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Research on Interruptible Scheduling Algorithm of Central Air Conditioning Load Under Big Data Analysis

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Abstract. The traditional algorithm is a combination of fuzzy dynamic programming and priority-based heuristic rules. The optimization performance of interruptible load scheduling is poor. For this reason, the central air conditioning load interruptible scheduling algorithm is proposed based on big data analysis. The algorithm adopts the characteristics of central air conditioning load management and selects the time scale of central air conditioning load scheduling. By optimizing the flexibility of interruptible scheduling, based on the central air conditioning load interruptible scheduling model, the optimal individual in the last generation population is decoded by binary coding, so as to realize the central air conditioning load interruptible scheduling algorithm. The experiment proves that the central air conditioning load interruptible scheduling algorithm has strong optimization performance.

Keywords: Optimized scheduling strategy · Time dimension · Interrupt load · Internal gene

1 Introduction

Central air conditioning load management is one of the core research contents of interruptible load. Domestic and foreign scholars have conducted in-depth research on the optimal scheduling strategy for interruptible load. Some researches on scheduling strategy algorithms use traditional optimization algorithms to establish a model combining fuzzy dynamic programming with priority-based heuristic rules. The adaptive system is used to solve the problem of interruptible load optimization scheduling. By adding the model reference adaptive system, the influence of load prediction error on interruptible load scheduling can be considered. Based on the optimal power flow framework, an algorithm for interruptible scheduling of central air conditioning load under big data analysis is proposed. It aims at solving the central air-conditioning load interruptible scheduling model with the minimum total system cost as the target, and can obtain the active shadow price and the interrupted load electricity price and interruption amount of each node. It also analyzes the impact of shadow electricity prices and interruptible electricity prices on the total cost of the system, but the essence

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is that it can interrupt the scheduling calculation problem. An interruptible load scheduling model that considers the impact of real-time electricity prices during peak power demand, taking into account the impact of power system network losses. The scheduling target comprehensively considers the minimum of the interruptible load cost and the network loss cost purchased by the grid company, and optimizes the scheduling of the interruptible load by using the queuing method. Although the central air conditioning load interruptible scheduling model can reduce the economic benefits brought by network loss, its constraint on interruptible load is simpler [1].

2 Central Air Conditioning Load Interruptible Scheduling Algorithm

2.1 Central Air Conditioning Load Scheduling Selection

Scheduling the interruptible load depends on the results of load forecasting and the estimation of the system side output. The prediction accuracy of the two is inversely proportional to the pre-calculation time, that is, the longer the pre-calculation time, the worse the prediction accuracy is. According to the above characteristics, this paper decomposes the interruptible load scheduling into three time scales before, before and after the time dimension. The interruptible load scheduling at different time scales can be coordinated with each other. Multi-time scale interruptible load coordination optimization scheduling through the coordinated coordination of interruptible load scheduling at different time scales, the error of scheduling requirements is gradually refined. The error caused by the previous time scale is corrected by the scheduling scheme of the next time scale to improve the accuracy and adaptability of the scheduling scheme [2].

According to the concept of multi-time scale interruptible load coordination optimization scheduling mode, the interruptible load contracts are divided into the following three categories according to the difference of advance notice time and minimum interruption duration at different time scales: Type A: Type A interruptible load users are mainly involved in the pre-monthly plan, including two types: the first type is the interruptible load rotation type contract. This kind of contract scheduling is set on a weekly basis, and the user is set a reference date of seven days a week according to the user's production scheduling habits. According to the dispatching instructions of several stops per week, the user will arrange the rotation of the production plan according to the base date and stop production within the specified time period to reduce the power load. The second type is an interruptible load monthly reduction contract. This type of contract is scheduled to be reduced in part by the specified time period within the specified time period of the request interruption according to the dispatch instruction to reduce the partial power load [3]. Considering that users need to adjust their production schedules, the advance notice time is usually half a month. Type B: Type B contract users are mainly involved in the day-to-day plan. The advance notice time is 24 h, taking into account the time interval from the day before the day before the scheduled dispatch to the next day. The minimum interruption duration is specified for specific users according to different industry production characteristics. The minimum interruption duration of each user is generally not less than 2 h. Type C: Type C contract users are mainly involved in emergency planning, and the advance notice time is 2 h. This type of contract is mainly based on reliability, and its minimum interruption duration is generally short, generally not less than 0.5 h. It mainly deals with emergency power shortage caused by faults in the power grid [4].

In the interruptible load scheduling of the central air conditioning load, the excitation method with high compensation for interrupted power is used. Since the monthly, the day and the emergency advance notice time are different, the unit price of the interrupted load interruption power compensation is also increased accordingly. The monthly plan is notified in advance, and the user has sufficient time to adjust the production schedule. Therefore, the unit price of the interruption compensation is the lowest. The users participating in the monthly plan can make certain adjustments according to the nature of the industry. The planned early notice time is shorter, so the user's interrupt compensation unit price is higher than the monthly plan. In addition, the difference in user interruption characteristics will also affect the cost of the interruptible load [5]. Studies have shown that the unit time interruption load cost and power outage duration decrease exponentially, that is, users who are also involved in the planned day, the longer the minimum interruption duration, the lower the cost of participating in the interruptible load. From a power company perspective, interruptible load scheduling with smaller interrupt durations and interruption intervals is more flexible. Therefore, under the same advance notice time, the longer the general interruption duration and the longer the interruption interval, the lower the interruption compensation cost. The emergency plan has the shortest notice time in advance, and the user response is high, the interruption reliability is strong, and the compensation unit price is the highest in the three time scales. Different users can also give different interrupt compensation unit price according to the difference of the degree of interruption reliability, and give higher interrupt compensation to users with high reliability, so as to encourage other low-reliability users to improve their reliability [6].

The interruptible load dispatching mode of central air-conditioning load management relies on a more economical monthly plan to limit the long-term load peak. Sacrificing part of the economy in the event of a grid emergency, using a more reliable emergency plan to ensure the safe and stable operation of the grid. As a scheduling mode with more balanced economy and reliability, the plan to link the monthly plan with the emergency plan is an important part of the central air-conditioning load interruptible load. The interruptible load of the central air-conditioning load management is coordinated and complemented, and the coordination and unification of the economic and reliability of the interruptible load dispatching is realized. So far, the construction of the central air conditioning load interruptible scheduling model is completed [7].

2.2 Modeling of Interruptible Scheduling Algorithms

The central air-conditioning load interruptible load dispatching is based on the fact that the user has signed an interruptible load contract with the user. According to the interrupt characteristics of different users, the user's interrupt scheduling is optimized, and the best economy is achieved under the premise of meeting the load dispatching requirements. In the multi-time scale interruptible load optimization scheduling model, the monthly and pre-planning scheduling model is a single-objective optimization problem, and the multi-objective function of the emergency planning scheduling is also transformed into a single-objective optimization problem after being processed. In addition to the user's interrupt capacity and interrupt price, the interruptible load scheduling needs to consider constraints such as the interrupt duration and interruption interval of each interruptible load user. This makes the optimization problem a relatively complex discrete non-convex function optimization problem [8].

This design uses genetic algorithm to solve the interruptible load scheduling problem of central air conditioning load, and the calculation process of each algorithm is described [9].

Genetic algorithms attempt to search for the optimal solution to a problem by simulating the evolution of a population. A population represents a set of solutions to the optimization problem, which consists of a number of genetically encoded numbers. A chromosome is the main carrier of genetic material in each individual, and its internal representation is a combination of genes that determines the external manifestation of the individual. Therefore, the use of genetic algorithms to solve problems requires mapping the external representation of the problem's potential solution set to its internal genes through coding work. After genetically encoding the first generation of population, according to the principle of survival of the fittest and the survival of the fittest in nature. Individuals are selected according to the degree of fitness of each individual in the population, and the genetic operators of natural genetics are used to combine and mutate the genes among individuals in the population. This process will lead to a population of natural evolution like the Miocene population is more adaptable to the environment than the previous generation and evolved better and better approximate solutions [10]. Because the work of gene encoding is complex, and to meet the completeness, soundness and non-redundant coding specifications, we often use binary coding to simplify. The optimal individual in the last generation population is decoded, which can be used as the approximate optimal solution of the problem. The flow chart of the genetic algorithm is as follows (Fig. 1);

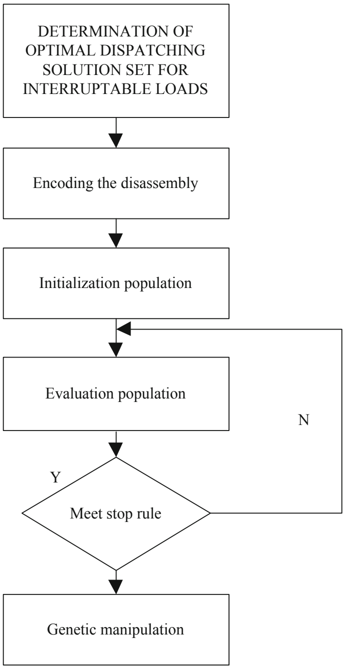

Fig. 1. Genetic algorithm flow

2.3 Implementation of Interruptible Scheduling Algorithm

With binary coding, the load interruption amount needs to be converted into a binary number for encoding. According to different ideas, two encoding methods can be used to encode it. The coding formula is as follows;

$$l_m = \frac{0102.\ldots..b}{1111.\ldots..b(a_i)} \times (l_{\min} - l_{i\min}) \tag{1}$$

In the formula (1), l represents the maximum value of the load amount, b represents the minimum value of the load amount, and a represents the number of codes. The advantage of this coding method is that the number of bits can be fixed, the coding is simple, and the data accuracy can be adjusted by the number of code bits [11]. The disadvantage is that if the fixed number of bits is small, there are cases where the optimization result is relatively rough.

The purpose of the interruptible load scheduling monthly plan is to minimize the scheduling compensation cost of the interruptible load on the premise of satisfying various constraints. The final fitness function formula is as follows:

$$g(t) = \frac{h}{\left(\sum_{e}^{m} [x(i,l)] \times [o(l)]\right]} \tag{2}$$

In the formula (2), g represents a constant, t represents a reduction amount, i represents a user, x represents a period number, o represents a penalty coefficient, and h represents a separation distance. The purpose of the interruptible load dispatch emergency plan is to pursue optimal economic performance on the basis of ensuring reliability. The fitness function adopted is as follows:

$$l_k = [x(i,l)] + [j(i_1 + l_2)] \tag{3}$$

In the formula (3), l represents the interrupt compensation amount, x represents the penalty coefficient, and i represents the reliability coefficient.

Regional minimum load reduction formula:

$$\sum_{m}^{n} t_{\min}(u)\Delta j_{\min} \geq o \tag{4}$$

In formula (4), t represents the demand reduction, and j represents the reduction amount. The user interruption amount constraint formula is obtained based on formula (4), and the formula is as follows;

$$y(b)\Delta v_{\min} \geq o \tag{5}$$

In formula (5), y indicates that the interrupt amount is met, and v indicates the minimum interrupt load amount. Based on the ultra-short-term load forecast, the short-time scale error correction is implemented.

The calculation result is obtained after the load scheduling task is satisfied or all interruptable load users are selected according to the sequence, and the scheduled interruptible load is statistically output. The interruptible scheduling algorithm is a bionic algorithm. The advantage is that the running process is simple, and it is easy to combine the objective function and constraints with high complexity. Moreover, the weighting of the penalty function in the constraint is set to meet different needs. For some complex optimization problems, some non-hard constraints can be ignored to achieve the purpose of solving the main problem.

Figure 2 is an interruptible scheduling algorithm that sorts the interruptible loads in order of priority. In the monthly plan and the current plan, the scheduling target is based on economy, and the system sorts the interruptible loads according to the interrupt compensation unit price of each interruptible load. In the emergency plan, the scheduling target is based on reliability and economical. The system sorts the reliability index of each interruptible load and the weighting coefficient of the interrupt compensation unit price. According to the order, the interruptible load is interrupted, and after each interruptable load is selected according to the priority order. The interruptible load is scheduled to be interrupted according to the completion of the load scheduling demand

and the interrupt limit condition for selecting the interruptible load. At this point, the central air conditioning load interruptable scheduling algorithm is implemented.

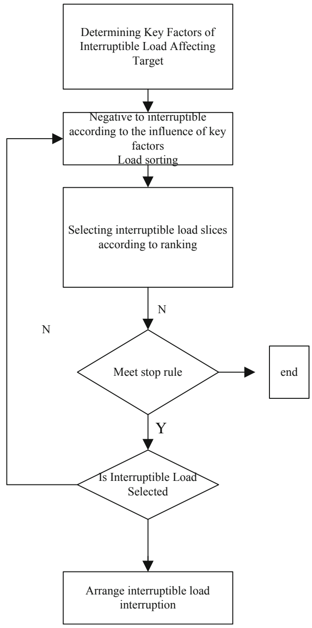

Fig. 2. Interruptible scheduling algorithm

3 Experimental Results

In order to verify the effectiveness of the central air conditioning load interruptible scheduling algorithm under big data analysis, the business solution software was used for calculation. The central air conditioning load interruptible load optimization scheduling problem is essentially a mixed integer programming problem. For such problems, the branch and bound method is generally used to solve the problem. By implicitly enumerating all possible combinations, the optimal solution of the problem can be obtained theoretically. Later, with the development of the theory of operations research, the cutting plane method was produced. Its core idea is to dynamically add the cutting plane constraint in the process of finding the optimal, and to cut off the area in the feasible domain that does not contain the integer feasible solution, and speed up the calculation process. By combining the branch and bound method with the cutting plane method, the branching plane method is formed, which greatly improves the efficiency of the mixed integer programming. The experimental data is selected as follows:

Table 1. Experimental data

Time	Hourly interrupt capacity	Actual interruption	Excess interruption
1	123	2354	3864
2	246	4579	348
3	365	479	358
4	525	5469	358
5	367	358	579
6	375	3534	382

Table 1 is the experimentally selected data, and the central air conditioning load interruptible scheduling algorithm under the big data analysis is tested. The experimental results are as follows:

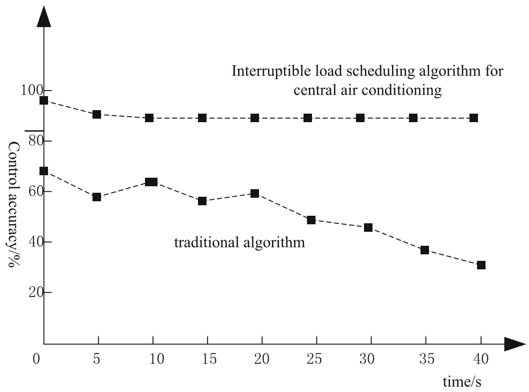

Fig. 3. Comparison of experimental results

Figure 3 is the experimental results. It can be seen that by comparing the optimization function of the central air-conditioning load interruptible scheduling algorithm under the traditional algorithm and big data analysis, the algorithm of this design has certain superiority. Traditional algorithms that minimize the number of interruptions can result in increased costs. As can be seen from Fig. 3, for some loads, the number of constraints is increased compared to the number of unconstrained interrupts. This is because the goal of the central air conditioning load interruptible scheduling algorithm is to minimize the overall system outage cost, rather than maximizing the economic compensation for individual loads. Therefore, some loads can be interrupted multiple times instead of other load interruptions to achieve the system's total number of interruptions and minimum interruption costs. The experiment proves that the central air conditioning load interruptible scheduling algorithm has a strong optimization function.

4 Conclusion

The central air-conditioning load interruptible scheduling algorithm based on big data analysis analyzes the application of the central air-conditioning load interruptible load and the continuous shortage of power system peak power consumption in the grid can reduce the power demand during the peak period of the power grid by coordinating the interrupted load dispatching on an emergency time scale one month ago, thereby ensuring the safe and stable operation of the power grid. In the power market where the interruptable load development is more mature, some high-cost peak-shaving unit output can be replaced by purchasing part of the interruptible load resources. The day-to-day economic dispatching link on the power generation side is transformed into a coordinated optimization economic dispatch of the generator set and the interruptible load, thereby reducing the marginal cost of the entire power grid purchase. Considering the network constraints, the limitations of traditional power transmission plug management are analyzed because of the transmission resistance phenomenon that may occur during peak power usage. By comparing the results of the transmission resistance plugging with interruptible load resources, the positive effect of interruptible load resources on the transmission resistance management is proved.

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