A Device Data Evaluation System Based on Hierarchical Weighting Algorithm

Yeqing Gu¹, Jian Yang¹ and Zhiyuan Wang¹
¹ NARI Group Corporation / State Grid Electric Power Research Institute
Email: gyqadi@126.com

Abstract. The more applications are supported by a dccloud, the higher quality are required on the fundamental data. This paper developed an evaluation system based on hierarchical weighting decision-making to evaluate the data quality of devices on dccloud. This evaluation system could also evaluate the satisfaction of applications on various devices, and the overall relationship among devices to improve data quality of device models.

1. Background
The device is the basis of the safe and stable operation of the power grid. State Grid started building the dccloud in 2016, aggregating the whole network data on the dccloud and building the application on top of that. Nowadays, with the improvement of the dccloud, the device data from high voltage level to low voltage level in all regions gradually moved to the cloud. Because of more and more devices and applications are supported on the cloud, the integrity, accuracy and consistency of the device model is critical to the application development on the dccloud. Currently, Regulation Cloud is able to evaluate the rationality, compliance, and statistics of the device model on the cloud, and verify the format, data range of the device parameters and the rationality associated with those device parameters regarding to the device itself. The evaluation rules are based on the device data itself, to validate the rationality and compliance of the devices as well as their parameters, which greatly improves the data quality of the device model. However, this evaluation method is closely related to the definition of evaluation index and has some deviation. Furthermore, in order to ensure the power system operate safely and stably, the grid company has built many applications on top of the dccloud platform to monitor and dispatch the power grid. The operation of the information system is closely related to the relationship between devices in the fundamental data. The health degree of the device model data directly affects whether the application can function properly. Therefore, the support degree of the device model to the application can reflect the health degree of the device from another aspect. This paper developed a grid device data assessment and evaluation system based on a hierarchical weighting decision algorithm to globally verify the integrity, accuracy and consistency of the device data on the dccloud from the perspective of device data evaluation and application demand to device data, to improve data quality of the device model on the dccloud and further improve the support for dccloud business applications.

2. Two Evaluation Programs

2.1. Device Data Evaluation Method
The device data evaluation method is a kind of evaluation method for the device itself, which first establishes a series of evaluation index, including the correctness of device parameters, correctness of device statistics, device compliance, etc. The system first assigns scores to the index according to the
importance of the index, then evaluates the device data by assessing the satisfaction degree of the index, and finally converts the scores into percentage scores.

2.2. Application of Needs Satisfaction Assessment
Application demand satisfaction is a method of evaluating device data by the degree of the application are supported by the device. The dispatching business has requirements on whether the device model is complete, whether the parameters are accurate, whether connection relationships, management relationships exist. If these data are not available, the functionality of the application is limited. The system recommends a set of standard models based on the needs of the business application, evaluates the model data of the dcloud device by comparing the differences between the standard model and the actual data, and finally converts the satisfaction into a percentage score.

3. Building a Hierarchical Analysis Algorithm-Based Data Quality Evaluation System for the Device Model
Hierarchical weighting decision thinking is a qualitative and quantitative combination of decision analysis methods that take a complex multi-objective decision problem as a system, decompose goals into multiple objectives and further decompose into multiple evaluation criteria. This paper uses the expert scoring method as the basis, and combines the fuzzy hierarchical analysis method with two evaluation schemes to establish the device data quality evaluation system. The system addresses the uncertainty of data quality and applies the idea of hierarchical analysis and decision making to the data quality evaluation system, evaluating the data quality of the device itself and the support strength of the device to the application, making the data quality evaluation results more practical and reliable. In this paper, the fuzzy consistency matrix is chosen as the judgment matrix. The meaning of the importance scale is shown in the Table [1].

| Significance scale | Implicit meaning |
|--------------------|-------------------|
| 1                  | Indicates that the two elements are of equal importance in comparison |
| 3                  | Indicates that the former is slightly more important than the latter compared to the two elements |
| 5                  | Indicates that the former is significantly more important than the latter compared to the two elements |
| 7                  | Indicates that the former is more important than the latter when compared to two elements |
| 9                  | Indicates that the former is more extremely important than the latter compared to the two elements |
| 2, 4, 6, 8         | Indicates the median value of the above judgment |
| countdown          | If the ratio of importance of element I to element j is aij, then the ratio of importance of element j to element I is aji=1/aij |

3.1. Building a Hierarchical Analysis Model
The system defines the evaluation system into three levels based on hierarchical analysis and decision making, as shown in Figure 1. The system first identifies two evaluation options: device evaluation and application demand satisfaction evaluation. Device evaluation evaluates data quality from the perspective of device objects; application demand satisfaction evaluation evaluates data quality from the perspective of application demand for devices, analyzes device object correlation relationships, and analyse topological connection relationships and regulatory relationships between device. Secondly, the industry usually classifies data quality into six dimensions, from which this paper selects the three dimensions that have the greatest impact on the dcloud platform: integrity, accuracy and consistency, to evaluate the data quality of the dcloud. Finally, the data quality of the device model was calculated by weighting the scheme layer and the criterion layer.
In this paper, by using the Delphi method, 10 experts were invited to score the importance of the criterion layer to the target layer in two ways. The judge matrix of criterion layer B to target layer A was confirmed as in Figure 2.

\[
A = \begin{bmatrix}
1 & 1/2 & 1 \\
2 & 1 & 2 \\
2 & 1/2 & 1 
\end{bmatrix}
\]

Figure 2. Judge matrix of layer A

Experts were invited to rate the importance of the schema layer to the target layer in two ways, confirming that the judge matrix of schema layer C versus normative layer B is as in Figure 3.

\[
B_1 = \begin{bmatrix}
1 & 1/3 \\
3 & 1 
\end{bmatrix}
B_2 = \begin{bmatrix}
1/2 & 2 \\
1 & 1/2 
\end{bmatrix}
B_3 = \begin{bmatrix}
1/2 & 1 
\end{bmatrix}
\]

Figure 3. Judge matrices of layer B

### 3.2. Harmonization of Weights

1. Calculate the weight of the guideline layer on the target layer. The judge matrix is normalized by the arithmetic average of the sum-of-take-column vectors as the feature vectors.

\[
A = \begin{bmatrix}
1 & 1 & 2 \\
1 & 1 & 2 \\
1/2 & 1/2 & 1 
\end{bmatrix}
\Rightarrow \begin{bmatrix}
0.4 & 0.4 & 0.4 \\
0.4 & 0.4 & 0.4 \\
0.2 & 0.2 & 0.2 
\end{bmatrix}
\Rightarrow \begin{bmatrix}
0.4 \\
0.4 \\
0.2 
\end{bmatrix} = \omega^0
\]

\[
A\omega_0 = \begin{bmatrix}
1.2 \\
1.2 \\
0.6 
\end{bmatrix}
\xrightarrow{A\omega_0=\omega^0} \lambda = \frac{1}{3} \left( \frac{1.2}{0.4} + \frac{1.2}{0.4} + \frac{0.6}{0.2} \right) = 3
\]

So the consistency indicator \( CI = \frac{\lambda - n}{n - 1} = 0 \)

CI Meet the requirement of consistency.

2. the weights of the schema layer to the normative layer are calculated in the same way, with the following precise results.
Integrity $\omega_1 = [0.25, 0.75]$  
Accuracy $\omega_2 = [0.67, 0.33]$  
Consistency $\omega_3 = [0.67, 0.33]$  

The final weighting of the two scenarios relative to the target layer was calculated as:  
$\omega = [\omega_1, \omega_2, \omega_3]^T \cdot \omega_0^T = [0.502, 0.498]$  

4. Application Study

The power grid is usually divided into five parts according to the functionality. The core work units for each part are power plant, acoline and dccline, substation, and other power containers. All devices belong to a grid container. In this paper, two 220kV power plants are selected as an example to evaluate the data quality. Besides of this, The technical design parameters of the two plants are at the same level in order to ensure the objective and impartial nature of the evaluation results.

1. Device evaluation method. Since the maximum voltage level of the plant is the same, the same assessment indicators are used, with a rating of 83 points for plant 1 device data and 85 points for plant 2 device data.

2. Application satisfaction, the system selects a typical application of dispatching operation ticket as an example to evaluate the satisfaction of two power plants with the application, with power plant 1 scoring 70 points and power plant 2 scoring 92 points.

So the final score of plant A is 76.53, and the score of plant B is 90.02. Through on-site data accounting, it was found that Power Plant 1 under-reported a 35kV transformer and related data, resulting in low application satisfaction, and the data quality score was generally consistent with the actual data situation, which objectively and fairly reflected the data situation in each container.

5. Conclusion

This study considers that data quality is not only related to the data itself, but also directly affects the application of the data. Therefore, it establishes an device evaluation system based on a hierarchical analysis algorithm, evaluates the data quality of the device through two options: device evaluation and application satisfaction evaluation, and selects three indicators of integrity, accuracy and consistency by combining the qualitative and quantitative methods of the Derby expert scoring method and the hierarchical analysis method to evaluate the data quality of the device and urge to improve the device data quality.

However, the evaluation of data quality is a relatively complex multidimensional problem, and the results will vary in practice due to the sophistication degree of indicator definitions, the choice of standard models to apply, and the personal habits of experts. Therefore, in the specific application process, different users can improve the model according to the actual situation, so as to obtain more accurate results.

6. References

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