Research on Load Balancing Dispatching Method of Power Network Based on Cloud Computing

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Abstract. With the continuous development of big data era and cloud computing (CC) technology, there are still a series of problems in the planning performance and related algorithms of CC grid, such as unbalanced grid load and uneven grid spatial distribution. However, with the continuous development of social economy and the continuous improvement of people's living standards and quality, the scale of power grid construction is also expanding, the load distribution of power grid is unbalanced, and the power distribution capacity is insufficient. In order to effectively analyze the load balance and scheduling of power grid, CC technology can accurately improve the accuracy of data analysis and processing. In the process of network load balancing and distribution, the use of CC can not only improve the scheduling efficiency, but also improve the quality and speed of work. Aiming at the problem of poor scheduling performance, this paper proposes a fuzzy iterative algorithm and applies it to CC environment. Plan load balancing for the current network. The experimental process of the algorithm is introduced in detail, the balanced distribution parameters of the load data are extracted, and the load model is established. Realize and improve the network load balance distribution. Experimental results show that the proposed method can improve the load balancing configuration of power grid, improve the management efficiency of power grid, and has good experimental performance.

Key words: CC, power network, load balance, fuzzy iterative control algorithm

1. Introduction

With the continuous development of the current power system, the scale and complexity of the power network load balancing dispatch system have also increased [1]. The use of traditional power network load balancing dispatching system is difficult to meet the demand for balanced dispatching of the power system due to the complex structure and management, and there will be many hidden troubles of failure [2]. With the continuous popularization of big data and CC technology, the use of computer technology in power network load balancing and dispatching continues to deepen, and a power
network load balancing dispatching system based on CC platforms has emerged, which improves the accuracy of grid load balancing and dispatching. The performance and efficiency ensure the normal operation and reliability of the power system, and realize the timely transmission and sharing of the load balance dispatching data of the power grid [3]. Therefore, this article briefly discusses the power grid load balancing dispatching platform based on CC technology, which has a certain guiding role for power grid load balancing [4].

The grid load balancing data construction method based on CC can be replicated in different environments, the grid balance dispatching automation resources can be integrated in multiple places, and multiple remote CC data centers can be built [5]. On this basis, the reliability of the power dispatching system can be guaranteed through strong interconnection between regions [6]. The power grid balance dispatch center and the multiple local dispatch systems of the remote CC power grid balance dispatch data center have established a cooperative relationship, realizing mutual disaster recovery assurance awareness. In the current normal state, the local master station system will periodically synchronize the virtual machine files with the remote grid balance scheduling data center, and establish a resource mapping mechanism to ensure normal network communication after system migration [7].

In recent years, many power companies have paid more and more attention to the application of CC technology, which has further promoted the intelligent development of power network load balancing and dispatching [8]. In the intelligent power dispatching mode, it is developed around the two aspects of data information collection and statistics in the power system, which can promote the development of data statistics to a large-scale trend [9]. Nowadays, CC technology is developing rapidly and its platform is constantly expanding. Under the influence of this situation, Chinese electric power companies can collect difficult data through this technology, and make full use of big data analysis technology to carry out systematic processing data, power network load balancing and dispatching big data information system itself has a relatively complex structure. It takes a lot of time to collect power big data, go through multiple links, and then to the final calculation and analysis. At this time, personnel and related equipment can construct a data statistical library database together [10].

2. Algorithm establishment and optimization analysis

2.1. The establishment of fuzzy loop iterative control algorithm

In the current CC environment, network load balancing analysis can be completed by reasonable distribution of network data. Reasonable distribution can improve the efficiency of energy resource allocation and management. The fuzzy iterative control algorithm proposed in this paper is a data balance algorithm which combines iterative calculation with control algorithm. According to the principle of data characteristics, the fuzzy cyclic iterative control is carried out. For example, suppose the original data set is formed in the form of vector control, as shown below. The mapping formula in the stack space is as follows:

\[ X_n = \left( x_{n}, x_{n-\tau}, ..., x_{n-(m-1)\tau} \right) \quad (1) \]

In the above formula, \( X \) is the time series of load sampling data, and \( \tau \) is the parameter data of sampling delay. The time interval formula for calculating data is as follows:

\[ h(\tau, T) = \sum_{i=1}^{N_m} a_i(t) e^{i\theta} \delta(t - \tau(t)) \quad (2) \]

The data containing four groups of elements are associated, the wisdom of data weight distribution is constructed, the constraint rate of orthogonal addition is calculated, and the attribute weight is classified. For a given task, the valid data are as follows:

\[ E(i, j) = \begin{cases} \frac{e_{ij} - e_{ij}(l)}{e_{max} - e_{ij}(l)} & e(i, j) < e_{ij} \\ \frac{e_{ij} - e_{ij}(l)}{e_{ij}(l) - e_{min}} & e(i, j) \geq e_{ij} \end{cases} \quad (3) \]
The parameters for calculating the balance of any point on the set \( A \) of the above data are shown in the following formula:

\[
R = w_1c_1 + w_2d_1 + w_3m_1 + w_4n_1
\]

At this time, define the parameters of the grid load balancing dispatch, and select the corresponding parameters and calculation method formula as shown below:

\[
Y = Ay + l [f(Y) + u]
\]

In the power network load scheduling plan, the length of the idle time slices can be recorded as the information of the K-th power to see that point. The definition formula is as follows:

\[
\delta_{ik}(t) = G(V = k | U, \theta(t))
\]

\[
S_w = \sum_{i=1}^{c} p_i \frac{1}{m_i} \sum_{k=1}^{n_i} [(X_k^{(i)} - m_i)(X_k^{(i)} - m_i)]
\]

3. Modeling method

3.1. Establishment of load balancing dispatch model for power network

For the load distribution model assuming grid connected, the output voltage \( V \) of the detection system is \( u(a, B, c) \), and the \( V \) phase amplitude as follow:

\[
U_{a,b,c} = \begin{cases} 
U_m \cos(\omega t) \\
U_m \cos(\omega t - \frac{2\pi}{3}) \\
U_m \cos(\omega t + \frac{2\pi}{3}) 
\end{cases}
\]

The definition of transforming ABC fixed coordinate system into two different rotating coordinate systems is as follows:

\[
T_{abc-dq} = \begin{pmatrix} \cos(\omega t) & \cos(\omega t - \frac{2\pi}{3}) & \cos(\omega t + \frac{2\pi}{3}) \\
\sin(\omega t) & \sin(\omega t - \frac{2\pi}{3}) & \sin(\omega t + \frac{2\pi}{3}) 
\end{pmatrix}
\]

The BARK transformation of the two models can be obtained:

\[
\begin{pmatrix} u_d \\
u_q 
\end{pmatrix} = T_{abc-dq} - U_{a,b,c} = \begin{pmatrix} u_m \\
0 
\end{pmatrix}
\]

3.2. Determination of the diagnosis model of power network load balancing dispatch

When applying the big data deep learning diagnosis model of long-term and short-term memory neural network, we usually evaluate the final diagnosis results of the diagnosis model, including the following formula:

\[
TDR = \frac{TP}{TP + FN}
\]

\[
TDR = \frac{FP}{FP + TN}
\]

\[
TDR = \frac{TN}{TP + TN}
\]

The constructed O-KELM method is applied to the power network load balancing scheduling diagnosis model prediction experiment. The modeling method in this paper is as follows, that is, the time series modeling method:

\[
y(t + D) = f(x_t), \forall t = \Delta \cdots l
\]
Using the operator of the triangle fusion model, the transmission delay of the power path can be fused with bandwidth, so that the fitness analysis function can be established. The fitness function is:

\[
F(x) = \frac{f_D(x) + f_B(x)}{1 - f_D(x) - f_B(x) + 2f_D(x) + f_B(x)}
\]

(14)

Assuming that all influencing factors are considered in the detection of load balancing distribution signals transmitted by the power grid, the ideal V, a, B and C obtained from the high V side of the power grid can be expressed as:

\[
U_A = \sqrt{2}I \cos \omega t
\]

\[
U_A = \sqrt{2}I \cos(\omega t - 120^\circ)
\]

\[
U_A = \sqrt{2}I \cos(\omega t + 120^\circ)
\]

(15)

The ideal A-phase, B-phase and c-phase currents obtained by users from the high V side can be expressed as follows:

\[
i_A = \sqrt{2}I \cos(\omega t - \varphi)
\]

\[
i_B = \sqrt{2}I \cos(\omega t - \varphi - 120^\circ)
\]

\[
i_C = \sqrt{2}I \cos(\omega t - \varphi - 120^\circ)
\]

(16)

U in the above formula is the effective value of the V in the load balancing dispatch data of the power network obtained by the user's high-V side, I is the effective value of the current obtained by the user's high-V side of the user's power network load balancing dispatch, and \(\omega\) is the user power obtained by the user's high-V detection. The angular frequency in the network load balancing dispatch data is the phase difference between the V and current in the power network load balancing dispatch data obtained for user high V detection.

3.3. Elman neural network

In recent years, BP neural network is widely used in the field of load balancing and dispatching of modern short-term power grid, and the process of load balancing and dispatching is a dynamic time modeling process. In the process of modeling, the static network is used for identification, which will inevitably lead to many problems due to the mismatch between dynamic and static. In order to achieve the load balance distribution of power grid, dynamic neural network is needed to reflect the dynamic characteristics of the system more clearly. The typical dynamic neural network is Elman neural network based on the basic structure of BP neural network. In order to have the function of dynamic feature mapping, the internal state of the network must be stored. Due to the mapping function of Elman neural network, the system has the ability to adapt to time-varying characteristics.

4. Data analysis and experimental evaluation results
4.1. Implementation and analysis of network load balancing based on fuzzy iterative control

Using Elman neural network and fuzzy iterative control algorithm for network load balancing and scheduling prediction research, the data of this experiment comes from the power network load data of the H area of East China Plain for two consecutive years. The maximum load is predicted, and the specific data is shown in the following table:

| Name | Parameter value | Name | Parameter value |
|------|-----------------|------|-----------------|
| A1   | 0.8723          | B1   | 0.3333          |
| A2   | 0.4329          | B2   | 0.5978          |
| A3   | 0.3359          | B3   | 0.3697          |
| A4   | 0.6478          | B4   | 0.6879          |
| A5   | 0.3659          | B5   | 0.6589          |
| A6   | 0.5798          | B6   | 0.3654          |

This article uses percent error and average absolute error to test the predicted results of the data output with these two error indicators, where $X_r$ represents the actual load value, and $X_f$ can be expressed as the predicted load value. The expression can be analyzed as shown in the following formula:

\[
P_e = \frac{X_f - X_r}{X_r} \times 100 \quad (4 - 1)
\]

\[
M_{APE} = \frac{1}{31} \sum_{t=1}^{31} \frac{|x_f - X_r|}{X_r} \quad (4 - 2)
\]

According to the fuzzy iterative control algorithm and the Elman neural network load forecasting algorithm proposed in this paper, after the optimization of its genetic algorithm, an improved fuzzy iterative control algorithm can be obtained for the optimal initial value of load balancing dispatch in the power network. It can be determined that the population size is 50, and the number of iterations can be set to 220. The predicted results are shown in Figure 1 as shown in the analysis diagram of the results of power network load balancing scheduling under different methods.

![Figure 1. Power network load balancing dispatch analysis under different algorithms](image)

4.2. A real-time power network load balancing dispatch strategy

The real-time power network load balancing scheduling strategy can generally be divided into the following two stages, namely the training phase and the real-time power network load balancing
scheduling strategy phase. First of all, in the training phase, the traditional two-objective real-time power network load balancing scheduling strategy method obtains the scheduling under different weights and different load conditions as the basic data for providing network training. This network trains real-time power. The network load balancing scheduling data must cover all load values under normal conditions. Then use its network training tools to construct its best power network link state. The input vector of this network can be formed by the system load and the weight of each objective function, and the output vector is the power generation of each generator set. In the real-time power dispatching phase, first refer to the hourly load forecast curve of the previous day, and use the real-time data acquisition system to obtain real-time system load data. This real-time load data is compared with the load forecast value of the previous day, if there is an error between the two very big.

4.3. Analysis of the evaluation results of the fuzzy iterative control algorithm in the network load balancing scheduling system

As shown in Figure 1, the final test results of the fuzzy iterative control algorithm in the network load balancing scheduling system show the execution time of each step, and the change of processor frequency will lead to the change of performance. This will eventually affect the fuzzy iterative control algorithm. Therefore, for the program execution time of network load balancing scheduling system, based on the comprehensive comparison of various parameters, the calculation process of total power consumption is unified, that is, the product of real-time power consumption and time. Total operating costs. This can also directly reflect the different DPA parameters. In the test, the total power consumption is calculated by running at the frequency of 3.5G, and then the power consumption is used as a reference. The abscissa in Figure 2 is the power consumption value obtained by other adjustment methods divided by the reference power consumption value at 3.5G frequency.

Figure 2. Evaluation result analysis of fuzzy iterative control algorithm in network load balancing scheduling system

As shown in Figure 1, the final test results of the fuzzy iterative control algorithm in the network load balancing scheduling system show the execution time of each step, and the change of processor frequency will lead to the change of performance. This will eventually affect the fuzzy iterative control algorithm. Therefore, for the program execution time of network load balancing scheduling system, based on the comprehensive comparison of various parameters, the calculation process of total power consumption is unified, that is, the product of real-time power consumption and time. Total operating costs. This can also directly reflect the different DPA parameters. In the test, the total power consumption is calculated by running at the frequency of 3.5G, and then the power consumption is used as a reference. The abscissa in Figure 2 is the power consumption value obtained by other adjustment methods divided by the reference power consumption value at 3.5G frequency.

5. Conclusion

CC-based grid load balancing dispatch data center is the development trend of power company data center. In order to solve the problem of low resource utilization and unbalanced load of data center, this paper proposes a dynamic migration load based on fuzzy iterative control algorithm for virtual machines. Balanced algorithm, and designed and implemented a load balancing system on the cloud platform, and verified the performance of the algorithm and system through experiments. With the continuous improvement of business systems in the power industry, the importance of load balancing and scheduling in power networks has become more and more obvious. CC provides almost unlimited
storage capacity for network applications, but CC will provide almost unlimited storage capacity for network applications. Unlimited storage capacity. Experimental results show that this method achieves good load balancing scheduling on virtual machines, and the required cost is low.

References
[1] Lan L, Xiaoyong Z, Kaiyang L, et al. An Energy-Aware Task Offloading Mechanism in Multiuser Mobile-Edge CC[J]. Mobile Information Systems, 2018, (2018-4-2), 2018, 2018:1-12.
[2] Du J, Zhao L, Feng J, et al. Computation Offloading and Resource Allocation in Mixed Fog/CC Systems with Min-Max Fairness Guarantee[J]. IEEE Transactions on Communications, 2018, 66(4):1594-1608.
[3] Wei W, Fan X, Song H, et al. Imperfect Information Dynamic Stackelberg Game Based Resource Allocation Using Hidden Markov for CC[J]. IEEE Transactions on Services Computing, 2018, 11(99):78-89.
[4] Xiong F U, Chen J, Deng S, et al. Layered virtual machine migration algorithm for network resource balancing in CC[J]. Frontiers of computer ence in China, 2018, 12(1):75-85.
[5] Wei W, Fan X, Song H, et al. Imperfect Information Dynamic Stackelberg Game Based Resource Allocation Using Hidden Markov for CC[J]. IEEE Transactions on Services Computing, 2018, 11(99):78-89.
[6] Zhang K, Lu L, Lei C, et al. Dynamic operations and pricing of electric unmanned aerial vehicle systems and power networks[J]. Transportation Research Part C: Emerging Technologies, 2018, 92(2018-7-4):472-485.
[7] Panda R K, Mohapatra A, Srivastava S C. Online Estimation of System Inertia in a Power Network Utilizing Synchrophasor Measurements[J]. IEEE Transactions on Power Systems, 2020, 35(4):3122-3132.
[8] Shaolei L U, Hao F, Yue W. Distributed Clustering Algorithm for Energy Efficiency and Load-Balance in Large-Scale Multi-Agent Systems[J]. Journal of Systems ence and Complexity, 2018, 31(2001):234-243.
[9] Qin D, Ji P, Yang S, et al. An efficient data collection and load balance algorithm in wireless sensor networks[J]. Wireless Networks, 2019, 25(7):3703-3714.
[10] Chen J, Li J. Fuzzy adaptive iterative learning coordination control of second-order multi-agent systems with imprecise communication topology structure[J]. International Journal of Systems Science, 2018, 49(1-4):546-556.