levels, 1, 2, and 3. In the four areas, there will be points marked with different levels of node attributes. The occupancy rate of the nodes is used to judge the level of demand in this area. In the real scene, the composition of nodes in a region is more complicated. The composition in a region may be composed of various elements such as commerce, industry, and residents. Therefore, the level is judged by the comparison of node occupancy NodeShare.

\[
\text{NodeRatio} = \frac{\text{Node(level)}}{\text{AllNode(area)}}
\]

(1)

AllNode(area) represents the number of all nodes in the area, and Node(level) is the number of nodes at the corresponding level.

According to the number of priority nodes, the demand priority levels in this area are judged as A1, A2, and A3.

2.2. Cost Degree
The relatively stable climate, electricity price, temperature and other information in the local area for a period of time are obtained in the preliminary investigation, and an average value is obtained through the average function to obtain the cost of different equipment information. In view of the uncertainty and complexity of the multi-objective model, the confidence interval is used to simplify the number of scene simulations. There are three areas A, B, C, and D in the simulation scene. Area A is a commercial area, and the power generation equipment has photovoltaic power generation panels. Area B is an industrial area, and the power generation equipment includes photovoltaic power generation panels and gas turbine power generation. Area C is a residential area, and the power generation equipment has photovoltaic power generation panels. Area D is the other area, where multiple power generation equipment is carried out simultaneously. Data on solar photovoltaic power generation projects that have been approved but have not yet been completed and put into production as of December 31, 2017 can be obtained. The current estimated installed cost of photovoltaic power generation projects for homes that have been verified and connected to the grid is 0.9 yuan/kWh. Can reach 0.7 yuan or less. You can get the relevant data sheet:

| Solar photovoltaic power generation | Thermal power | Wind power (6.5 m/s) |
|-----------------------------------|--------------|---------------------|
| 0.7-0.8 /degree                   | 0.25-0.30 /degree | 0.45-0.50 /degree |
| 0.8-0.9 /degree                   | 0.30-0.35 /degree | 0.50-0.55 /degree |
| 0.9- /degree                      | 0.35-0.5 /degree  | 0.55-0.60 /degree   |
### Table 2. Cost range in different regions

| A area (commercial area) | B area (industrial zone) | C area (Residential area) | D area (Other areas) |
|-------------------------|--------------------------|---------------------------|---------------------|
| Photovoltaic power generation | Photovoltaic power generation, Thermal | Photovoltaic power generation | Photovoltaic, thermal power generation, wind power |
| 0.7-0.9                 | 0.475-0.7                | 0.7-0.9                   | 0.466-0.666         |

#### 2.3. Loss Degree

After obtaining the overall power loss of the distribution network, calculate the energy loss of the distribution network for a period of time. There are generally three modes of low-voltage transportation, high-voltage transportation, and ultra-high-voltage transportation in power transportation. Due to the complexity of the distribution network structure, the diversity of parameters and the imperfection of data, it is difficult to accurately calculate the theoretical line loss of the distribution network. The line loss mainly includes the loss of the original network consumption, the loss of the power generation equipment itself and the variable loss. The idea of the average load curve characteristic is used here. Calculate the power loss rate of the distribution network, and use the power loss rate to approximate the power loss.

\[
R = \frac{w_{\text{user}}}{w_{\text{factory}}}
\]  

#### 3. Data Analysis

This paper proposes an evaluation index system for distribution network planning considering microgrid access, and related indexes are obtained through data clustering to improve the effectiveness of index evaluation, and a comprehensive scoring method that considers index weights is used to score planning schemes. The principles that need to be followed when constructing evaluation indicators are as follows:

- The index system is comprehensive, and the index system can fully reflect system performance.
- The indicators are independent, and the indicators are not repeated and independent of each other. Paragraphs should be justified.
- Consistency, all indicators are aimed at evaluating the wealth of the distribution network.
- Measurability, determined indicators can be expressed using data.
- Comparability, each index is different according to the degree of contribution to the evaluation target.

Construct a set of distribution network index system, as shown in the figure 1:

The optimal sequence diagram method is adopted to calculate the weight value, and the indicators are compared in pairs. If the indicator \( x \) is more important than the indicator \( y \), then \( x \) gets one point. If the indicator \( x \) is generally more important than the indicator \( y \), then \( x \) is 0.75. If it is equally important, then \( x \) gets 0.5 points, if \( x \) is less important than \( y \), it will get 0 points, and if it is not generally important, it will get 0.25 points. Finally, the index score obtained is:

\[
\sum_{k=1}^{n} \alpha_{ik} = A_i
\]  

The weight of the parameter can be obtained:

\[
\alpha_i = \frac{A_i}{\sum_{k=1}^{n} A_k}
\]
Figure 1. A set of distribution network index system

From this we can get the comparison matrix of the indicators as:

Table 3. Index comparison matrix

|                  | Loss degree | Cost degree | Demand degree | Power supply characteristics | Spare battery | Index score |
|------------------|-------------|-------------|---------------|------------------------------|---------------|-------------|
| Loss degree      | 0.5         | 0.75        | 0             | 0.25                         | 0             | 1.5         |
| Cost degree      | 0.25        | 0.5         | 0             | 0                            | 0             | 0.75        |
| Demand degree    | 1           | 1           | 0.5           | 0.75                         | 0.25          | 3.5         |
| Power supply characteristics | 0.75     | 1           | 0.25          | 0.5                          | 0             | 2.5         |
| Spare battery    | 1           | 1           | 0.75          | 1                            | 0.5           | 4.25        |

The weight ratio of each parameter can be obtained by calculation:

Table 4. The weight ratio of each parameter

|                  | Loss degree | Cost degree | Demand degree | Power supply characteristics | Spare battery |
|------------------|-------------|-------------|---------------|------------------------------|---------------|
| Loss degree      | 0.12        | 0.06        | 0.28          | 0.2                          | 0.34          |

In the actual scenario, the structure between the device nodes is complex, as shown in Figure 2. In order to simplify the model to realize the power distribution plan, all the collected node information is divided into regions to obtain a simple graph node model, which is illustrated in Figure 3.
According to the calculated demand level, cost and loss of different regions, it is assumed that the number of different devices in different regions is the same, and the cost range of each region is calculated according to

$$M_n = (\sum_{i=1}^{n} A_i) / n$$  

(5)

To calculate the cost range of each area.

We adopt the following indicators to quantify it:

**Table 5. Index quantification**

| Loss degree | Quantized value | Cost degree | Quantized value | Demand degree | Quantized value |
|-------------|----------------|-------------|----------------|---------------|----------------|
| A1          | 30             | 0.46-0.66   | 30             | 3%-8%         | 30             |
| A2          | 20             | 0.66-0.76   | 20             | 8%-10%        | 20             |
| A3          | 10             | 0.76-0.9    | 10             | 10%-20%       | 10             |

For the four area nodes of ABCD, their quantified node attributes are obtained through the above calculation:

**Table 6. Node attributes**

| Area | Loss degree | Cost degree | Demand degree | Power supply characteristics | Spare battery |
|------|-------------|-------------|---------------|-----------------------------|---------------|
| A    | 30          | 10          | 30            | Unstable/10                 | 0/1           |
| B    | 20          | 20          | 20            | stable/30                   | 0/1           |
| C    | 30          | 20          | 30            | Unstable/20                 | 0/1           |
| D    | 30          | 30          | 10            | stable/30                   | 0/1           |

According to the formula:

$$W_n = \sum_{n=1}^{n} N_n P_n$$  

(6)

Calculate the total attribute values of the nodes in the four areas of ABCD, where N is the attribute value of each node, p is the weight ratio of the attribute value, and the difference between the attribute values of the two nodes is the weight value, which can be obtained:

**Table 7. Node total attribute value**

| Area | A   | B   | C   | D   |
|------|-----|-----|-----|-----|
| Value| 35  | 35.6| 37.6| 34.6|

![Figure 4. The attribute values of the nodes](image)
Then according to the generated weight map, we can easily see that if a failure in area A causes an abnormal electricity consumption, then its optimal principle is to purchase electricity directly from area D.

4. Conclusion
This model uses the mean-shift clustering algorithm and the optimal sequence graph method to calculate the index weights of the distribution network planning scheme by planning similar node groups in different regions into one node, and obtains a weighted graph and data set. This model is only the most A simple but also the most basic quadrilateral model. In the future, we will collect enough grid-connected interface nodes and import the data set into Apache Spark and Neo4j to display the target graph we want to build. The optimal path can be obtained using the path finding algorithm. Finally, the optimal solution is reached.

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