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Task Scheduling Method of Ocean Engineering Simulation Calculation Based on Numerical Pool

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Abstract: With the rapid improvement of high-performance computer resources and CFD technology, numerical wave pools have attracted more and more scholars' attention due to their rich and diverse functions and low forecasting costs. Numerical wave pools and traditional physical experimental pools complement each other's advantages and disadvantages, and have become an indispensable and important means of ship hydrodynamic performance research, wave power generation and ocean engineering. This paper studies the task scheduling method of ocean engineering simulation calculation based on numerical pool. This paper introduces the CFD execution process, analyzes the characteristics of the CFD solving task, proposes an evaluation method for the task size, and finally compares the different algorithms.

1. Introduction

The numerical pool simulation computing platform is a system for numerical simulation of fluid mechanics in ships and marine engineering. It integrates various simulation sub-systems on the basis of high-performance computer clusters, and uses CFD application technology to complete the requirements for physical pools. Simulation, to provide users with the application technology of virtual simulation experiments [1]. In order to improve the task execution efficiency of the numerical pool platform and improve the utilization rate of platform resources, this paper studies the intelligent allocation between tasks and virtual machines.

Diverse user tasks also bring new challenges to cloud computing. Shaghaghi M studied that modern radars can be designed to perform multiple functions such as surveillance, tracking and fire control. Each function requires the radar to perform multiple transmit-receive tasks. The radar

resource management module makes decisions on parameter selection, prioritization and scheduling of such missions. Radar resource management becomes particularly challenging under overload conditions, and some of these missions may need to be delayed or even discarded. Generally speaking, task scheduling is an NP-hard problem. In this work, branch-and-bound methods are improved, which can obtain optimal solutions but with exponential computational complexity. On the other hand, heuristics have low complexity but relatively poor performance. We turn to machine learning-based techniques to solve this problem; specifically, an approximation algorithm based on a Monte Carlo tree search method is proposed [2]. Jain R studies that cloud computing is becoming an influential architecture for performing complex and large-scale computations. It provides on-demand access to a "pay-as-you-go" service. In a cloud computing environment, task scheduling is a fundamental technique necessary to assign tasks to appropriate resources to achieve proper resource utilization and optimize overall system performance. Task scheduling is an NP-hard problem. An improved ant colony optimization algorithm is proposed, which serves improved task scheduling with minimal completion time while maintaining cost. This algorithm mainly helps to minimize the total completion time of scheduled tasks on resources. This is achieved by splitting the tasks submitted in order into a set of tasks [3]. Efficient task scheduling and resource scheduling have become an important research direction of cloud computing.

This paper studies the task scheduling method of ocean engineering simulation calculation based on numerical pool. First, the CFD execution process is introduced, and an evaluation method of task size is proposed through the analysis of the characteristics of CFD solving tasks. The model first collects the load information, quantifies the collected information, and then predicts the load of the virtual machine when the task is fully executed. On the basis of this model, a task scheduling method MS-SVLL algorithm for marine engineering simulation calculation based on numerical pool is proposed, and simulation experiments are carried out through CloudSim. The total waiting time and virtual machine load imbalance are compared in three aspects.

2. Research on Task Scheduling Method of Ocean Engineering Simulation Calculation Based on Numerical Pool

2.1. Research Background and Significance

The numerical pool is an efficient scientific computing software system, which is realized by using computer and Internet technology according to the theoretical model of hydrodynamics and refined numerical algorithms [4]. It can simulate the fluid dynamics experiment in the field of ship and ocean engineering, greatly reducing the experiment cost. The numerical pool simulation platform can not only simulate the towing experiment, cavitation water tunnel experiment, seakeeping simulation experiment, and maneuverability experiment of the ship entity, but also can be applied to the related simulation of wind, wave and current experiments in marine engineering. It can analyze the specific causes of the fluid flow phenomenon by analyzing the dynamic situation of the tiny flow field of the ship.

The numerical pool simulation platform is built by using the world's leading high-performance supercomputer. In terms of flow field observation, it has much finer observation capabilities than physical pools, and the observation direction is relatively free, which is convenient for ships to combine marine wind and wave weather conditions in practice. to select the appropriate optimal route for the simulation [5]. Numerical pool is an application technology for engineers and technicians. It uses the new computing mode of network technology and cluster computing technology to solve platform problems in resource management, knowledge sharing and operation and maintenance. The ability to dynamically allocate and adjust resources according to the needs of users enables users to conduct virtualization experiments anytime and anywhere, and to obtain

computing services without caring about the internal implementation details. However, in the platform, a large number of applications will share various resources. How to improve the performance of these applications is a problem that needs to be solved in task scheduling. The function of task scheduling is to refer to the real-time platform cluster load. The tasks are continuously and dynamically allocated, and the task operation arrangement is scheduled according to the task category requested by the user, the required resources, the remaining resources of the platform and the load of the machine with the resource, etc., so as to improve the operating efficiency of system tasks and the utilization rate of platform resources. . For tasks submitted to the platform, if you want to shorten the running time required to complete the task, you need to find a way to reasonably allocate resources to the task. The tasks of the numerical pool platform have a certain complexity. Although tasks can be classified as simulation calculations, they may be computationally intensive, data-intensive or both, and the arrival, processing, and execution of tasks are also very different. , it is difficult to determine [6].

2.2. Research Status of Task Scheduling Algorithms

At present, many multi-task scheduling algorithms have been proposed in the academic world, and the scheduling algorithms can be classified according to different standards. This section will introduce two types of scheduling algorithms, traditional task scheduling and heuristic task scheduling [7].

(1) Traditional task scheduling algorithm.

Among them, Min-Min algorithm, Max-Min algorithm and Suffrage algorithm are the classic scheduling algorithms in grid computing. At present, there are a lot of researches on the improvement and application of these traditional algorithms [8]. Aiming at the uncertainty-based task assignment problem in heterogeneous multi-cloud systems, the Min-Min algorithm is combined to study. The average task minimum and Max-Min algorithms are combined to shorten task turnaround time and improve resource utilization. To achieve load balancing, a Max-Min task scheduling algorithm for elastic cloud load balancing is proposed. Aiming at the problem that the set of independent tasks to be scheduled on the grid is large in scale, by combining the Suffrage algorithm and Min-Min, a concept of task division is proposed, that is, the task is divided according to the machine with the earliest completion time. As a result, several tasks in different task partitions can be scheduled simultaneously, reducing the scope of task search and avoiding task reallocation [9]. The main goal of traditional scheduling algorithms is to improve the execution efficiency of tasks. Generally, traditional scheduling algorithms need to be improved or applied in combination with other algorithms.

(2) Heuristic task scheduling algorithm.

Generally speaking, in high-performance computing, grid computing, and cloud computing, the task mapping problem with infinite computing resources belongs to NP-hard problems [10-11]. In this type of problem, no algorithm can produce an optimal solution in polynomial time. An exhaustive search based solution is not feasible because the running cost of generating the schedule is very high. Heuristic-based techniques address these problems, yielding a near-optimal solution in a reasonable amount of time. Heuristic algorithms have gained enormous popularity over the past few years due to their efficiency and effectiveness in solving large and complex problems [12].

Furthermore, scheduling algorithms differ according to the degree of dependencies between tasks to be scheduled [13]. If there is a prioritization in the tasks, the tasks can only be scheduled after all parent tasks are completed, whereas in the case of tasks independent of the tasks, the tasks can be scheduled in any order. The former is dependent scheduling or the more common workflow scheduling, the latter is called independent scheduling. There are also corresponding scheduling

algorithms based on different goals, including optimal span, economic principles, service quality, load balancing, etc. [14].

2.3. Task Scheduling Method of Ocean Engineering Simulation Calculation Based on Numerical Pool

(1) Task scheduling method

At present, in the process of scientific research, high-performance computing has become indispensable for computing tasks that require a large amount of computing resources. However, traditional high-performance computing clusters use an exclusive way to allocate resources, which results in that when multiple tasks are allocated, other tasks must wait until the running task is completed before they can be processed, resulting in a serious waste of resources [15]. Virtualization has the characteristics of high fault tolerance, customizable operating environment, and reusable computing resources, which can make full use of physical computing resources.

In the numerical pool platform, the CFD solvers are deployed on different virtual machines. In order to better utilize resources, one virtual machine deploys multiple solvers. When a task is scheduled to be assigned, it is essentially a match between the task and the virtual machine on which the solver is deployed. Different virtual machines have different resource ratios. During resource allocation, a list of virtual machines that meet the task resource requirements is screened from the virtual machine cluster. In the list of virtual machines that meet the task resource requirements, tasks are scheduled according to the task load of the virtual machines. In order to improve the task execution efficiency of the numerical pool platform and improve the utilization rate of platform resources, this paper studies the intelligent allocation between tasks and virtual machines [16].

(2) Analysis of the task characteristics of the numerical pool platform

The task studied in this paper is the CFD task in the numerical pool, which refers to the task of setting the experimental data in the software subsystem improved on the basis of CFD, and selecting the solver to solve it. CFD is Computational Fluid Dynamics, which simulates real fluid experiments by means of numerical simulation [17-18]. The basic flowchart of the solution based on CFD software is shown in Figure 1:

The first step is to establish an overall model for the problem, which is a mathematical description of the problem under study. The second step is to divide the overall model grid, and the granularity of the calculation is determined by dividing the grid. The third step is to solve the calculation task how to configure the solver, and finally process the results and visualize the results.

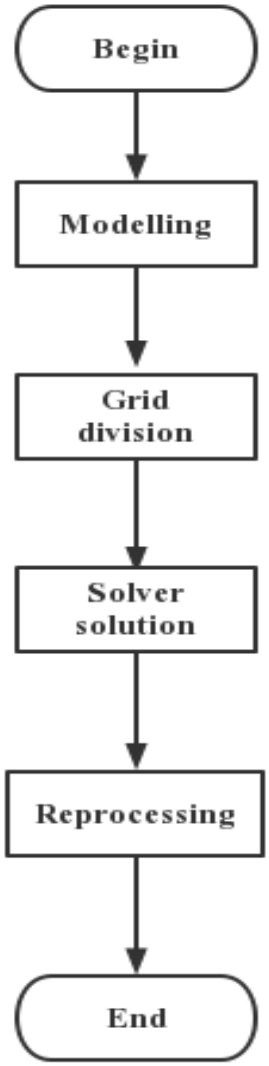

Figure 1. CFD execution process

3. Investigation and Research on Task Scheduling Method of Ocean Engineering Simulation Based on Numerical Pool

3.1. Experiment

In this section, the performance of the MS-SVLL algorithm is verified by experiments. The experimental environment is: the operating system Window7, the memory is 8G, the programming language is Java, the programming environment is Eclipse, and the CloudSim4.0 simulation tool is used to perform the task execution process of the real numerical pool platform. Because the functional improvement of the numerical pool platform is not perfect enough, it cannot be put into application. In addition, the task type studied in this paper has a long execution period and high resource requirements. In order to reduce the experimental cost, the task data used in the experiment in this paper is simulated data, and the CloudSim simulation tool is used to conduct the simulation

experiment.

3.2. Task Size Evaluation Method

Through the analysis, it can be known that the factors affecting the size of this type of task include the grid division method, the number of grid divisions, the size of the flow field, the setting of the boundary conditions, the choice of the solver, the program algorithm flow, the size of the relaxation factor, the water quality point factor size. The number of grid divisions is represented by n, the size of the flow field is represented by v, the size of the relaxation factor is represented by u, and the size of the water quality point factor is represented by k. The formula for calculating the task size is as follows:

$$S_t = \frac{nkv}{u}, n \le N \tag{1}$$

$$S_t = \frac{\left[N + ln(n - N + 1)\right]kv}{u}, n \phi\ N \tag{2}$$

4. Analysis and Research on Task Scheduling Method of Ocean Engineering Simulation Calculation Based on Numerical Pool

In the experiments in this paper, it is assumed that the idealized model distinguishes all tasks only by the size of the task, and the settings of other attributes are the same. Set virtual machines with three different attributes. The specific attribute values are shown in Table 1 and Figure 2:

Table 1. Virtual machine attribute values

VMsID	1	2	3
MIPS	4000	3000	2000
ImageSize (MB)	8000	8000	8000
VMmemory (MB)	7541	5412	4514
Bandwidth (Mbps)	800	600	500
NumberofCPU	7	6	5

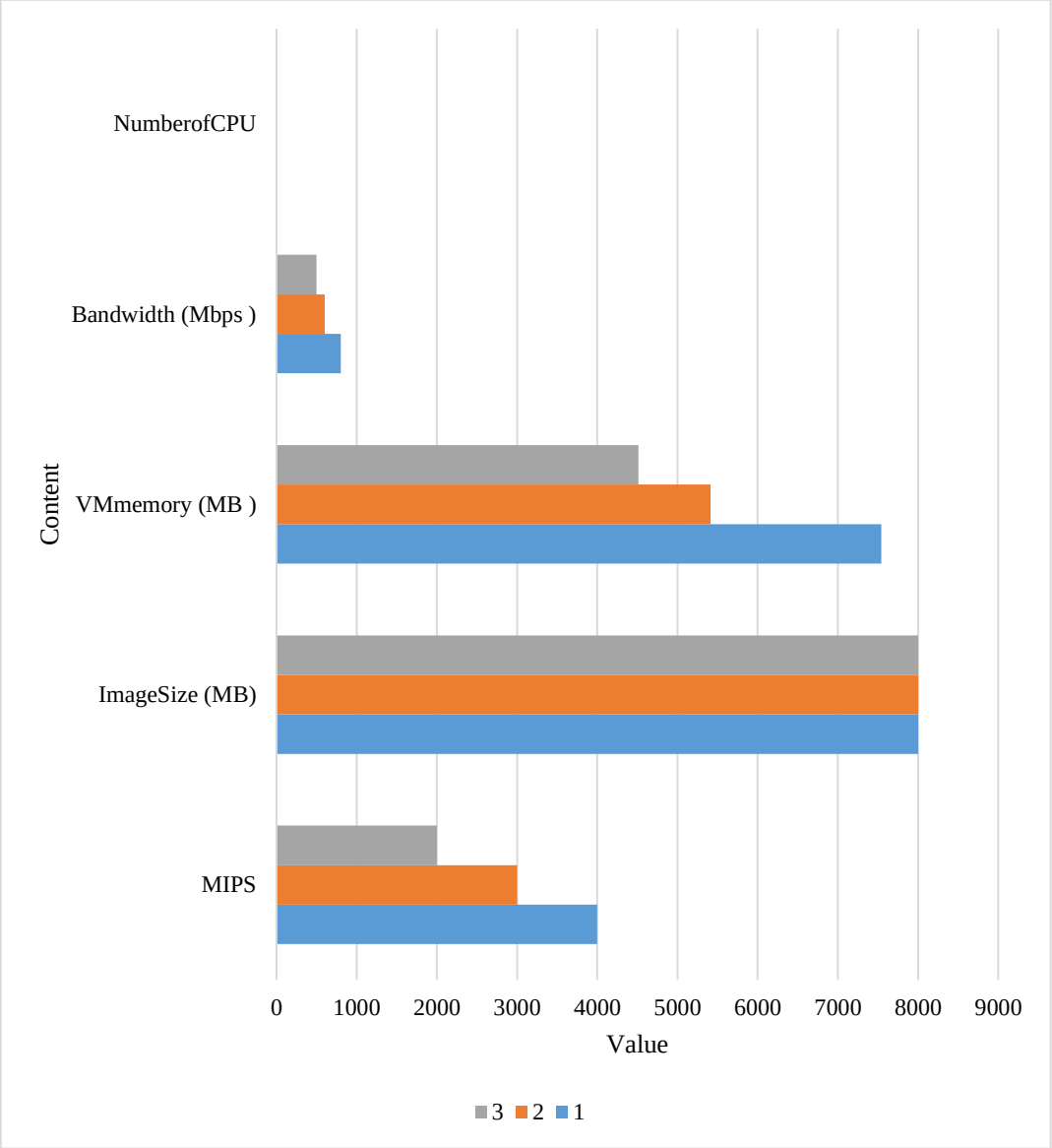

Figure 2. Virtual machine data diagram

Different algorithms are run 10 times on 10 tasks, and the size settings of 10 tasks and the results of each experimental indicator are displayed in tabular form. Aspects of the average results are shown in Table 2 and Figure 3:

Table 2. Average experimental results

	FCFS	Min-Min	Max-Min	MS-SVL L
TET	5984.2	5874.21	5531.25	4532.21
TWT	1587.32	869.35	1524.35	865.31
L	0.58	0.71	0.61	0.46

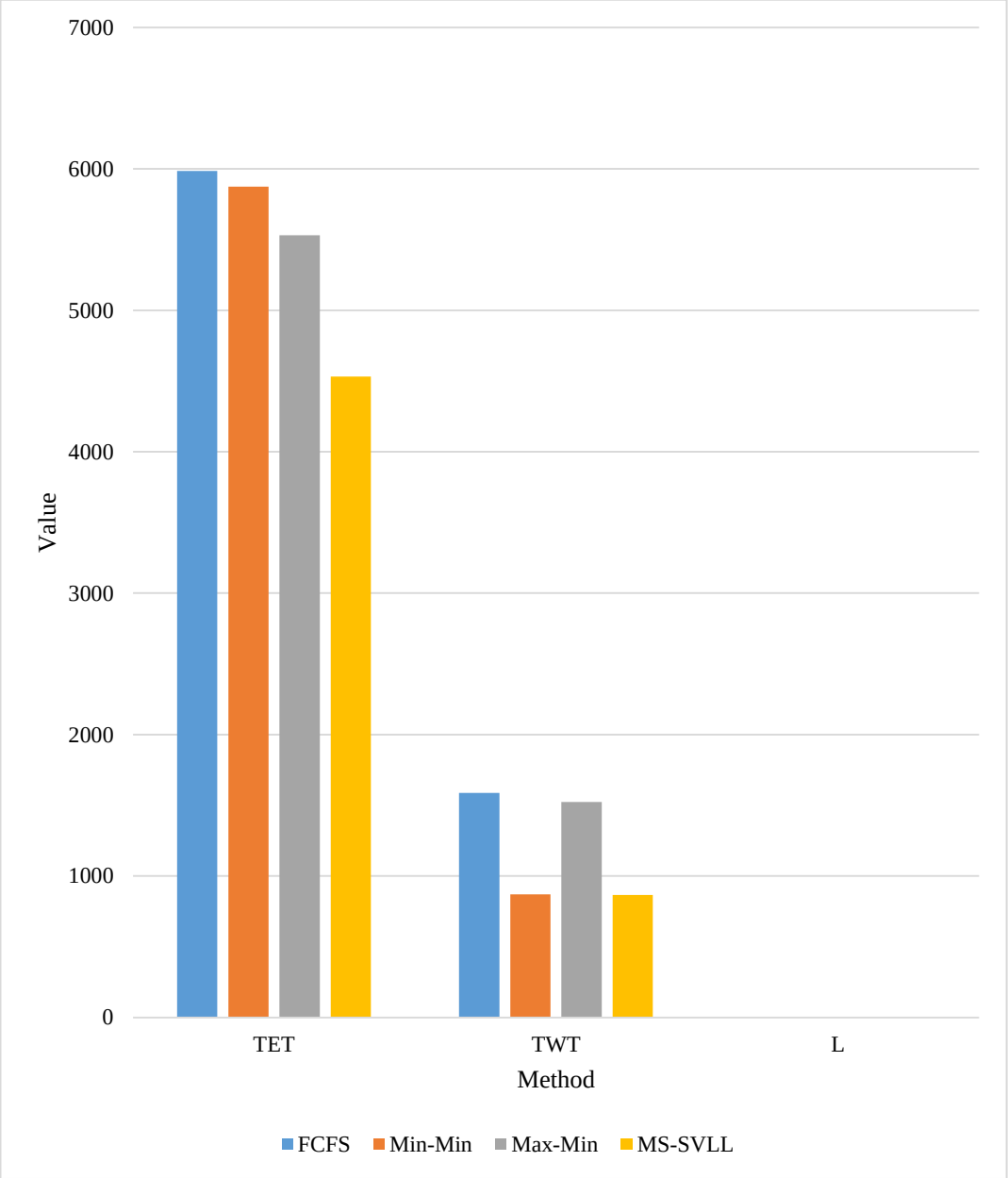

Figure 3. Comparison diagram of the experimental data

It can be concluded from the experimental data that in the experiment of 10 tasks, the MS-SVLL algorithm performs well in three aspects: total task execution time, total task waiting time, and virtual machine load imbalance.

5. Conclusion

High-performance cluster computing and virtual machine migration technology are the research hotspots in recent years. The task scheduling method of the numerical pool platform studied in this paper mainly involves these two technologies. Aiming at the characteristics of the tasks and underlying resources of the numerical pool simulation computing platform, this paper studies the intelligent allocation between tasks and virtual machines and the resource scheduling method for the purpose of physical cluster load balancing. Numerical pool technology is currently becoming

more and more mature. As an important means to study ship performance tests, the interaction between waves and structures, and the use of wave energy to generate electricity, its application prospects are very broad. Therefore, the pursuit of stable, accurate and high-efficiency wave making methods will inevitably It may eventually become a highlight of the Numerical Wave Pool Research Center.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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