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Parallel Computing Technology Based on Computer Simulation

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A parallel computing model is a medium connecting computer software and hardware. The parallel computing model is an abstract computing model generated based on the abstract extraction of essential features of various parallel computing technologies. On this computing model, the optimal solution algorithm of the problem required by the design scheme was analyzed and designed, and the optimization algorithm was completed by compiling the programming language efficiently. In order to better study the model of parallel computing technology, this paper explored parallel computing based on computer simulation. It was found that parallel computing based on computer simulation took much less time to execute the computing of different data scales than traditional parallel computing methods. The usage rate of the central processing unit (CPU) of the parallel computing technology system proposed in this paper was less than that of the traditional parallel computing system under different data scales. When the data was 10000, the CPU utilization of the parallel computing system studied in this paper was 43%, which was 10% lower than that of the traditional parallel computing system. It can increase the saving of CPU resources and help the system run better and faster. Therefore, it is worthwhile studying parallel computing based on computer simulation.

Keywords: parallel computing technology, computer simulation, traditional parallel computing, matrix laboratory

1. INTRODUCTION

With the gradually increasing application of computer simulation, the operating scale of the simulation system is also increasing, and there is a greater need for higher computer speed. If the speed of only a single computer is increased, computer simulation becomes problematic [1–2]. Computer simulation is used to transform the comprehensive mathematical analysis model into a form that can be handled by the computer, that is, by means of a simulation model experiment. The aim of carrying out an optimization test on the data machine is to obtain the solution of the differential formula by means of numerical integration. Parallel computing is one of the important methods applied to solve large and complex calculation problems. With parallel computing, a large calculation problem is decomposed into many smaller sub-problems according to certain rules; then, these sub-problems are distributed to different connection points on the big data processing platform for calculation. This decomposition of a problem can greatly shorten the time required for problem processing, and improve the utilization of hardware resources. The application of parallel computing in all walks of life has made great progress in terms of theoretical research and widespread application [3]. In recent years, with the rapid development of the Internet, the speed of collecting and storing data has accelerated, and the scale of data has increased exponentially, leading to the big data phenomenon . How to carry out the efficient mining of big data is currently one of the hot topics of scientific research. Parallel computing can provide the computing power required to handle big data, and parallel computing can solve the problems associated with massive amounts of data. Therefore, it is of practical significance to study a parallel computing framework.

Parallel computing is one of the hot issues in the field of computer research. Many countries have invested heavily in the development of high-performance parallel computing systems with faster computing speed. For this reason, many experts and scholars have carried out research and presented a series of research results. Wu reviewed nine enabling technologies through parallel computing in railway research and the use of enabling technologies in parallel computing, and discussed the reasons why these enabling technologies were suitable for parallel computing, and the applicability of various enabling technologies to different types of parallel computing [4]. Memeti conducted a systematic literature review of existing software optimization methods for parallel computing systems, and summarized, analyzed and classified them. He reviewed the method of using machine learning or meta-heuristics to optimize software during compilation and operation, which helped to better understand the advantages of using machine learning and meta-heuristics to process software optimization of parallel computing systems [5]. Kiy introduced a parallel computing image processing software system based on geometric histogram method, which was used for the concise description and segmentation of color images, and the design of real-time image understanding system. He found that parallel processing was different from most existing image segmentation methods, and the proposed method was designed to use *n* independent threads to execute pixel arrays [6]. Xia proposed a high-performance model for compute-intensive and data-intensive geospatial processing in urban simulation using vectorization and parallel computing technology. In order to convert the original algorithm into a vectorization algorithm, he defined the neighborhood set of the cell space and improved the operation paradigm of neighborhood calculation, transition probability calculation and cell state transition [7]. Researchers have used a variety of research methods to study parallel computing, but few experts and scholars have considered using computer simulation to study it.

Various other scholars have different views on the research of parallel computing technology. Shukur introduced some workflows of cluster parallel computing for distributed systems, aiming to improve the performance of distributed systems and shorten the time interval between system performance and response time. He conducted a comprehensive study and comparison of the characteristics of synchronous mode and asynchronous mode [8]. Zhong developed a program based on large-scale ranking and selection to solve large-scale problems in a parallel computing environment. This procedure was not affected by whether the difference between alternatives was known, which could theoretically achieve the lowest growth rate of the expected total sample size relative to the number of alternatives, so it was the best in terms of speed [9]. Cho believed that it was necessary to extend LLVM IR (Intermediate Representation) to support vector/matrix more effectively in order to support various parallel computing systems. He designed LLVM IR as machine code, which required mapping each instruction in LLVM IR to the target architecture [10]. Behnezhad introduced the adaptive massively parallel computing model, which was an extension of the massively parallel computing model. At a high level, the adaptive massively parallel computing model strengthened the massively parallel computing model by storing all messages sent in a round in a distributed data store [11]. Experts and scholars have conducted a great deal of research on parallel computing, providing a sound theoretical basis for this study.

People's consumption of computer-enabled technologies is endless. Whether it is computing simulation used in science and engineering, or data mining used in commercial services, and many other industries, parallel computing has already had a great impact. Parallel computing has already had a significant impact on the development of several science and engineering disciplines. At the same time, parallel computing technology is also widely used in marketing applications, which can help marketing operations use and manage large-scale transaction data to improve customer service and product inventories, and expand their markets.

2. PARALLEL COMPUTING TECHNOLOGY AND COMPUTER SIMULATION METHOD

2.1 Computer Simulation

Computer simulation technology generally refers to the use of computer image processing and development technology to create a 3D virtual simulation of a solid model. At the same time, a series of experimental analyses is carried out on the established 3D model [12]. 3D simulation technology, with its characteristics of high efficiency and safety, can be less constrained by natural conditions, and can change the time and model proportion specifications according to the actual needs of the project [13]. Computer-generated 3D simulation has three characteristics. Immersion refers to the actual degree to which the users immerse themselves in the virtual environment. The idealized virtual environment can make users unable to distinguish the reality from the virtual, as occurs in some 3D visual scenes. These scenes generally change with the change of perspective, and may even be better than the reality. For instance, the virtual scene may have more realistic indoor lighting than in reality. Interactivity refers to the degree to which users can actually operate the object entity model in the 3D virtual environment, and the type of feedback from the environment. For example, users can have full control of objects in a virtual environment, and can also move freely within it. When they encounter flowers, trees or courtyard walls in the virtual environment, users can be blocked by objects and stop moving. The latest development of computer simulation technology is shown in Figure 1.

The key to improving computer simulation technology is to engage in the development of 3D simulation engineering projects, as well as the integration of its software and hardware configuration systems. Through these, people's imagined images can be presented through computer 3D visualization platforms, which are widely used in various industries [14–15]. The most basic concept of computer simulation is based on scalar value. Computers are used to simulate the operation of various processes or systems in practice, thus obtaining extremely important statistical and decision-making information. Computer simulation technology can take full advantage of the rapid processing speed of the computer to fully consider the possible impact of various elements in random events or changing laws for the dynamic operation of the system. Computer simulation technology is used to simulate the system, which can analyze the operational status of the system, and predict and analyze the rationality of the process. The "short board" of the system can help to improve the performance of the system at all

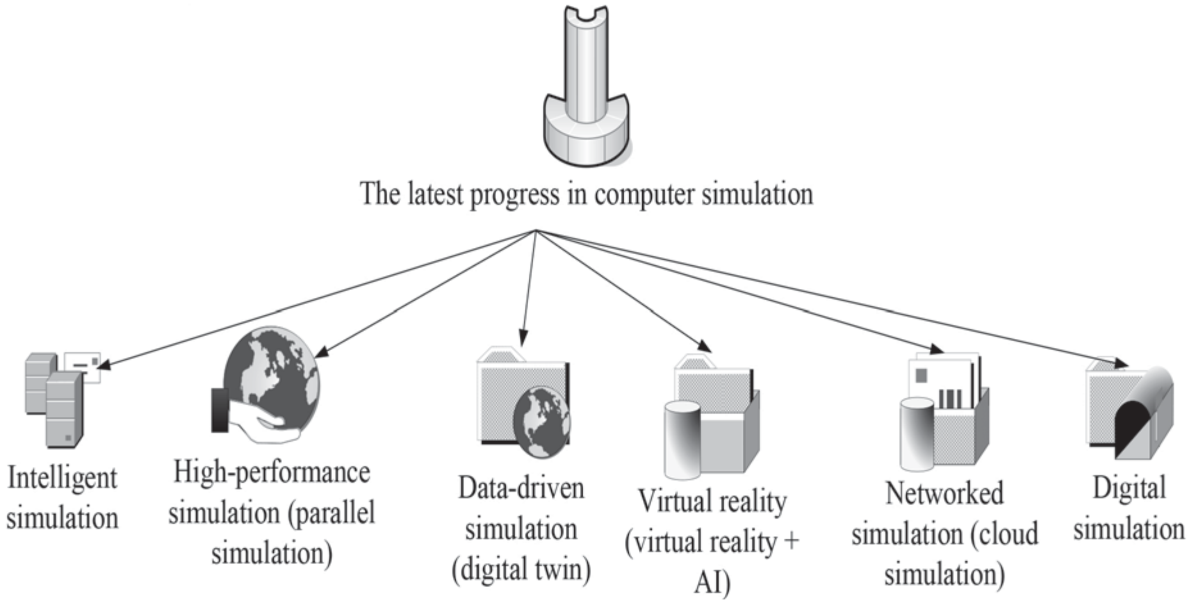


Figure 1 Latest progress of computer simulation technology.

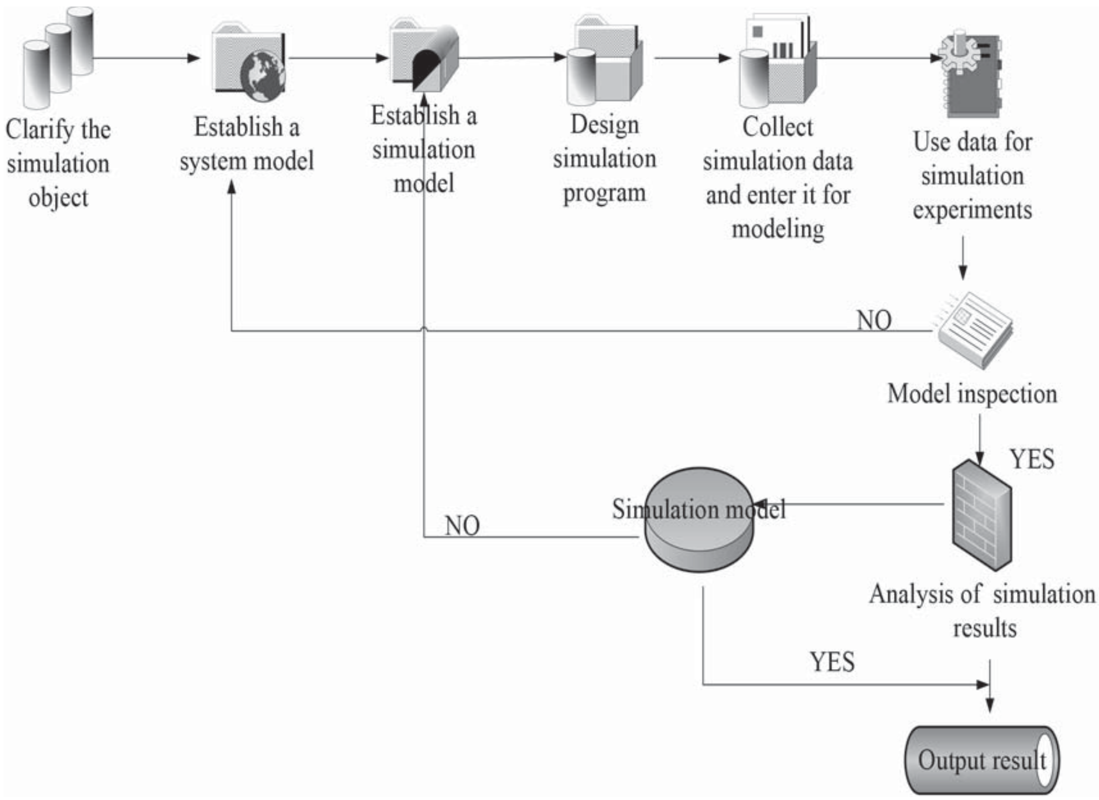


Figure 2 Computer simulation procedure diagram.

stages, achieving overall improvement. Computer simulation generally includes three basic stages [16]. The relationship between computer simulation steps can be shown in Figure 2.

Computer simulation technology has existed for a long time and was first used in the defense industry. However, with the development of computer technology and the improvement of application level, due to the continuous expansion of the diversity of service and production systems, system planning and business units often encounter the situation where scientific decisions about the system have to be made in a timely manner. Computer simulation technology has been widely used in this context.

2.2 Parallel Computing

Parallel computing, which is synonymous with high-performance computing and human supercomputing, generally refers to computing on parallel computing systems. This is because all high-performance computing is inseparable

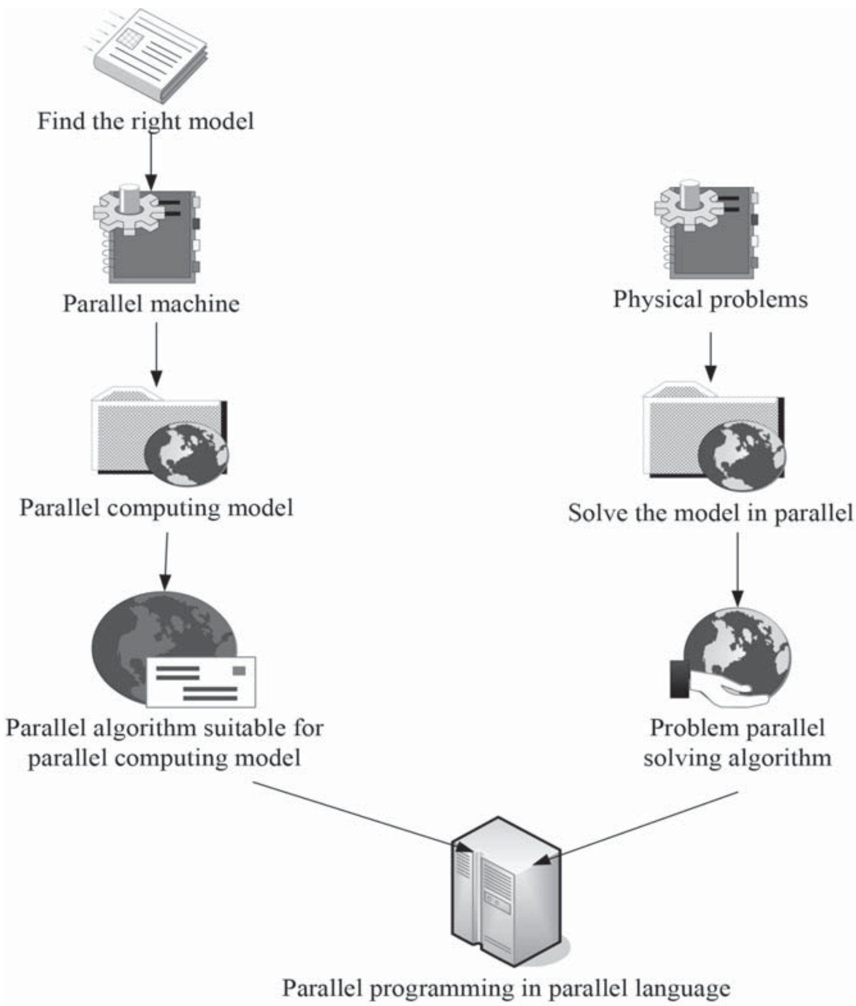


Figure 3 Steps for the parallel solution of the problem.

from the use of parallel computing technology [17–18]. The parallel computer consists of a group of processing units that cooperate with each other at speeds according to their communication and cooperation in order to jointly complete a large-scale computing task. Therefore, the parallel computer has two most important components (the processing unit and the Internet). Nowadays, computational science has become the third science alongside traditional science, namely basic theoretical science and experimental science. Their close connection with each other has promoted the development of science and society in general. Parallel computing has greatly improved people's ability to engage in scientific exploration and greatly accelerated the process of transforming high-tech into productivity, which has a real impact on people's ways and means of understanding and creating the world. The steps for the parallel solution of the problem are depicted in Figure 3.

Compared with serial communication measurement, parallel computing can be divided into temporal parallelism and spatial parallelism. Time-parallelism is the command pipeline structure, which is mainly carried out by transforming the whole process of executing a command into many process steps [19]. Each process step is completed by a separate component, which can reduce the execution time of all tasks by executing different commands together. It does not reduce the execution time of each command, but improves the performance by increasing the throughput of the command executed by the microcontroller. In a broader sense, the parallel computing model plays the role of providing hardware and software pages for parallel computing. A parallel computing model is the premise of parallel computer algorithm and analysis, and also the abstraction of the essential characteristics of parallel computer [20]. Although a variety of parallel computing models have been proposed, there is no calculation model in parallel computing algorithms that can be applied to a variety of parallel computing system architectures. The parallel computing model is not a parallel computer, and it is different from the specific parallel computer [21].

MATLAB, a programming platform, is being widely used in communication research because it offers high computing power and a variety of calculation and operational features. In addition, MATLAB also provides special auxiliary tools for communication, including various communication optimization algorithms and modules [22]. It provides consumers with instant learning, research and application, and has incomparable advantages over other languages. The parallel calculation method of MATLAB is shown in Table 1.

The ideal simulation is completely based on the real situation. The performance of all links in the system should be considered, and the transmission of real data should be achieved by each link. The calculation formula is as follows:

Table 1 MATLAB parallel computing mode.

Matlab parallel computing	Method of implementing a function	Scope of application	Resource consumption	Advantages
Parallel loop function	Parfor/spmd	Multiple independent cycles	Less	Avoid dependencies between tests
General parallel scheme	Parcluster	Single device universal	Many	Low cost, fast speed
MDCS	Configure IP to build a cluster	Multi-device universal	Many	Avoid too much confusion in coding
Distributed matrix	Codistributed	Split large-scale matrix	Less	Efficiently manage test data

$$SNR_{awgn} = -\gamma In\left(\frac{1}{H_{sub}}\sum_{j=1}^{H_{sub}} exp\left\{-\frac{1}{\gamma}SINR_j\right\}\right) \quad (1)$$

The calculation formula for the communication overhead between computer simulation microprocessors is:

$$P_I^H = \sum_{i=1}^{m}\left(q^0 + q' * g_i\right) = m * g_0 + \sum_{i=1}^{m} q' * g_i \quad (2)$$

In a processing cycle, if the calculated scale and steps of a module is particularly large, it is impossible to obtain a high acceleration ratio by means of pipelining. Then, the method of cloning this module to n processors can be used. The formula for calculating the theoretical acceleration ratio is:

$$H_n = \frac{\sum q_i}{\left(\sum q_i - q_p\right) + q_p/n} = \frac{1}{1 - \frac{n-1}{n}q_i} \quad (3)$$

Acceleration ratio: Parallel execution time is Q_h. If the parallel execution time of x processors is $Q_t(x)$, the formula for calculating the acceleration ratio $H_t(x)$ is:

$$H_t(x) = \frac{Q_h}{Q_t(x)} \quad (4)$$

Let the parallel factor ϑ be the proportion of the parallel part; then the calculation formula is:

$$H_m = \frac{\left(M_x + M_y\right)}{\frac{M_x}{M_x+M_y} + \frac{M_x/m}{M_x+M_y}} = \frac{1}{\vartheta + (1-\vartheta)/m} \quad (5)$$

Generally speaking, the performance of each computing node in a cluster is different. If the same amount of computation is allocated to each computing node, the load of these nodes will be unbalanced. If the load difference is large, this seriously reduces the overall performance of the system.

$$B_j(H_i) = x_1 * B(B_i) + x_2 * B(N_i) + x_3 * B(R_i) + x_4 * B(W_i) \quad (6)$$

Among them, $x = (x_1, x_2, x_3, x_4)$ is the weight of each parameter when measuring node performance, and $B(B_i)$ is CPU performance.

2.3 Design of Parallel Computing Technology Framework Based on Computer Simulation

Computer simulation technology is a comprehensive technology that uses a variety of professional technologies as the carrier, computers and various physical effect machines and equipment as special tools, and uses the system entity model to carry out experimental research on specific or future systems [23]. Its advantages are the safety factor, rationality and repeatability. It is important to use it to research parallel processing technology. The architecture of the overall framework is shown in Figure 4.

The contents of parallel computing framework based on computer simulation are shown in Table 2.

After receiving the calculation request from the client, the service node transmits the status of the calculation node to the control node to facilitate the sharing of the calculation request. The calculation node in the available status also receives the calculation task. After receiving each calculation result, the service node returns the calculation conclusion to the client. The operation of the service node control module is shown in Figure 5.

The service node module is comprised of three parts: service manager, distributor and collector.

The Com_Info table records the information of calculation nodes. The table structure is shown in Table 3. In the current design, there are only two statuses of computing nodes: available or unavailable.

The Com_Per_Info table records the performance information of the calculation node. The table structure is shown in Table 4.

3. PARALLEL COMPUTING EXPERIMENT BASED ON COMPUTER SIMULATION

3.1 Parallel Strategy Design

(1) Data sharing

In a cluster consisting of several devices, if distributed system is used, it causes very high communication overhead when processing its data. Even in a fast Ethernet interface environment, data transmission in the cluster also takes a lot of

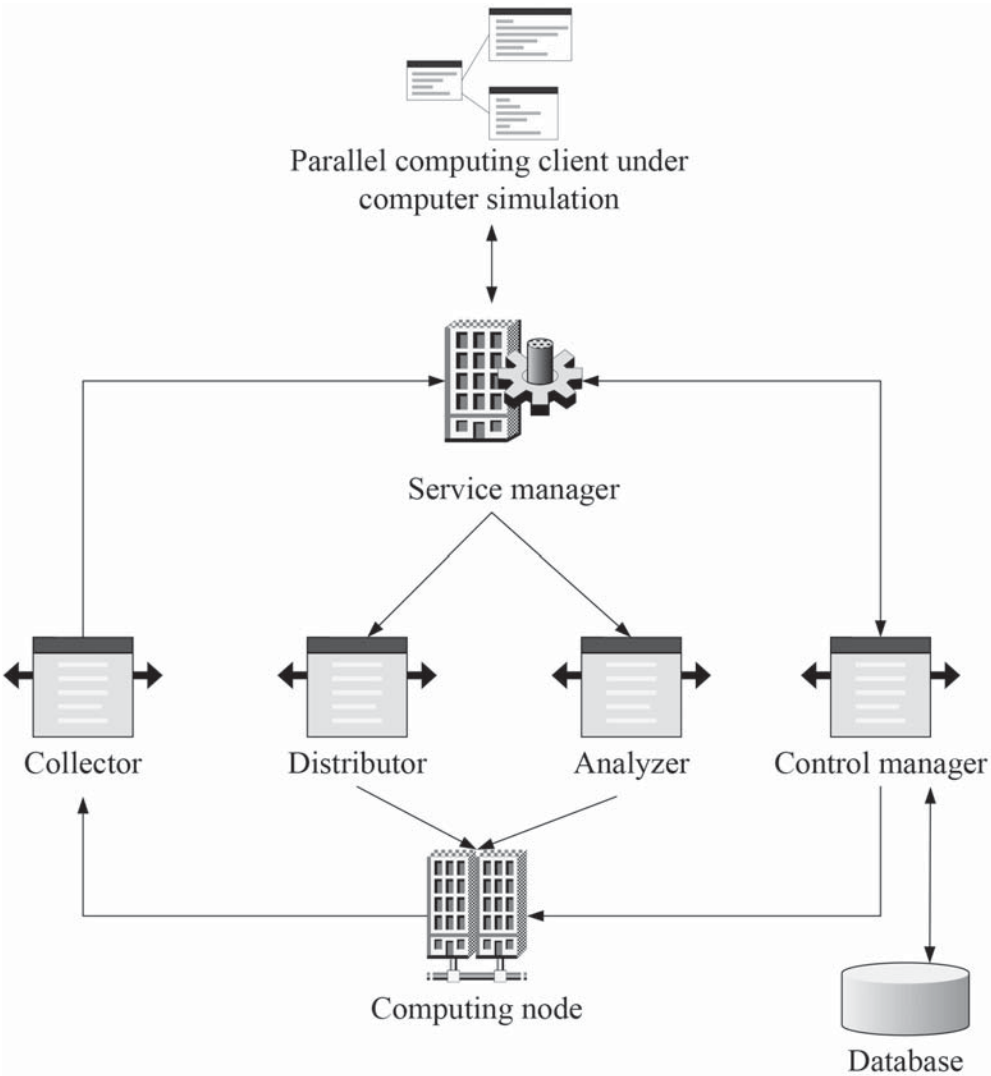


Figure 4 Design diagram of parallel computing technology framework based on computer simulation.

Table 2 Contents of parallel computing framework based on computer simulation.

Architectural components	Meaning
Client	It is used to send calculation requests, perform parallel algorithm programming on the client (that is, lightweight virtual machine embedded code), and send the code together with the calculation data to the server to process the request.
Control manager	It is used to collect the status information of the computing node, provide query services for the service node, and return the status information of the computing node (whether it is available) to the service node.
Database	It is used to store the status information of the computing node collected by the control manager. The control node consists of the control manager and the database.
Service manager	It is used to receive the client's calculation request and return the calculation result to the client.
Collector	It is used to collect the calculation results of the computing node.

time. Now the development of high-speed local area network technology has increased the reading and writing speed of the shared storage Internet. In the framework designed in this paper, the data is analyzed according to the fast Ethernet connection.

(2) Data parallelism

After the data acquisition and sharing, data parallelism involves the division of the data in the calculation data, and then the allocation of these partitions to several calculation nodes to perform the same operation. However, when paralleling data, the following two issues need to be noted.

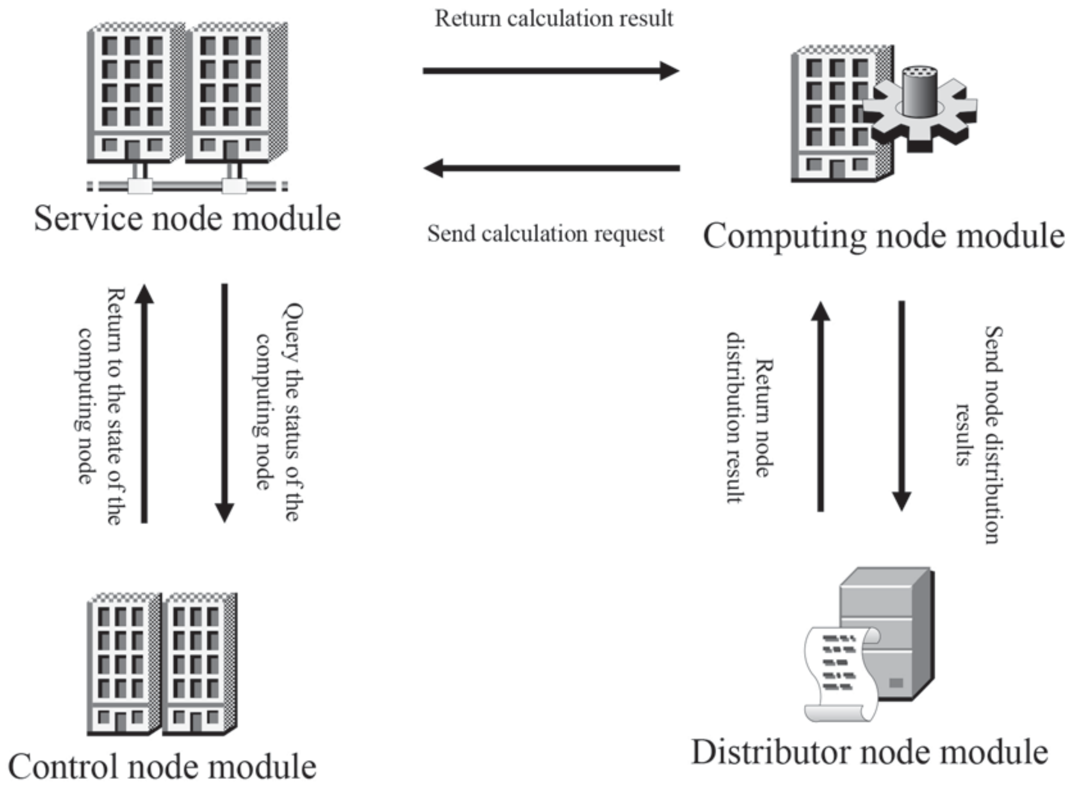


Figure 5 Function diagram of service node module.

Table 3 Com_Info table structure.

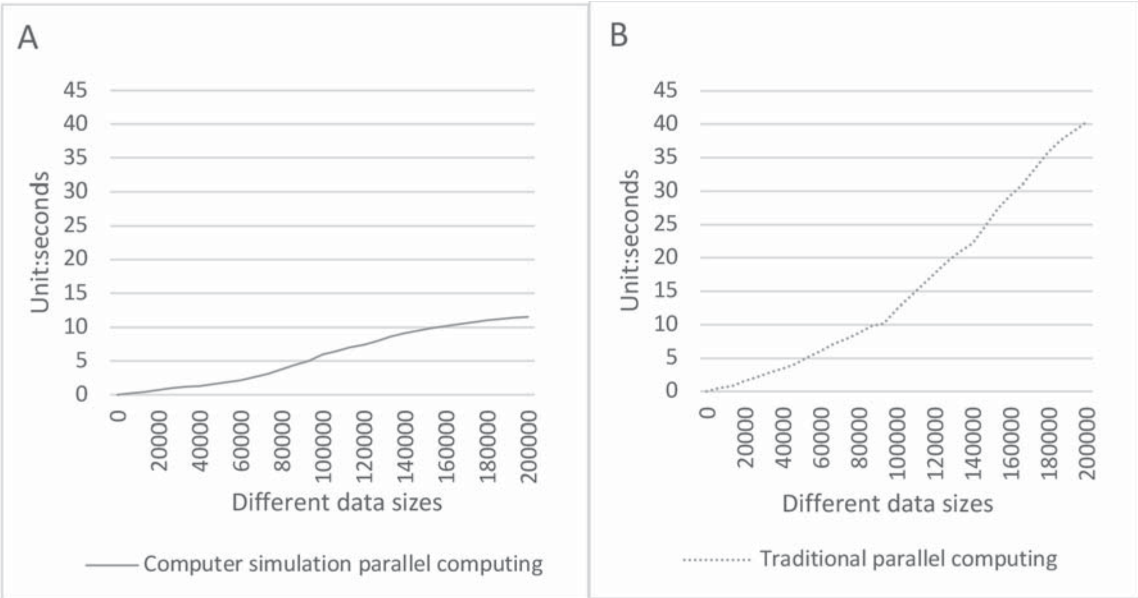
Field	Type	Description
Id	Int	Primary key
com-id	Int	Computing node id
Mac	Varchar(20)	Mac address
Status	Varchar(15)	Computing node status
mem_usage	Float	Memory usage
io_usage	Int	Disk I/O weight
cpu_usage	Float	CPU usage

Table 4 Com_Per_Info table structure.

Field	Type	Description
Cpu-num	Int	Number of cpus
Cpu-fre	Varchar(20)	CPU frequency
Mem	Varchar(20)	Memory capacity
Io	Flot	Maximum disk rate
Net	Flot	Maximum network broadband
Mem_weight	float	Memory weight
Cpu_weight	Int	CPU weight
Id	Int	Primary key

Firstly, the stability of the nodes must be determined. If the computing node in the cluster has an abnormal, the computing task also fails. The parallel computing system based on computer score calculation contains manipulation nodes that can minimize the failure rate of equipment. When a computing node has a fault, it can be marked as unavailable by the supervising node, and does not participate in the assignment of computing tasks. It can be added again after the fault is eliminated.

Secondly, the stability of shared storage must be ensured. Because the calculation data is stored in shared storage, the parallel computing system is selected to ensure the stability of the stored content. The cluster consists of several addresses and nodes, making the parallel computing system highly reliable.



(a) Computer simulation parallel computing (b) Traditional parallel computing

Figure 6 Comparison of computing time of two computing technologies for different data scales.

3.2 Experimental Results

In order to better demonstrate the advantages of parallel computing technology based on computer simulation, it is compared with traditional parallel computing. These two computing technologies are applied to different data scales simultaneously, and the times required for the final calculation are compared. For comparison, the results are shown in Figure 6.

As shown in Figure 6, parallel computing based on computer simulation takes much less time to run computing for different data scales than traditional parallel computing, and the fluctuation of its running time is also smaller than traditional parallel computing. With the increase of data size, the time range of parallel computing in this study is gradually decreasing and the running speed is faster, while traditional parallel computing becomes slower with the increase of data size. In this study, when the data size is 20000, the parallel computing time is 0.71 seconds, while the traditional parallel computing time is 1.56 seconds - a difference of 0.85 seconds. The time spent in operation is not different. When the data size is 100000, the parallel computing time is 5.96 seconds, while the traditional parallel computing time is 12.37 seconds - a difference of 6.41 seconds. The running time starts to increase gradually. When the data size is 200000, the parallel computing time studied in this paper is 11.56 seconds, while the traditional parallel computing time is 40.29 seconds. The parallel computing in this study takes 28.73 seconds less than the traditional parallel computing, and the computing time is greatly increased. The results show that parallel computing based on computer simulation has definite advantages for large-scale data processing and can greatly improve the speed of operation.

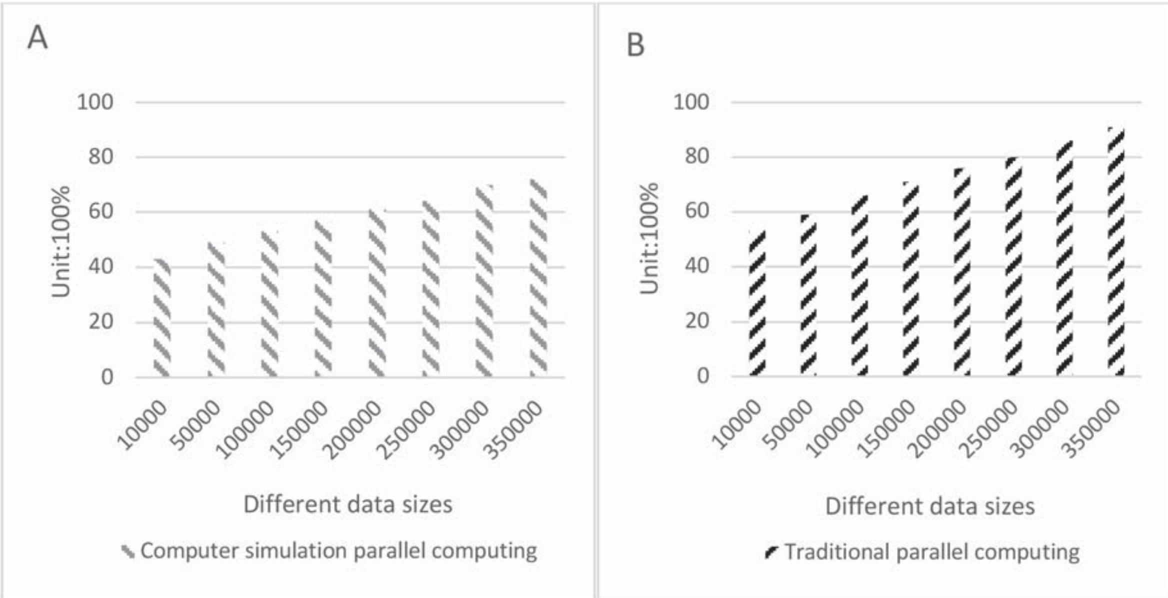
Acceleration was discussed in the above section. Acceleration can affect the performance of parallel computing. The faster the acceleration, the better the parallel calculation and the better the calculation performance. In order to verify the performance of the parallel computing technology studied in this paper, it is compared with traditional parallel computing. The acceleration changes with the increasing number of parallel computing nodes under different data scales were compared. The comparison results are shown in Table 5.

As shown in Table 5, the acceleration of parallel computing in this paper under different data scales and different number of parallel computing nodes is faster than that of traditional parallel computing. It also shows that the performance of parallel computing technology based on computer simulation is better than that of traditional parallel computing technology. When there is only one node for parallel computing, the acceleration of parallel computing increases with the increase of data size. Although the increase in speed is not very large, compared with the speed of traditional parallel computing, the acceleration is much faster. When there are five nodes in parallel computing and the data scale is 50000, the parallel computing acceleration is $2.12m/s^2$, $1.51m/s^2$higher than that of traditional parallel computing. When the data scale is 200000, the parallel computing acceleration is $2.94m/s^2$, $2.23m/s^2$ higher than that of traditional parallel computing. When there are 7 nodes in parallel computing and the data scale is 50000, the parallel computing acceleration is $3.15m/s^2$, $2.22m/s^2$ higher than that of traditional parallel computing. When the data scale is 200000, the parallel computing acceleration is $4.12m/s^2$, $3.13m/s^2$ higher than that of traditional parallel computing. These results demonstrate that the performance of parallel computing technology based on computer simulation is better than that of traditional parallel computing technology.

In this study, a new parallel computing system is built by computer simulation, which is compared with traditional parallel computing. The index for comparison is the CPU utilization of the two systems under different data scales. The comparison results are shown in Figure 7.

Table 5 Comparison results of two parallel calculation accelerations.

Calculation method	Calculate data scale	Parallel computing (1pc)	Parallel computing (3pc)	Parallel computing (5pc)	Parallel computing (7pc)
Computer simulation parallel computing	50000	0.45	1.35	2.12	3.15
	100000	0.48	1.42	2.34	3.32
	150000	0.52	162	2.77	3.57
	200000	0.55	1.78	2.94	4.12
Traditional parallel computing	50000	0.23	0.47	0.61	0.93
	100000	0.25	0.50	0.64	0.96
	150000	0.26	0.52	0.67	0.98
	200000	0.26	0.53	0.71	0.99



(a) Computer simulation parallel computing

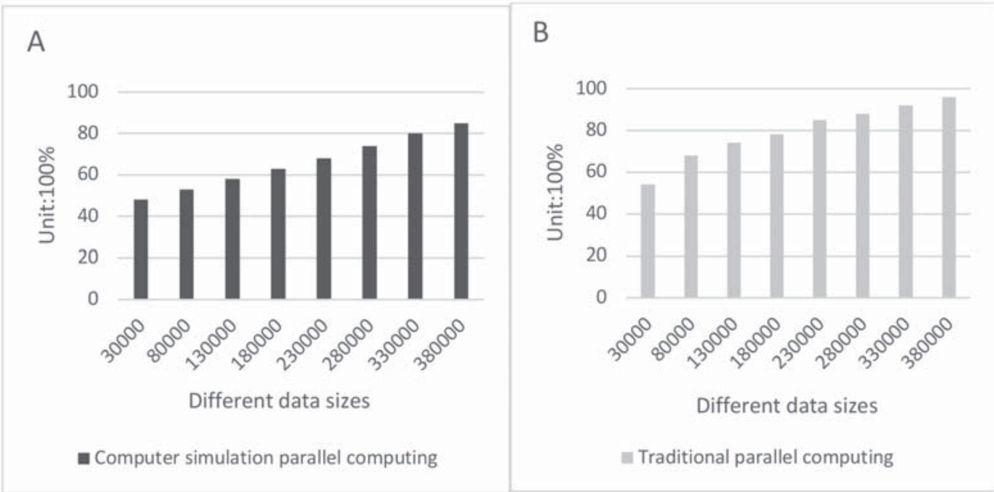
(b) Traditional parallel computing

Figure 7 Comparison of CPU utilization of two systems under different data scales.

As shown in Figure 7, the CPU utilization rate of the parallel computing technology system proposed in this paper is lower than that of the traditional parallel computing system under different data scales, which indicates that the parallel computing system consumes a smaller amount of CPU resources. When the data is 10000, the CPU utilization of the parallel computing system is 43%, which is 10% lower than that of the traditional parallel computing system. When the data is 200000, the CPU utilization of the parallel computing system is 61%, which is 15% lower than that of the traditional parallel computing system. When the data is 350000, the CPU utilization of the parallel computing system is 72%, which is 19% lower than that of the traditional parallel computing system. The difference in CPU utilization between the two parallel computing systems is the largest. The data scale ranges from 10000 to 350000. The CPU system utilization of the parallel computing system has increased by only 29%, while the traditional parallel computing system has increased by 38%.

The comparison between the two systems is continued. The comparison index is CPU memory usage. The comparison results are shown in Figure 8.

As shown in Figure 8, the CPU memory utilization rate of the parallel computing technology system proposed in this paper is lower than that of the traditional parallel computing system under different data scales, indicating that the former consumes less CPU memory resources. When the data is 30000, the CPU memory utilization rate of the parallel computing system is 48%, which is 6% lower than that of the traditional parallel computing system. When the data is 230000, the CPU memory utilization rate of the parallel computing system is 68%, which is 17% lower than that of the traditional parallel computing system. When the data is 380000, the CPU memory utilization rate of the parallel computing system is 85%, which is 11% lower than that



(a) Computer simulation parallel computing (b) Traditional parallel computing

Figure 8 Comparison of CPU memory usage of two systems under different data scales.

of the traditional parallel computing system. The data size ranges from 30000 to 380000. The CPU memory utilization of the parallel computing system has increased by only 37%, while the traditional parallel computing system has increased by 42%.

4. CONCLUSIONS

With the rapid development of science and technology and the advent of the information age, the amount of information that people need to process is increasing rapidly. However, improvement of the computing speed of a single processor and the application of traditional serial communication measurement technology are unable to meet the data processing requirements of the training set. Hence, parallel computers and parallel computing technologies have emerged at the same time. The traditional application fields of parallel computing include climate, diagnosis and treatment, crude oil, national defense, scientific research, etc. With the expansion of application scope, financial institutions, telecommunications networks, entertainment and other fields have also become important customers of parallel computing. Parallel computing is an efficient way to improve the computing speed and processing ability of computer software. However, traditional parallel computing has led to the gradual deterioration of machine and equipment performance, as well as the high requirements for programmers. This paper has studied parallel computing based on computer simulation technology. It was found that parallel computing based on computer simulation technology not only runs faster and takes less time, but also requires fewer CPU resources and less memory for different data scales, which could help increase the computing speed.

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