Edge Computing Regulation Optimization Technology Based on Power Internet of Things

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Abstract. In the long-term operation of the power grid, local faults sometimes occur, which are mainly caused by excessive load of users, excessive power consumption, insufficient reactive power compensation and other reasons, resulting in low node voltage and large system loss. To solve this problem, based on the edge computing of power Internet of Things, the regulation optimization technology is studied. In this paper, firstly, the development status of edge computing in power Internet of Things is summarized, the importance of reactive power compensation in power grid under edge computing environment is introduced, and the application of improved particle swarm optimization (GPSO) algorithm in reactive power compensation in power grid is studied. GPSO algorithm is used to compensate the system with local faults, and the compensation effect is compared with that of particle swarm optimization algorithm and genetic algorithm. Then, the power flow calculation and reactive power compensation of the power grid are analyzed theoretically, and the reactive power loss, reactive power compensation device and reactive power compensation mode of the power grid are studied, and some mathematical models and practical working methods are summarized. In addition, according to an actual network example in a certain area, particle swarm optimization, genetic algorithm and GPSO algorithm are used to calculate the reactive power compensation of the power grid, and the reactive power compensation equipment is connected to the power grid reasonably, thus increasing the node voltage and reducing the network loss. Finally, by comparing the grid node voltages of the three algorithms under edge computing conditions, it is proved that GPSO algorithm has improved the power Internet of Things, that is, it is a good regulation and optimization technology to compensate the reactive power of the grid by using GPSO algorithm.

Keywords: Power Internet of Things Edge Computing, Regulation Optimization Technology, Reactive Power Compensation, GPSO Algorithm.

1. Introduction
Electric energy is an important energy source, and human production and life depend on it. With the development of the world, the load of household electricity is increasing, and the requirement of power quality is getting higher and higher. For a long time, primary energy is the main energy of
power grid, and it is a traditional way of generating electricity. Although this traditional power generation method can meet the power demand of many users, the defects of the traditional power generation method are more and more obvious. In order to solve this common sudden problem, reactive power compensation has been applied in power grid and achieved certain results. People pay more and more attention to power network reconfiguration, and reactive power compensation equipment is used more and more.

As for the research of reactive power compensation equipment technology, foreign countries studied it earlier and developed rapidly. Pardeshi developed a bi-level programming model, which was used to measure the initial parameters of power supply in power network and establish a mathematical model, and used particle swarm optimization algorithm to calculate the optimal merging point and merging capacity of power supply. However, due to the simplified model of power system, the conclusion is relatively single and limited, but the bilateral model is relatively novel [1]. The research on reactive power compensation in China started late, but it has a wide application prospect and is developing rapidly. Mao Yuyi designed a four-tier architecture based on data fusion and operation collaboration between heterogeneous platforms based on the framework of edge computing home energy system, which provides a new idea for the application of edge computing technology in the field of smart energy use [2].

In this paper, based on the edge computing of the power Internet of Things, the optimization technology of regulation and control is studied, and the application of GPSO algorithm in reactive power compensation of power network is studied. Due to its advantages of economy, flexibility and environmental protection, reactive power compensation equipment can effectively improve the problems existing in the traditional power generation mode. Because the current power system network is mature and complete, it also makes the power network more complex and heavier, and the power flow distribution of the power system is difficult to change, and reactive power compensation equipment just makes up for this shortcoming, so rational use of reactive power compensation equipment is the key to solve the development of power network at present. This technology not only improves the situation of long-distance power supply, but also advocates sustainable development, which is an important technology for regulation and optimization.

2. Research on The Technology of Edge Computing Control Optimization Based on Power Internet of Things

2.1. Reactive Power Compensation Mode of Power Network

(1) substation compensation

When the reactive power loss in the power network is large, the compensation device can be incorporated into the power network at the substation to improve the power factor of the power network by supplying reactive power. The reactive power supply increases the bus voltage, so the reactive power loss in the power grid is compensated. And the compensation device is usually installed on the low-voltage bus to ensure more stable operation and higher security [3].

(2) Random compensation

Random compensation means that the compensation device is connected to the motor, which can not only reduce the reactive power loss of the system, but also improve the energy sent by the motor. Random compensation has the advantages of convenient installation, long service life and less investment, which is suitable for compensating reactive power.

(3) Follow-up compensation

Follow-up compensation is a method of installing a device on the secondary side of a transformer to compensate when there is no load, which has high efficiency. The disadvantage is that there are many transformers installed and distributed widely in the power network, which requires more installation funds and higher maintenance costs in the later period [4].

(4) Tracking compensation
Tracking compensation is a way to integrate compensation devices into the power network to protect the whole, and to compensate the low voltage position of the user in the power network. Tracking compensation is similar to follower compensation in working mode. Tracking compensation has better compensation effect on power network, but it has higher operating cost and complicated device [5].

(5) SVG static var generator
Through frequent actions of internal electronic switches, the current opposite to harmonic current is generated, and the generated reactive power is used to filter out harmonics, and the reactive power compensation of the system is realized by adopting the electric energy conversion technology.

(6) SVC static reactive power compensation device
The current information of the system is detected by the external detection circuit, then the current information is analyzed by the control chip, and the compensated driving signal is given by the controller. Finally, the inverter circuit composed of the power electronic inverter circuit sends out the compensated current [6].

2.2. Reactive Power Compensation Device of Power Network
The reactive power compensation equipment in power network is commonly used as synchronous phase adjuster, static reactive power compensator, on-load voltage regulating transformer, capacitor, etc [7].

(1) synchronous camera adjustment
When reactive power loss occurs in the power grid, the synchronous condenser can send reactive power to the system. Synchronous motor controls the reactive power generated by synchronous motor by controlling the power factor, but it will be limited by the working limit of synchronous motor. Synchronous camera is stable and easy to use, but it can't be widely used because of its high cost and high cost of operation and later maintenance.

(2) Static Var Compensator
Static var compensator can also change the reactive power of power network quickly, and then achieve the effect of reactive power optimization, so it is usually used as a reactive power compensation device. Static var compensator has strong adaptability, low power loss and easy maintenance, so it can be applied in power network.

(3) On-load voltage regulating transformer
Changing the tap position of on-load voltage regulating transformer in power network can effectively adjust the line voltage in power network and improve the power flow distribution in power network with reactive power compensation. However, because the on-load voltage regulating transformer does not have the condition to provide reactive power by itself, it can only redistribute reactive power, so it can not directly compensate reactive power like parallel compensation capacitor, which is easy to cause voltage collapse, and is only suitable for use in the case of less loss of reactive power [8].

(4) Capacitors
Capacitors incorporated into the power network can provide reactive power, and if multiple capacitors are connected, they will be connected to the power network at the same time. If the capacitor wants to send large reactive power, it needs to increase the voltage; On the contrary, if small reactive power is needed, the voltage will decrease. Because the capacitor is discontinuous in reactive power compensation, it has poor adjustment ability and sometimes causes resonance. However, because of its low cost, easy equipment in power network and simple fault repair, it is widely used in power grid [9].

2.3. Power Internet of Things Edge Computing
The standard deviation of resource utilization (RUSD) in edge computing indicates the discrete degree of multidimensional resource utilization on mobile edge computing server. The smaller the standard
deviation of resource utilization, the more balanced the resource utilization. The formula for calculating the standard deviation of resource utilization of the ith server is:

\[ \text{RUSD}_i = \sqrt{\frac{1}{k} \sum_{k=1}^{k} (u_i^k - u_i^{ave})^2} \]

Where \( u_i^k \) represents the utilization rate of the kth dimension resource on MEC i server, and \( u_i^{ave} = \frac{1}{k} \sum_{k=1}^{k} u_i^k \) represents the average resource utilization rate of MEC server. When the utilization rate of a certain resource on the MEC server is high, while the utilization rate of other resources is very low and balanced, the value of the MEC server is also low, but in fact, the remaining amount of this kind of resource is small [10].

3. Experimental Research on Edge Computing Optimization Cased on Power Internet of Things

3.1. Experimental Data Collection
In order to verify the GPSO algorithm based on edge computing of power Internet of Things in the regulation optimization technology studied in this paper, it is compared with the traditional PSO algorithm and GA algorithm. The node numbers of the three algorithms are gradually increased from 0 to 20 to 120. Comparing the node voltage values, the node voltage values range from 0.94pu to 1.06pu.

3.2. Experimental Design
(1) the principle of 1) GPSO algorithm
1) adding selection and crossover operation to PSO algorithm, screening out some excellent particles according to the set probability, and entering the hybrid resource pool, cross-matching the particles in the hybrid resource pool, after matching, the offspring particles continue to exist in the hybrid resource pool instead of the parent particles, ensuring that the total number of particles in the whole hybrid resource pool remains unchanged and information is shared, thus accelerating convergence speed.

2) In the process of PSO algorithm, if it is detected that particles can't jump out of the solution space of small area, the mutation operation will be carried out for particles that can't continue to converge. Initialize the particles whose iteration speed tends to zero to help the particles to be re-optimized.

(2) The flow of 2) GPSO algorithm
1) initialization of particle population.
2) Set the parameters of GPSO algorithm.
3) According to different solving problems, set a suitable fitness value, that is, a target value function, and obtain the target values of different particles by solving this function.
4) Selecting particles with higher target value from the whole population and adding them into the hybridization pool.
5) Determine the probability by roulette wheel selection method, cross-pair the particles in the hybridization pool according to the selection probability, compare the target value of the generated offspring particles with the parent particles, and continue the algorithm operation if the target value is higher;
6) Observe whether the algorithm is in a stopped state through the variation characteristics of the measured population target value. If the algorithm is stagnant at this time, the mutation operation is added to the population to get the mutation probability.
7) Calculate the current target value to compare with the individual extreme value, and if it is better, replace the individual extreme value;
8) Calculate the target value of the current target value compared with the global extreme value, and replace it if it is better;
9) Update the speed and position of particles.
10) If the fitness value meets the precision requirement or reaches the maximum iteration times, the algorithm is ended to obtain the global optimal solution. Otherwise, repeat the third step and continue the iterative operation.

4. Experimental Analysis Based on Edge Computing Optimization of Power Internet of Things

4.1. GPSO Algorithm Analysis of An Actual Example in A Certain Area
The actual power network model in a certain area is simulated by Matlab software using Niulafa. At the same time, the reactive power compensation is carried out by GPSO algorithm, and the minimum network loss is taken as the target value. After 25 iterations of convergence, the minimum network loss of the actual power network in a certain area is 0.85MW, and the network loss is reduced by 12.9%. The voltage comparison of actual power network with or without compensation device in a certain area is shown in Table 1.

| Node number | Initial state 0 | 20 | 40 | 60 | 80 | 100 | 120 |
|-------------|----------------|----|----|----|----|-----|-----|
| Initial state | 1.05pu | 0.955pu | 1.05pu | 0.956pu | 1.041pu | 0.956pu | 1.021pu |
| GPSO        | 1.05pu | 0.998pu | 1.05pu | 0.997pu | 1.047pu | 0.999pu | 1.029pu |

After the node 18 and the node 95 are incorporated into the compensation device, the node voltage of the actual power network system in a certain area increases to within the range of [0.95,1.05]. The voltage is reasonably increased. Due to the existence of constraints, the overall voltage level is optimized.

4.2. Comparison of Reactive Power Compensation of Three Algorithms
PSO and GA are used to optimize the reactive power of an actual example in a certain area according to the same method, and compared with GPSO algorithm, as shown in Figure 1.

![Figure 1. Comparison of reactive power compensation with three algorithms](image)

The compensation equipment with corresponding capacity is obtained through algorithm calculation, and the application of particle swarm optimization in reactive power optimization is improved in a certain area. After the actual example system is incorporated into the compensation
equipment for reactive power compensation, GPSO algorithm has the strongest improvement level on the node voltage of the actual example system in a certain area, and at the same time, it has the greatest help to keep the voltage level of the whole system stable. It can be seen from the comparison of effective parameters after optimization of three algorithms in three examples that PSO algorithm and GA algorithm can effectively optimize reactive power in power network system with less nodes, and the optimization effect is slightly worse than GPSO algorithm. However, in the power network system with a large number of nodes, the optimization results of PSO algorithm and GA algorithm are not ideal, while GPSO algorithm still has a good optimization effect, and GPSO algorithm is more suitable for practical reactive power optimization of power network.

5. Conclusions

Based on the edge computing of power Internet of Things, this paper studies the regulation optimization technology. The reactive power of three examples is optimized by GPSO algorithm, and the effect of reactive power compensation by GPSO algorithm is analyzed through fitness function, i.e. active power loss and system node voltage in critical state. After reactive power compensation by GPSO algorithm, the active power loss of the power grid decreases, the node voltage increases, and the whole power grid remains stable. The influence of the best position and capacity calculated by GPSO algorithm on the compensation effect is analyzed. It is found that the compensation effect of reactive power compensation equipment incorporating the best capacity in the best position is the best, which proves the effectiveness of reactive power optimization by GPSO algorithm. At the same time, comparing the node voltage and active network loss data after reactive power compensation by genetic algorithm and particle swarm optimization algorithm, it is proved that GPSO algorithm has more obvious iterative speed and reactive power optimization effect, and GPSO algorithm is more suitable for regulation and optimization based on edge calculation of power Internet of Things, so it is a better regulation and optimization technology to apply GPSO algorithm to power grid reactive power compensation.

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