Research on Microgrid Operation Control Based on Matrix Multiplication MPI Parallel Algorithm

Rui Dai

Xinhua College of Ningxia University, Ningxia, Yinchuan, China

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Abstract: The MPI parallel algorithm based on matrix multiplication can effectively improve the operational stability and control accuracy of microgrids, and has high computational efficiency. Microgrids have operational characteristics such as flexibility, reliability, security, sustainability, and economy. MPI parallel algorithm is a parallel computing method based on message passing mechanism, which has become one of the important tools for solving large-scale computing problems due to its efficiency and scalability. The implementation path of microgrid operation control based on MPI parallel algorithm mainly includes defining microgrid operation control problems, designing MPI parallel algorithms, writing MPI parallel programs, testing and debugging, application and optimization. In the future, further research should be conducted on the optimization and improvement of this algorithm to meet the constantly changing requirements of microgrid control.

1. Introduction

With the rapid development and popularization of renewable energy, microgrids, as an emerging form of power system, have gradually received widespread attention. Microgrids are composed of various types of distributed energy and loads, and their operating characteristics are greatly different from traditional power systems. Therefore, how to effectively control the operation of microgrids is an important research direction. The microgrid should be modeled as a constrained nonlinear optimization problem and solved using MPI parallel algorithm to ensure its stability and safety.

2. Composition and operating characteristics of microgrid

A microgrid is a small power system composed of various types of distributed energy and loads. Typically, microgrids consist of the following three main components. One is distributed energy resources, such as solar photovoltaic panels, wind turbines, gas generators, ground source heat pumps, etc. These energy resources can generate electricity locally and be regulated and managed through power electronic devices within the microgrid. The second is energy storage equipment, such as lithium-ion batteries, supercapacitors, etc., which can store electricity and release it when needed to balance the supply and demand relationship within the microgrid. The third is the load, including household appliances, commercial facilities, factory equipment, etc. These loads require the consumption of electricity to maintain normal operation[1].

The operational characteristics of microgrids mainly include five aspects: flexibility, reliability, safety, sustainability, and economy. In terms of flexibility, microgrids can achieve a balance between power supply and demand by adjusting the relationship between distributed energy and load, thereby meeting different load demands and changes in energy supply. In terms of reliability, microgrids can ensure the reliability of power supply through various means, such as backup power sources and energy reserves. In terms of security, microgrids need to achieve power regulation and management through power electronic devices and control systems, which need to have high security and reliability to avoid power accidents and system failures. In terms of sustainability, microgrids can reduce their dependence on traditional energy, achieve sustainable energy utilization, and reduce environmental pollution by using renewable energy and energy storage technologies. In terms of economy, microgrids need to achieve maximum economic benefits by optimizing energy

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utilization and load management, while reducing energy consumption and operating costs.

3. Principles and Characteristics of 2 MPI Parallel Algorithms

3.1 Basic Principles of MPI Parallel Algorithm

MPI parallel algorithm is a parallel computing method based on message passing mechanism, which decomposes a large computing task into multiple small tasks and assigns them to multiple computing nodes for calculation. By using a messaging mechanism, communication and coordination between computing nodes can be achieved. You can also utilize the functions provided by the MPI library to achieve data communication and synchronization, and fully utilize the computing resources of computing nodes through load balancing and task scheduling. The above measures can further improve computational efficiency.

On the one hand, the MPI parallel algorithm adopts a process based parallel computing model, which decomposes the entire computing task into several subtasks, each completed by one or more computing nodes. In MPI parallel computing, each computing node is referred to as a process, and each process can execute a portion of the computing task. The MPI parallel computing model can support multiple parallel computing methods, including Single Program Multiple Data (SPMD), Multi Program Multiple Data (MPMD), and Multi Program Single Data (MPI). On the other hand, MPI parallel algorithms achieve communication and coordination between computing nodes through message passing mechanisms. In MPI parallel computing, each process has a unique process ID (rank) that identifies its position in the computing node. The MPI parallel algorithm sends and receives messages through functions provided by the MPI library, and processes can exchange data, synchronize computation, and coordinate computation tasks through message passing. The most basic message types in MPI parallel algorithms include point-to-point messages and set messages. Peer to peer messaging refers to a process sending messages to another process, while collective messaging refers to a process sending messages to multiple processes.

3.2 Main characteristics of MPI parallel algorithm

In MPI parallel computing, each computing node is referred to as a process, and processes exchange data, synchronize computing, and coordinate computing tasks through message passing, thus achieving large-scale parallel computing. The efficiency and scalability of MPI parallel algorithms make them one of the important tools for solving large-scale computing problems.

One is that MPI parallel algorithms have high-performance characteristics, which can fully utilize the computing resources of computing nodes and achieve efficient parallel computing. MPI parallel algorithms can achieve load balancing through dynamic load balancing and static load balancing to ensure that all processes have fair execution opportunities. Secondly, the MPI parallel algorithm has strong flexibility and can adapt to various computing tasks and environments. MPI parallel algorithms can support different communication modes and synchronization primitives, and different algorithms and strategies can be selected based on specific computing tasks. Thirdly, the MPI parallel algorithm has strong scalability, which can expand the computational scale by increasing the number of computing nodes, thereby achieving higher computational performance. The MPI parallel algorithm can support various parallel computing platforms and operating systems, and can run on different computers. Fourthly, MPI parallel algorithms have strong portability and can be ported and run on different computer systems and operating systems. MPI parallel algorithm is a standardized parallel computing model that can use different MPI libraries and compilers to achieve cross platform parallel computing.

4. Implementation Path of Microgrid Operation Control Based on MPI Parallel Algorithm

4.1 Defining the operational control issues of microgrids

When defining the operation control problem of microgrids, it is necessary to consider aspects such as control objectives, control strategies, and control parameters. The control objective is usually to maintain the voltage stability of the microgrid. The control strategy can be based on model predictive control, model reference adaptive control, etc. The control parameters can be control gain, control period, etc. In addition, factors such as the topology structure, load characteristics, generator sets, and energy storage system of the microgrid need to be considered in order to better develop control strategies and parameters[2].

In practical applications, the operation and control problems of microgrids are often complex and require comprehensive consideration of multiple factors. For example, there may be multiple generator sets and loads in a microgrid, and their interactions and impacts need to be considered; There may be multiple generator sets and energy storage devices in a microgrid, and it is necessary to consider their synergistic effects and the selection of control strategies. Therefore, when defining the operation control problem of microgrids, it is necessary to fully consider these factors and select appropriate control strategies and parameters based on the actual situation.

4.2 Design MPI parallel algorithms

When designing MPI parallel algorithms, it is necessary to consider how to decompose the microgrid operation control problem into multiple subtasks and use MPI_ Send and MPI_ The Recv function enables data transmission between different computing nodes. Common decomposition methods include task decomposition based methods and data decomposition based methods. Among them, the task decomposition method decomposes the entire microgrid operation control problem into several sub problems, with each sub problem being solved by a computing node; The method based on data decomposition decomposes the data of microgrid operation control problems into multiple parts, which are processed by different computing nodes.

Regardless of the decomposition method used, it is necessary to consider how to allocate the decomposed tasks to different computing nodes and ensure communication and synchronization between computing nodes. Common methods include message passing based methods and shared memory based methods[3].

4.3 Writing MPI Parallel Programs

When writing MPI parallel programs, it is necessary to implement MPI_ Send and MPI_ Recv function, and MPI_ Barrier function and other MPI library functions. MPI_ Send and MPI_ The Recv function is used to achieve data transmission between different computing nodes, MPI_ The Barrier function is used to achieve synchronization between computing nodes. In addition, it is also necessary to implement specific control algorithms for microgrid operation, such as model predictive control algorithms, model reference adaptive control algorithms, etc.

Except for MPI_ Send and MPI_ Recv function, MPI library also provides many other functions and tools, such as MPI_ Comm_ Split function, MPI_ Comm_ Join function, MPI_ Group_ Include function and MPI_ Opaque data types and other functions and tools can be used to implement more complex parallel computing tasks.

4.4 Testing and Debugging

After completing the writing of MPI parallel programs, testing and debugging are necessary, which is an important part of developing MPI parallel programs. The purpose of testing and debugging is to verify the correctness and reliability of the program, identify and solve potential problems. To achieve this, it is necessary to integrate the MPI parallel algorithm and other control algorithms into the microgrid control system, and conduct testing and verification. During the testing process, various practical situations need to be considered, such as load changes, energy equipment failures, etc., to ensure the stability and reliability of the microgrid control system; You can also use computing nodes of different scales for testing and evaluate the performance and correctness of the program. If problems are found in the program, debugging is necessary, such as checking for bugs in the program, optimizing program performance, etc.

4.5 Application and Optimization

After completing testing and debugging, the MPI parallel program can be applied to the actual microgrid operation control system, which is the final step in developing MPI parallel programs. During the system integration and testing phase, the microgrid control system can be optimized and improved based on the test results and actual application situation. The system performance and efficiency can be improved by adjusting control algorithm parameters and improving communication protocols. In the application process, it is necessary to consider the actual application situation, such as changes in microgrid state, load changes, and other factors, in order to optimize the performance and efficiency of the program. At the same time, the program can also be optimized based on actual application situations, such as adjusting communication protocols, optimizing data transmission methods, etc., to improve the performance and efficiency of the program.

5. Conclusion

With the development of society and technological progress, the application of renewable energy is becoming increasingly widespread. As a new type of energy system, microgrids have important application value. However, the operation control of microgrids is a complex and critical issue that requires the use of efficient control algorithms to achieve stable control of microgrids. The MPI parallel algorithm based on matrix multiplication can effectively improve the efficiency and stability of microgrid operation control. At the same time, integrating other control algorithms can further improve the performance and reliability of microgrid control systems. In the future, we should continue to conduct in-depth research on microgrid control algorithms and validate and optimize them in conjunction with more practical application scenarios. At the same time, efforts should also be made to explore more efficient and flexible MPI parallel algorithms. By doing so, we aim to meet the growing demand for computing and further improve the operational efficiency and stability of microgrids. Greater contributions should be made to achieve sustainable energy development.

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